#### Vision and Mission of the Department

#### Vision:

To empower the Electronics and Communication Engineering students with technological excellence, professional commitment and social responsibility.

#### Mission:

- ME1. Attaining academic excellence in Electronics and Communication Engineering through dedication to duty, innovation in learning and research, state of the art laboratories and industry driven skill development.
- ME2. Establishing suitable environment for the students to develop professionalism and face life challenges with ethical integrity.
- ME3. Nurturing the students to understand the societal needs and equip them with technical expertise to provide appropriate solutions.
- ME4. Providing breeding ground to obtain entrepreneurial skills and leadership qualities for self and social growth.

#### Program Educational Objectives (PEOs):

- PEO1. Graduates will be capable of developing specification and design procedures, prototyping and test methodologies for modern electronics and communication systems and gadgets that perform analog and digital processing functions.
- PEO2. Graduates will be able to work and adapt to changes in allied areas of Electronics and Communication Engineering through personal success and life long learning.
- PEO3. Graduates will be able to identify technological requirements for the society and provide cost effective solutions.
  - These objectives will be evidenced by professional visibility (publications, presentations, inventions, patents and awards), entrepreneurial activities, international activities (participation in international conferences, collaborative research and employment abroad)

#### Program Outcomes: Engineering Graduates will be able to:

- 1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- 2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- 3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- 4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- 5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- 6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- 8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- 9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- 10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- 11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- 12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

# Program Specific Outcomes:

Engineering Graduates will be able to

- PSO1. Design circuits and systems for complex engineering problems in Electronics and Communication and allied areas.
- PSO2. Apply research methodologies to provide solutions for contemporary problems in the areas including RF, Signal Processing, Image Processing, VLSI, Optical Communication, Networks and Embedded Systems for given specifications.
- PSO3. Actively contribute as a member or leader in diverse teams, and communicate effectively on complex engineering activities and involve in life-long learning, by applying reasoning and ethical principles.

# PEO- Mission Mapping:

	ME1	ME2	ME3	ME4
PEO1	S	М	М	L
PEO2	L	S	М	М
PEO3	М	L	S	М

#### **PEO-PO-PSO Mapping:**

	P 0 1	P 0 2	P 0 3	P 0 4	P 0 5	P 0 6	P 0 7	P O 8	P O 9	P O 10	P 0 11	P 0 12	PS O 1	PS O 2	PS O 3
PEO 1															
PEO 2															
PEO 3															

#### **PO-GA Mapping:**

	GA	GA	GA	GA	GA	GA	GA	GA	GA	GA1	GA1	GA1
	1	2	3	4	5	6	7	8	9	0	1	2
PO1						ST.	2 D					
PO2					R		L'A					
PO3												
PO4					PV-		57	5				
PO5							Ale.					
PO6					No.		~ W/					
PO7												
PO8					/	a em						
PO9							~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~				
PO1												
0												
PO1												
1												
PO1												
2												

### TCE PROFICIENCY SCALE (CDIO Curriculum Framework)

TCE Proficiency Scale (TPS)	Proficiency	Cognitive	Affective	Psychomotor
TPS1	To have been exposed to	Remember	Receive	Perception, Set
TPS2	To be able to interpret and imitate	Understand	Respond	Guided Response
TPS3	To be skilled in the practice or implement	Apply	Value	Mechanism
TPS4	To be able to participate in and contribute	Analyse	Organise	Complex Overt Responses
TPS5	To be able to judge and adapt	Evaluate	Organise	Adaptation
TPS6	To be able to lead and innovate	Create	Characterize	Origination

S.No	Category	Cre	dits
		Regular	Lateral
А	Foundation Courses	53 – 58	23-28
	Humanities and Social Science (HSS)	9 -11	6-8
	Basic Science (BS)	21	6
	Engineering Science (ES)	23 – 26	11-14
В	Professional Core Courses	55	45
С	Elective Courses	24 – 48	24-48
	Programme Specific Elective	12-24	12-24
	Programme Elective for Expanded Scope	6 – 12	6-12
	General Elective	3-6	3-6
	Foundation Elective	3-6	3-6
D	Project work, seminar, internship in industry or at	15	15
	Higher Learning institutions		
E	Mandatory Courses – Environment Science,	Non-Credit	Non-Credit
	Induction Programme, Indian Constitution,	(Not included	(Not included
	Essence of Indian Tradition knowledge,	for CGPA)	for CGPA)
1	consumer Affairs ( as per UGC guideline)		
	Minimum Credits to be earned for the award of	160	120
	the Degree	(from A to D)	(from A to D)
		and the	and the
		successful	successful
		completion of	completion of
	log the start	Mandatory	Mandatory
	Son Care of	Courses	Courses

#### **Credit Distribution**

- General electives are courses offered by different departments that do not have any prerequisites and could be of interest to students of any branch
- All students have to undertake co-curricular and extra-curricular activities that include activities related to NCC, NSS, Sports, Professional Societies, participation in identified activities which promote the growth of Departments and the College.

Batch: 2018-19 onwards

## THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015 (A Govt. Aided Autonomous Institution affiliated to Anna University)

# CATEGORIZATION OF COURSES (CHOICE BASED CREDIT SYSTEM)

Programme: ECE

A. F	OUNDATIC	ON COURSES: Total Cree	dits t	o be	earne	ed: {	53-58
	a. Huma	anities and Social Science (09-11)					
S.No.	Course	Name of the Course	Number of Hours / Week				Credit
	Code		Hou	rs / V	Veek		
			L	Т	P		
THEOF	<u> </u>						
1.	18EG140	English	2	-	-		2
2.	18EC610	Accounting and Finance	3	-	-		3
3.	18EC490	Project Management	3	-	-		3
THEOF	<u>RY CUM PR</u>	ACTICAL					
1.	18EG460	Professional Communication	-	1	2		2
PRACT	<u>FICAL</u>						
1.	18EG170	English Laboratory	-	-	2		1
	b. Basio	Science (21)					
S.No.	Course	Name of the Course	Nur	nber	of Ho	urs	Credit
	Code			/ W	eek		
			- 1		т	P	-
THEOP	27	ALLERINA					
	18MA110	Engineering Calculus	3		1	_	4
1.	1000/0110	Physics	- 0		-		- T
Ζ.	18PHB20	Physics	3		-	-	3
3.	18CHB30	Chemistry Matrices and Ondinant Differential	3		-	-	3
4.	18MA210	Equations	Ζ		I	-	3
5.	18EC310	Complex Analysis and Linear Algebra	2		1		3
6.	18EC410	Optimization and Numerical Methods	2		1		3
PRACT	ΓICAL						
1.	18PH180	Physics Laboratory	-		-	2	1
2.	18CH190	Chemistry Laboratory	-		-	2	1
	c. Engii	neering Science (23-26)					
S.No.	Course	Name of the Course	N	lumb	er of		Credit
	Code		Ho	urs /	Week	(	
			L	Т	P		
THEOF	<u> </u>						
1.	18ES150	Engineering Exploration	3	-	-		3
2.	18EC240	Semiconductor Physics	3	-	-		3
3.	18EC630	Data Structures and Algorithms	2	-	-		2
4.	18XXPE0	Engineering Sciences Elective	3	-	-		3
THEOF	RY CUM PR	ACTICAL					
1.	18ME160	Engineering Graphics	3	-	2		4
2.	18EC360	Programming for Problem Solving	2	-	2		3
3.	18ES390	Design Thinking	1	-	2		2
4.	18ES590	System Thinking	1	-	1		2
PRACT	<b>FICAL</b>						
1.	18EC280	Electronics Workshop	-	-	2		1
2.	18ES290	Lateral Thinking	-	-	2		1
3.	18EC670	Data Structures and Algorithms	-	-	2		1

Laboratory

Degree: B.E.

# **Engineering Sciences Elective**

S.No.	Course	Name of the Course	N N	Number of Hours / Week		Credit
	Code		TIC	Hours / Week		
			L	T	P	
THEOF	۲Y					
1.	18ECEA0	MEMS Technology	3	-	-	3
2.	18ECEB0	Machine Learning for All	3	-	-	3
3.	18ECEC0	IOT Sensors and Device	3	-	-	3
4.	18ECED0	Blockchain Technology	3	-	-	3
5.	18ECEE0	5G Wireless Networks	3	-	-	3
THEOF	RY CUM PRA	ACTICAL				
	-	-	-	-	-	-

# B. PROFESSIONAL CORE COURSES

# Credits to be earned: 55

SI. No.	Course	Name of the Course	Nu	mbe	Credit	
	Code		H	lours	s /	
			۱	<u>Nee</u>	k 📃	
			L	Т	Р	
THEOR	Y					
1.	18EC220	Network Theory	2	1	-	3
2.	18EC230	Electronic Devices	3	-	-	3
3.	18EC320	RF Passive Devices and Circuits	2	1	-	3
4.	18EC330	Electronic Circuits	3	-	-	3
5.	18EC340	Signals and Systems	2	1	-	3
6.	18EC350	Microprocessors and Microcontrollers	2	1	-	3
7.	18EC420	RF Active Circuits	2	1	-	3
8.	18EC430	CMOS VLSI Systems	3	-	-	3
9.	18EC440	Signal Processing	2	1	-	3
10.	18EC510	Data Communication Networks	2	1	-	3
11.	18EC530	Analog and Digital Communication	2	1	-	3
		Systems				
12.	18EC620	Control Systems	2	1	-	3
13.	18EC710	Consumer Electronics	1	-	-	1
THEOR	Y CUM PRAC	TICAL				
14.	18EC260	Digital System Design	2	-	2	3
15.	18EC520	Antenna and Wave Propagation	2	-	2	3
16.	18EC560	Digital Image Processing	2	-	2	3
17.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTI	CAL					
18.	18EC270	Circuits and Devices Laboratory	-	-	2	1
19.	18EC370	Microprocessor and Microcontroller	-	-	2	1
		Laboratory				
20.	18EC380	Electronic Circuits Laboratory	-	-	2	1
21.	18EC470	RF Circuits Laboratory	-	-	2	1
22.	18EC480	Signal Processing Laboratory	-	-	2	1
23.	18EC570	Data Communication Networking	-	-	2	1
		Laboratory				
24.	18EC580	Analog and Digital Communications	-	-	2	1
		Laboratory				

C. El	<b>ECTIVE COURS</b>	SES: Credits	s to be earned: 24-48					
a. Pr	ogramme Specifi	c Elective Credits t	o be	earn	ed:12	2-24		
SI. No.	Course Code	Name of the Course	Nu H	mbe lour: Nee	er of s / k	Credit		
THEOD	<pre></pre>		L		P			
		Computer Vision and Applications	3			3		
1. 2		Data Compression	2	-	-	2		
2.		Wireless Communication Systems	3 2	-	-	<u>、</u> 2		
3. 1		FRCA Record Digital System Design	2		-	<u> </u>		
4.		FPGA Based Digital System Design	<u>、</u>	-	-	<u> </u>		
5.	18ECPHU	Instruments	3	-	-	3		
6.	18ECPJ0	Network Security	3	-	-	3		
7.	18ECPK0	Optical Communication	3	-	-	3		
8.	18ECPM0	Planar Antennas for Wireless	2	-	2	3		
9.	18ECPN0	Electromagnetic Interference and Compatibility	3	-	-	3		
10.	18ECPQ0	Statistical Signal Processing	2	1	-	3		
11.	18ECPT0	Deep Learning For Speech Processing	2	1	-	3		
12.	18ECPU0	VLSI Device Modeling	3	-	-	3		
13.	18ECPY0	ASIC Design	3	-	-	3		
14.	18ECPZ0	IoT System and Applications	3	-	-	3		
15.	18ECRA0	Real Time Embedded Systems	3	-	-	3		
THEOR	Y CUM PRACTIC	AL						
16.	18ECPC0	DSP Architecture and Programming	2	-	2	3		
17.	18ECPE0	Biomedical Signal Processing	2	-	2	3		
18.	18ECPG0	Analog System Design	2	-	2	3		

b. Program	me Elective f	or Expanded	Scope		Credits to	o be e	earne	)
01.11	•		6.41	~				_

b. Program	b. Programme Elective for Expanded Scope Credits to					
SI. No.	Course	Name of the Course	Nu	Number of		Credit
	Code		Н	lours	s /	
			Week			
			L	Т	Ρ	
THEORY						
1.	18ECPL0	Medical Imaging and Processing	3	-	-	3
2.	18ECPP0	RF MEMS Design and Technology	3	-	-	3
3.	18ECPR0	LDPC and Polar Codes	2	1	-	3
4.	18ECPS0	Physical Channel Processing in 5G	2	1	-	3
		NR				
5.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3
6.	18ECPW0	CAD for VLSI	3	-	-	3
7.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3
8.	18ECRC0	Multimedia Compression Techniques	3	1	-	4
9.	18ECRD0	Signal Processing in 5G NR	3	1	-	4
10.	18ECRE0	Algorithms for VLSI Design	3	1	-	4
		Automation				
11.	18ECRF0	Low Power VLSI Design	3	1	-	4
12.	18EC1A0	Field Tests for a 5G Future	1	-	-	1
13.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1
14.	18EC1C0	Synchronization for 5G NR	1	-	-	1

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

15.	18EC1D0	Speech Signal Processing	1	-	-	1
16.	18EC1E0	VLSI Implementation of	1	-	-	1
		Communication Transceivers				
17.	18EC1F0	Embedded System Design	1	-	-	1
THEORY CUI	M PRACTICA	AL				
	-	-	-	-	-	-

c. General Elective

# Credits to be earned: 03-06

SI. No.	Course Code	Name of the Course	Nu H	mbe ours Vee	Credit	
			L	Т	Р	
THEORY						
1.	18ECGA0	Consumer Electronics	3	-	I	3
2.	18ECGB0	Multimedia Systems	3	-	-	3
3.	18ECGC0	Telecommunication Systems	-	-	3	
4.	18ECGD0	Applied Image Processing	3	-	-	3

# d. Electives from foundation courses- HSS, BS, ES

## D. Project

#### Credits to be earned: 15

Credits to be earned: 03-06

S.No.	Course Code	Name of the Course	Nı Hou	Number of Hours / Week		Credit
		and the second sec	L	Т	Р	
1.	18ES690	Engineering Design Project	2	-	4	3
2.	18ES790	Capstone Design Project	-	-	6	3
3.	18EC810	Project	-	-	18	9

E. M	E. Mandatory Courses (Not included for CGPA)												
S.No.	Course	Name of the Course	Nu	ımbe	r of	Credit							
	Code		Hou	irs / V									
THEORY													
1.	18CHAA0	Environmental Sciences	-	-	2	0							
2.	18CHAB0	Constitution of India	-	-	2	0							
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0							
THEOR	Y CUM PRA	CTICAL											
-	-	-	-	-	-	-							
PRACT	ICAL												
-	-	-	-	-	-	-							

Minimum credits to be earned for the award of the degree = 160

# THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015 (A Govt. Aided Autonomous Institution affiliated to Anna University)

# CATEGORIZATION OF COURSES (CHOICE BASED CREDIT SYSTEM)

Degree:	: B.E.	Programme: ECE	Batch: 2021-22 onwards						
F. F		IN COURSES: Total Cred	dits t	o be	earne	d: 5	3-58		
	d. Huma	anities and Social Science (09-11)							
S.No.	Course	Name of the Course	Νι	impe	er of		Credit		
	Code		Hou	rs / \	Neek	_			
			L	T	P				
THEOF	<b></b> Υ			1					
1.	18EG140	English	2	-	-		2		
2.	18EC610	Accounting and Finance	3	-	-		3		
3.	18EC490	Project Management	3	-	-		3		
THEOF	RY CUM PR	ACTICAL			-				
1.	18EG460	Professional Communication	-	1	2		2		
PRACT	<u>FICAL</u>	1			-				
1.	18EG170	English Laboratory	-	-	2		1		
· · · · · ·	e. Basic	: Science (21)					1		
S.No.	Course	Nur	nber	of Hou	urs	Credit			
	Code			/ W	/eek				
			1		Т	Р	-		
THEOF	<del>Υ</del> Υ	AT COMPANY	-		•	•			
1.	18MA110	Engineering Calculus	3		1	-	4		
2.	18PHB20	Physics	3	,	-	-	3		
3.	18CHB30	Chemistry	3		-	-	3		
4.	18MA210	Matrices and Ordinary Differential	2		1	-	3		
		Equations							
5.	18EC310	Complex Analysis and Linear Algebra	2		1		3		
6.	18EC410	Optimization and Numerical Methods	2		1		3		
PRAC	FICAL				r		1		
1.	18PH180	Physics Laboratory	-		-	2	1		
2.	18CH190	Chemistry Laboratory	-		-	2	1		
	f. Engir	neering Science (23-26)	1						
S.No.	Course	Name of the Course	N	lumb	er of		Credit		
	Code		Ho	urs /	Week	_			
			L	Т	P				
THEOF	<u> </u>								
1.	18ES150	Engineering Exploration	3	-	-	_	3		
2.	21EC240	Electronic Materials	3	-	-	_	3		
3.	18EC630	Data Structures and Algorithms	2	-	-	_	2		
4.			3	-	-		3		
THEOP							4		
1.	18ME160	Engineering Graphics	3	-	2		4		
2.	18EC360	Programming for Problem Solving	2	-	2		<u>১</u>		
3.	18ES390		1	-	2		2		
4.	1865590	System I ninking	1	-	1		2		
PRACI		Flootropics Marketer			<u> </u>		4		
1.	18EC280	Leteral Thinkin a	-	-	2		1		
2.	185290		-	-	2	_	1		
3.		Laboratory	-	-	2		Т		

# **Engineering Sciences Elective**

S.No.	Course Code	Name of the Course	N Ho	lumb ours /	er of Week	Credit
			L	Т	Р	
THEOF	۲Y					
1.	18ECEA0	MEMS Technology	3	-	-	3
2.	18ECEB0	Machine Learning for All	3	-	-	3
3.	18ECEC0	IOT Sensors and Device	3	-	-	3
4.	18ECED0	Blockchain Technology	3	-	-	3
5.	18ECEE0	5G Wireless Networks	3	-	-	3
THEOF	RY CUM PRA	ACTICAL				
	-	-	-	-	-	-

# G. PROFESSIONAL CORE COURSES

# Credits to be earned: 55

SI No	Course	Name of the Course	NI	mha	rof	Cradit
SI. NO.	Course	Name of the Course		Barrie	;iUI ~/	Creat
	Code			Nac	5/	
				/vee ∣⊤	r P	
THEOR	│ ✔		_ L		F	
25	18FC220	Network Theory	2	1	_	3
26	18EC231	Electronic Devices	3			3
20.	18EC320	RE Passive Devices and Circuits	2	1		3
28	18EC330	Electronic Circuits	2			3
20.	18EC340	Signals and Systems	2	1		3
30	18EC350	Microprocessors and Microcontrollers	2	1		3
31	18EC420	REActive Circuits	2	1		3
32	18EC430	CMOS VI SI Systems	3	<u> </u>	_	3
33	18EC440	Signal Processing	2	1	-	3
34	18EC510	Data Communication Networks	2	1	-	3
35	18EC530	Analog and Digital Communication	2	1	-	3
00.	1020000	Systems	-	'		Ŭ
36.	18EC620	Control Systems	2	1	-	3
37.	18EC710	Consumer Electronics	1	-	-	1
THEOR	Y CUM PRAC	TICAL				-
38.	18EC260	Digital System Design	2	-	2	3
39.	18EC520	Antenna and Wave Propagation	2	-	2	3
40.	18EC560	Digital Image Processing	2	-	2	3
41.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTI	CAL			1	I	
42.	18EC270	Circuits and Devices Laboratory	-	-	2	1
43.	18EC370	Microprocessor and Microcontroller	-	-	2	1
		Laboratory				
44.	18EC380	Electronic Circuits Laboratory	-	-	2	1
45.	18EC470	RF Circuits Laboratory	-	-	2	1
46.	18EC480	Signal Processing Laboratory	-	-	2	1
47.	18EC570	Data Communication Networking	-	-	2	1
		Laboratory				
48.	18EC580	Analog and Digital Communications	-	-	2	1
		Laboratory				

H. EL		SES: Credits	to be	ear	med:	24-48
a. Pr	ogramme Specif	ic Elective Credits to	o be (	earn	ed:12	-24
SI. No.	Course	Name of the Course	Nu	mbe	er of	Credit
	Code		H	lours	s /	
			۱	Nee	k	
			L	Т	Р	
THEOR	Y					
19.	18ECPA0	Computer Vision and Applications	3	-	-	3
20.	18ECPB0	Data Compression	3	-	-	3
21.	18ECPD0	Wireless Communication Systems	2	1	-	3
22.	18ECPF0	FPGA Based Digital System Design	3	-	-	3
23.	18ECPH0	Electronic Measurement and	3	-	-	3
		Instruments				
24.	18ECPJ0	Network Security	3	-	-	3
25.	18ECPK0	Optical Communication	3	-	-	3
26.	18ECPM0	Planar Antennas for Wireless	2	-	2	3
		Applications				
27.	18ECPN0	Electromagnetic Interference and	3	-	-	3
		Compatibility				
28.	18ECPQ0	Statistical Signal Processing	2	1	-	3
29.	18ECPT0	Deep Learning for Speech Processing	2	1	-	3
30.	18ECPU0	VLSI Device Modeling	3	-	-	3
31.	18ECPY0	ASIC Design	3	-	-	3
32.	18ECPZ0	IoT System and Applications	3	-	-	3
33.	18ECRA0	Real Time Embedded Systems	3	-	-	3
THEOR	Y CUM PRACTIO	CAL				
34.	18ECPC0	DSP Architecture and Programming	2	-	2	3
35.	18ECPE0	Biomedical Signal Processing	2	-	2	3
36.	18ECPG0	Analog System Design	2	-	2	3

# b. Programme Elective for Expanded Scope Credits to be earned: 06-12

SI. No.	Course Code	Name of the Course	Nu H	mbe lours	er of s /	Credit
			\	Nee	k	
			L	Т	Р	
THEORY	/					
18.	18ECPL0	Medical Imaging and Processing	3	-	-	3
19.	18ECPP0	RF MEMS Design and Technology	3	-	-	3
20.	18ECPR0	LDPC and Polar Codes	2	1	-	3
21.	18ECPS0	Physical Channel Processing in 5G	2	1	-	3
		NR				
22.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3
23.	18ECPW0	CAD for VLSI	3	-	-	3
24.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3
25.	18ECRC0	Multimedia Compression Techniques	3	1	-	4
26.	18ECRD0	Signal Processing in 5G NR	3	1	-	4
27.	18ECRE0	Algorithms for VLSI Design	3	1	-	4
		Automation				
28.	18ECRF0	Low Power VLSI Design	3	1	-	4
29.	18EC1A0	Field Tests for a 5G Future	1	-	-	1

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

Credits to be earned: 03-06

Credits to be earned: 15

30.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1
31.	18EC1C0	Synchronization for 5G NR	1	-	-	1
32.	18EC1D0	Speech Signal Processing	1	-	-	1
33.	18EC1E0	VLSI Implementation of	1	-	-	1
		Communication Transceivers				
34.	18EC1F0	Embedded System Design	1	-	-	1
THEORY	CUM PRACTICA	AL				
	-	-	-	-	-	-

d. Genera	I Elective	Credits to be earned: 03-06							
SI. No.	Course	Name of the Course	Nu	mbe	er of	Credit			
	Code		⊢	lours					
			Wee						
	L	T	Р						
THEORY	·								
5.	18ECGA0	Consumer Electronics	3	-	-	3			
6.	18ECGB0	Multimedia Systems	3	-	-	3			
7.	18ECGC0	Telecommunication Systems	3	-	-	3			
8.	18ECGD0	Applied Image Processing	3	-	-	3			

d. Electives from foundation courses- HSS, BS, ES

# I. Project

#### S.No. Course Name of the Course Number of Credit Code Hours / Week L Т Ρ Engineering Design Project 18ES690 2 4 3 1. -2. Capstone Design Project 18ES790 -6 3 -3. 18EC810 Project 18 9 --

J. M	landatory Co	ourses (Not included for CGPA)								
S.No.	Course	Name of the Course	Nu	ımbe	r of	Credit				
	Code		Hou	rs / V	Veek					
			L	Т						
THEORY										
1.	18CHAA0	Environmental Sciences	-	-	2	0				
2.	18CHAB0	Constitution of India	-	-	2	0				
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0				
THEOR	Y CUM PRA	CTICAL								
-	-	-	-	-	-	-				
PRACT	ICAL									
-	-	-	-	-	-	-				

Minimum credits to be earned for the award of the degree = 160

Se m est er		Theory						Theory cum Practical Practical				Audit Courses (Mandato ry Non- credit}	Cr edi ts
	1	2	3	4	5	6	7	8	9	10	11	12	
I	18MA110 Engineering Calculus (4)	18PHB20 Physics (3)	18CHB 30 Chemistry (3)	18EG180 English (2)	18ES150 Engg Explorati on (3)		18ME160 Engg Graphics (4)	18EG170 English Lab. (1)	18PH180 Physics Lab. (1)	18CH19 0 Chemist ry Lab. (1)	-	-	22
II	18MA210 Matrices and Ordinary Differential Equations (3)	18EC220 Network Theory (3)	18EC230** Electronic Devices (3)	18EC240** Semicondu ctor Physics (3)			18EC260 Digital System Design (3)	18EC270 Circuits and Devices Lab (1)	18EC280 Workshop (1)	-	18ES290 Lateral Thinking (1)	18CHAA0 Environm ental Sciences (0)	18
111	18EC310 Complex Analysis and Linear Algebra (3)	18EC320 RF Passive Devices and Circuits (3)	18EC330 Electronic Circuits (3)	18EC340 Signals and Systems (3)	18EC350 Micropro cessors and Microcont rollers (3)		18EC360 Programmin g for Problem Solving (3)	18EC370 Microproc essor and Microcont roller Lab (1)	18EC380 Electronic Circuits Lab (1)	-	18ES390 Design Thinking (TCP) (2)		22
IV	18EC410 Optimization and Numerical Methods (3)	18EC420 RF Active Circuits (3)	18EC430 CMOS VLSI Systems (3)	18EC440 Signal Processing (3)	18YYFX0 Foundati on Elective I (3)	-	18EG460 Professional Communicat ion (2)	18EC470 RF Circuits Lab (1)	18EC480 Signal Processin g Lab (1)	-	18EC490 Project Managem ent (3)	18CHAB0 Constituti on of India (0)	22
V	18EC510 Data Communicat ion Networks (3)	18EC520 Antenna and Wave Propagatio n (TCP) (3)	18EC530 Analog and Digital Communicat ions (3)	18ECPX0 Prog. Elective -I (3)	18YYGX 0 Gen. Elective .I (3)	-	18EC560 Digital Image Processing (3)	18EC570 Data Commn. Networkin g Lab `(1)	18EC580 Analog and Digital Commn. Lab (1)	-	18ES590 System Thinking (2)	Essence of Indian Knowledg e (0)	22

# SCHEDULING OF COURSES FOR 2018-19 onwards (B.E. ECE Programme)\*

Passed in BoS Meeting 22.06.2021

Se m est er			Theory	,			Theory cum Practical		Practical		Special Courses	Audit Courses (Mandato ry Non- credit}	Cr edi ts
	1	2	3	4	5	6	7	8	9	10	11	12	
VI	18EC610 Accounting and Finance (3)	18EC620 Control Systems (3)	18EC630 Data Structures and Algorithms (2)	18ECPX0 Prog. Elective II (3)	18ECPX 0 Prog. Elective/ 18YYFX0 Foundati on Elective II (3)	Engg Scienc es Electiv e (3)	18EC660 Digital Communicat ion System Design (2)	18EC670 Data Structures and Algorithm s Lab (1)	-	-	18ES690 Engineeri ng Design Project (3)	-	23
VII	18EC710 Consumer Electronics (1)	18ECPX0 Prog. Elec.III (3)	18ECPX0 Prog. Elec IV (3)	18ECPX0 Prog. Elec.V (3)	18ECPX 0 Prog. Elec. VI / 18YYFX0 General Elective (3)				-	-	18ES790 Capstone Design Project (3)	-	16
VIII	18XXPX0 Prog. Elec. VII (3)	18XXPX0 Prog. Elec. VIII (3)		-	- 7	6	<u> -                                   </u>	-	-	18EC81 0 Project (9)	-	-	15

\*This schedule shows an optimal way of completing the B.E. Degree programme successfully in 4 Years \*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

Total Credits for Curricular Activities: 160

## THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI - 625 015

#### B.E Degree (Electronics and Communication Engineering) Program

## COURSES OF STUDY

(For the students admitted from the Academic year 2018-19 onwards)

#### **FIRST SEMESTER**

Course code	Name of the Course	Category	Number of Hours / Week		Credits	
			L	Τ	Ρ	
THEORY						
18MA110	Engineering Calculus	BS	3	1	-	4
18PHB20	Physics	BS	3	-	-	3
18CHB30	Chemistry	BS	3 -		-	3
18EG140	English	HSS	2	-	-	2
18ES150	Engineering Exploration	ES	3	-	-	3
THEORY CL	IM PRACTICAL					
18ME160	Engineering Graphics	ES	3	-	2	4
PRACTICAL						
18EG170	English Laboratory	HSS	-	-	2	1
18PH180	Physics Laboratory	BS	-	-	2	1
18CH190	Chemistry Laboratory	BS	-	-	2	1
	Total		17	1	8	22

#### SECOND SEMESTER

Course code	Name of the Course	Category	Nu	Number of Hours / Week		Credits
			L	T	Ρ	
THEORY						
18MA210	Matrices and Ordinary Differential	BS	2	1	-	3
	Equations					
18EC220	Network Theory	PC	2	1	-	3
18EC230**	Electronic Devices	PC	3	-	3	
18EC240**	Semiconductor Physics	ES	3	-	-	3
THEORY CL	JM PRACTICAL					
18EC260	Digital System Design	PC	2	-	2	3
PRACTICAL						
18EC270	Circuits and Devices Laboratory	PC	-	-	2	1
18EC280	Electronics Workshop	ES	-	-	2	1
18ES290	Lateral Thinking	ES	-	-	2	1
Non-credit co	ourse (Mandatory) – Audit Course					
18CHAA0	Environment Sciences	ES	1	-	1	-
	Total		13	2	9	18

\*\*For students joined from 2021-22 onwards,

18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

# THIRD SEMESTER

Course codeName of the CourseCatego		Category	Nu Hou	imber Irs / V	r of Veek	Credits
			L	T	P	
THEORY	I				-	
18EC310	Complex Analysis and Linear Algebra	BS	2	1	-	3
18EC320	RF Passive Devices and Circuits	PC	2	1	-	3
18EC330	Electronic Circuits	PC	3	-	-	3
18EC340	Signals and Systems	PC	2	1	-	3
18EC350	Microprocessors and Microcontrollers	PC	2	1	-	3
THEORY O	CUM PRACTICAL	•				
18EC360	Programming for Problem Solving	ES	2	-	3	
18ES390	Design Thinking	ES	1	-	2	2
PRACTICA	AL					
18EC370	Microprocessor and Microcontroller Laboratory	PC	-	-	2	1
18EC380	Electronic Circuits Laboratory	PC	-	-	2	1
	Total		14	4	8	22
FOURTH SI	EMESTER					
			Number of			
Course	Name of the Course	Category	Nu	ımbeı	r of	Credits
Course code	Name of the Course	Category	Nu Hou	imbei rs / V	r of Veek	Credits
Course code	Name of the Course	Category	Nu Hou L	imbei irs / V T	r of Veek P	Credits
Course code THEORY	Name of the Course	Category	Nu Hou L	imbei irs / V T	r of Veek P	Credits
Course code THEORY 18EC410	Name of the Course Optimization and Numerical Methods	Category BS	Nu Hou L	Imbei Irs / V T	r of Veek P	Credits 3
Course code THEORY 18EC410 18EC420	Name of the Course Optimization and Numerical Methods RF Active Circuits	Category BS PC	Nu Hou L 2 2	Imbei Irs / V T 1 1	r of Veek P -	Credits 3 3
Course code THEORY 18EC410 18EC420 18EC430	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems	Category BS PC PC	Nu Hou 2 2 3	Imbei Irs / V T 1 1 -	r of Veek P - -	Credits 3 3 3
Course code THEORY 18EC410 18EC420 18EC430 18EC440	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing	Category BS PC PC PC	Nu Hou 2 2 3 2	Imbei Irs / V T 1 1 - 1	r of Veek P - - -	Credits 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing Foundation Elective I	Category BS PC PC PC BS	Nu Hou 2 2 3 2 3	Imbei Irs / V T 1 1 - 1 -	r of Veek P - - - -	Credits 3 3 3 3 3 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC490	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing Foundation Elective I Project Management	Category BS PC PC PC BS HSS	Nu Hou 2 2 3 2 3 3 3	Imbei Irs / V T 1 - 1 - -	r of Veek P - - - - - -	Credits 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490 THEORY C	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing Foundation Elective I Project Management CUM PRACTICAL	Category BS PC PC PC BS HSS	Nu Hou 2 2 3 2 3 3 3	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	r of Veek P - - - - - -	Credits 3 3 3 3 3 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460	Name of the CourseOptimization and Numerical MethodsRF Active CircuitsCMOS VLSI SystemsSignal ProcessingFoundation Elective IProject ManagementCUM PRACTICALProfessional Communication	Category BS PC PC PC BS HSS HSS	Nu Hou 2 2 3 2 3 3 -	1 1 1 1 - 1 - 1 - 1 1 -	r of Veek P - - - - - - - 2	Credits 3 3 3 3 3 3 2
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         Name of the Lective I	Category BS PC PC PC BS HSS HSS	Nu Hou 2 2 3 2 3 3 3 -	Imber           Irs         / V           T         -           1         -           1         -           -         -           -         -           1         -           1         -           1         -           1         -           1         -           1         -	r of Veek P - - - - - - 2	Credits 3 3 3 3 3 2 2
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Original Processing	Category BS PC PC PC BS HSS HSS	NL Hou 2 2 3 2 3 3 -	Imber           rs / V           T           1           -           1           -           1           -           1           -           1           -           1           -           1           -           -           1	r of Veek P - - - - - 2	Credits 3 3 3 3 3 2 1 (
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC470	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory	Category BS PC PC PC BS HSS HSS	Nu Hou 2 2 3 2 3 3 - -	Imber Irs / V T 1 - 1 - - 1 - - -	r of Veek P - - - - - - - 2 2 2	Credits 3 3 3 3 3 2 1 1 1
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY ( 18EG460 PRACTICA 18EC470 18EC470 18EC480 AUDIT CO	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing Foundation Elective I Project Management CUM PRACTICAL Professional Communication CUM RF Circuits Laboratory Signal Processing Laboratory URSE - NON-CREDIT MANDATORY COU	Category BS PC PC PC BS HSS HSS HSS JRSE	Nu Hou 2 3 3 3 3 - -	Imber           Irs         / V           T         -           1         -           1         -           -         -           1         -           -         -           -         -           -         -           -         -           -         -           -         -	r of Veek P - - - - - - 2 2 2	Credits 3 3 3 3 3 2 1 1 1 6
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC470 18EC480 AUDIT CO 18CHAB0	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         AL         RF Circuits Laboratory         Signal Processing Laboratory         URSE - NON-CREDIT MANDATORY COU         Constitution of India	Category BS PC PC PC BS HSS HSS PC PC JRSE HSS	Nu Hou 2 2 3 2 3 3 - -	Imber           Irs / V           T           1           -           1           -           1           -           1           -           -           -           -           -           -           -           -           -           -           -           -           -           -           -           -           -	r of Veek P - - - - - 2 2 2	Credits 3 3 3 3 3 3 2 1 1 0 0

# **FIFTH SEMESTER**

Course code	Name of the Course	Category	Number of Hours / Week		r of Veek	Credits
			L	Т	Ρ	
THEORY						
18EC510	Data Communication Networks	PC	2	1	-	3
18EC530	Analog and Digital Communication	PC	2	2 1		3
	Systems		2		-	
18ECPX0	Programme Elective -I	PE	3	-	-	3
18YYGX0	General Elective - I	GE	3	-	-	3
THEORY C	CUM PRACTICAL					
18EC520	Antenna and Wave Propagation	PC	2	-	2	3
18EC560	Digital Image Processing	PC	2	-	2	3
18ES590	System Thinking	ES	1	-	2	
PRACTICA	NL .					

18EC570	Data Communication Networking	PC	-	-	2	1							
	Laboratory					-							
18EC580	Analog and Digital Communications	PC	-	-	2	1							
	Laboratory												
AUDIT CO	URSE - NON-CREDIT MANDATORY CO	URSE											
18CHAC0	Essence of Indian Knowledge	HSS	-	-	2	0							
	Total		15	2	11	22							
*One hour p	One hour per week is allotted for off the classroom work												
SIXTH SEM	ESTER												
Course	Name of the Course	Category	Nu	Imbe	r of	Credits							
code			Hou	ırs / V	Veek								
			L	Τ	Ρ								
THEORY		I											
18EC610	Accounting and Finance	HSS	3	-	-	3							
18EC620	Control Systems	PC	2	1	-	3							
18EC630	Data Structures and Algorithms	ES	2	-	-	2							
18ECPX0	Programme Elective-II	PE	3	-	-	3							
18YYZX0	Programme / Foundation Elective - I	PE/FE	3	-	-	3							
18ESEX0	Engineering Sciences Elective	ES	3	-	-	3							
THEORY C	UM PRACTICAL												
18EC660	Digital Communication Transceiver	PC	1	-	2	2							
PRACTICA	<u> </u>												
18EC670	Data Structures and Algorithms	ES	-	-	2	1							
	Laboratory												
PROJECT													
18ES690	Engineering Design Project	Project	1	-	4	3							
	Total		18	1	8	23							

# SEVENTH SEMESTER

Course code	Name of the Course	Category	Nu Hou	ımbeı ırs / V	r of Veek	Credits
			L	Т	Ρ	
THEORY						
18EC710	Consumer Electronics	PC	1	-	-	1
18ECPX0	Programme Elective -III	PE	3	-	-	3
18ECPX0	Programme Elective -IV	PE	3	-	-	3
18ECPX0	Programme Elective -V	PE	3	-	-	3
18YYZX0	Programme-VI / General Elective - II	PE/GE	3	-	-	3
THEORY C	CUM PRACTICAL					
-	-	-	-	-	-	-
PRACTICA	\L					
-	-	-	-	-	-	-
PROJECT						
18ES790	Capstone Design Project	Project	-	-	6	3
	Total		13	-	6	16

#### **EIGHTH SEMESTER**

Course code	Name of the Course	Category	Nu Hou	mbei rs / V	r of Veek	Credits
			L T P			
THEORY						
18ECPX0	Programme Elective -VII	PE	3	-	-	3
18ECPX0	Programme Elective -VIII	PE	3	-	-	3
THEORY C	UM PRACTICAL					
-	-	-	-	-	-	-
PRACTICA	\L					
-	-	-	-	-	-	-
PROJECT						
18EC810	Project	Project	-	-	18	9
	Total		6	-	18	15

- BS : Basic Science
- HSS : Humanities and Social Science
- ES : Engineering Science
- PC : Programme Core
- PE : Programme Elective
- GE : General Elective
- FE : Foundation Elective
- L : Lecture
- T : Tutorial
- P : Practical

#### Note:

- 1 Hour Lecture/week is equivalent to 1 Credit
- 1 Hour Tutorial/week is equivalent to 1 Credit
- 2 Hours Practical/week is equivalent to 1 Credit

#### THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E Degree (Electronics and Communication Engineering) Program SCHEME OF EXAMINATIONS

(For the students admitted from the Academic Year 2018-19 onwards) **SECOND SEMESTER** 

Course code	Name of the Course	Duration of	N	larks		Minimum for Pass	Marks
		Terminal	Continuous	Terminal	Max.	Terminal	Total
		Exam\	Assessment*	Exam**	Marks	Exam	
		in Hrs.					
THEORY	•						
18MA210	Matrices and	3	50	50	100	25	50
	Ordinary						
	Differential						
	Equations						
18EC220	Network	3	50	50	100	25	50
	Theory						
18EC230***	Electronic	3	50	50	100	25	50
	Devices						
18EC240***	Semiconductor	3	50	50	100	25	50
	Physics						
THEORY CU	M PRACTICAL						
18EC260	Digital System	3	50	50	100	25	50
	Design						
PRACTICAL							
18EC270	Circuits and	3	50	50	100	25	50
	Devices						
	Laboratory						
18EC280	Electronics	3	50	50	100	25	50
	Workshop						
18ES290	Lateral	-	50	50	100	25	50
	Thinking						
AUDIT COUI	RSE - NON-CRED	IT MANDA	TORY COURS	E			
18CHAA0	Environmental	-	50	50	100	25	50
	Sciences						

\*\*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

#### THIRD SEMESTER

Course code	Name of the Course	Duration of End			Minimum for Pass	Marks	
		Semester Exam\ in Hrs	Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Fxam	Total
THEORY				Exam		Exam	
18EC310	Complex Analysis and Linear Algebra	3	50	50	100	25	50
18EC320	RF Passive Devices and Circuits	3	50	50	100	25	50
18EC330	Electronic Circuits	3	50	50	100	25	50
18EC340	Signals and Systems	3	50	50	100	25	50

18EC350	Microprocessors	3	50		50	100	25	50
	and							
THEORY								
18EC360	Programming for	3	50		50	100	25	50
1020000	Problem Solving	Ŭ	00			100	20	
18ES390	Design Thinking	-	50		50	100	25	50
PRACTIC	AL Ö			1	1		•	1
18EC370	Microprocessor	3	50		50	100	25	50
	and							
	Microcontroller							
4050000	Laboratory	2	50		50	100	05	50
18EC380	Electronic	3	50		50	100	25	50
	Laboratory							
FOURTH S	EMESTER							
Course	Name of the	Duration c	of	Ма	arks		Minimum	Marks
code	Course	End					for Pass	
		Semester	Continuou	s	End	Max.	End	Total
		Exam\	Assessme	nt*   S	Semester	Marks	Semester	
		in Hrs.			Exam**		Exam	
THEORY					50	400	05	50
18EC410	Optimization	3	50		50	100	25	50
	Methods							
18FC420	RF Active	3	50		50	100	25	50
1020120	Circuits	Ũ			00	100	20	00
18EC430	CMOS VLSI	3	50		50	100	25	50
	Systems							
18EC440	Signal	3	50		50	100	25	50
	Processing						-	
18YYFX0	Foundation	3	50		50	100	25	50
4050400	Elective I		50		50	100	05	50
18EC490	Project	3	50		50	100	25	50
THEORY								
18EG460	Professional	-	50		50	100	25	50
1020100	Communication						20	
PRACTICA	ÁL		I			1		
18EC470	RF Circuits	3	50		50	100	25	50
	Laboratory							
18EC480	Signal	3	50		50	100	25	50
	Processing							
	Laboratory							
	Constitution of	UII MANDA			50	100	25	50
	India	-	50		50	100	20	50
	inula							

## **FIFTH SEMESTER**

		<b>D</b> "				<b>.</b> .	
Course code	Name of the Course	Duration of End	ſ	Marks		for Pass	Marks
		Semester Exam\ in Hrs.	Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY		1					
18EC510	Data Communication Networks	3	50	50	100	25	50
18EC530	Analog and Digital Communication Systems	3	50	50	100	25	50
18ECPX0	Programme Elective -I	3	50	50	100	25	50
18YYGX0	General Elective	3	50	50	100	25	50
THEORY C		L. L			1		1
18EC520	Antennas and Wave Propagation	3	50	50	100	25	50
18EC560	Digital Image Processing	3	50	50	100	25	50
18ES590	System Thinking	-	50	50	100	25	50
PRACTICA	L	L. L			1		-
18EC570	Data Communication Networking Laboratory	3	50	50	100	25	50
18EC580	Analog and Digital Communications Laboratory	3	50	50	100	25	50
AUDIT COU	JRSE - NON-CREDI	T MANDATO	DRY COURSE			•	
18CHAC0	Essence of Indian Knowledge	-	50	50	100	25	50
SIXTH SEME	ESTER	1	1				
Course code	Name of the Course	Duration of End		Marks		Minimum I for Pass	Marks
		Semester Exam\ in Hrs.	Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY	1	1	1	1			
18EC610	Accounting and Finance	3	50	50	100	25	50
18EC620	Control Systems	3	50	50	100	25	50
18EC630	Data Structures and Algorithms	3	50	50	100	25	50
18ECPX0	Programme Elective -II	3	50	50	100	25	50
18YYZX0	Programme / Foundation Elective - I	3	50	50	100	25	50

	- · ·	•	50	50	100	05	50
18ESEX0	Engineering	3	50	50	100	25	50
	Science Elective						
THEORY C	UM PRACTICAL					-	
18EC660	Digital	3	50	50	100	25	50
	Communication						
	System Design						
PRACTICA	L	1	11			1	
18FC670	Data Structures	3	50	50	100	25	50
1020010	and Algorithms	Ũ		00	100	20	
	Laboratory						
Project	Laboratory						
	<b>F</b> inalizations		50	50	100	05	50
18ES690	Engineering	-	50	50	100	25	50
	Design Project						
SEVENTH S	EMESTER	1	1			1	
Course	Name of the	Duration	[	Marks		Minimum	Marks
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY				1		1	
18FC710	Consumer	3	50	50	100	25	50
1020710	Flectronics	Ũ			100	20	
	Drogrammo	2	50	50	100	25	50
TOLOFIN	Floativo	5	50	50	100	25	50
		0	50	50	400	05	50
18ECPX0	Programme	3	50	50	100	25	50
	Elective -IV	-					
18ECPX0	Programme	3	50	50	100	25	50
	Elective -V						
18YYZX0	Programme-VI /	3	50	50 50		25	50
	General Elective -						
	11						
Project	I	1	l	•	I	ł	
18ES790	Canstone Design	-	50	50	100	25	50
1020100	Project		00	00	100	20	00
	Nome of the	Duration		Morke		Minimum	Marka
course		of End	1	VIAINS		for Dooo	IVIAI NO
code	Course						<b>-</b>
		Semester	Continuous	End	Max.	End	lotal
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY							
18ECPX0	Programme	PE	3	-	-	3	-
	Elective -VII						
18ECPX0	Programme	PE	3	_	-	3	50
	Flective -V/III						
Project		1		1	1	1	1
1850810	Project		50	50	100	25	50
		-	50	50	100	20	50

\*Continuous Assessment evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\*End Semester Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of End semester examination marks.

\*\*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.



Passed in Board of Studies on 14.07.2018

Approved in 56<sup>th</sup> Academic Council Meeting on 21.07.2018

S.No	Category	Credits
А	Foundation Courses	
	Humanities and Social Science (HSS)	12 -15
	Basic Science (BS)	21 - 27
	Engineering Science (ES)	21 - 27
В	Professional Core Courses	53
С	Elective Courses	36 - 45
	Programme specific Elective	15-21
	Programme Elective for Expanded Scope	6 - 12
	General Elective	6
	Foundation Elective	6
D	Project work, seminar, internship in industry or at Higher	12 – 15
	Learning institutions	
Е	Mandatory Courses as per UGC/AICTE Guidelines	Non Credit
	(Not to be included for CGPA)	
	Minimum Credits to be earned for the award of the Degree	160
		( from A to D) and the successful completion of Mandatory Courses

#### **Credit Distribution**

- General electives are courses offered by different departments that do not have any prerequisites and could be of interest to students of any branch
- All students have to undertake co-curricular and extra-curricular activities that include activities related to NCC, NSS, Sports, Professional Societies, participation in identified activities which promote the growth of Departments and the College

# THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

#### **COURSES OF STUDY**

(For the candidates admitted from 2018-19 onwards)

#### **FIRST SEMESTER**

Course	Name of the Course	Category	No. of Hours			credits
Code				/We	ek	
			L	Т	Ρ	
THEORY						
18MA110	Engineering Calculus	BS	3	1	-	4
18PHA20/	Physics	BS	3	-	-	3
18PHB20/						
18PHC20						
18CHA30/	Chemistry	BS	3	-	-	3
18CHB30/						
18CHC30						
18EG140	English	HSS	2	-	-	2
18ES150	Engineering Exploration	ES	3	-	-	3
THEORY C	UM PRACTICAL					
18ME160	Engineering Graphics	ES	3	-	2	4
PRACTICA	L					
18EG170	English Laboratory	HSS		-	- 2	1
18PH180	Physics Laboratory	BS	-	-	2	1
18CH190	Chemistry Laboratory	BS	-	-	2	1
	Total		17	1	8	22

BS : Basic Science

HSS : Humanities and Social Science

ES : Engineering Science

- L : Lecture
- T : Tutorial
- P : Practical

## Note:

1 Hour Lecture is equivalent to 1 credit

- 1 Hour Tutorial is equivalent to 1 credit
- 2 Hours Practical is equivalent to 1 credit

# THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programme

### SCHEME OF EXAMINATIONS

(For the candidates admitted from 2018-19 onwards)

# FIRST SEMESTER

S.No.	Course	Name of the	Duration		Marks		Minimum	Marks
	Code	Course	of				for Pa	ass
			Terminal	Contin	Termin	Max.	Terminal	Total
			Exam. in	uous	al	Mark	Exam	
			Hrs.	Asses	Exam	S		
				sment	**			
				*				
THEO	RY							
1	18MA110	Engineering	3	50	50	100	25	50
	TOWATTO	Calculus						
2	18PHA20/	Physics	3	50	50	100	25	50
	18PHB20/							
	18PHC20							
3	18CHA30/	Chemistry	3	50	50	100	25	50
	18CHB30/							
	18CHC30							
4	18EG140	English	3	50	50	100	25	50
5	1859150	Engineering	3	50	50	100	25	50
	1023130	Exploration						
THEO	RY CUM PRAC	TICAL						
6	18ME160	Engineering	3	50	50	100	25	50
		Graphics						
PRAC	TICAL							
7	18EG170	English Laboratory	3	50	50	100	25	50
8	18PH180	Physics Laboratory						
9	1804100	Chemistry	3	50	50	100	25	50
	1001190	Laboratory						

\* CA evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\* Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

3

		Category	L	Т	Ρ	Credit
18MA110	ENGINEERING CALCULUS	BS	3	1	0	4

#### Preamble

This course aims to convey to the student a sense of the utility of calculus and develop technical competence. This course is designed to implement the calculus through geometrically, numerically, algebraically and verbally. Students will apply the main tools for analyzing and describing the behavior of functions of single and multi variables: limits, derivatives, integrals of single and multi variables to solve complex engineering problems using analytical methods and MATLAB.

#### Prerequisite

NIL

#### Course Outcomes

On the successful completion of the course, students will be able to

CO1	Understand the concept of functions, limits and continuity	Understand
CO2	Compute derivatives and apply in solving engineering problems	Apply
CO3	Employ partial derivatives to find maxima minima of functions of multi variables	Apply
CO4	Demonstrate and apply the techniques of integration	Apply
CO5	Apply integrals of multivariable to find areas enclosed between two curves and volume enclosed between surfaces	Apply

## Mapping with Programme Outcomes

COs	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	М								
CO2	S	S	М	М								
CO3	S	S	S	М								
CO4	S	S	S	М								
CO5	S	S	S	М								
S- Strong; M-Medium; L-Low												

# Assessment Pattern

Bloom's Category	Continuo	ous Assessmo	- Terminal Examination			
bioon s category	1	1 2 3				
Remember	10	10	10	0		
Understand	30	30	30	30		
Apply	60	60	60	70		
Analyse	0	0	0	0		
Evaluate	0	0	0	0		
Create	0	0	0	0		

#### **Course Level Assessment Questions**

#### Course Outcome 1(CO1)

- 1. Define function and limit.
- 2. Estimate the value of  $\lim_{x\to 0} \frac{\sin x}{\sin \pi x}$ .
- 3. If f(x) is continuous on  $(-\infty,\infty)$ , what can you say about its graph?

#### Course Outcome 2(CO2)

1. What is wrong with this equation  $\frac{x^2+x-6}{x-2} = x+3$  and investigate why the equation

$$\lim_{x \to 2} \frac{x^2 + x - 6}{x - 2} = \lim_{x \to 2} (x + 3)$$
 is correct.

- 2. Between 0°C and 30°C, the volume V (in cubic centimeters) of 1 kg of water at a temperature T is given approximately by the formula V = 999.87 0.06426T +  $0.0085043T^2$   $0.0000679T^3$ , Compute the temperature at which water has its maximum density.
- 3. The voltage, *v*, across a capacitor of capacitance, in series with a resistor of resistance, *v*, is given by  $(t + 1)e^{-1000 t}$  where  $C = 1\mu F$ , E > 0, is a constant. Determine *i* where  $i = C \frac{dv}{dt}$ .

#### Course Outcome 3(CO3)

- 1. Define partial derivative of a function of two variables.
- 2. Suppose that the temperature at a point (x, y, z) in space is given by 80

 $T(x, y, z) = \frac{80}{1 + x^2 + 2y^2 + 3z^2}$ , where *T* is measured in degrees Celsius and

(x, y, z) in meters. In which direction does the temperature increase fastest at the point (1,1,-2)? Identify the maximum rate of increase.

- 3. Compute the dimensions of the rectangular box with largest volume if the total surface area is given as 64 cm<sup>2</sup>.
- 4. Show that the Cobb-Douglas production function  $P = bL^{\alpha}K^{\beta}$  satisfies the equation  $\partial P = \partial P = P$

$$L\frac{\partial P}{\partial L} + K\frac{\partial P}{\partial K} = \alpha \frac{P}{L}$$

#### Course Outcome 4(CO4)

- 1. State fundamental theorem of calculus.
- 2. Find the volume of the solid obtained by rotating the region bounded by  $y = x^3$ ,

y = 8 and x = 0 about the y axis.

3. A charged rod of length L produces an electric field at point P(a,b) given by

$$E(P) = \int_{-a}^{L-a} \frac{\lambda b}{4\pi\varepsilon_0 (x^2 + b^2)^{3/2}} dx$$
 where  $\lambda$  is the charge density per unit length on the

rod and  $\varepsilon_0$  is the free space permittivity (see the below figure). Evaluate the integral to determine an expression for the electric field E(P).



4. A cantilever beam of length *L*, fixed at one end and deflected by a distance *D* at the free end has strain energy *V* given by  $V = \frac{EI}{2} \int_{0}^{L} \left(\frac{d^2y}{dx^2}\right)^2 dx$  where *EI* is the flexural rigidity. The deflection *y* at a distance *x* from the fixed end is given by  $y = D\left[1 - \cos\left(\frac{\pi x}{2L}\right)\right]$ Find *V* 

#### Course Outcome 5(CO5)

- 1. Recall any three properties of double integrals
- 2. Calculate the static moments of homogeneous lamina with respect to the coordinate axes. The lamina is bounded by lines  $\frac{x^2}{9} + \frac{y^2}{4} = 1$ , 2x + 3y 6 = 0.
- 3. Calculate the coordinates of the center of mass of homogeneous solid bounded by surfaces x=0, y = 0, z = 0, x + y = 1,  $x^2 + y^2 = 1$ .



Passed in Board of Studies on 14.07.2018

#### Syllabus

#### DIFFERENTIAL CALCULUS

Representation of functions - New functions from old functions - Limit of a function - Continuity - Limits at infinity - Derivative as a function - Differentiation rules(formula and problems only) –The mean value theorem - Maxima and Minima of functions of one variable - Application problems in engineering – Application problems using MATLAB.

### FUNCTIONS OF SEVERAL VARIABLES

(12 hours)

(12 hours)

Partial derivatives – Chain rule - Vector functions and their Derivatives - Directional derivatives and gradient vector - Maxima and minima of functions of two variables - Lagrange Multipliers - Application problems in engineering - Application problems using MATLAB.

## INTEGRAL CALCULUS

Area under curves - The definite integrals – Fundamental theorem of calculus - Integration by parts - Volume of solid of revolution - Area of surface of revolution - Improper integrals - Application problems in engineering - Application problems using MATLAB

## MULTIPLE INTEGRAL

#### (12 hours)

(12 hours)

Iterated integrals - Double integrals over general regions - Double integrals in polar coordinates - Applications of double integrals (density, mass, moments & moments of inertia problems only) - Triple integrals - Triple integrals in cylindrical coordinates - Triple integrals in spherical coordinates - Change of variables in multiple integrals - Application problems in engineering

## **Text Book**

1) James Stewart, "Calculus Early Transcendentals", 7e, Cengage Learning, New Delhi, 2017.

DIFFERENTIAL CALCULUS: [Sections: 1.1, 1.3, 2.2,2.5,2.6,2.8, 3.1-3.6,4.1,4.2]

 FUNCTIONS OF SEVERAL VARIABLES: Sections: 14.3, 14.5, 13.1, 13.2, 14.6-14.8]

 INTEGRAL CALCULUS:
 [Sections: 5.1-5.4, 7.1, 6.2, 8.2 and 7.8]

 INTEGRAL CALCULUS:
 [Sections: 5.1-5.4,7.1, 6.2, 8.2 and 7.8]

 MULTIPLE INTEGRAL:
 [Sections: 15.2-15.5, 15.7-15.10]

2) Lecture Notes on Engineering Mathematics-I Application Problems and Solution Manual, Department of Mathematics, Thiagarajar College of Engineering, Madurai.

# **Reference Books**

- 1) Kuldeep Singh, "Engineering Mathematics Through Appplications",2e, Palgrave Macmillan, 2011.
- 2) Erwin Kreszig, "Advanced Engineering Mathematics", 10th edition, Wiley, 2017.
- 3) George B. Thomas, "Thomas Calculus: early transcendentals ", Pearson, New Delhi, 2013.
- 4) R.K.Jain, S.R.K.Iyengar, "Advanced Engineering Mathematics"5e, Narosa Publishing House, 2016.

#### **Course Contents and Lecture Schedule**

S.No	Торіс	No. of Hours
1	DIFFERENTIAL CALCULUS	
1.1	Representation of functions, New functions from old functions	1
1.2	Limits of a function	1
1.3	Continuity, Limits at infinity	1
1.4	Tutorial	1
1.5	Derivatives as a function, Differentiation rules	2

S.No	Торіс	No. of
		Hours
1.6	The mean value theorem	1
1.7	Maxima and minima of function of one variable	1
1.8	Tutorial	1
1.9	Application problems in engineering	2
1.10	Application problems using MATLAB(Tutorial)	1
2	FUNCTIONS OF SEVERAL VARIABLES	
2.1	Partial derivatives, Chain rule	2
2.2	Vector functions and their derivatives	1
2.3	Tutorial	1
2.4	Directional derivatives, Gradient vector	1
2.5	Maxima and minima of functions of two variables	2
2.6	Lagrange Multipliers	1
2.7	Tutorial	1
2.8	Application problems in engineering	2
2.9	Application problems using MATLAB(Tutorial)	1
3	INTEGRAL CALCULUS	
3.1	Area under curves, The definite integrals, fundamental theorem of	2
	calculus	
3.2	Integration by parts	1
3.3	Tutorial	1
3.4	volume of solid of revolution, area of surface of revolution	2
3.5	Improper integrals	2
3.6	Tutorial	1
3.7	Application problems in engineering	2
3.8	Application problems using MATLAB(Tutorial)	1
4	MULTIPLE INTEGRAL	
4.1	Iterated integrals	1
4.2	Double integrals over general regions	1
4.3	Double integrals in polar coordinates	1
4.4	Tutorial	1
4.5	Applications of double integrals	1
4.6	Triple integrals	2
4.7	Tutorial	1
4.8	Triple integrals in cylindrical coordinates	1
4.9	Triple integrals in spherical coordinates	1
4.10	Change of variables in multiple integrals	1
4.11	Tutorial	1
	Total	48

#### **Course Designers**

- 1. Dr.V.Gnanaraj
- vgmat@tce.edu
  sjbmat@tce.edu
- 2. Dr.S.Jeyabharathi
- sjbmat@tce.edu gjlmat@tce.edu
- -3. Dr.G.Jothilakshmi

Approved in 56<sup>th</sup> Academic Council Meeting on 21.07.2018

- 4. Dr.A.Anitha
- 5. Dr.R.Suresh
- anithavalli@tce.edu
- suresh080183@tce.edu

	PHYSICS	Category	L	Т	Ρ	Credit
18PHA20	(Common to Civil, Mechanical and Mechatronics)	BS	3	0	0	3

### Preamble

The course work aims in imparting fundamental knowledge of oscillations, waves and optics, and mechanics which are essential in understanding and designing mechanical systems and measuring devices.

# Prerequisite

Nil

#### **Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Solve for the solutions and describe the behavior of a damped											Арр	oly
	harmo	onic oso	cillator a	and wa	ves								
CO2	Explain the fundamentals of optical phenomena and its application.											Und	derstand
CO3	Use the vector analytical techniques for analysis of forces an											App	oly
	moments in mechanical systems												
CO4	Demor	nstrate	ability	to utiliz	ze princ	ciples c	of vecto	or mech	nanics	to analy	ze	Und	derstand
	weathe	er syste	ems										
CO5	Explain the fundamental concepts of kinetics and kinematic of rigid Understand												
	bodies for analysis of practical problems.												
CO6	Use th	e princ	iples of	f angula	ar velo	city to s	study th	nree dir	nensio	nal moti	on	Арр	oly
	of rigid	bodies	6										
Mapp	ing witl	h <mark>Prog</mark>	ramme	Outco	omes								
COs	PO1	PO2	PO3	PO4	PO5	PO6	P07	PO8	PO9	PO10	PC	011	PO12
CO1	S	М	L	L					L	L			
CO2	М	L	L	-					L	L			
CO3	S	М	L	L					L	L			
CO4	М	L	L	-					L	L			
CO5	М	L	L	-					L	L			
CO6	3 S M L L L L L												
S- Str	ong; M-	Mediur	n; L-Lo	W									

Assessment Pattern

Bloom's Catagony	Continuous Assessment Tests			Terminal Examination	
bioonis Calegory	1	2	3		
Remember	20	20	20	0	
Understand	30	30	30	50	
Apply	50	50	50	50	
Analyse	0	0	0	0	
Evaluate	0	0	0	0	
Create	0	0	0	0	

#### **Course Level Assessment Questions**

## Course Outcome 1 (CO1):

- A 5.00 × 10<sup>5</sup> kg subway train is brought to a stop from a speed of 0.500 m/s in 0.400 m by a large spring bumper at the end of its track. What is the force constant k of the spring?
- 2. Show that the wave velocity of deep water waves is twice the group velocity.
- 3. Derive the law of reflection based on Fermats principle.

# Course Outcome 2 (CO2):

- Consider a lower energy level situated 200 cm<sup>-1</sup> from the ground state. There are no other energy levels nearby. Determine the fraction of the population found in this level compared to the ground state population at a temperature of 300 K. Boltzmann's constant is equal to 1.38 x 10<sup>-23</sup> JK<sup>-1</sup>. The conversion from cm<sup>-1</sup> to joules is given by: E(J) = 100hC E(cm<sup>-1</sup>), where h is Planck's constant (6.62 x 10<sup>-34</sup> Js) and c is the speed of light in a vacuum (3 x 10<sup>8</sup> ms<sup>-1</sup>)
- 2. Explain the principle, construction and working of Mach-Zehnder interferometer.
- 3. What is a four level solid state laser? Discuss the principle and operation of Nd:YAG Laser.

# Course Outcome 3 (CO3):

- 1. A 10, 000 lb aircraft is descending on a cylindrical helix. The rate of descent is  $z^{\cdot} = -10$  ft/s, the speed is v = 211 ft/s, and  $\theta^{\cdot} = 3^{\circ} \approx 0.05$  rad/s. This is standard for gas turbine powered aircraft. Find out the force on the aircraft and the radius of curvature of the path
- 2. Derive Newton's second law of motion in spherical and cylindrical coordinate systems.
- 3. A particle attached to a string of length 2 m is given an initial velocity of 6 m/s. The string is attached to a peg and, as the particle rotates about the peg, the string winds around the peg. By conservation of angular momentum, find the length of string wound around the peg when the velocity of the particle is 20 m/s?

# Course Outcome 4 (CO4):

- 1. Consider a situation where a cricket player (fielder) slides to a stop on level ground. Using energy considerations (in non conservative forces),calculate the distance the 60 kg cricket player slides, given that his initial speed is 7 m/s and the force of friction against him is a constant 430 N.
- 2. Compute the centripetal force per unit mass on a spacecraft in an 820 km circular Polar orbit as it flies over the equator and the South pole.
- 3. Solve Newton's equations of motion in polar coordinates

# Course Outcome 5 (CO5):

- 1. A motor shaft attains a velocity of 1500 rpm in 3 seconds starting from rest. Assuming constant angular acceleration, find out the number of full revolution of the shaft during this period.
- 2. Derive Euler's equations of motion of a rigid body.
- 3. A cylinder of diameter 500 mm rolls down an inclined plane with uniform acceleration (of the center-of-mass)  $a = 0.1 \text{ m/s}^2$ . At an instant  $t_0$ , the mass-center has speed  $v_0 = 0.5 \text{ m/s}$ . (i) Find the angular speed  $\omega$  and the angular acceleration  $\omega^{\circ}$  at  $t_0$ . (ii) How many revolutions does the cylinder make in the next 2 seconds?

# Course Outcome 6 (CO6):

- A solid right circular cone of base radius *r* and height *h* rolls on a flat surface without slipping. The centre of the circular base moves in a circular path around the z- axis (vertical axis passing through the tip of the cone) with a constant speed *v*. Determine the angular velocity and angular acceleration of the solid cone.
- 2. Derive an expression for angular velocity and its rate of change for three dimensional motion of a rigid body.
- 4. Discuss the conical motion of a rod with center of mass fixed.



# Oscillations and Waves

Simple harmonic motion - Mechanical and Electrical simple harmonic oscillators - energy decay in a damped harmonic oscillator - Non-dispersive transverse and longitudinal waves in one dimension - Waves with dispersion - water waves- Acoustic waves- superposition of waves - wave groups and group velocity – Rayleigh criteria for limit of resolution and its applications to imaging.

#### Optics

Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer - Fraunhofer diffraction from a single slit and a circular aperture - Einstein's theory of matter radiation interaction and A and B coefficients  $-CO_2 - Nd$ -YAG lasers - applications of lasers.

#### **Vector Mechanics of Particles**

Transformation of scalars and vectors under Rotation transformation - Forces in Nature - Newton's laws and its completeness in describing particle motion - Solving Newton's equations of motion in polar coordinates -Conservative and non-conservative forces - curl of a force field -Conservation of Angular Momentum - Energy equation and energy diagrams – circular and elliptical orbits.- Applications to Satellite manoeuvres

## **Rigid Body Mechanics**

Motion of a rigid body in the plane - Rotation in the plane - Kinematics in a coordinate system rotating and translating in the plane - Angular momentum about a point of a rigid body in planar motion - Euler's laws of motion - their independence from Newton's laws - Two-dimensional motion in terms of angular velocity vector, and its rate of change – Difference between 2D & 3D motion.

### Text Book

- 1. Ian G.Main, Vibrations and waves in Physics -3<sup>rd</sup> edition, Cambridge University, Press, 1994.
- 2. M.K.Verma, Introduction to Mechanics, CRC Press, 2009.
- 3. JL Meriam and L.G. Kraige, Engineering Mechanics Dynamics 7<sup>th</sup> edition, Wiley, 2015.
- 4. D. Kleppner and R. Kolenkow, An Introduction to Mechanics 1<sup>st</sup> edition, McGraw Hill, 2009.

#### Reference Books

- 1. M.K.Harbola, Engineering Mechanics-2<sup>nd</sup> edition, Cengage Learning, 2012.
- 2. JL Synge & BA Griffiths, Principles of Mechanics, McGraw-Hill Book company Inc, 1949.
- 3. WT Thomson, Theory of Vibrations with Applications, -3<sup>rd</sup> edition, CBS Publishers, 2002.

#### **Course Contents and Lecture Schedule**

S No.	Торіс	No. of Hours					
1.	Oscillations & Waves						
1.1	Simple harmonic motion – Mechanical and Electrical simple harmonic	2					
	oscillators.						
1.2	Energy decay in a damped harmonic oscillator – Non-dispersive transverse						
	and longitudinal waves in one dimension.						
1.3	Waves with dispersion – water waves- Acoustic waves – superposition of						
	waves – wave groups and group velocity.						
1.4	Rayleigh criteria for limit of resolution and its applications to imaging						
2	Optics						
2.1	Fermat's principle of stationary time - reflectance and transmittance -						
	evanescent wave. Mach-Zehnder interferometer.						
2.2	Fraunhofer diffraction from a single slit and a circular aperture .						
2.3	Einstein's theory of matter radiation interaction and A and B coefficients .						
2.4	CO <sub>2</sub> Laser.	1					
2.5	Nd-YAG lasers Applications of lasers.						
3.	Vector Mechanics of Particles						
3.1	Transformation of scalars and vectors under rotation transformation	2					
3.2	Forces in Nature, Newton's laws and its completeness in describing particle	2					
	motion						
3.3	Solving Newton's equations of motion in polar coordinates	2					
3.4	Conservative and non-conservative forces, curl of a force field,	2					
	Conservation of angular momentum						
3.5	Energy equation and energy diagrams, circular and elliptical orbits						
3.6	Applications to Satellite manoeuvres						
4.	Rigid Body Mechanics						
S No	Торіс						
-------	---	----	--	--	--	--	--
5 NO.							
4.1	Motion of a rigid body in the plane, Rotation in the plane	2					
4.2	Kinematics in a coordinate system rotating and translating in the plane	2					
4.3	Angular momentum about a point of a rigid body in planar motion	2					
4.4	Euler's laws of motion, their independence from Newton's laws	2					
4.5	Two-dimensional motion in terms of angular velocity vector, and its rate of	2					
	change.						
4.6	Distinction between 2D & 3D motion	2					
	Total	36					

#### **Course Designers**

- 1. Dr. M.Mahendran
- 2. Dr. N. Sankara Subramanian
- 3. Dr. R. Kodipandyan
- 4. Dr. A. Karuppasamy
- mmphy@tce.edu nssphy@tce.edu rkp@tce.edu
- akphy@tce.edu

Passed in Board of Studies on 14.07.2018

	PHYSICS	Category	L	Т	Ρ	Credit
TOFTIDZU	(Common to EEE and ECE)	BS	З	0	0	3

The course work aims in imparting fundamental knowledge of oscillations and waves and electromagnetic theory which are essential in understanding and explaining engineering devices.

## Prerequisite

Basic course (No prerequisite)

#### Course Outcomes

On the successful completion of the course, students will be able to

CO1	Solve for the solutions and describe the behavior of a damped	Apply								
	harmonic oscillator and waves									
CO2	Explain the fundamentals of optical phenomena and its application.	Understand								
CO3	Understand the fundamentals of electrostatics and Calculation of	Apply								
	electric field and electrostatic potential for a charge distribution									
CO4	Explain bound charges due to electric polarization and estimation of	Understand								
	vector potential through concepts of magneto statics.									
CO5	Describe and make calculations of plane electromagnetic waves in	Understand								
	homogeneous media and derive Poynting theorem									
CO6	Learn the propagation of EM waves and its applications by solving Apply									
	physical problems and Energy and Momentum carried by									
	electromagnetic waves through linear media.									

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	P07	PO8	PO9	PO10	PO11	PO12
CO1	S	М	L	L					L	L		
CO2	М	L	L	-					L	L		
CO3	S	М	L	L					L	L		
CO4	М	L	L	-					L	L		
CO5	М	L	L	-					L	L		
CO6	S	М	L	L					L	L		
S- Strong; M-Medium; L-Low												

## Assessment Pattern

Bloom's Category	Continuo	ous Assessmo	Terminal Examination				
bioon s category	1	1 2 3					
Remember	20	20	20	20			
Understand	30	30	30	30			
Apply	50	50	50	50			
Analyse	0	0	0	0			
Evaluate	0	0	0	0			
Create	0	0	0	0			

#### **Course Level Assessment Questions**

#### Course Outcome 1 (CO1):

- Assuming a car is 900 kg and has a suspension system that has a force constant 6.5x10<sup>4</sup> N/m. The car hits a bump and bounces with an amplitude of 0.100 m. What is its maximum vertical velocity if no damping occurs?
- 2. Establish the connection between quality factor, width of response and energy dissipation.
- 3. State the Rayleigh's criteria for limit of resolution.

## Course Outcome 2 (CO2):

- 1. Differentiate between laser light and ordinary light.
- 2. Predict the working of the CO2 laser without Helium gas in the mixture.
- 3. Explain the construction and working of Nd-YAG Laser

## Course Outcome 3 (CO3):

- 1. Discuss the Continuous charge distribution and the electric field produced by it.
- 2. Derive Laplace's and Poisson's equation
- 3. Deduce Gauss' law.

## Course Outcome 4 (CO4):

- 1. Summarize physical interpretation of bound charges
- 2. Define vector potential and give its significance.
- 3. Explain the magnetic field of a steady current and hence obtain Bio-Savart law .

## Course Outcome 5 (CO5):

1. Derive and interpret Continuity equation for current densities.

2.Write and explain the importance of Poynting vector

3. Deduce Faraday's law of electromagnetic from the Maxwell's equation

## Course Outcome 6 (CO6):

- 1. Discuss the propagation of EM waves through vacuum.
- 2. Define and obtain expressions for transmission and reflection coefficients
- 3. Find the reflection and transmission coefficients of an electric field wave travelling

in wave and incident normally on a boundary between air and a dielctric having Permeability  $\mu 0$  and permittivity 4.74.

#### **Concept Map**



#### Syllabus

#### **Oscillations and Waves**

Simple harmonic motion - Mechanical and Electrical simple harmonic oscillators - energy decay in a damped harmonic oscillator - Non-dispersive transverse and longitudinal waves in one dimension - Waves with dispersion - water waves –Acoustic waves - superposition of waves - wave groups and group velocity – Rayleigh criteria for limit of resolution and its applications to imaging

#### Optics

Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer - Fraunhofer diffraction from a single slit and a circular aperture - Einstein's theory of matter radiation interaction and A and B coefficients  $-CO_2 - Nd$ -YAG lasers - applications of lasers.

#### **Electromagnetic Theory**

Electrostatics: Introduction, Calculation of electric field and electrostatic potential for a charge distribution - Gauss' law, Divergence and curl of electrostatic field, Application: Faraday's cage and coffee-ring effect(qualitative only). Electrostatic field and potential of a dipole. Bound charges due to electric polarization; Electric displacement; Solving simple electrostatics problems in presence of dielectrics.

Magnetostatics: Bio-Savart law, Divergence and curl of static magnetic field; vector potential and calculating it for a given magnetic field using Stokes' theorem. Lenz's law; Electromagnetic breaking (qualitative only)

#### Electromagnetic waves

Continuity equation for current densities- Modifying equation for the curl of magnetic field – Energy in an electromagnetic field - Flow of energy and Poynting vector - Maxwell's equations- The wave equation- Plane electromagnetic waves in Vacuum– their transverse nature and Polarization ; relation between electric and magnetic fields of an electromagnetic

17

## (12 hours)

(6 hours)

(6 hours)

(12 Hours)

wave -Energy and Momentum carried by electromagnetic waves, Propagation through linear media-Normal incidence - problems.

## Text Books

- 1. Ian G.Main, Vibrations and waves in Physics -3<sup>rd</sup> edition, Cambridge University Press,1994.
- 2. David J. Griffiths, Introduction to Electrodynamics, Prentice Hall, Second Indian edition, 1981.
- 3. Paul Lorrain , Dale R. Corson , Francois Lorrain, Electromagnetic Fields and Waves, 3rd Edition, W.H. Freeman, 1990.
- 4. A.A. Rangwala,A.S. Mahajan, Electricity and Magnetism 1<sup>st</sup> edition, McGraw Hill Education, 2004.

#### Reference

1. Halliday Resnick Krane, Physics Volume 2, Fifth edition, Wiley Publications, 2002.

2. W. Saslow, Electricity, Magnetism and light, Academic press 2005.

3. WT Thomson, Theory of Vibrations with Applications, -3<sup>rd</sup> edition, CBS Publishers, 2002.

Course Contents and Lecture Schedule							
S No.	Торіс	No. of Hours					
1.	Oscillations & Waves						
1.1	Simple harmonic motion – Mechanical and Electrical simple harmonic oscillators.	2					
1.2	Energy decay in a damped harmonic oscillator – Non-dispersive transverse and longitudinal waves in one dimension.	2					
1.3	Waves with dispersion – water waves – Acoustic waves – superposition of waves – wave groups and group velocity.	1					
1.4	Rayleigh criteria for limit of resolution and its applications to imaging.	1					
2	Optics						
2.1	Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer.	2					
2.2	Fraunhofer diffraction from a single slit and a circular aperture .	1					
2.3	Einstein's theory of matter radiation interaction and A and B coefficients	1					
2.4	CO <sub>2</sub> Laser	1					
2.5	Nd-YAG lasers Applications of lasers.	1					
3	Electromagnetic Theory						
3.1	Electrostatics: Introduction, Calculation of electric field and electrostatic potential for a charge distribution - Gauss' law – work done- Electric potential problems. Divergence and curl of electrostatic field	4					
3.2	Applications: Faraday's cage and coffee-ring effect. Electrostatic field and potential of a dipole.	2					
3.3	Bound charges due to electric polarization; Electric displacement; Solving simple electrostatics problems in presence of dielectrics.	2					
3.4	Magnetostatics: Bio-Savart law, Divergence and curl of static magnetic field	2					
3.5	vector potential and calculating it for a given magnetic field using Stokes'	2					

S No.	Торіс							
	theorem. Lenz's law; Electromagnetic breaking (qualitative only)							
4	Electromagnetic waves							
4.1	Continuity equation for current densities- Modifying equation for the curl of magnetic field –	2						
4.2	Energy in an electromagnetic field - Flow of energy and Poynting vector - Maxwell's equations- The wave equation-	3						
4.3	Plane electromagnetic waves in Vacuum- their transverse nature and Polarization	2						
4.4	Relation between electric and magnetic fields of an electromagnetic wave	2						
4.5	Energy and Momentum carried by electromagnetic waves, Propagation	3						
	through linear media- Reflection and Transmission coefficients, problems.							
	Total	36						
Cours	e Designers							

#### Course Designers

1.	Dr.S.Rajathi	<u>srphy@tce.edu</u>
2.	Dr. V.Gayathri	vgphy@tce.edu
3.	Dr.M.Senthamizh selvi	mssphy@tce.edu
4.	Dr. A.L.Subramaniyan	alsphy@tce.edu

18PHC20	PHYSICS	Category	L	Т	Ρ	Credit
101 11020	(Common to CSE and IT)	BS	3	0	0	3

The course work aims in imparting fundamental knowledge of oscillations and waves and optics and quantum mechanics which are essential in understanding and explaining engineering devices.

#### Prerequisite

Basic course (No prerequisite)

#### Course Outcomes

On the successful completion of the course, students will be able to

CO1	Solve for the solutions and describe the behavior of a damped	Apply
	harmonic oscillator and waves	
CO2	Explain the fundamentals of optical phenomena and its application.	Understand
CO3	Explain the basic principles of Quantum mechanic	Understand
CO4	Use the principles of quantum mechanics to calculate observables	Apply
	on known wave functions	
CO5	Solve Schrodinger equation for simple potentials ,scattering and	Understand
	related phenomena	
CO6	identify and relate the Eigen value problems for energy, momentum,	Apply
	angular momentum and explain the idea of spin	

#### Mapping with Programme Outcomes

COs	P01	PO2	PO3	PO4	PO5	PO6	P07	PO8	PO9	PO10	PO11	PO12
CO1	S	М	L	L					L	L		
CO2	М	L	L	-					L	L		
CO3	М	L	L	-					L	L		
CO4	S	М	L	L					L	L		
CO5	М	L	L	-					L	L		
CO6	S	М	L	L					L	L		
S- Stro	S- Strong; M-Medium; L-Low											

#### **Assessment Pattern**

Bloom's Catagory	Continuc	ous Assessm	Torminal Examination				
Bioonin's Calegory	1	1 2 3					
Remember	20	20	20	20			
Understand	30	30	30	30			
Apply	50	50	50	50			
Analyze	0	0	0	0			
Evaluate	0	0	0	0			
Create	0	0	0	0			

## **Course Level Assessment Questions**

#### Course Outcome 1 (CO1)

- Assuming a car is 900 kg and has a suspension system that has a force constant 6.5x10<sup>4</sup> N/m. The car hits a bump and bounces with an amplitude of 0.100 m. What is its maximum vertical velocity if no damping occurs?
- 2. Establish the connection between quality factor, width of response and energy dissipation.
- 3. State the Rayleigh's criteria for limit of resolution.

## Course Outcome 2 (CO2)

- 1. Find the ratio of population of two energy states in a Laser the transition between which is responsible for the emission of photons of wavelength6893A at a temperature of 300K.Comment on the type of emission based on the ration of population.
- 2. Analyze the role of mixture of gases for a CO<sub>2</sub> laser and predict the working of the laser without Helium gas in the mixture.
- 3. Differentiate between CO<sub>2</sub> laser and Nd-YAG Laser with respect to their construction and energy level diagram.

## Course Outcome 3 (CO3)

- 1. List the properties of wave function.
- 2. Set up the time independent Schrodinger wave equation and explain the Eigen functions and Eigen values.
- 3. Describe an experiment to verify the uncertainty principle.

## Course Outcome 4 (CO4)

- 1. Calculate the expectation value of the position of a particle trapped in a box of length 10A° wide.
- 2 Compute the smallest possible uncertainty in position of an electron moving with a Velocity of  $3x10^7$  m.
- 3 An electron is constrained to a one dimensional box of side 1nm.Calculate the first four Eigen values in electron volt.

## Course Outcome 5 (CO5)

- 1. Assuming the time independent Schrödinger wave equation, discuss the solution for a particle in a three dimensional potential well of infinite height.
- 2. Discuss the barrier tunneling phenomenon for a rectangular finite potential barrier of height  $V_{o.}$
- 3. State the principle of STM and describe its working.

## Course Outcome 6 (CO6)

- 1. Identify the degeneracies in hydrogen atom energy level based on the principle of quantum numbers.
- 2. Illustrate the vector model of orbital angular momentum
- 3. Given  $\psi(x) = A\sin(kx)$ . Find the Eigen values of the operator  $0 = \frac{\partial^2}{\partial x^2}$ . Identify whether  $\frac{\partial}{\partial x}$  is an Eigen operator



#### **Syllabus**

**Oscillations and Waves:** Simple harmonic motion - Mechanical and Electrical simple harmonic oscillators - energy decay in a damped harmonic oscillator - Non-dispersive transverse and longitudinal waves in one dimension - Waves with dispersion - water waves – Acoustic waves - superposition of waves - wave groups and group velocity – Rayleigh criteria for limit of resolution and its applications to imaging.

**Optics** : Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer - Fraunhofer diffraction from a single slit and a circular aperture - Einstein's theory of matter radiation interaction and A and B coefficients  $-CO_2 - Nd$ -YAG lasers - applications of lasers.

#### Introduction to Quantum mechanics

Wave nature of Particles, Time-dependent and time independent Schrodinger equation for wave function, Born interpretation, probability current, Expectation values, Free-particle wave function and wave-packets, Uncertainty principle – Derivation & Experiment. Solution

of stationary-state Schrodinger equation for one dimensional problems- particle in a box, Square-well potential, linear harmonic oscillator.

## Applying the Schrodinger equation

Numerical solution of stationary-state - Schrodinger equation for three dimensional problems for different potentials and related examples - Angular momentum operator - Hydrogen atom ground-state, orbitals - interaction with magnetic field, spin. Scattering from a potential barrier and tunneling; related examples like alpha-decay, field ionization Schrodinger equation for spherically symmetric potentials and scanning tunneling microscope.

## Text Books

- 1. Ian G. Main, Vibrations and waves in Physics -3rd edition, Cambridge University press, ,1994.
- 2. David .J. Griifiths, Introduction to quantum mechanics -2<sup>nd</sup> edition, Cambridge University press, 2017.
- 3. P M Mathews, K.Venkatesan, Quantum mechanics, 2<sup>nd</sup> edition, Tata McGraw-Hill Education, 2010.

## Reference

- http://nptel.ac.in/courses/115106066/Quantum mechanics Prof. S. Lakshmi Bala, IIT Madras.
- 2. http://nptel.ac.in/courses/115101010/ Quantum mechanics Prof. S. H.Patil, IIT Bombay.
- 3. http://nptel.ac.in/courses/115104096/ Introduction to quantum mechanics, Prof Manoj K.Harbola, IIT Kanpur

## **Course Contents and Lecture Schedule**

S No.	Торіс									
1.	Oscillations & Waves									
1.1	Simple harmonic motion – Mechanical and Electrical simple harmonic oscillators.	2								
1.2	Energy decay in a damped harmonic oscillator – Non-dispersive transverse and longitudinal waves in one dimension.									
1.3	Waves with dispersion – water waves – Acoustic Waves – superposition of waves – wave groups and group velocity.									
1.4	Rayleigh criteria for limit of resolution and its applications to imaging.									
2	Optics									
2.1	Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer.	2								
2.2	Farunhofer diffraction from a single slit and a circular aperture.	1								
2.3	Einstein's theory of matter radiation interaction and A and B coefficients.	1								
2.4	CO <sub>2</sub> Laser.	1								
2.5	Nd-YAG lasers -Applications of lasers.	1								
3	Introduction to Quantum mechanics									
3.1	Wave nature of Particles, Time-dependent and time independent Schrodinger equation for wave function.	3								
3.2	Born interpretation, probability current, Expectation values.	3								
3.3	Free-particle wave function and wave-packets, Uncertainty principle -	3								

S No.	Τορίς						
	·F ·						
	Derivation & Experiment.						
3.4	Schrodinger equation for one dimensional problems- particle in a box,	3					
	square-well potential, linear harmonic oscillator.						
4	Applying the Schrodinger equation						
4.1	Numerical solution of stationary-state	1					
4.2	Schrodinger equation for one dimensional problem for different potentials	3					
	and related examples.						
4.3	Angular momentum operator, Hydrogen atom ground-state, orbitals,	3					
	interaction with magnetic field, spin						
4.4	Scattering from a potential barrier and tunneling; related examples like	3					
	alpha-decay, field ionization						
4.5	Schrodinger equation for spherically symmetric potentials	1					
4.6	Scanning tunneling microscope.	1					
	Total	36					
Course	Designers						

# 1. Dr. M.Mahend

1.	Dr. M.Mahendran	<u>mmphy@tce.edu</u>
2.	Mr. V.Veeraganesh	vvgphy@tce.edu

3. Dr. A.L.Subramaniyan alsphy@tce.edu

4. Dr.T.Manichandran <u>stmanichandran@tce.edu</u>

18CHA30	CHEMISTRY	Category	L	Т	Ρ	Credit
	(COMMON TO CIVIL, MECHANICAL AND MECHATRONICS)	BS	3	0	0	3

The objective of this course is to bestow a better understanding of basic concepts of chemistry and its applications on Civil, Mechanical and Mechatronics domain. It also imparts knowledge on properties of water and its treatment methods, spectroscopic techniques for material characterization, corrosion and protection of metals. This course also highlights preparation, properties and applications of polymer and composite materials. It also gives basic idea about adhesives and lubricants and their mechanisms.

#### Prerequisite

Nil

#### Course Outcomes

On the successful completion of the course, students will be able to

CO1	Identify the properties of water and its treatment methods	Understand								
CO2	Summarize the Principles and Instrumentations of Spectroscopic	Understand								
	techniques									
CO3	Select the appropriate spectroscopic techniques for characterization of	Apply								
	materials									
CO4	Adapt the customized corrosion control methods									
CO5	Dramatize the preparation, properties and applications of Engineering	Understand								
	materials									
CO6	Describe the mechanism of adhesion and lubrication	Understand								
Марр	Mapping with Programme Outcomes									

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1.	М	-	-	-	-	-	-	-	-	-	М	-
2.	М	L	L	-	-	-	-	-	-	-	-	-
CO3.	S	S	М	М	-	-	-	-	-	-	-	-
CO4.	S	S	М	М	-	-	L	-	-	-	L	-
CO5.	М	М	М	-	-	-	L	-	-	-	-	-
CO6.	М	-	L	-	-	-	-	-	-	-	-	-
S- Strong: M-Medium: L-Low												

## Assessment Pattern

Bloom's Category	Continuc	ous Assessm	Torminal Examination		
Bloom S Category	1	1 2 3			
Remember	20	20	20	20	
Understand	40	40	40	40	
Apply	40	40	40	40	
Analyze	-	-	-	-	
Evaluate	-	-	-	-	
Create	-	-	-	-	

#### **Course Level Assessment Questions**

#### Course Outcome 1 (CO1):

- 1. Distinguish between scale and sludge.
- 100 ml of given water sample consumed 48 ml of EDTA during titration using EBT indicator. 35 ml of same EDTA consumed by 100 ml of standard hard water containing 1 mg of pure CaCO<sub>3</sub> per ml. Calculate the permanent, temporary and total hardness of given water sample in CaCO<sub>3</sub> equivalents.
- 3. Outline the steps involved in the waste water treatment process.

## Course Outcome 2 (CO2):

- 1. State Beer-Lambert law.
- 2. Write the selection rule in absorption spectroscopy.
- 3. Explain the procedure involved in finding the metals present in an alloy sample using ICP-OES.

## Course Outcome 3 (CO3):

1. Compare the stretching frequencies of carbonyl functional groups in the following compounds



2. Following Woodward-Fiesher- scott rules, it has been observed that the following compounds have absorption maximum at (i) 225 nm, (ii) 220 (iii) 230. Explain which is which.



3. Describe the function of different magnets available to generate magnetic field in MRI scanner.

## Course Outcome 4 (CO4)

- 4. Illustrate the different forms of corrosion with appropriate mechanism
- 5. Dramatize suitable methods to prevent corrosion of iron bar used in construction.
- 6. Discuss in detail about the constituents and functions of paint.

## Course Outcome 5 (CO5)

- 1. Explain the application of composite materials in automobile engineering.
- 2. Demonstrate the applications of polymer in the enhancement of concrete properties.
- 3. Summarize the properties and application of reinforced composite materials.

## Course Outcome 6 (CO6)

- 1. List the types of lubricant materials.
- 2. Identify the factors which influence the action of adhesive.
- 3. Discuss the mechanism of lubrication.



#### **Syllabus**

**Water Chemistry :** Water- sources-Hardness of water-types-Estimation of hardness of water by EDTA method. Disadvantages of hardwater -Boiler troubles- scale & sludge. Internal treatment methods. External treatment methods- zeolite, ion exchange. Desalination process- reverse osmosis, electrodialysis, multi stage flash distillation. Waste water treatment processes.

**Spectroscopic technique and applications**-Principles of spectroscopy and selection rules-Electronic spectroscopy, Fluorescence- applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules- Applications. Nuclear magnetic resonance and magnetic resonance imaging. Atomic Absorption Spectroscopy and Inductively Coupled Plasma-Optical Emission Spectroscopy- Principle, instrumentation and applications.

**Corrosion and its prevention-**Corrosion- causes- factors- types- chemical, electrochemical corrosion (galvanic, differential aeration), Corrosion of steel in various environments. Rate of corrosion. Corrosion control - material selection and design aspects - electrochemical protection – sacrificial anode method and impressed current cathodic method. Coatings – Metallic – Chromate conversion coating, electroplating – precious metal coating. Paints-constituents and function.

**Engineering materials –** Polymers - Introduction-classification-properties –applications in construction and manufacturing processes. Composite Materials: Introduction-Classification – Preparation, properties and applications. Fiber-Reinforced Composites-preparation, properties and applications..Adhesives- Introduction-classification-fundamental aspects – mechanism of adhesion- factors influencing adhesive action. Lubricants-introduction-classification-properties-functions-mechanism of lubrication.

## Text Book

- 1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, DhanpatRai publications, New Delhi, 16<sup>th</sup> edition, 2015.
- 2. C. N. Banwelland E.M. McCash, "Fundamentals of Molecular Spectroscopy", Tata McGraw-Hill (India), 5<sup>th</sup> Edition, 2013.

#### **Reference Books**

- 1. S.S. Dara and S.S.Umare, "A Textbook of Engineering Chemistry", S.Chand & Company, 12<sup>th</sup> Edition, Reprint, 2013.
- 2. Shashi Chawla, " A text book of Engineering Chemistry", Dhanpat Rai & Co.(pvt) Itd, 3<sup>rd</sup> edition, reprint 2011.

#### **Course Contents and Lecture Schedule**

S. No.	Торіс						
		hours					
1.0	Water Chemistry	0					
1.1	Introduction -Water- sources-Hardness of water-types	1					
1.2	Estimation of hardness of water by EDTA method	2					
1.3	Disadvantages of hard water -Boiler troubles- scale & sludge.	1					
1.4	Internal treatment methods	1					
1.5	External treatment methods- zeolite, ion exchange	1					
1.6	Desalination process- reverse osmosis, electrodialysis, multi stage flash	1					
1.0	distillation						
1.7	Waste water treatment processes	2					
2.0	Spectroscopic technique and applications						
2.1	Introduction	1					
2.2	Principles of spectroscopy and selection rules	1					
2.3	Electronic spectroscopy, Fluorescence- applications in medicine.	1					
2.4	Vibrational and rotational spectroscopy of diatomic molecules-	2					
2.4	Applications	2					
2.5	Nuclear magnetic resonance and magnetic resonance imaging	2					
	Atomic Absorption Spectroscopy and Inductively Coupled Plasma-						
2.6	Optical Emission Spectroscopy- Principle, instrumentation and	2					
	applications.						
3.0	Corrosion and its prevention	•					
3.1	Corrosion- causes- factors-	1					
2.0	types- chemical, electrochemical corrosion (galvanic, differential	2					
3.2	aeration), Corrosion of steel in various environments (Marine)						
3.3	Rate of corrosion	1					
3.4	Corrosion control - material selection and design aspects	1					
2.5	electrochemical protection – sacrificial anode method and impressed	1					
3.5	current cathodic method						
2.0	Coatings – Metallic - Chromate conversion coating, electroplating –	2					
3.0	precious metal coating.						
3.7	Paints- constituents and function.	1					
4.0	Engineering materials						

Торіс					
Applications in construction and mechanical domains	1				
Composite Materials: Introduction-Classification – Preparation,	1				
properties and applications of Polymer Matrix Composites,					
Metal Matrix Composites, Ceramic Matrix Composites Carbon-Carbon	2				
Composites					
Fiber-Reinforced Composites- Glass, Silica, Kevlar, carbon, boron,	2				
silicon carbide, and boron carbide fibers and nature-made composites,					
and applications.					
Adhesives- Introduction-classification-fundamental aspects –	1				
mechanism of adhesion- factors influencing adhesive action					
Lubricants-introduction-classification-properties-functions-mechanism of	1				
lubrication.					
Total	36				
	TopicPolymers - Introduction-classification-propertiesApplications in construction and mechanical domainsComposite Materials: Introduction-Classification – Preparation, properties and applications of Polymer Matrix Composites,Metal Matrix Composites, Ceramic Matrix Composites Carbon-Carbon CompositesFiber-Reinforced Composites- Glass, Silica, Kevlar, carbon, boron, silicon carbide, and boron carbide fibers and nature-made composites, and applications.Adhesives- Introduction-classification-fundamental aspects – mechanism of adhesion- factors influencing adhesive actionLubricants-introduction-classification-properties-functions-mechanism of lubrication.				

#### **Course Designers:**

1. Dr. M.Kottaisamy

- 2 Dr.(Mrs).K.Radha
- 2. Dr.S.Rajkumar
- 3. Dr.M.Velayudham
- hodchem@tce.edu krchem@tce.edu rajkumarsubramanium@tce.edu mvchem@tce.edu

Passed in Board of Studies on 14.07.2018

18CHB30	CHEMISTRY (Common to EEE and ECE)	Category	L	Т	Ρ	Credit
		BS	3	0	0	3

This course work aims in imparting fundamental knowledge of materials and their applications in electrical, electronics and communication engineering. This course provides exposure to the students regarding the characterization of materials by spectroscopic methods. This course also deals with the selection of materials based on their properties for application in energy storage, energy conversion and electronic devices. It also extends the importance of water and gives better understanding of Water treatment processes.

#### Prerequisite

NIL

#### Course Outcomes

On the successful completion of the course, students will be able to

CO1.	Identify the properties of water and its treatment methods	Understand
CO2.	Summarize the Principles and Instrumentations of Spectroscopic	Understand
	Techniques	
CO3.	Select the appropriate spectroscopic techniques for characteristics of	Apply
	materials	
CO4.	Outline the importance of industrial electrochemical processes and	Understand
	protective coating	
CO5.	Indicate the materials best suited for the construction of energy	Apply
	storage devices for different applications	
CO6.	Identify the implications of material properties in the performance of	Apply
	electronic devices.	

#### **Mapping with Programme Outcomes**

		-										
COs	P01	PO2	PO3	PO4	PO5	P06	P07	PO8	PO9	PO10	P011	PO12
CO1	М	М	L	-	-	-	-	-	-	-	-	L
CO2	М	М	L	-	-	-	-	-	-	-	-	-
CO3	S	S	L	-	-	-	-	-	-	-	-	-
CO4	М	М	М	М	-	-	L	-	-	-	-	L
CO5.	S	S	М	М	-	-	М	-	-	-	-	L
CO6	S	S	М	М	-	-	М	-	-	-	-	L
C Strong	C. Strong: M. Modium: L. Low											

S- Strong; M-Medium; L-Low Assessment Pattern

Bloom's Catogory	Continuc	ous Assessm	Terminal Examination	
BIOOIII S Calegory	1 2		3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	50	50
Analyze	_	_	_	_
Evaluate	_	_	_	_
Create	_	_	_	_

#### **Course Level Assessment Questions**

#### Course Outcome 1 (CO1):

- 1. Distinguish between scale and sludge.
- 100 ml of given water sample consumed 48 ml of EDTA during titration using EBT indicator. 35 ml of same EDTA consumed by 100 ml of standard hard water containing 1 mg of pure CaCO<sub>3</sub> per ml. Calculate the permanent, temporary and total hardness of given water samples in CaCO<sub>3</sub> equivalents.
- 3. Outline the steps involved in the waste water treatment process.

## Course Outcome 2 (CO2):

- 4. State Beer-Lambert law.
- 5. Write the selection rule in absorption spectroscopy.
- 6. Explain the procedure involved in finding the metals present in an alloy sample using ICP-OES.

## Course Outcome 3 (CO3):

1. Compare the stretching frequencies of carbonyl functional groups in the following compounds



2. Following Woodward-Fiesher- scott rules, it has been observed that the following compounds have absorption maximum at (i) 225 nm, (ii) 220 (iii) 230. Explain which is which.

3. Describe the function of different magnets available to generate magnetic field in MRI scanner.

## Course Outcome 4 (CO4)

- **1.** Explain the drawbacks of gold electroplating.
- 2. Name the different types of electrolyte used in platinum electroplating.
- **3.** Write the equations for hydrogen generation by electrolysis process under acidic and alkaline conditions.

## Course Outcome 5 (CO5)

- 1. Illustrate the working principle, charging and discharging reactions in Lead acid battery.
- 2. With the help of comparative chart of different battery types, justify the reason for considering Lithium ion batteries as future power source.



3. Illustrate  $H_2$ - $O_2$  fuel cell construction and explain associated electrochemical reactions.

## Course Outcome 6 (CO6)

- 1. Explain the conduction mechanism of polyaniline as a host for enzyme in biosensor.
- 2. In the following profile, identify the reason why the conductivity of polymer has been increased with dopant level.



3. Identify the suitable bio sensing materials for the detection of glucose in human blood serum.

## **Concept Map**



## Syllabus

**Water Chemistry:** Water- sources-Hardness of water-types-Estimation of hardness of water by EDTA method. Disadvantages of hardwater -Boiler troubles- scale & sludge.Internal treatment methods. External treatment methods- zeolite, ion exchange. Desalination process- reverse osmosis, electrodialysis, multi stage flash distillation. Waste water treatment processes.

**Spectroscopic technique and applications** -Principles of spectroscopy and selection rules- Electronic spectroscopy, Fluorescence- applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules- Applications. Nuclear magnetic resonance and magnetic resonance imaging. Atomic Absorption Spectroscopy and Inductively Coupled Plasma-Optical Emission Spectroscopy- Principle, instrumentation and applications.

**Electrochemical power system-**Electrochemistry–Basics - Industrial electrolytic process – Water electrolysis – Hydrogen generator- Electroplating - Decorative and functional coating-Value added coatings and Electroless process of making printed circuit board- Materials for Energy storage: Batteries - High energy density and Power density batteries - Operational characteristics – Primary and Secondary batteries– Fuel cells – Basic concept and types - Advantages and Disadvantages of fuel cell-Hydrogen Economy-Hydrogen storage- Super capacitors.

Advanced Engineering materials: Polymers and its composites for Electronic devices -Dielectric, mechanical and electrical properties-chemical methods for tailoring the properties-Conducting polymers – principle and preparation method-conduction mechanism–application of polymer and its composites in communication and flexible electronic devices - Frequency selective surfaces-Sensing properties of materials-concept-Applications

#### Text Book

- 1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, DhanpatRai publications, New Delhi, 16<sup>th</sup> edition, 2015.
- 2. C. N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, TataMcGraw-Hill (India), 5<sup>th</sup> Edition, 2013.

#### **Reference Books**

- 1. A.J. Bard and L.R. Faulkner, Electrochemical Methods, Fundamentals and Application. Wiley,2001
- 2. 2.Y.R.Sharma, Elementary Organic Spectroscopy, S. Chand, 2007.
- 3. 3.ShashiChawla, A text book of Engineering Chemistry, Dhanpat Rai& Co.(pvt) Ltd, 3<sup>rd</sup> Edition, reprint 2013

#### **Course Contents and Lecture Schedule**

S.No	Торіс			
1.0	Water Chemistry			
1.1	Introduction -Water- sources-Hardness of water-types	1		
1.2	Estimation of hardness of water by EDTA method	2		
1.3	Disadvantages of hard water -Boiler troubles- scale & sludge.	1		
1.4	Internal treatment methods	1		
1.5	External treatment methods- zeolite, ion exchange	1		
1.6	Desalination process- reverse osmosis, electrodialysis, multi stage flash distillation	1		
1.7	Waste water treatment processes	2		
2.0	Spectroscopic technique and applications			
2.1	Introduction	1		
2.2	Principles of spectroscopy and selection rules	1		
2.3	Electronic spectroscopy, Fluorescence- applications in medicine.	1		
2.4	Vibrational and rotational spectroscopy of diatomic molecules- Applications	2		

S.No	Торіс	No. of
2.5	Nuclear magnetic resonance and magnetic resonance imaging	2
2.0	Atomic Absorption Spectroscopy and Inductively Coupled Plasma-Optical	0
2.0	Emission Spectroscopy- Principle, instrumentation and applications.	Z
3.0	Electrochemical power system	
	Industrial electrolytic process - Water electrolysis - Hydrogen generator-	2
3.1	Decorative and functional coating-Electroplating Protective coating (Zn and Ni);	
3.2	Value added coatings (Au, Pt).and Electroless process of making printed circuit board	1
	High energy density and Power density batteries-Operational characteristics	2
3.3	- Primary (Zn/MnO <sub>2</sub> or Zn/Ag <sub>2</sub> O) and Secondary batteries (Pb- acid and	
	Lithium ion/polymer batteries)	
34	Fuel cells - Basic concept and types Proton exchange membrane FC-	2
0.4	Methanol FC-solid oxide FC- (principle only)	
3.5	Advantages and Disadvantages of fuel cell-Hydrogen Economy-Hydrogen	2
0.0	storage- Super capacitors – EDLC and Hybrid type (principle only)	
4.0	Advanced Engineering materials	
4.1	Dielectric, mechanical and electrical properties-chemical methods for	2
	tailoring the properties-Doping-Functionalization-core/shell nanostructure	
4.2	Conducting polymers – principle and preparation method-conduction	2
	mechanism-(conjugated polymers- conjugated doped polymers)	-
4.3	application of polymer and its composites in sensors, light emitting diodes.	2
	telecommunications, power transmissions	
4.4	antistatic coatings, conducting adhesives, artificial nerves - EMI shielding,	1
	Frequency selective surfaces	
4.5	Sensing properties of materials-concept-Applications- Electronic sensors in	2
	Environmental monitoring process	
	lotal	36

## **Course Designers:**

- 1. Dr.M.Kottaisamy
- 2. Dr..J.Shanmugapriya

hodchem@tce.edu shanmugapriya@tce.edu Sbalaji@tce.edu

3. Dr.S.Balaji

	CHEMISTRY	Category	L	Т	Ρ	Credit
18CHC30	(Common to CSE and IT)	BS	3	0	0	3

The objective of this course is to bestow the better understanding of basic concepts of chemistry and its applications in Computer Science and Engineering and Information Technology. This course provides exposure on corrosion and its protection in computer components. It also imparts knowledge on properties and application of nano-materials in data storage devices. Besides, it highlights properties of water and its treatment methods, spectroscopic techniques for material characterization, properties and applications of polymers.

#### Prerequisite

NIL

## Course Outcomes

On the successful completion of the course, students will be able to

CO 1.	Identify the properties of water and its treatment methods	Understand
CO 2.	Summarize the principles and instrumentations of spectroscopic	Understand
	techniques	
CO 3.	Select the appropriate spectroscopic techniques for characteristics of	Apply
	materials	
CO 4.	Adapt the suitable corrosion control methods	Apply
CO 5.	Describe the preparation, properties and applications of polymers	Understand
	and nanomaterials.	
CO 6.	Discuss the significance of nanomaterials in computer peripherals	Understand
	and data storage devices	

#### **Mapping with Programme Outcomes**

COs	P01	PO2	PO3	PO4	PO5	P06	P07	P08	PO9	PO10	P011	PO12
CO1	М	-	-	-	-	-	-	-	-	-	L	-
CO2	М	L	L	-	-	-	-	-	-	-	-	-
CO3.	S	S	М	М	-	-	-	-	-	-	-	-
CO4.	S	S	М	М	-	-	L	-	-	-	L	-
CO5.	М	М	М	М	-	-	L	-	-	-	-	-
CO6.	Μ	М	М	М	L	-	Μ	-	-	-	-	-
C Strong	C. Strong: M. Madium: L. Law											

S- Strong; M-Medium; L-Low

Bloom's Category	Continuc	ous Assessmo	Terminal Examination					
biooni s category	1	1 2 3						
Remember	20	20	20	20				
Understand	40	40	40	40				
Apply	40	40	40	40				
Analyze	-	-	-	-				
Evaluate	-	-	-	-				
Create	-	-	-	-				

## **Course Level Assessment Questions**

#### Course Outcome 1 (CO1):

- 1. Distinguish between scale and sludge.
- 100 ml of given water sample consumed 48 ml of EDTA during titration using EBT indicator. 35 ml of same EDTA consumed by 100 ml of standard hard water containing 1 mg of pure CaCO<sub>3</sub> per ml. Calculate the permanent, temporary and total hardness of given water samples in CaCO<sub>3</sub> equivalents.
- 3. Outline the steps involved in the waste water treatment process.

## Course Outcome 2 (CO2):

- 1. State Beer-Lambert law.
- 2. Write the selection rule in absorption spectroscopy.
- 3. Explain the procedure involved in finding the metals present in an alloy sample using ICP-OES.

## Course Outcome 3 (CO3):

1. Compare the stretching frequencies of carbonyl functional groups in the following compounds



2. Following Woodward-Fiesher- scott rules, it has been observed that the following compounds have absorption maximum at (i) 225 nm, (ii) 220 (iii) 230. Explain which is which.



3. Describe the function of different magnets available to generate magnetic field in MRI scanner.

## Course Outcome 4 (CO4):

- Linear polarisation of steel specimen (0.1 x 0.1 cm<sup>2</sup>) kept in 4% aqueous NaCl solution is studied. It gives corrosion current I<sub>corr</sub> = 50 μA/cm<sup>2</sup>.Equivalent weight and density of steel are 55.85 g/mol and 8.05 g/ cm<sup>3</sup> respectively. Calculate the rate of corrosion of steel in mm/year.
- 2. Demonstrate causes and control measures of corrosion in computer peripherals and electronic devices.
- 3. Explain the factors influencing rate of corrosion.

## Course Outcome 5 (CO5):

- 1. Demonstrate the mechanism of conducting polymer of poly acetylene.
- 2. Explain the application of polymer material application in display devices.
- 3. Compare OLED vs LCD in display properties.

## Course Outcome 6 (CO6):

- 1. Recall the classification of nanomaterials
- 2. Explain size dependent properties on nanomaterials
- 3. Describe the role of nanomaterials in data storage devices.

#### **Concept Map**



## Syllabus

## Water Chemistry:

Water- sources-Hardness of water-types-Estimation of hardness of water by EDTA method. Disadvantages of hardwater -Boiler troubles- scale & sludge. Internal treatment methods. External treatment methods- zeolite, ion exchange. Desalination process- reverses osmosis, electrodialysis, multi stage flash distillation. Waste water treatment processes.

#### Spectroscopic technique and applications:

Principles of spectroscopy and selection rules- Electronic spectroscopy, Fluorescenceapplications in medicine. Vibrational and rotational spectroscopy of diatomic molecules-Applications. Nuclear magnetic resonance and magnetic resonance imaging. Atomic Absorption Spectroscopy and Inductively Coupled Plasma-Optical Emission Spectroscopy-Principle, instrumentation and applications.

#### Corrosion in computer components:

Introduction -types of corrosion-electrochemical analysis-Polarization and Impedance - Rate of corrosion determination- influencing factors in corrosion-corrosion degradation in computer peripherals, electronic devices -control measures-self protecting corrosion products –Pilling Bed worth rule- precious metal coating and impact-salt spray- electroless plating-Printed Circuit Board (PCB) manufacturing.

#### Advanced Engineering Materials:

**Polymers** – introduction – structure- property relationship of polymer -conducting polymers – properties and applications in biosensors, organic light emitting diodes.Polymers in telecommunications, power transmission and liquid crystalline display devices, flexible

electronic devices. Polymer composite–classification and applications in computer components. **Nanomaterials**: Difference between nano and bulk materials- classifications-size dependent properties. Data storage materials – properties and applications.

## Text Book

- 1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, DhanpatRai publications, New Delhi, 16<sup>th</sup> edition, 2015.
- 2. C. N. Banwelland E.M. McCash, "Fundamentals of Molecular Spectroscopy", Tata McGraw-Hill (India), 5<sup>th</sup> Edition, 2013.

#### **Reference Books**

- 1. Shashi Chawla, " A text book of Engineering Chemistry", Dhanpat Rai & Co.(pvt) Itd 3<sup>rd</sup> edition, reprint 2011.
- Mars Fontana, "Corrosion Engineering, Mc Graw Hill Education 3<sup>rd</sup> edition reprint, 2017.R.V.Gadag, A. Nityananda Shetty "Engineering Chemistry" I.K. international Publishing Pvt Ltd. 3<sup>rd</sup> edition 2014.

## **Course Contents and Lecture Schedule**

S. No.	Торіс	No. of hour
1.0	Water Technology	
1.1	Introduction -Water- sources-Hardness of water-types	1
1.2	Estimation of hardness of water by EDTA method	2
1.3	Disadvantages of hardwater -Boiler troubles- scale & sludge.	1
1.4	Internal treatment methods	1
1.5	External treatment methods- zeolite, ion exchange	1
1.6	Desalination process- reverse osmosis, electrodialysis, multi stage flash distillation	1
1.7	Waste water treatment processes	2
2.0	Spectroscopic techniques and applications	
2.1	Introduction	1
2.2	Principles of spectroscopy and selection rules	1
2.3	Electronic spectroscopy, Fluorescence- applications in medicine.	1
2.4	Vibrational and rotational spectroscopy of diatomic molecules- Applications	2
2.5	Nuclear magnetic resonance and magnetic resonance imaging	2
2.6	Atomic Absorption Spectroscopy and Inductively Coupled Plasma- Optical Emission Spectroscopy- Principle, instrumentation and applications.	2
3.0	Corrosion in computer components	
3.1	Types of corrosion, Electrochemical analysis – polarisation and impedance	2
3.2	Rate of corrosion determination	1
3.3	Factors influencing corrosion-local heat generation	2
3.4	Corrosion in computer peripherals and electronic devices	1
3.5	Corrosion control methods and precious metal coating	2
3.6	Printed Circuit Board Manufacturing	1

S. No.	Торіс			
4.0	Advanced Engineering Materials			
4.1	Polymers - Structure property relationship of polymer	2		
4.2	Conducting polymers – synthesis, properties and applications in biosensors and OLED	3		
4.3	Polymer composites – classification and applications in computer components.	1		
4.4	Nanomaterials – classification and size dependent properties	1		
4.5	Properties of Data storage nanomaterials	2		
	Total	36		

## **Course Designers:**

1. Dr. M. Kottaisamy

hodchem@tce.edu velkannan@tce.edu

- Dr. V. Velkannan
  Dr. S. Sivailango
- drssilango@tce.edu

18EG140	ENGLISH	Category	L	Т	Ρ	Credit
		HSS	2	0	0	2

The course aims at developing communication skills in English essential for understanding and expressing the ideas in different academic, social, and professional contexts. The students acquire the skills of listening, speaking, reading, and writing competencies in English language, making them employable in the globalised scenario.

## Prerequisite

NIL

## **Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Recall the basics of language in terms of vocabulary, grammar, pronunciation, syntax and semantics.	Remember
CO2	Understand the grammatical nuances and use them accordingly in	Understand
CO3	Read and comprehend the content in English in general and technical	Understand
CO4	Write with coherence and cohesion effectively.	Apply
CO5	Apply the language in established structure with precision in social and professional contexts.	Apply

## Mapping with Programme Outcomes

COs	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.										S		S
CO2.										S		М
CO3.										S		S
CO4.										S		S
CO5.										S		S
S- Stro	ong; M-	Mediu	m; L-Lc	w			•					<u>.</u>

## Assessment Pattern

Bloom's Catagory	Continu	Terminal		
Bioonin's Calegory	1	2	3	Examination
Remember	-	-	-	-
Understand	15	15	30	30
Apply	35	35	70	70
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

#### **Course Level Assessment Questions**

#### Course Outcomes 1, 2 and 3

- 1. Rewrite as directed.
  - a) Write a basic definition of a "mobile".
    - b)Combine the following sentences to bring out the "Purpose and Function".
    - The coal gas is compressed. Condensation in the gas mains can be avoided.
  - c) Expand the following nominal compounds: i) car race ii) race car
  - d) Combine the following sentences using a relative clause.

Smart meters are small computers. They provide real-time information on how much electricity is being used by each customer.

e) Combine the following sentences to bring out the "Cause and Effect"

Sand is mixed with the cement. It prevents the excessive shrinkage during drying.

- f) Give the words for the following transcriptions
  - i) /tekˈnɒl.ə.dʒi/ ii) /prəˌnʌn*t*.siˈeɪ.ʃən/
- g) Write down the phonetic symbols of the letters underlined. i). Thick ii) Pleasure
- h) Syllabify the word and underline the stressed syllable: Communication
- i) Frame question tags for the following sentence: Don't open your books
- j) Fill in the blank with the correct form of the verb given in brackets. Tamil Nadu's share of students in the IITs and NITs \_\_\_\_\_ (register) a considerable drop in the recent years.
- 2. Read the following passage and answer the following (different types of) questions.
  - Descriptive questions for eliciting short answers
  - True or false
  - Sentence Completion
  - Synonyms/meaning of the words in the text

## Course Outcomes 4 & 5

- 1. Write a paragraph in about 100-150 words on E-learning
- 2. Write a paragraph in about 100-150 words on Plastics
- 3. Write an e-mail to a company requesting permission to attend in-plant training for a fortnight.
- 4. Draft a letter to a company requesting you to undergo in-plant training there, inventing necessary details, in proper format.
- 5. Prepare a set of 10 instructions on how to draw money from an ATM.
- 6. Prepare a set of 12 recommendations to keep our environment clean.
- 7. Make notes of the passage given in appropriate format with a title and summarize in about 100 words.
- 8. Interpret the following graphic data in about 150 words



9. Write an essay in about 250 words on 'The Impact of Technology on Nature'



## Syllabus:

MODULE- I

Basics of language – Phonetics - Phonemes, Syllables and Stress, Vocabulary – Word Analysis, Prefix, Suffix, Roots, Parts of Speech, Sentence Patterns.

## MODULE- II

Basics of grammar – Tenses, Subject-Verb Agreement, Impersonal Passive Voice, Relative Clauses; Notions for Technical English – Noun Compounds, Classifications and Definitions, Cause and Effect, Purpose and Function, Numerical Adjectives, Reading Comprehension – Skimming, Scanning, Skipping (as tested in BEC Vantage Level)

## MODULE-III

Writing with coherence and cohesion, Summarizing, Note-Making, Interpretation of Graphics, Writing Instructions and Recommendations, Paragraph and Essay Writing. MODULE-IV

Writing with correct spelling, punctuation and grammar, Blog writing, E-mail Writing (BEC Vantage Writing-Unit I) – Formal Letters by students for Bonafide Certificate/Permission.

## Suggested Reading:

#### Books:

- 1. Murphy, Raymond, English Grammar in Use with Answers; Reference and Practice for Intermediate Students, Cambridge: CUP, 2004
- 2. Jones, Daniel. An English Pronouncing Dictionary, Cambridge: CUP, 2006

- 3. Brook-Hart,Guy. Cambridge English- Business Benchmark-Upper Intermediate, CUP,2014.
- 4. Dhanavel, S.P. English and Communication Skills for Students of Science & Engineering, Orient BlackSwan, Chennai: 2016.
- 5. Swan, Michael. Practical English Usage.4<sup>th</sup> Edn. OUP. 2016.

Websites:

- 1. http://www.englishclub.com
- 2. http://owl.english.purdue.edu
- 3. https://www.oxfordonlineenglish.com
- 4. www.bbclearningenglish.com

#### **Course Contents and Lecture Schedule**

S.No	Торіс	No. of Hours
1.	Introduction	1
2.	Sentence Patterns	1
3.	Tenses	2
4.	Subject-Verb Agreement	1
5.	Phonetics – Consonants, Vowels, Dipthongs	1
6.	Phonetics – Syllable and Stress	1
7.	Word Formation – Prefixes, Suffixes and Root Words	1
8.	Reading Comprehension - I (Skipping, Skimming, and Scanning)	1
9.	Note-Making and Summarizing	1
10.	Writing Instructions and Recommendations	1
11.	Tutorials	1
12.	Defining and Non-Defining Relative Clauses	1
13.	Impersonal Passive Voice	2
14.	Notions of Technical English – Noun Compounds, Definitions, Cause & Effect, Purpose and Function, Numerical Adjectives	1
15.	Paragraph / Essay Writing- Topic and Supporting Sentences, Coherence	2
16.	E-Mail Writing – (BEC Vantage Writing Task I)	1
17.	Formal Letters by students for Bonafide Certificate/Permission	1
18.	Interpretation of Graphics	1
19.	Reading Comprehension – II (As tested in BEC Writing Task III)	2
20.	Tutorials	1
	Total	24

#### **Course Designers:**

- 1 Dr. S. Rajaram
- 2 Dr.A.Tamilselvi
- 3 Mr. R. Vinoth
- 4 Dr. R. K. Jaishree Karthiga

sreng@tce.edu tamilselvi@tce.edu vino@tce.edu jai@tce.edu

18ES150	ENGINEERING EXPLORATION	Category	L	Т	Ρ	Credit
		ES	1	2	-	3

The course Engineering Exploration provides an introduction to the engineering field. It is designed to help the student to learn about engineering and how it affects our everyday lives. On the successful completion of the course, students will be to explain how engineering is different from science and technology and how science, mathematics and technology are an integral part of engineering design.

## Prerequisite

NIL

## **Course Outcomes**

On the successful completion of the course, students will be able to

CO1. Explain technological & engineering development, change and impacts	Understand
of engineering	
CO2. Draw a product in enough detail that others can accurately build it and	Apply
write specification sheet for a given product	
CO3. Complete initial steps (Define a problem, list criteria and constraints,	Apply
brainstorm potential solutions and document the ideas) in engineering design	
process	
CO4. Draw sketches to a design problem and provide a trade-off matrix	Apply
CO5. Communicate possible solutions through drawings and prepare project	Apply
report	
CO6. Use reverse engineering to suggest improvements in a tool design	Apply
CO7. Apply the concept of engineering fundamentals in Civil, Mechanical,	Apply
Electrical and Computer Engineering	

#### **Mapping with Programme Outcomes**

COs	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C01	М	L	-	-	-	-	-	-	-	-	-	-
C02	S	Μ	L	-	-	-	-	-	-	-	-	-
C03	S	Μ	L	-	-	-	-	-	-	-	-	-
C04	S	Μ	L	-	-	-	-	-	-	-	-	-
C05	S	Μ	L	-	-	-	-	-	-	-	-	-
C06	S	Μ	L	-	-	-	-	-	-	-	-	-
C07	S	М	L	-	-	-	-	-	-	_	_	-

S- Strong; M-Medium; L-Low

## Assessment Pattern

S No	Bloom's category	Continu	End Semester Examinations		
0.110	Dioonno odtogory	1	2	3	
1	Remember	20	20	20	20
2	Understand	20	20	20	20
3	Apply	60	60	60	60
4	Analyze	0	0	0	0

Passed in Board of Studies on 14.07.2018

5	Evaluate	0	0	0	0
6	Create	0	0	0	0

## Course Level Assessment Questions

## Course Outcome 1 (CO1):

- 1. What is the role of Engineer?
- 2. How do you believe the growth of engineering has impacted the product that we have today?
- 3. Select an engineering product, list the specifications and constraints that must be considered when designing the product. Make a list of tradeoff.

## Course Outcome 2 (CO2):

- 1. List the steps of a design problem.
- 2. Identify the problem you see in the product you used in your daily life.
- 3. Determine the design constraint and criteria for a problem.
- 4. Create an isometric drawing of a design.

## Course Outcome 3 (CO3):

- 1. List the five factors when considering development problem.
- 2. Imagine you have noticed the car you are riding is making a squeaking noise from the engine compartment. Define the problem with your vehicle. Classify the potential problem.
- 3. Imagine you are hired by your local city to develop a new public transportation.
  - a. Define the problem.
  - b. List the criteria and constraint.
  - c. List the potential solution.

## Course Outcome 4 (CO4):

- 1. Imagine you are an engineer who is designing a portable sitting device; you need to design a chair that will be portable that will fit in the trunk of the car which hold 100 kg individual and will be easily produced. Create sketches using a four step process to this design problem.
- 2. Imagine you are an engineer who develops method to automatically sort books at college library. Develop possible sketches and list potential solution and give the tradeoff matrix.
- 3. How can your research improve the design?

## Course Outcome 5 (CO5):

- 1. What details are able to show with the perspective drawing?
- 2. What is the difference between mockup and prototype?
- 3. List five different question engineers must ask about function of the design.

## Course Outcome 6 (CO6):

- 1. Select a product to analyze with respect to function, fit, aesthetics, safety and environment impact. Write a summary on evaluation of the product. If you would like make changes to the design list the changes.
- 2. What design components should be reconsidered in reverse engineering processes? Why?
- 3. What are the benefits of reverse engineering?

## Course Outcome 7 (CO7):

- 1. Explain ohms law and list the related formulas.
- 2. What role do you think the range selection plays in the accuracy of the measurements?
- 3. Why it is important for a civil engineer to study structural forces?
- 4. Describe the differences between fluids used in hydraulics and pneumatics.

## **Concept Map**



#### Syllabus

What is Engineering: Engineering Requirement, Knowledge within Engineering disciplines, Engineering advancements Engineering Design: Problem definition, idea generation through brainstorming and researching, solution creation through evaluating and communicating, text/analysis, final solution and design improvement. Defining problems and Brainstorming: Researching design, sketching problem solving Communicating solution: Dimensioning orthographic drawing, perspective drawing Modeling and Testing final output: Product evaluation, reverse engineering, final project report. Civil Engineering: Structural forces structural analysis, bridge design components, structural design Mechanical Engineering: Types of motion, mechanical power system, mechanical power formula, mechanical design. Electrical Engineering: Reading analog multimeter, measuring current, voltage and resistance, electricity from chemicals, solar cells, magnets, Ohms law and watts law, circuit identification and circuit calculation, resistor color code, continuity Computer Engineering: Logic gates, algorithms, computer architecture, binary code

#### **Reference Books**

- 1. Ryan A.Brown, Joshua W.Brown and Michael Berkihiser: "Engineering Fundamentals: Design, Principles, and Careers", Goodheart-Willcox Publisher, Second Edition, 2014.
- 2. Saeed Moaveni , "Engineering Fundamentals: An Introduction to Engineering", Cengage learning, Fourth Edition, 2011.

## Course Contents and Lecture Schedule

No.	Торіс	No. of
		Lectures
1.	What is Engineering	
1.1	Engineering Requirement	1
1.2	Knowledge within Engineering disciplines,	1
1.3	Engineering advancements	1
2	Engineering Design	
2.1	Problem definition,	1
2.2	idea generation through brainstorming and researching	1
2.3	solution creation through evaluating and communicating,	1
2.4	text/analysis	1
2.5	final solution and design improvement	1
3	Defining problems and Brainstorming:	
3.1	Researching design	1
3.2	sketching problem solving	2
4	Communicating solution	
4.1	Dimensioning orthographic drawing	1
4.2	perspective drawing	1
5	Modeling and Testing final output	
5.1	Product evaluation	1
5.2	reverse engineering	1
5.3	final project report	1
6	Civil Engineering	
6.1	Structural forces structural analysis	2
6.2	bridge design components	2
6.3	structural design	1
7	Mechanical Engineering	
7.1	Types of motion	2
7.2	mechanical power system	1
7.3	mechanical power formula	1
7.4	mechanical design	1
8	Electrical Engineering:	
8.1	Reading analog multimeter, measuring current, voltage and	1
	resistance	
8.2	electricity from chemicals, solar cells, magnets,	1
8.3	Ohms law and watts law, circuit identification and circuit	1
	calculation	
8.4	resistor color code, continuity	2

No.	Торіс	No. of Lectures
9	Computer Engineering	
9.1	Logic gates, algorithms,	1
9.2	computer architecture,	2
9.3	binary code	2
	Total	36

## **Course Designers:**

1. Dr.S.J. Thiruvengadam

2. Dr. S.Baskar

sjtece@tce.edu sbeee@tce.edu

			Category	L	Т	Ρ	Credit		
18ME160	ENGINEERING GRAPHICS		ES	3	0	2	4		

Engineering Graphics is referred as language of engineers. An engineer needs to understand the physical geometry of any object through its orthographic or pictorial projections. The knowledge on engineering graphics is essential in proposing new product designs through drawings and in reading or understanding existing drawings. This course covers orthographic and pictorial projections, sectional views, development of surfaces and use of computer aided drafting tools.

## Prerequisite

NIL

## Course Outcomes

On successful completion of the course, students will be able to

CO1	Draw conic Sections such as ellipse, parabola, hyperbola and rectangular hyperbola.	Apply
000		A 1
CO2	Draw the orthographic projections (Elevation and Plan) of straight lines	Арріу
	inclined to both reference planes.	
CO3	Draw the orthographic projections (Elevation, Plan and End view) of	Apply
	plane surfaces inclined to both reference planes	
CO4	Draw the orthographic projections (Elevation and Plan) of regular solids	Apply
	(Prisms, Pyramids, Cylinder and Cone) with axis inclined to any one	
	reference plane.	
CO5	Draw the orthographic projections (Elevation and Plan) of sectioned	Apply
	solids (Prisms, Pyramids, Cylinder and Cone) with axis perpendicular to	
	horizontal plane and true shape of the sections.	
CO6	Draw the development of surfaces (base and lateral) of sectioned	Apply
	regular solids (Prisms, Pyramids, Cylinder and Cone).	
CO7	Draw the isometric projections of regular solids and combined solids	Apply
	(Prisms, Pyramids, Cylinder, Cone and sphere) and of solid parts from	
	the orthographic views.	
CO8	Develop computer-aided 3D models for the given part drawing (2D/3D)	Apply
	and draw orthographic views for the 3D model with appropriate	
	dimensioning using CAD package. (Continuous Assessment only)	

**Mapping with Programme Outcomes** 

	-	-										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	S	М	S	М	М	_	_	_	М	М	_	-
CO2.	S	М	S	М	М	_	_	-	М	М	_	-
CO3.	S	М	S	М	М	_	_	-	М	М	_	-
CO4.	S	М	S	М	М	_	_	-	М	М	_	-
CO5.	S	М	S	М	М	_	_	_	М	М	_	-
CO6.	S	М	S	М	М	_	_	_	М	М	_	_
CO7.	S	M	S	M	M	_	_	_	М	М	_	_
CO8.	S	М	S	М	S	_	_	_	М	М	_	_
Assessment Fattern												
-----------------------------------	----------------------------	----------------------	--	--	--	--	--	--	--	--	--	
Bloom's Category	Continuous Assessment Test	Terminal Examination										
Remember	0	0										
Understand	0	0										
Apply	100	100										
Analyse	0	0										
Evaluate	0	0										
Create	0	0										
Course Level Assessment Questions												

# **Assessment Pattern**

# Course Outcome 1 (CO1)

- 1. Draw an ellipse if the distance of focus from the directrix is 70 mm and the eccentricity is <sup>3</sup>/<sub>4</sub>.
- 2. Draw a parabola if the distance of focus from the directrix is 60 mm.

# Course Outcome 2 (CO2)

- 2. One end "A" of a straight line AB 85 mm long is 10 mm above HP and 15 mm in front of VP. The line is inclined to HP at 40° and inclined to VP at 30°. Draw the projections.
- 3. A line CD has its end "C" 20 mm above HP and 25 mm in front of VP. The other end "D" is 45 mm above HP and 40 mm in front of VP. The distance between the end projectors is 60 mm. Draw its projections and find its true length.

# Course Outcome 3 (CO3)

- 1. A semi circular plate of 80 mm diameter has its straight edge on V.P and inclined at 30° to H.P. The surface of the plate is inclined at 45° to V.P. Draw the projections of the plate.
- 2. A thin rectangular plate of 60 x 40 mm size has its shorter edge on H.P and inclined 30° to V.P. Draw the projections of the plate when its top view is a square of 40 mm side.

# Course Outcome 4 (CO4)

- 1. A hexagonal prism of side of base 35 mm and axis length 80 mm rests on HP on one of its rectangular faces such that its axis is inclined to VP by 45°. Draw its elevation and plan.
- 2. A square pyramid of base side 40 mm and axis 75 mm long is resting on one of its base edges in such a way that one of its triangular faces is perpendicular to both HP and VP. Draw its front view and top view.

# Course Outcome 5 (CO5)

- 1. A cone of base 75 mm diameter and axis 80 mm long is resting on its base on H.P. It is cut by a section plane perpendicular to VP, inclined at 45° to H.P and cutting the axis at a point 35 mm from the apex. Draw the front view, sectional top view and true shape of the section.
- 2. A hexagonal pyramid, base 30 mm side and axis 65 mm long is resting on its base on HP with two edges of the base parallel to V.P. It is cut by a section plane perpendicular to V.P and inclined 45° to H.P, intersecting the axis at a point 25 mm above the base. Draw the front view, sectional top view and true shape of the section.

# Course Outcome 6 (CO6)

- 1. A cone of base diameter 60 mm and axis 70 mm long is resting on its base on H.P. A section plane perpendicular to H.P and V.P cuts the cone at a distance of 10 mm from the axis. Draw the development of the cut solid.
- 2. A pentagonal prism of base side 30 mm and axis height 75 mm is resting on its base on HP such that rectangular face is parallel to V.P. It is cut by a cutting plane perpendicular to V.P and 30° inclined to H.P. It meets the axis 15 mm below the top base. Draw the development of the cut prism.

# Course Outcome 7 (CO7)

- 1. Draw the isometric projection of hexagonal prism of base side 40 mm and height 60 mm with a right circular cone of base diameter 50 mm and altitude 50 mm resting on its top such that the axes of both solids are collinear and vertical.
- 2. Draw the isometric view of the part with the following orthographic views.



# Course Outcome 8 (CO8)

1. Develop a 2D model using CAD package for the given figure.



2. Develop a 3D model using CAD package for the given part drawing.



2. Draw the orthographic views for the given 3D model with appropriate dimensioning using CAD package.



52

### **Concept Map**



## Syllabus

**Introduction**- Significance of engineering graphics, Use of drawing instruments –Standards, Lettering, numbering and dimensioning, Principles of orthographic projections, First angle projection, Scales.

**Conic Sections** - Construction of ellipse, parabola, hyperbola (Eccentricity Method only) and rectangular hyperbola.

Projection (Elevation and Plan) of points located in all quadrants.

**Projection (Elevation and Plan) of straight lines** inclined to both reference planes - Determination of true lengths and true inclinations by rotating line method.

**Projection (Elevation, Plan and End view) of planes** inclined to both reference planes by rotating object method.

**Projection (Elevation and Plan) of regular solids** (Prisms, Pyramids, Cylinder and cone) by rotating object method when the axis is inclined to one of the reference planes.

**Projection (Elevation and Plan) of sectioned solids** (Prisms, Pyramids, Cylinder and cone) and true shape of the sections, when the axis of the solid is perpendicular to horizontal plane.

**Development of surfaces** (base and lateral) **of sectioned regular solids** (Prisms, Pyramids, Cylinder and Cone).

**Isometric projection** – Principle, isometric scale, Isometric views and Isometric projections of single solid and combined solids (Prisms, Pyramids, Cylinder, Cone and sphere) when the axis is vertical. **Conversion of orthographic projections** (Elevation, Plan and End view) of solid parts / engineering components into isometric view.

**Computer Aided Drafting** (For Continuous Assessment only):

Overview of Computer Graphics, list of computer technologies, impact on graphical communication. Demonstrating knowledge of the theory of CAD software such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area

(Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects. Setting up of units and drawing limits.

Drawing geometric entities such as lines, arcs and circles in isometric views. Development of 3D wire-frame and shaded models. Dimensioning – Guidelines – ISO and ANSI standards for coordinate dimensioning - Defining local coordinate systems – Dimensioning in iso-metric and orthographic views.

# Text Book

1. Bhatt N.D., Panchal V.M. and Ingle P.R., (2014) "Engineering Drawing", Charotar Publishing House.

# **Reference Books**

- 1. Natarajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2009.
- 2. Basant Agarwal and Agarwal C.M., "Engineering Drawing", Tata McGraw Hill Publishing Company Limited, New Delhi, 2008
- 3. Venugopal K. and Prabhu Raja V., "Engineering Graphics", New Age International (P) Limited, 2008.
- 4. Gopalakrishna K.R., "Engineering Drawing" (Vol. I&II combined), Subhas Stores, Bangalore, 2007.
- 5. Shah M.B, and Rana B.C (2008) "Engineering Drawing and Computer Graphics", Pearson Education.
- 6. (Corresponding set of) CAD Software Theory and User Manuals.

# **Course Contents and Lecture Schedule**

SI.No	Торіс	Lecture Hours	Practice Hours
1	<b>Introduction</b> - Significance of engineering graphics, Use of drawing instruments –Standards, Lettering, numbering and dimensioning, Principles of orthographic projections, First angle projection, Scales.	2	1
2	<b>Conic Sections</b> - Construction of Ellipse, Parabola, hyperbola and rectangular hyperbola (Eccentricity Method only).	2	3
3	<b>Projection (Elevation and Plan) of points</b> located in all quadrants.	2	1
4	<b>Projection (Elevation and Plan) of straight lines</b> inclined to both reference planes - Determination of true lengths and true inclinations by rotating line method.	4	2
5	<b>Projection (Elevation, Plan and End view) of planes</b> inclined to both reference planes by rotating object method.	5	2
6	<b>Projection (Elevation and Plan) of regular solids</b> (Prisms, Pyramids, Cylinder and cone) by rotating object method when the axis is inclined to one of the reference planes.	5	3
7	<b>Projection (Elevation and Plan) of sectioned solids</b> (Prisms, Pyramids, Cylinder and cone) and true shape of the sections, when the axis of the solid is perpendicular to horizontal plane.	4	2
8	<b>Development of surfaces</b> (base and lateral) <b>of sectioned regular solids</b> (Prisms, Pyramids, Cylinder and Cone).	4	2

9	<b>Isometric projection</b> – Principle, isometric scale, Isometric views and Isometric projections of single solid and combined solids (Prisms, Pyramids, Cylinder, Cone and sphere) when the axis is vertical. <b>Conversion of orthographic projections</b> (Elevation, Plan and End view) of solid parts / engineering components into isometric view.	4	2
10	<b>Computer Aided Drafting</b> (For Continuous Assessment only): <b>10.1</b> Overview of Computer Graphics, list of computer technologies, impact on graphical communication. Demonstrating knowledge of the theory of CAD software such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects. Setting up of units and drawing limits.	1	1
	<b>10.2</b> Drawing geometric entities such as lines, arcs and circles in isometric views. Development of 3D wire-frame and shaded models. Dimensioning – Guidelines – ISO and ANSI standards for coordinate dimensioning - Defining local coordinate systems – Dimensioning in iso-metric and orthographic views.	3	5
	TOTAL	36	24

# **Question Pattern for Terminal Examination**

Question Number	Description	Marks	
1	Conic sections	Either or type	10
2	Projection of lines	Either or type	15
3	Projection of planes	Either or type	15
4	Projection of solids	Either or type	15
5	Section of solids	Either or type	15
6	Development of surfaces	Either or type	15
7	Isometric projections of combined solids Or Orthographic views to isometric view	Either or type	15
	100		

# Marks Allocation for Continuous Assessment:

SI. No	Description	Marks
1	Plates (Drawing sheets) submission	20
2	Computer Aided Drafting (CAD) Exercises	15
3	Continuous Assessment Test (CAT)	15
	Total	50

# Note:

1. One test or two tests will be conducted locally by respective faculty-in- charge during regular class hours to account for continuous assessment test (CAT) marks.

2. Terminal examination (3 hrs) will be conducted centrally by the office of controller of examinations.

# **Course Designers**

- 1. Dr. A.Samuel Raja
- 2. Prof. M.Kannan

samuel1973@tce.edu mknmech@tce.edu

18EG170	ENGLISH LABORATORY	Category	L	Т	Ρ	Credit
		HSS	0	0	2	1
Dreemble						

## Preamble

This practical course enables the students to develop and evaluate their basic English language skills in Language Lab, equipped with English Software, through individualized learning process and immediate feedback, and facilitates students with the need-based student-centric presentation sessions in a multi-media driven classroom environment.

## Prerequisite

NIL

# Course Outcomes

On the successful completion of the course, students will be able to

CO1	Pronounce words intelligibly through listening and watching contents on social, technical and day-to-day conversations and respond to questions related to them	Apply						
CO2	Apply appropriate lexicon in various contexts, by differentiating variations pertaining to spelling, pronunciation, meaning and grammar	Apply						
CO3	Comprehend passages on various topics like general, business and science at various levels							
CO4	Read texts in newspapers, magazines, and articles on a variety of issues with clarity to understand and to be understood							
CO5	Prepare and present on a topic to a group of audience with ICT and other educational aids							
Mann	ing with Drogramma Outcomes							

Mapping with Programme Outcomes

COs	P01	PO2	PO3	PO4	PO5	PO6	P07	PO8	PO9	PO10	PO11	PO12
CO1										S		S
CO2										S		М
CO3										S		S
CO4										S		М
CO5										S		S

# **Assessment Pattern**

Internal: No Continuous Assessment Test will be conducted

Students' performance will be assessed in the classroom as given below

- Spoken Task General / Technical Presentation / BEC Speaking Tests II: 25 Marks
- Listening Task Answering questions
- **External:** Tested on Phonetics, Grammar, and Vocabulary in the lab for 1 hour : 80 Marks Submission of Students Record on Practical Tasks in the Class and Lab : 20 Marks

: 25 Marks

# List of Experiments

	•	
S.No	Торіс	Hours
	LAB ACTIVITES	
1	Listening	2
2	Vocabulary	2
3	Grammar	2
4	Phonetics	2
5	Reading Comprehension – I (General)	2
6	Reading Comprehension – II (BEC Vantage Level)	2
	CLASSROOM ACTIVITIES	
7	Reading Practice (Extensive Reading)	2
8	English through Audios & Videos (Note-Taking & answering questions)	2
9	Presentation - I	2
10	Presentation - II	2
11	Revision	2
12	Model Test	2
	Total	24

# Software Used:

- 1. Business English Certificate-Vantage- Practice Software
- 2. English Software

# Extensive Reading: (Not for Terminal Exam, Prescribed only for Spoken Tasks)

1. Khera, Shiv, You Can Win, Macmillan Books, New York, 2003.

# **Teaching Resources and Websites:**

- 1. Oxford / Cambridge Online English Videos
- 2. Free Video Downloads from Youtube
- 3. https://learningenglish.voanews.com/
- 4. https://www.ted.com/talkshttp://
- 5. <u>www.esl-galaxy.com/video.htm</u>

# **Course Designers:**

- 1 Dr. S. Rajaram
- 2 Dr.A.Tamilselvi
- 3 Mr. R. Vinoth
- 4 Dr. R. K. Jaishree Karthiga

sreng@tce.edu tamilselvi@tce.edu vino@tce.edu jai@tce.edu

		Category	L	Т	Ρ	Credit
18PH180	PHYSICS LABORATORY	BS	0	0	2	1

# Preamble

This course ensures that students learn to apply the basic physics concepts and carry out the experiments to determine the various physical parameters related to the material

- Learn the necessary theory to understand the concept involved in the experiment.
- Acquire the skills to carry out the experiment.
- Tabulate the observed data and use the formula to evaluate the required quantities.
- Plot the data in a graph and use it for calculation.

# **Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Analyze mechanical ,electrical oscillations and determine their	Apply								
	resonance frequency									
CO2	Analyze the diffraction and interference patterns for characterization									
CO3	Determine the numerical aperture and bending loss in optical fiber	Apply								
CO4	Determine the Planck's constant by using LEDs									
CO5	Plot the VI characteristics of solar cell									
CO6	Determine the time constant of an RC circuit									
C07	Determine the reversibility of classical and quantum logic gates									
Manali										

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	P07	PO8	PO9	PO10	P011	PO12
CO1	S	S	S	S	-	-	-	-	-	-	-	-
CO2	S	S	S	S	-	-	-	-	-	-	-	-
CO3	S	S	S	S	-	-	-	-	-	-	-	-
CO4	S	S	S	S	-	-	-	-	-	-	-	-
CO5	S	S	S	S	-	-	-	-	-	-	-	-
CO6	S	S	S	S	-	-	-	-	-	-	-	-
CO7	S	S	S	S	-	-	-	-	-	-	-	-

S- Strong; M-Medium; L-Low

# List of Experiments

# OSCILLATIONS AND WAVES

- 1. Torsion pendulum- Determination of Moment of inertia of a disc
- 2. Compound pendulum Determination of acceleration due to gravity

# OPTICS

- 3. Spectrometer-Determination of Refractive index of the material of the prism.
- 4. Laser Diffraction Determination of wavelength of Laser and particle size in a thin film.
- 5. Air wedge Determination of diameter of wire by interference principle.
- 6. Fiber optics-Determination of numerical aperture and bending losses.

# **QUANTUM MECHANICS**

- 7. Photoelectric effect-Determination of Planck's constant
- 8. Solar cell-Plotting and studying of V-I characteristic
- 9. Study of Classical and quantum Logic gates.

# **ELECTROMAGNETIC THEORY**

- 10. RC circuit –Determination of time constant
- 11. LCR Circuit- Determination of resonant frequency

# **Course Designers:**

- 1. Dr. R. Vasuki <u>rvphy@tce.edu</u>
- 2. Dr. M.Mahendran mmphy@tce.edu
- 3. Mr. V.Veeraganesh vvgphy@tce.edu
- 4. Dr. A.L.Subramaniyan alsphy@tce.edu
- 5. Dr.D.Ravindran drphy@tce.edu

18CH190 CHEMISTRY L	CHEMISTRY LABORATORY	Category	Г	Т	Р	Credit
		BS	0	0	2	1

# Preamble

This course aims to provide the students, a basic practical knowledge in chemistry. The objective of this course is to develop intellectual and psychomotor skills of the students by providing hands on experience in quantitative, electrochemical and photo-chemical analysis. **Course Outcomes** 

# On the successful completion of the course, students will be able to

CO1	Estimate the chemical water quality parameters of sample water	Apply
CO2	Demonstrate the rate of corrosion of steel by weight loss method	Apply
CO3	Estimate the strength of acidic solution and pH of soil by conductometric and	Apply
	pH metric titrations	
CO4	Illustrate the strength of oxidisable materials present in given sample by	Apply
	potentiometric method	
CO5	Adapt colorimetric method for determination of iron in water	Apply

# **Mapping with Programme Outcomes**

	5	J										
COs	PO1	PO2	PO3	PO4	PO5	PO6	P07	PO8	PO9	PO10	P011	PO12
CO1	S	S	М	-	-	-	L	-	L	-	-	-
CO2	S	S	М	-	-	-	L	-	L	-	-	-
CO3	S	S	М	-	-	-	L	-	М	-	-	-
CO4	S	М	-	-	-	-	-	-	-	-	-	-
CO5	S	S	М	-	-	-	L	-	-	-	-	-

# List of Experiments

# A. Quantitative analysis

- 1. Estimation of Total hardness of water
- 2. Estimation of Ca<sup>2+</sup> and Mg<sup>2+</sup> individual hardness of water samples
- 3. Estimation of alkalinity of water sample
- 4. Estimation of COD of industrial effluent
- 5. Estimation of Chloride in a water sample
- 6. Estimation of rate of corrosion of steel by weight loss method

# B. Electrochemical and photochemical analysis

- 1. Conductometry Titration (Strong acid vs Strong base)
- 2. Potentiometric redox Titration (K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> vs FAS, KMnO<sub>4</sub> vs FAS)
- 3. Determination of pH of soil by pH metric titration
- 4. Estimation of iron content of water sample using colorimeter

# **Course Designers:**

-	
Dr. M. Kottaisamy	hodchem@tce.edu
Dr. K. Radha	krchem@tce.edu
Dr. J. Shanmugapriya	shanamugapriya@tce.edu
Dr. S. Rajkumar	rajkumarsubramanian@tce.edu
Dr. S. Balaji	sbalaji@tce.edu
Dr. V. Velkannan	velkannan@tce.edu
Dr. S. Sivailango	drssilango@tce.edu
Dr. M. Velayudham	mvchem@tce.edu

# CURRICULUM AND DETAILED SYLLABI

FOR

# B. E. DEGREE PROGRAMME (Electronics and Communication Engineering)

FIRST SEMESTER

# FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2021-22

# THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided ISO 9001:2008 certified Autonomous Institution affiliated to Anna University) MADURAI – 625 015, TAMILNADU

> Phone : 0452 – 2482240, 41 Fax : 0452 2483427 Web : <u>www.tce.edu</u>

Approved in 56<sup>th</sup> Academic Council Meeting on 21.07.2018 Approved in 57<sup>th</sup> Academic Council Meeting on 05.01.2019 Approved in 61<sup>st</sup> Academic Council Meeting on 03.07.2021

# THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B. E. DEGREE PROGRAMME (Electronics and Communication Engineering)

# COURSES OF STUDY

(For the students admitted in the Academic Year 2021-22)

# FIRST SEMESTER

Course	Name of the Course	Category	No. of Hours		credits	
Code				/We	ek	
			L	Т	Р	
THEORY		-				
18MA110	Engineering Calculus	BS	3	1	-	4
21PH120	Physics	BS	3	-	-	3
21CH130	Chemistry	BS	3	-	-	3
18EG140	English	HSS	2	-	-	2
18ES150	Engineering Exploration	ES	3	-	-	3
PRACTICA	L					
18EG170	English Laboratory	HSS	-	-	2	1
21PH180	Physics Laboratory	BS	-	-	2	1
21CH190	Chemistry Laboratory	BS	-	-	2	1
18EC280	Electronics Workshop	ES	-	-	2	1
	Total		14	1	8	19

BS : Basic Science

HSS : Humanities and Social Science

ES : Engineering Science

PC : Programme Core

- L : Lecture
- T : Tutorial
- P : Practical

# Note:

1 Hour Lecture is equivalent to 1 credit

1 Hour Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

# THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B. E. DEGREE PROGRAMME (Electronics and Communication Engineering)

# SCHEME OF EXAMINATIONS

(For the Students admitted in the academic year 2021-22)

# FIRST SEMESTER

S.No.	Course	Name of the	Duration		Minimum Marks			
	Code	Course	of				for Pass	
			Terminal	Continuous	Terminal	Max.	Terminal	Total
			Exam. in	Assessment	Exam **	Marks	Exam	
			Hrs.	*				
THEO	RY							
1	191/0110	Engineering	3	50	50	100	25	50
	TOWATTO	Calculus						
2	21PH120	Physics	3	50	50	100	25	50
3	21CH130	Chemistry	3	50	50	100	25	50
4	18EG140	English	3	50	50	100	25	50
5	1958150	Engineering	3	50	50	100	25	50
	1023150	Exploration						
PRAC	TICAL							
6	1950170	English	3	50	50	100	25	50
	18EG170	Laboratory						
7	2104190	Physics	3	50	50	100	25	50
	21611100	Laboratory						
8	2104100	Chemistry	3	50	50	100	25	50
	2101190	Laboratory						
9	10000	Electronics	3	50	50	100	25	50
	1000200	Workshop						

\* CA evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\* Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

# 18MA110

#### **ENGINEERING CALCULUS**

Category	L	т	Ρ	Credit
BS	3	1	0	4

#### **Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Understand the concept of functions, limits and continuity	Understand
CO2	Compute derivatives and apply in solving engineering problems	Apply
CO3	Employ partial derivatives to find maxima minima of functions of multi variables	Apply
CO4	Demonstrate and apply the techniques of integration	Apply
CO5	Apply integrals of multivariable to find areas enclosed between two curves and volume	Apply
	enclosed between surfaces	

#### Assessment Pattern

Bloom's Catogory	Continu	ious Assessmer	Terminal Examination		
Bloom's category	1 2 3				
Remember	10	10	10	0	
Understand	30	30	30	30	
Apply	60	60	60	70	
Analyse	0	0	0	0	
Evaluate	0	0	0	0	
Create	0	0	0	0	

#### Syllabus

#### DIFFERENTIAL CALCULUS

Representation of functions - New functions from old functions - Limit of a function - Continuity - Limits at infinity - Derivative as a function - Differentiation rules(formula and problems only) –The mean value theorem - Maxima and Minima of functions of one variable - Application problems in engineering – Application problems using MATLAB.

#### FUNCTIONS OF SEVERAL VARIABLES

Partial derivatives – Chain rule - Vector functions and their Derivatives - Directional derivatives and gradient vector - Maxima and minima of functions of two variables - Lagrange Multipliers - Application problems in engineering - Application problems using MATLAB.

#### INTEGRAL CALCULUS

Area under curves - The definite integrals – Fundamental theorem of calculus - Integration by parts - Volume of solid of revolution - Area of surface of revolution - Improper integrals - Application problems in engineering - Application problems using MATLAB

#### MULTIPLE INTEGRAL

Iterated integrals - Double integrals over general regions - Double integrals in polar coordinates - Applications of double integrals (density, mass, moments & moments of inertia problems only) - Triple integrals - Triple integrals in cylindrical coordinates - Triple integrals in spherical coordinates - Change of variables in multiple integrals - Application problems in engineering

#### **Text Book**

1) James Stewart, "Calculus Early Transcendentals", 7e, Cengage Learning, New Delhi, 2017.

DIFFERENTIAL CALCULUS: [Sections: 1.1, 1.3, 2.2,2.5,2.6,2.8, 3.1-3.6,4.1,4.2], FUNCTIONS OF SEVERAL VARIABLES: Sections: 14.3, 14.5,13.1,13.2,14.6-14.8], INTEGRAL CALCULUS:

[Sections: 5.1-5.4,7.1, 6.2, 8.2 and 7.8], **MULTIPLE INTEGRAL:** [Sections: 15.2-15.5, 15.7-15.10] 2) Lecture Notes on Engineering Mathematics-I Application Problems and Solution Manual, Department of

# Mathematics, Thiagarajar College of Engineering, Madurai. Reference Books

- 1) Kuldeep Singh, "Engineering Mathematics Through Appplications", 2e, Palgrave Macmillan, 2011.
- 2) Erwin Kreszig, "Advanced Engineering Mathematics", 10th edition, Wiley, 2017.
- 3) George B. Thomas, "Thomas Calculus: early transcendentals ", Pearson, New Delhi, 2013.
- 4) R.K.Jain, S.R.K.Iyengar, "Advanced Engineering Mathematics" 5e, Narosa Publishing House, 2016.

# (12 hours)

(12 hours)

#### (12 hours)

# (12 hours)

	DUVOIOO	Category	L	Т	Ρ	Credit
21PH120	PHYSICS	BS	3	0	0	3

#### **Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Apply the vector calculus approach and Newton's law in polar coordinates to	Apply
	solve problems in mechanics	
CO2	Solve for the solutions and describe the behavior of a damped harmonic	Apply
	oscillator and waves.	
CO3	Use the laws of electrostatics and magnetostatics to explain electromagnetic	Apply
	wave propagation	
CO4	Explain the fundamentals of optical phenomena and its applications	Understand
CO5	Make use of Schrodinger equation to arrive at the energy values of particle in a	Apply
	box and linear harmonic oscillator	
A	name and Defferm	

#### Assessment Patter

Bloom's Catagory	Continue	ous Assessme	Terminal Examination		
BIOOIII'S Category	1	1 2 3			
Remember	20	20	20	20	
Understand	30	30	30	30	
Apply	50	50	50	50	
Analyze	-	-	-	-	
Evaluate	-	-	-	-	
Create	-	-	-	-	
Syllahua					

Mechanics of Particles: Scalars and vectors under rotation transformation, coordinates - cartesian, polar, spherical, cylindrical - Forces in nature - Newton's second law of motion- Central forces -Conservative and non-conservative forces - Work-Energy theorem - Conservation of angular momentum - Satellite manoeuvres. Oscillations and Waves: Simple harmonic oscillators - Energy decay in a Damped harmonic oscillator - Q factor - Impedance matching- Wave groups and group velocity -Non-dispersive transverse and Longitudinal waves - Waves with dispersion - Water waves -Acoustic waves - Earthquake and Tsunami waves. Electromagnetic Fields and Waves: Motion of a charge in electric field - Electric potential - Charge distribution - Current and conservation of charge in materials - Magnetic force on an electric charge- Circular motion in a constant magnetic field -Vector potential - Stokes' theorem - Magnetic force on current loops - Gauss' law for magnetism-Maxwell's equation - Energy and momentum of EM waves - CT/MRI scan. Optics: Ray paths in inhomogeneous medium and its solutions - Two-slit Fraunhofer diffraction -Interference in non-reflecting films - Fabry-Perot interferometer- resolving power -Einstein's theory - CO2 -Nd- YAG - Quantum Cascade lasers -Fiber optic sensors (Displacement/Pressure). Quantum Mechanics: Wave nature of particles - wave function -probability current density and expectation values - Schrodinger wave equation - Uncertainty principle - Particle in a box in 1D - Linear harmonic oscillator - Quantum tunnelling - Scanning tunnelling microscope - Quantum computation (qubit).

#### **Text Books**

- Principles of Physics, Halliday, Resnick and Jearl Walker, 9th Edition, Wiley, 2011. 1.
- Paul A. Tipler and G. Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2. 2008.

#### **Reference Books**

MECHANICS OF PARTICLES

- 1. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters - 4, 9 & 10).
- 2. Manoj K. Harbola, Engineering Mechanics, 2nd Edition, Cengage, 2018

OSCILLATIONS AND WAVES

- 1. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters 14 & 15).
- 2. H. J. Pain, The Physics of Vibrations and Waves, 6th Edition, John Wiley, 2005 (Chapters 2, 5 & 6).

ELECTROMAGNETIC FIELDS AND WAVES

- 1. Principles of Physics, Halliday, Resnick and Jearl Walker, 9th Edition, Wiley, 2011, (Chapters 23, 24, 32 & 33)
- 2. Paul M. Fishbane, Stephen G. Gasiorowicz and Stephen T. Thornton, Physics for Scientists and Engineers with Modern Physics, 3rd Edition, Pearson, 2005 (Chapters 26, 28, 31 & 34).

OPTICS

- 1. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters 31 & 33).
- 2. Ajoy Ghatak, Optics, 5th Edition, Tata McGraw Hill, 2012 (Chapters 3, 18, 20)

QUANTUM MECHANICS

- 1. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters 34 & 35).
- 2. Stephen T. Thornton and Andrew Rex, Modern Physics for Scientists and Engineers, 4th Edition, Cengage, 2013. (Chapters 5 & 6).
- 3. R. Shankar, Fundamentals of Physics I, II, Yale University Press, 2014, 2016

	CHEMISTRY	Category	L	т	Ρ	Credit
21CH130		BS	3	0	0	3

#### **Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Identify the properties of water and its treatment methods	Understand
CO2	Summarize the Principles and Instrumentations of Spectroscopic techniques	Understand
CO3	Select the appropriate spectroscopic techniques for characterization of materials	Apply
CO4	Adapt the customized corrosion control methods	Apply
CO5	Dramatize the preparation, properties and applications of Engineering materials	Understand
CO6	Describe the mechanism of adhesion and lubrication	Understand

#### **Assessment Pattern**

Bloom's Catogory	Continue	ous Assessme	Terminal Examination	
BIODIN'S Category	1	1 2 3		
Remember	20	20	20	20
Understand	40	40	40	40
Apply	40	40	40	40
Analyze	-	-	-	-
Evaluate	-	-	-	-
Create	_	-	-	-

#### Syllabus

Water: Water- sources- physical - characteristics - alkalinity - hardness of water - types determination of hardness by EDTA method. Boiler trouble-Softening of water: External and Internal treatment methods. Waste water treatment process. Electrochemical technologies for energy storage and surface engineering: Electrochemistry and Surface Engineering -Basics -Corrosion - causesfactors- types - corrosion of metal and computer components- Corrosion control. Electroplating -Electroless process. Energy storage: Batteries - High energy density and Power density batteries -Primary and Secondary batteries- Hydrogen Generator - Hydrogen Economy- Fuel cells - Super capacitors - Batteries for automotive - standards and performance and challenges for E-mobility. Spectroscopic technique and applications: Principle and instrumentation: UV-Visible spectroscopyatomic Absorption Spectroscopy - fluorescence spectroscopy - Inductively Coupled Plasma - Optical Emission Spectroscopy - Vibrational spectroscopy - Raman spectroscopy - surface enhanced raman spectroscopy - nuclear magnetic resonance spectroscopy- X-ray-diffraction. Application of spectroscopy. Engineering materials: Properties of materials: Structure of atom - bonding and their influences on the property of materials - melting point - brittleness, ductility - thermal conductivityionic and electrical conductivity- superconductivity - optical - magnetic properties, hydrophobic, hydrophilic. Polymers and polymer composites - types- structure and properties-applications. Ceramics and advanced ceramics - types-properties-applications-Nano-materials - types - structure and properties -applications.

#### **Text Books**

- 1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, DhanpatRai publications, New Delhi, 17th edition, 2018 (Unit I –IV)
- 2. C.N.Banwell and E.M.McCash," Fundamentals of Molecular Spectroscopy", Tata McGraw-Hill (India), 5th Edition, 2013. (Unit III)

3. V. Raghavan, Materials Science and Engineering; PHI Delhi, 6th edition, 2019.(Unit – IV) Reference Books

 Satya Prakash & Manisha Agarwal, Enginering Chemistry – Concepts in Chemistry for Engineering, Khanna Publishing, revised edition, 2020. (Unit I – IV)

- Shashi Chawla, "A text book of Engineering Chemistry", Dhanpat Rai & Co.(pvt) ltd, 3rd edition, reprint 2017. (Unit I – IV)
- 3. Vikas Saini, Corrosion and Corrosion control, Scitus publications, 2016 (Unit II)
- 4. H.A.Kiehne, Battery Technology Hand book, CRC press, 2nd edition, 2003. (Unit II)
- 5. Albert N.Link et al, Battery technology for electric vehicles, Earthscan, 2015. (Unit II)
- 6. W.F. Smith, Principles of Materials Science and Engineering: An Introduction; Tata Mc-Graw Hill, 2008. (Unit IV)
- 7. T.Pradeep, NANO: The Essentials: Understanding of Nano-science and Nanotechnology, Mc-Graw Hill Education, 2017 (Unit – IV)

18EG140	ENGLISH	Category	L	Т	Ρ	Credit
		HSS	2	0	0	2

Course Outcomes On the successful completion of the course, students will be able to

011.0		
CO1	Explain the basics of language in terms of vocabulary, grammar, pronunciation, syntax and semantics.	Understand
CO2	Explain the grammatical nuances and use them accordingly in respective contexts.	Understand
CO3	Read and comprehend the content in English in general and technical contexts as well.	Understand
CO4	Write with coherence and cohesion effectively.	Apply
CO5	Apply the language in established structure with precision in social and professional contexts.	Apply

#### **Assessment Pattern**

Bloom's Catogory	Continu	Terminal		
Bloom's category	1	2	3	Examination
Remember	-	-	-	-
Understand	15	15	30	30
Apply	35	35	70	70
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

#### Syllabus:

**MODULE- I:** Basics of language – Phonetics - Phonemes, Syllables and Stress, Vocabulary – Word Analysis, Prefix, Suffix, Roots, Parts of Speech, Sentence Patterns.

**MODULE- II:** Basics of grammar – Tenses, Subject-Verb Agreement, Impersonal Passive Voice, Relative Clauses; Notions for Technical English – Noun Compounds, Classifications and Definitions, Cause and Effect, Purpose and Function, Numerical Adjectives, Reading Comprehension – Skimming, Scanning, Skipping (as tested in BEC Vantage Level)

**MODULE-III:** Writing with coherence and cohesion, Summarizing, Note-Making, Interpretation of Graphics, Writing Instructions and Recommendations, Paragraph and Essay Writing.

**MODULE-IV:** Writing with correct spelling, punctuation and grammar, Blog writing, E-mail Writing (BEC Vantage Writing-Unit I) – Formal Letters by students for Bonafide Certificate/Permission.

#### **Suggested Reading:**

Books:

- Murphy, Raymond, English Grammar in Use with Answers; Reference and Practice for Intermediate Students, Cambridge: CUP, 2004
- 2. Jones, Daniel. An English Pronouncing Dictionary, Cambridge: CUP, 2006
- 1. Brook-Hart, Guy. Cambridge English- Business Benchmark-Upper Intermediate, CUP, 2014.
- 2. Dhanavel, S.P. English and Communication Skills for Students of Science & Engineering, Orient BlackSwan, Chennai: 2016.
- 3. Swan, Michael. Practical English Usage.4th Edn. OUP. 2016.

#### Websites:

- 1. http://www.englishclub.com
- 2. http://owl.english.purdue.edu
- 3. <u>https://www.oxfordonlineenglish.com</u>
- 4. www.bbclearningenglish.com

18F	-51	50
	-01	

#### ENGINEERING EXPLORATION

Category	L	Т	Ρ	Credit
ES	1	2	-	3

#### **Course Outcomes**

On the successful completion of the course, students will be able to

CO1. Explain technological & engineering development, change and impacts of	Understand
engineering	
CO2. Draw a product in enough detail that others can accurately build it and write	Apply
specification sheet for a given product	
CO3. Complete initial steps (Define a problem, list criteria and constraints, brainstorm	Apply
potential solutions and document the ideas) in engineering design process	
CO4. Draw sketches to a design problem and provide a trade-off matrix	Apply
CO5. Communicate possible solutions through drawings and prepare project report	Apply
CO6. Use reverse engineering to suggest improvements in a tool design	Apply
CO7. Apply the concept of engineering fundamentals in Civil, Mechanical, Electrical and	Apply
Computer Engineering	

#### **Assessment Pattern**

S No	Bloom's category	Contin	End Semester Examinations		
0.110	Discille subgery	1	2	3	
1	Remember	20	20	20	20
2	Understand	20	20	20	20
3	Apply	60	60	60	60
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

#### Syllabus

What is Engineering: Engineering Requirement, Knowledge within Engineering disciplines, Engineering advancements Engineering Design: Problem definition, idea generation through brainstorming and researching, solution creation through evaluating and communicating, text/analysis, final solution and design improvement. Defining problems and Brainstorming: Researching design, sketching problem solving Communicating solution: Dimensioning orthographic drawing, perspective drawing Modeling and Testing final output: Product evaluation, reverse engineering, final project report. Civil Engineering: Structural forces structural analysis, bridge design components, structural design Mechanical Engineering: Types of motion, mechanical power system, mechanical power formula, mechanical design. Electrical Engineering: Reading analog multimeter, measuring current, voltage and resistance, electricity from chemicals, solar cells, magnets, Ohms law and watts law, circuit identification and circuit calculation, resistor color code, continuity Computer Engineering: Logic gates, algorithms, computer architecture, binary code

#### **Reference Books**

- 1. Ryan A.Brown, Joshua W.Brown and Michael Berkihiser: "Engineering Fundamentals: Design, Principles, and Careers", Goodheart-Willcox Publisher, Second Edition, 2014.
- 2. Saeed Moaveni ,"Engineering Fundamentals: An Introduction to Engineering", Cengage learning, Fourth Edition, 2011.

	18EG170	
HSS 0 0 2		

#### Course Outcomes

On the successful completion of the course, students will be able to

CO1	Pronounce words intelligibly through listening and watching contents on social, technical and day-to-day conversations and respond to questions related to them.	Apply
CO2	Apply appropriate lexicon in various contexts, by differentiating variations pertaining to spelling, pronunciation, meaning and grammar	Apply
CO3	Comprehend passages on various topics like general, business and science at various levels	Apply
CO4	Read texts in newspapers, magazines, and articles on a variety of issues with clarity to understand and to be understood	Apply
CO5	Prepare and present on a topic to a group of audience with ICT and other educational aids	Apply
1000	acmont Dottorn	

#### Assessment Pattern

Internal: No Continuous Assessment Test will be conducted

Students' performance will be assessed in the classroom as given below

Spoken Task - General / Technical Presentation / BEC Speaking Tests II: 25 Marks

Listening Task - Answering questions
25 Marks
External: Tested on Phonetics, Grammar, and Vocabulary in the lab for 1 hour
80 Marks
Submission of Students Record on Practical Tasks in the Class and Lab : 20 Marks

#### List of Experiments:

S.No	Торіс	Hours
	LAB ACTIVITES	
1	Listening	2
2	Vocabulary	2
3	Grammar	2
4	Phonetics	2
5	Reading Comprehension – I (General)	2
6	Reading Comprehension – II (BEC Vantage Level)	2
	CLASSROOM ACTIVITIES	
7	Reading Practice (Extensive Reading)	2
8	English through Audios & Videos (Note-Taking & answering questions)	2
9	Presentation - I	2
10	Presentation - II	2
11	Revision	2
12	Model Test	2
	Total	24

#### Software Used:

- 1. Business English Certificate-Vantage- Practice Software
- 2. English Software

#### Extensive Reading: (Not for Terminal Exam, Prescribed only for Spoken Tasks)

1. Khera, Shiv, You Can Win, Macmillan Books, New York, 2003.

#### Teaching Resources and Websites:

- 1. Oxford / Cambridge Online English Videos
- 2. Free Video Downloads from Youtube
- 3. https://learningenglish.voanews.com/
- 4. https://www.ted.com/talkshttp://
- 5. <u>www.esl-galaxy.com/video.htm</u>

21PH180	PHYSICS LABORATORY	Category	L	Т	Ρ	Credit
		BS	0	0	2	1
• • •						

#### **Course Outcomes**

On the successful completion of the course, students will be able to

CO1	Analyze the mechanical & electrical oscillations and determine their resonance frequency	Apply
CO2	Analyze the interference and diffraction patterns for micron size objects	Apply
CO3	Investigate the V-I characters of photodiode at dark and bright illumination conditions	Apply
CO4	Determine the Planck's constant by using LEDs	Apply
CO5	Plot the VI characteristics of solar cell	Apply
CO6	Determine the long and short time constant of an RC circuit	Apply
CO7	Identify the type of semiconductor and measure Hall coefficient	Apply
CO8	Determine the reversibility of classical and quantum logic gates	Apply
CO9	Identify the variation of magnetic field with distance for circular coils	Apply

#### List of Experiments

## OPTICS

- 1. Laser Diffraction Determination of wavelength of Laser and particle size in a thin film
- 2. Photo diode -V-I characteristics.
- 3. Air wedge-Determination of thickness of wire

#### **QUANTUM MECHANICS**

- 4. Photoelectric effect-Determination of Planck's constant
- 5. Solar cell-Plotting and studying of VI characteristic
- 6. Study of Classical and quantum Logic gates.

#### **ELECTROMAGNETIC THEORY**

- 7. RC circuit Determination of time constant
- 8. LCR Circuit Determination of resonant frequency
- 9. Hall effect Determination of Hall voltage
- 10. Helmohltz coil -Determination of magnetic field

#### MECHANICS

11. Torsional Pendulum -Determination of Rigidity modulus and moment of inertia

~ 4	~	~~
21	CH1	90

**CHEMISTRY LABORATORY** 

Category	L	Т	Ρ	Credit
BS	0	0	2	1

**Course Outcomes** On the successful completion of the course, students will be able to

On the	successful completion of the course, students will be able to				
CO1	Estimate the chemical water quality parameters of sample water / effluent	Apply			
CO2	Demonstrate presence of essential ions and pollutant in milk and food sample	Apply			
CO3	Determine the physicochemical property of oil and lubricant	Apply			
CO4	Estimate the strength of acid and pH of soil by conducto-metric and pH metric titration	Apply			
CO5	Illustrate the strength of oxidisable materials present in given sample by potentio- metric method	Apply			
CO6	Compare amount of pollutant present in effluent from various industries using colorimetric method and UV–visible spectroscopy	Apply			
CO7	Calculate the efficiency of electroplating and electroless plating	Apply			
CO8	Determine the rate of corrosion of metal & alloy using potentio-dynamic polarisation method	Apply			
List of	f Experiments				
Quant	itative analysis (Any Five Experiment)				
1. Esti	mation of total hardness of water sample				
2. Esti	mation of COD of industrial effluent				
3. Esti	mation of Chloride in a water sample				
4. Det	ermination of Ca <sup>2+</sup> ion in milk sample				
5. Esti	mation of adulterant in food sample				
6. Det	ermination of the Phosphoric Acid Content in Soft Drinks using pH meter				
7. Find	out saponification number of oil - oil adulteration				
8. Det	ermination Surface Tension of lubricants.				
Electr	ochemical and photochemical analysis (Any Five Experiment)				
1. Cor	ductometric Titration (Strong acid vs Strong base)				
2. Det	ermination of pH of soil by pH metric Titration				
3. Pote	entiometric redox Titration (K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> vs FAS, KMnO <sub>4</sub> vs FAS)				
4. Esti	mation of iron content of water sample using colorimeter				
5. Esti	mation of fluoride content of water sample using colorimeter				
6. Ana	lysis of materials by UV-Vis spectroscopy				
7. Esti	mation of current density of electroplating process using Hull cell				
8. Elec	8. Electroplating of and Ni & Zn and determination of cathode efficiency				
9. Elec	9. Electroless plating of copper				
10. Determination of rate of corrosion of metal and alloy using potentiodynamic polarization technique (TAFEL)					

## **Reference Books:**

1. Vogel's Textbook of Quantitative Chemical Analysis (8THedition, 2014)

2. Laboratory Manual – Department of Chemistry, Thiagarajar College of Engineering (2021)

18EC280
---------

Category	L	т	Ρ	Credit
ES	0	0	2	1

## **Course Outcomes**

On successful completion of the course, students will be able to

COs	Course Outcome Statement	Weightage***
		in %
CO1	Identify various basic electronic components and packages and for	10
	understanding the operational principles of instruments, power	
	supply and equipment	
CO2	Experiment the connection of circuits in general board and specific	20
	Printed circuit board.	
CO3	Develop a schematic circuit and acquire the knowledge for preparing	20
	necessary tools and customizing the tools for PCB design	
CO4	Develop a PCB layout for the required specification, learn to use tools	30
	for layout preparation under various design constraints	
CO5	Acquire the skills of soldering and de-soldering in engineering practice	10
	and to learn the safety procedures	
CO6	Test the assembled circuit in board with engineering IPC standards	10
· / / / · · · ·		

\*\*\* Weightage depends on Bloom's Level, number of contact hours

Assessment Pattern

Cognitive Levels	Model Examination	Terminal Examination
Remember	0	0
Understand	10	10
Apply	10	10
Analyse	10	10
Evaluate	10	10
Create	15	15

# List of Experiments/Activities with CO Mapping

1. Identification of components and packages (CO1)

Experimenting with -

Active and passive components:

Resistor with various power rating, capacitors and inductors Through Hole Packages:

Axial lead, Radial Lead, Single Inline Package (SIP), Dual Inline Package (DIP), Transistor Outline (TO), Pin Grid Array (PGA)

Surface mount Packages:

Metal Electrode Face (MELF), Leadless Chip Carrier (LCC), Small Outline Integrated Circuit (SOIC), Quad Flat Pack (QPF) and Thin QFP (TQFP), Ball Grid Array (BGA), Plastic Leaded Chip Carrier (PLCC)

- 2. Exploration of instruments, power supply and equipment (CO1) Experimenting with analog (MI and MC types) and digital meters. Fixed power supply, various power supply, function generator and oscilloscope
- 3. Experimenting with breadboard and dotted board connections (CO2) Experimenting with circuit-boards and its internal connection such as bread board and dotted boards
- 4. Practising soldering and de-soldering procedures (CO3) Experimenting with circuit board connection by practising soldering and removing the components from the PCB by de-soldering

# 5. Development of schematic circuit (CO3)

Experimenting with software tool for schematic capture and developing schematic by knowing the specification of the circuit and functionality of the tool. Practicing on available library of components and working through wiring and schematic designing and making new component symbols

6. Investigation of Printed circuit Board (CO4) Understanding and investigation of the following: Various PCB Substrates: Standard FR-4 Epoxy Glass, Multifunctional FR-4, Tetra Functional FR-4, Cyanate Aster, Plyimide Glass, Teflon Term and keyword: Footprint, Pad stacks, Vias, Tracks, Color of Layers, PCB Track Size Calculation Formula Track rules: Track Length, Track Angle, Rack Joints, Track Size PCB tool terms: Schematic Entry, Netlisting, PCB Layout Designing, Prototype

Designing, Design Rule Check (DRC), Design For Manufacturing (DFM), PCB Making, Printing, Etching, Drilling

# 7. Development of PCB Layout design (CO4)

Connecting the schematic from the software netlist, Selecting the Components Footprints as per design, Picking and placing the Component, Making New Footprints, assigning Footprint to components

8. Practising PCB fabrication (CO5) Printing the design, etching, drilling, interconnecting and packaging electronic circuits (IPC) standards, gerber Generation, soldering and desoldering, component mounting, PCB testing.

IPC Standard for Schematic Design, Designing, Materials, PCB Fabrication 9. Assembling components and packing procedures (CO5)

- For the given PCB the components are fixed and assembled with safety measure in terms of human and components
- **10. Practicing circuit in PCB testing procedures (CO6)** Continuity testing of PCB without components and output signal measurement procedures with components

# Learning Resources

- 1. Teachers Soft copy manual for Electronic components and symbols
- 2. https://img.ozdisan.com/content/library/IC\_Packages.pdf
- 3. CAD for Schematic and PCB Design Software.
- 4. Printed circuit board design techniques for EMC compliance, a handbook for designers 2<sup>nd</sup> edition. Mark I.Montrose, Wily publication 2016
- 5. http://www.ipc.org/4.0\_Knowledge/4.1\_Standards/OEM-Standards/IPC-OEM-Stds-A4-English-1111-ONLINE.pdf

18MA210	MATRICES AND ORDINARY DIFFERENTIAL EQUATIONS	Category	L	Т	Ρ	Credit
		BS	3	0	0	3

#### Preamble

In engineering, particularly Solid Mechanics, Aerodynamics, Fluid Flow, Heat Flow and Robotics have application that requires an understanding of Vector Calculus and Differential Equations. Also Mathematical tool Laplace Transforms is very much essential to solve ordinary differential equations that occur in the above areas. Eigen values and Eigenvectors are extremely important while creating engineering models in control systems, designing bridges, communication systems and searching algorithms. The course is designed to impart the knowledge and understanding of the above concepts to all Engineers and apply them in their areas of specialization.

#### Prerequisite

18MA110 Engineering Calculus

#### **Course Outcomes**

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Compute the Laplace transform and inverse Laplace transform of different functions	10%
CO2	Solve the given initial value problem using Laplace transform	15%
CO3	Apply matrix algebra techniques for transformations of conic sections into principle axes	25%
CO4	Solve the model developed for the given system using ordinary differential equation	25%
CO5	Compute divergence and curl of vector functions	10%
CO6	Apply the concepts of vector differentiation and vector integration to fluid flow and heat transfer problems	15%

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	rning Doma	ain Level	CDIO Curricular Components
	Proficiency	Cognitive	Affective	Psychomotor	
	Scale	_		_	
CO1	TPS2	K2	A2	-	1.1
CO2	TPS3	K3	A3	-	1.1
CO3	TPS3	K3	A3	-	1.1
CO4	TPS3	K3	A3	-	1.1
CO5	TPS2	K2	A2	-	1.1
CO6	TPS3	K3	A3	-	1.1

Mapping with Programme Outcomes and Programme Specific Outcomes												
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	S	М			-	-	-	-		-	-	
CO2.	S	S	S		-	-	-	-	М	-	-	М
CO3.	S	S		S	-	-	-	-		-	-	S
CO4.	S	S	S	S	-	-	-	-	М	-	-	М
CO5.	S	М										
CO6.	S	S	S									

S- Strong; M-Medium; L-Low

ASSESSMENT											
		Continuo	ous	A	ssignmei						
Cognitive Levels	Assessment Tests			gnitive Assessment Tests evels							
	1	2	3	1	2	3					
Remember	10	10	10				10				
Understand	30	30	30				20				
Apply	60	60	60	100	100	100	70				
Analyse	00	00	00				00				
Evaluate	00	00	00				00				
Create	00	00	00				00				

#### **Assessment Pattern: Cognitive Domain**

## Sample Questions for Course Outcome Assessment\*\* Course Outcome 1

- **1.** Show that Laplace transform of  $\frac{1}{\sqrt{t}}$  is  $\frac{\sqrt{\pi}}{s}$ .
- **2.** Identify the inverse Laplace transform of  $\log\left(\frac{s^2+1}{(s-1)^2}\right)$ .
- **3.** Discuss any three properties of Laplace transforms.

# Course Outcome 2

- **1.** Apply Laplace transform solve  $y''+9y = \delta\left(t-\frac{\pi}{2}\right)$ , y(0) = 2, y'(0) = 0.
- **2.** By using Laplace transform, solve  $x''(t) + 3x'(t) + 2x(t) = 2(t^2 + t + 1)$ ; with x(0) = 2, x'(0) = 0.
- **3.** Apply convolution theorem, Solve the Voltera integral equation of the second kind  $y(t) \int_{0}^{t} y(\tau) \sin(t-\tau) d\tau = t$ .

# **Course Outcome 3**

- **1.** An elastic membrane in the  $x_1 x_2$  plane with boundary circle  $x_1^2 + x_2^2 = 1$  is stretched so that a point  $P; (x_1, x_2)$  goes over into the point  $Q; (y_1, y_2)$  given by
  - $y_1 = 5x_1 + 3x_2$
  - $y_2 = 3x_1 + 5x_2$

Find the principal directions that is the directions of the position vector X of P for which the direction of the position vector Y of Q is the same or exactly opposite. Predict the boundary circle take under this deformation?

**2.** Discover the type of conic section the following quadratic form represents and transform it to principal axes:  $Q = 17x_1^2 - 30x_1x_2 + 17x_2^2 = 128$ .

**3.** Diagonalize the matrix 
$$\begin{bmatrix} 6 & 0 & 0 \\ 12 & 2 & 0 \\ 21 & -6 & 9 \end{bmatrix}$$

# **Course Outcome 4**

- **1.** Reduce to first order and solve y''-y'=0
- **2.** Compute the general solution for  $y''+y'+(\pi^2+1/4)y = e^{-x/2} \sin \pi x$
- **3.** Solve  $(x^2D^2 4xD 6)y = c$

# Course Outcome 5

**1.** Predict the value of  $div(curl\vec{F})$ .

 $x^2 + y^2 = 4, z = -3$ 

2. If  $\phi_1$  and  $\phi_2$  are scalar point functions and  $\vec{F}$  is a vector point function such that  $\phi_1 \vec{F} = \nabla \phi_2$  then identify  $\vec{F}.curl \vec{F}$ .

3. Estimate 
$$curl \vec{v}$$
, where  $\vec{v} = \left[e^{-z^2}, e^{-x^2}, e^{-y^2}\right]$ .

# **Course Outcome 6**

- **1.** Predict the work done by the force  $\vec{F} = [y^2, -x^2]$  acting on a particle in  $y = 4x^2$  from (0,0) to (1,4).
- **2.** Compute the amount of fluid that crosses the surface in a flow per unit time at any one instant, if the velocity field is  $\vec{v} = y\vec{\iota} + x\vec{j} + z\vec{k}$  over the boundary of the region enclosed by the paraboloid  $z = 1 x^2 y^2$  and the plane z = 0.
- **3.** Apply Stokes theorem to compute  $\int_{C} \vec{F} \cdot \vec{r'} ds$  where  $\vec{F} = [y, xz^3, -zy^3]$  and C is circle



# Syllabus

LAPLACE TRANSFROMS: Laplace transform, Linearity, First Shifting theorem Transforms of derivatives and integrals, ODEs – Unit step function, Second shifting theorem Short Impulses, Dirac's delta function, partial fractions – Convolution, Integral Equations – Differentiation and integration of transforms. MATRIX EIGEN VALUE PROBLEM: The Matrix Eigen value Problem, Determining Eigenvalues and Eigenvectors - Some Applications of Eigen value Problems - Symmetric, Skew symmetric and orthogonal matrices - Eigen bases, Diagonalization, Quadratic forms. ORDINARY DIFFERENTIAL EQUATION: Homogeneous Linear ODEs of second order - Homogeneous Linear ODEs with constant coefficients - Euler Cauchy Equation - Existence and uniqueness of solutions, Wronskian - Nonhomogeneous ODE - Modelling: Electric Circuits- Solution by Variation of Parameters. VECTOR CALCULUS: Divergence of a Vector Field- Curl of a Vector Field-Line Integrals- Path independence of line integrals- Green's Theorem in the plane- Surface Integrals- Triple Integrals, Divergence Theorem of Gauss- Applications of the Divergence Theorem- Stoke's Theorem.

#### Learning Resources

- 1. Erwin Kreszig, "Advanced Engineering Mathematics", 10th edition, Wiley, 2017.
  - a. Laplace transforms
  - : [sections 6.1,6.2,6.3,6.4,6.5,6.6] b. Matrix eigen value problem : [sections 8.1,8.2,8.3,8.4]
  - c. Ordinary differential equations : [sections 2.1,2.2,2.5,2.6,2.7,2.9,2.10]
  - d. Vector calculus : [sections 9.8.9.9,10.1,10.2,10.4,10.6, 10.7,10.8,10.9]
- 2. Peter V.O'Neil, "Advanced Engineering Mathematics", 7th ed., Cengage Learning, 2017.
- 3. Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, New Delhi, 2016.
- 4. Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics", Narosa Publications, New Delhi, 3rd Edition, 2007.
- 5. Made Easy Team, Engineering Mathematics, Made Easy Publications, 2018.

#### **Course Contents and Lecture Schedule**

Module	Торіс	No. of	Course
No.		Hours	Outcome
1.	LAPLACE TRANSFORMS		
1.1	Laplace Transform. Linearity. First Shifting Theorem (s-Shifting)	2	CO1
1.2	Transforms of Derivatives and Integrals. ODEs	2	CO2
1.3	Unit Step Function (Heaviside Function). Second Shifting Theorem ( <i>t</i> -Shifting)	1	CO1
1.4	Short Impulses. Dirac's Delta Function. Partial Fractions	1	CO1
1.5	Convolution. Integral Equations	2	CO2
1.6	Differentiation and integration of transforms	1	CO1
2	MATRICES EIGEN VALUE PROBLEMS		
2.1	Determining Eigenvalues and Eigenvectors	2	CO3
2.2	Some Applications of Eigenvalue Problems	1	CO3
2.3	Symmetric, Skew-Symmetric, and Orthogonal Matrices	2	CO3
2.4	Eigenbases. Diagonalization.	2	CO3
2.5	Quadratic Forms	2	CO3
3	ORDINARY DIFFERENTIAL EQUATION		
3.1	Homogeneous Linear ODEs of Second Order	2	CO4
3.2	Homogeneous Linear ODEs with Constant Coefficients	1	CO4
3.3	Euler–Cauchy Equations	1	CO4
3.4	Existence and Uniqueness of Solutions. Wronskian	1	CO4
3.5	Nonhomogeneous ODEs	2	CO4
3.6	Solution by Variation of Parameters	2	CO4
4	VECTOR CALCULUS		
4.1	Divergence and Curl of a Vector Field	2	CO5
4.2	Line Integrals	2	CO6
4.3	Green's Theorem in the Plane	1	CO6
4.4	Surface Integrals	1	CO6
4.5	Triple Integrals. Divergence Theorem of Gauss	1	CO6
4.6	Applications of the Divergence Theorem	1	CO6
4.7	Stoke's Theorem	1	CO6
	TOTAL No. of Hours	36	
Course	Decigners		

# 1. Dr.V.Gnanaraj

- vgmat@tce.edu
- 2. Dr.S.Jeyabharathi sjbmat@tce.edu -
- 3. Dr.G.Jothilakshmi gilmat@tce.edu -
- 4. Dr.C.S.Senthil kumar kumarstays@tce.edu -
- 5. Dr.R.Suresh suresh080183@tce.edu \_

	18EC220	NETWORK THEORY	Category	L	T	P	Credit
PC 2 1 0 3			PC	2	1	0	3

#### Preamble

A network refers to any interconnected set of objects. An 'electrical network' is an interconnection of electrical elements such as resistors, inductors, capacitors, transformers, diodes, sources, controlled sources and switches. All electrical and electronic devices can be represented by electric circuits. So formulation of equivalent circuit and the study of behavior of the networks are formulated by analyzing the equivalent circuit with network laws and theorems. The objective is to acquaint the students with the fundamental principles of circuit theory and network analysis.

#### Prerequisite

NIL

#### Course Outcomes

On the successful completion of the course students will be able to

011 410		
CO#	Course Outcome Statement	Weightage in %
CO1	Apply Network solutions method to solve electrical networks	20
CO2	Apply Network theorems to simplify electrical networks.	15
CO3	Apply Sinusoidal Steady state analysis methods for RL, RC and RLC circuits.	15
CO4	Examine the transient and steady state response of RL, RC and RLC circuits in time domain.	15
CO5	Examine the transient and steady state response of RL, RC	15
	and RLC circuits in frequency domain.	
CO6	Compute Linear two port network parameters.	20

#### CO Mapping with CDIO Curriculum Framework

		<u> </u>													
CO		TCE		Learning Domain Level								CDIO (	Curricul	ar	
#	Pr	oficier	icy 🗌	Cogn	itive	Affe	ective	P	sycho	moto	or	Components			;
		Scale		-					-				(X.	Y.Z)	
CO1		TPS3		Ар	ply	Valu	е	-				1.2.1	1, 2.1.1	, 2.1.2,	2.4.2,
												2.4.6	6, 2.5.1	, 3.1.1,	3.2.3,
												4.5.5	5, 4.6.2		
CO2		TPS3		Ар	ply	Valu	е	-				1.2.1	1, 2.1.1	, 2.1.2,	2.5.1,
												3.1.1	l, 3.2.3	, 4.5.5,	4.6.2
CO3		TPS3		Ар	ply	Valu	е	-				1.2.1	1,, 2.1.1	, 2.1.2,	
												2.5.1	I, 3.1.1	, 3.2.3,	4.5.5,
												4.6.2			
CO4		TPS4		Ana	lyse	Orga	anise	C	omple	x Ov	ert	1.2.1, 2.1.1, 2.1.2, 2.1.			2.1.3,
					-			Re	espon	ses		2.5.1			
CO5		TPS4		Ana	lyse	Orga	anise	Co	omple	x Ov	ert	1.2.1, 2.1.1, 2.1.2, 2.1.3			
					-			Re	espon	ses		2.5.1			
CO6		TPS3		Ар	ply	Valu	е	M	echan	ism		1.2.1	1, 2.1.1	, 2.1.2,	2.5.1
Марр	oing w	ith Pr	ograr	nme (	Dutco	mes a	nd Pr	ograr	nme S	Spec	ific (	Dutco	omes		
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	М	1	-	1	-	_			10		12	м	_	1
$CO^2$	<u> </u>	M											M	_	
CO2	0	N/		-		-	-				-			-	
CO3	0			-		-	-				-			-	
C04	0	0				-	-				-		<u> </u>	-	
005	3	3				-	-				-		<u> </u>	-	
	S			-		-	-				-	1 1		-	1 1

S- Strong; M-Medium; L-Low

Assessment Pattern. Cognitive Domain												
Cognitive Levels	Contir	nuous Ass Tests	sessment		Assignme	Terminal Examination						
	1	2	3	1	2	3						
Remember	0	0	0	0	0	0	0					
Understand	20	20	20	0	0	0	20					
Apply	80	20	60	100	30	30	60					
Analyse	0	60	20	0	40	40	20					
Evaluate	0	0	0	0	0	0	0					
Create	0	0	0	0	0	0	0					

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	30
Complex Overt Responses	-	-	-
Adaptation	- marco	-	-
Origination	Father	-	-

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

1. A pair of automotive headlamps is connected to a 12 V battery via the arrangement shown below. In the figure, the triangular symbol is used to indicate that the terminal is connected directly to the metal frame of the car.



a) Construct a circuit model using resistors and an independent voltage source.

b) Identify the correspondence between the ideal circuit element and the symbol component that it represents.

2. The circuit shown below is a DC model of a residential power distribution circuit.

a) Use the node-voltage method to find the branch currents  $i_1$ - $i_6$ 

b) Test your solution for the branch currents by showing that the total power dissipated equals the total power developed.



#### Course Outcome 2 (CO2):

1. The fixed-attenuator pad shown below is called a *bridged tee*. Use a Y-to- transformation to show that R<sub>ab</sub>=R<sub>L</sub> if R=R<sub>L</sub>



2. In the R-2R ladder of DAC shown below, Node Ak is connected to VR if input bit Sk is 1; else, it is connected to ground.



The original Network is equivalent to



Find out the Thevenin's resistance.

3. A loudspeaker is connected to an amplifier as shown in figure given below. If a  $10-\Omega$  loudspeaker draws the maximum power of 12 W from the amplifier, determine the maximum power a  $4-\Omega$  loudspeaker will draw.



## Course Outcome 3 (CO3):

- 1. A personal computer with a monitor and keyboardrequires 40 W at 115 V (rms). Calculate the rms value of the current carried by itspower cord.
- 2. A laser printer for the personal computer in(a) is rated at 90 W at 115 V (rms). If this printeris plugged into the same wall outlet as the computer, what is the rms value of the current drawnfrom the outlet?
- 3. In a radio tuner resonance is produced by an incoming electromagnetic wave rather than an AC voltage source. The tuner circuit consists of an inductor (inductance coil) and a variable capacitor. Changing the station changes the value of the capacitance. Each radio station transmits electromagnetic waves at a particular frequency and all of these frequencies from the various stations reach the antenna of your radio. Only the frequency corresponding to the natural frequency of the tuner circuit will produce a large enough current to be picked up and then amplified. An FM radio tuner is set to receive a station. The tuner has a 1.4 microHenry (1µH = 1 x 10<sup>-6</sup> H) inductance coil and a variable capacitor that is set to 1.8 picoFarad (1pF =1 x 10<sup>-12</sup> Farad). What is the frequency of the waves emitted by this station? (Hint: FM stations broadcast from 87.5MHz to 107.5 MHz. Recall that 1MHz= 1 x 10<sup>6</sup> Hz.)

#### Course Outcome 4 (CO4):

- 1. In a RLC series circuit, the initial values are  $i_L$ =5A and  $V_c(0)$ =1V. The source voltage is  $V_s$  =12 sin 5t. Find i(t) for t > 0.
- 2. An automobile airbag igniter is modeled by the circuit shown below. Determine the time it takes the voltage across the igniter to reach its first peak after switching from A to B. Let  $R=3\Omega$ , C=1/30F and L = 60mH.



#### Course Outcome 5 (CO5):

1. Obtain the transfer function  $H(S) = v_0/i$ .



2. Obtain the network function for the given pole –zero plot shown below and Explain its stability.



#### Course Outcome 6 (CO6):

- Representing a transmission line by the two port network, in terms of ABCD parameters, a) Express V<sub>s</sub> which is the sending end voltage, in terms of V<sub>R</sub>, Which is the receiving end voltage, and I<sub>R</sub> the receiving end current,
  - b) Express the sending end current  $I_{s}$  , in terms of  $V_{R}$  and  $I_{R_{\cdot}}$



 Two identical amplifiers are connected in cascade, as shown below. Each amplifier is described in terms of its *h* parameters. The values are h<sub>11</sub>=1000Ω, h<sub>12</sub>=.0015, h<sub>21</sub>=100, h<sub>22</sub>=mho. Find voltage gain V<sub>2</sub>/V<sub>q</sub>



3. Find the **ABCD** parameters for the  $4\Omega$  resistor in the network shown below. Also show that the **ABCD** Parameters for a single  $16\Omega$  resistor can be obtained by **(ABCD)**<sup>4</sup>





#### Syllabus

Network Solution Methods : Charge and Current, Voltage, Power and Energy, Network Elements, Ohm's Law and Kirchhoff's Laws, Series and parallel connection of electrical elements, Voltage and current sources, Source transformation, Voltage and Current Division, Mesh Analysis, Node Analysis. Network Theorems: Thevenin's theorem, Norton's Maximum power transfer theorem, Superposition theorem, Wye-Delta theorem, transformation, Duality. Sinusoidal Steady State Analysis: Characteristics of sinusoidal functions, Sinusoids and Phasors, Impedance and Admittance, AC circuit analysis - Mesh, Node and theorems, Resonance, Magnetically coupled circuits. Time Domain Analysis: Source free RL and RC circuits, Transient Response of RL and RC circuits for DC excitation, Transient Response of RL and RC circuits for Sinusoidal excitation. Frequency Domain Analysis: The concept of complex frequency, Laplace Transform of standard functions, Transient Response of RL, RC, RLC circuits for DC and Sinusoidal excitation using Laplace transform. Network functions of one-port network, Driving point and transfer function of Twoport networks, Poles and Zeros of network functions. Two-Port Networks- Impedance, Admittance, Hybrid and Transmission parameters, Relationships between parameters, Properties of Two-port Networks, Analysis of interconnected two-port networks - parallel, series, and cascade connections, Zeros of transmission.

#### Learning Resources

- 1. Hayt, Kemmerley and Durbin, "Engineering Circuit Analysis", 8th edition, Tata McGraw-Hill, 2013.
- 2. DeCarlo, R.A. and Lin, P.M., "Linear Circuit Analysis: Time Domain, Phasor and Laplace Transform Approaches", Oxford University Press. 2003.
- 3. M.E. Van Valkenburg, "Network Analysis", 3rd edition, Pearson, 2006.
- 4. Charles Alexander and Matthew Sadiku, "Fundamentals of Electric Circuits", 6th Edition, 2017.
- 5. Dr. Nagendra Krishnapura IIT Madras, Basic Electrical Circuits, NPTEL video Lectures: https://nptel.ac.in/courses/117106108/
- SC Dutta Roy, Circuit Theory, NPTEL Video Lectures: <u>http://nptel.iitm.ac.in/video.php?subjectId=108102042</u>
|      |   |        | 22       |
|------|---|--------|----------|
| NO.  | lopic   | NO. OF | COs      |
|      |   | Hours  |          |
| 1    | Network Solution Methods  |        |          |
| 1.1  | Charge and Current, Voltage, Power and Energy, Network            | 2      | CO1      |
|      | Elements, Ohm's Law and Kirchhoff's Laws, Series and parallel     |        |          |
|      | connection of electrical elements                                 |        |          |
| 1.2  | Voltage and current sources, Voltage and Current Division,        | 1      | CO1      |
|      | Source transformation   |        | 004      |
| 1.3  | Mesh analysis   | 2      | <u> </u> |
| 1.4  | Node Analysis   | 2      | CO1      |
| 2    | Network Theorems  |        |          |
| 2.1  | Thevenin's theorem  | 1      | CO2      |
| 2.2  | Norton's theorem  | 1      | CO2      |
| 2.3  | Maximum power transfer theorem                                    | 1      | CO2      |
| 2.4  | Superposition theorem   | 1      | CO2      |
| 2.5  | Wye-Delta transformation, Duality                                 | 1      | CO2      |
| 3    | Sinusoidal Steady state analysis                                  | ,,     |          |
| 3.1  | Characteristics of sinusoidal functions                           | 1      | CO3      |
| 3.2  | Sinusoids and Phasors   | 1      | CO3      |
| 3.3  | Impedance and Admittance 🛛 🖌 🥜 🔼 🤸 🔪                              | 1      | CO3      |
| 3.4  | AC circuit analysis- Mesh, Node, theorems                         | 1      | CO3      |
| 3.5  | Resonance, Magnetically coupled circuits                          | 1      | CO3      |
| 4    | Time Domain Analysis:   |        |          |
| 4.1  | Source free RL and RC circuits                                    | 2      | CO4      |
| 4.2  | Transient Response of RL and RC circuits for DC excitation        | 2      | CO4      |
| 4.3  | Transient Response of RL and RC circuits for Sinusoidal           | 2      | CO4      |
|      | excitation  |        |          |
| 5.   | Frequency Domain Analysis   |        |          |
| 5.1  | The concept of complex frequency, Laplace Transform of            | 1      | CO5      |
|      | standard functions  |        |          |
| 5.2  | Transient Response of RL, RC and RLC circuits for DC and          | 1      | CO5      |
|      | Sinusoidal excitation using Laplace transform                     |        |          |
| 5.3  | Network functions of one-port network, Driving point and transfer | 2      | CO5      |
|      | function of Two-port networks                                     |        |          |
| 5.4  | Poles and Zeros of network functions                              | 2      | CO5      |
| 6    | Two-Port Networks   |        |          |
| 6.1  | Network parameters - Impedance, Admittance, Hybrid and            | 2      | CO6      |
| 62   | Relationships between parameters Properties of Two-port           | 3      | CO6      |
|      | networks  |        |          |
| 6.3  | Analysis of interconnected Two-port networks -parallel, series,   | 2      | CO6      |
| L    | and cascade connections, zeros of transmission                    |        |          |
| Cour | se Designers.   |        |          |

1. Dr.B.SathyaBama

Oscenso Oscetanta and Lasterna Oskadula

sbece@tce.edu

2. Dr.V.R.Venkatasubramani venthiru@tce.edu

18EC230	ELECTRONIC DEVICES	Category	L	Т	Р	Credit
		PC	3	0	0	3

#### Preamble

This is an introduction course to semiconductor electronic devices. The course is handled in parallel with the course 18EC240 Semiconductor Physics. The concept of energy bands formation in semiconductors and equilibrium statistics of electrons and holes, drift, diffusion currents, and generation and recombination processes is handled in 18EC240 Semiconductor Physics. In this course the principles and operations of essential semiconductor devices used in today's electronics: diodes, light detectors and emitters, bipolar junction transistors and MOSFETs are introduced. It includes the characterisation, analysis and interpretation of model parameters from the corresponding datasheet of the devices which is the prerequisite for next level courses. The goal is to develop a solid understanding of the device concepts that will be needed in a broad range of areas from semiconductor to circuit (analog, digital and VLSI) design and engineering.

### Prerequisite

#### NIL

#### **Course Outcomes**

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage***
Number		in %
CO1	Provide solution to numerical problems for diode based	20
	application circuits.	
CO2	Characterise the minority and majority carrier profile and	20
	parasitic in Bipolar Junction Transistor.	
CO3	Illustrate the formation of energy band and threshold voltage	20
	of MOS capacitor structure of Field Effect Transistor.	
CO4	Investigate the model parameters of Diode, BJT and	20
	MOSFET devices from the datasheet.	
CO5	Explain the internal structure and principle of operation of	10
	diode, BJT, FET and special devices (Tunnel diode, Solar	
	cells, MESFET).	
CO6	Suggest the necessary active device for specific application	10
	based on their modes of operation and characteristics.	

\*\*\* Weightage depends on Bloom's Level, number of contact hours,

### CO Mapping with CDIO Curriculum Framework

CO	TCE	Learr	ning Domair	n Level	CDIO Curricular Components
#	Proficiency Scale	Cognitive	Affective	Psychomotor	(X.Y.Z)
CO1	TPS3	Apply	Value	-	1.2.2, 2.1.1, 2.1.2, 2.4.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS3	Apply	Value	-	1.2.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	-	1.2.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS4	Analyse	Organise	-	1.2.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS2	Understand	Respond	-	1.2.2, 2.5.4, 3.2.6
CO6	TPS5	Evaluate	Organise	Mechanism	1.2.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1

### Mapping with Programme Outcomes and Programme Specific Outcomes

								U							
Cos	P01	PO2	PO	P01	PO1	P01	PSO	PSO	PSO						
			3	4	5	6	7	8	9	0	1	2	1	2	3
CO1	S	М	L	-	L	-	-	L	L	L	-	L	M	-	L
CO2	S	М	L	-	L	-	-	L	L	L	-	L	M	-	L
CO3	S	Μ	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	S	M	L	L	-	-	L	L	L	-	L	S	-	L
CO5	М	L	-	-	-	-	-	-	L	L	-	L	S	-	L
CO6	S	S	Μ	Μ	L	-	-	-	-	-	-	-	S	-	-

S- Strong; M-Medium; L-Low

#### **Assessment Pattern: Cognitive Domain**

Cognitive	As	Continuo sessment	us Tests		Assignme	Terminal	
Levels	1	2	3	1	2	3	Examinati on
Remember	10	0	10	-	-	-	10
Understand	10	20	20	-	-	-	10
Apply	80	40	30	100	50	-	50
Analyse	0	30	30	0	50	50	20
Evaluate	0	10	10	0	0	20	10
Create	0	0	0	0	0	0	0

#### 

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment 3
Perception	
Set	Contraction of the second seco
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

#### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

- 1. Calculate the built-in potential and depletion –region width for the given silicon diode. Given data: On p-type side:  $N_a=10^{17}/cm^3$  on n-type side: $N_d=10^{20}/cm^3$ .Assumptions:Room-temperature operations with  $V_T=0.025$  V.
- Consider an ideal pn junction diode at T=300K operating in the forward-bias region. Calculate the change in diode voltage that will cause a factor of 10 increases in current.Repeat part (a) for a factor of 100 increases in current.

#### Course Outcome 2(CO2):

- 1. Assuming the transistor is biased in the active region and the recombination factor is unity. Calculate the collector current for  $V_{BE}$ =0.5V.
- 2. Assuming the transistor is biased in the active region and the recombination factor is unity. Calculate the collector current for  $I_E$ =1.5mA.

#### Course Outcome 3(CO3):

- Consider an n-channel silicon JFET with the given function :Na=3\*10<sup>18</sup>cm<sup>-3</sup>,Nd=8\*10<sup>16</sup> cm and a=0.5µm.(a) Calculate the internal pinchoff voltage.(b) Determine the gate voltage required such that the undepleted channel is 0.20µm.
- 2. Consider an aluminium gate-silicon dioxide p-type silicon MOS structure with  $t_{ox}$ =450A.The silicon doping is Na=2\*10<sup>16</sup> cm<sup>-3</sup> and the flat-band voltage is V<sub>FB</sub>=-1.0V.Determine the fixed oxide charge Q<sub>ss</sub>.

3. An ideal n-channel MOSFET has an inversion carrier mobility  $\mu$ n=525 cm2/V-s a threshold voltage, V<sub>T</sub>=+0.75V and an oxide thickness t<sub>ox</sub>=400A.When biased in the saturation region, the required rated current is I<sub>D(sat)=</sub>6mA when V<sub>GS</sub>=5V.Determine the required W/L ratio.(b) A p-channel MOSFET has the same requirements when V<sub>GS</sub>=5V and has the same parameter as part(a) except  $\mu_p$ =300cm2/V-s and V<sub>T</sub> = -0.75V.Determine the W/L ratio.

#### Course Outcome 4 (CO4):

- 1. Consider the datasheet of 1N4007 PN junction diode, examine the different parameters given in the datasheet with the model parameters given in anyone of the SPICE simulation tool.
- 2. Compare the datasheet of BJT transistors BC547, BC107 and conduct an investigation to find the scenario of limitation of the transistors.

#### Course Outcome 5 (CO5):

- 1. Compare the internal structure of SCR, DIAC and TRIAC
- 2. With the help of neat diagram, describe the operation of MESFET.
- 3. Describe the working principle of HEMT.

#### Course Outcome 6(CO6):

- 1. Consider the communication receiver section which uses envelope detector to retrieve the amplitude modulated message signal. Give suggestion for an active device which can be used for the retrieval of the received signal.
- 2. Consider the immediate preamplifier section following the microphone in an public addressing system. The scenario is the microphone generates a low voltage signal and it has to be amplified by the immediate stage constructed by an active device. The need of the hour is the amplifer input impedance must be high enough so that it will not load the microphone section. Recommend an active device which can provide better solution.



#### Syllabus

**P-N JUNCTION DIODE**: Open Circuit Analysis, P-N Junction Diode under forward and reverse bias, Current Components and V-I characteristics, Temperature dependence, transition and diffusion capacitance, Switching Characteristics, breakdown of junctions on reverse bias (Zener and avalanche breakdowns), Diode datasheet, Applications Rectifier circuits, Voltage regulator, clipper and clamper circuits. **BIPOLAR JUNCTION TRANSISTOR (BJT)**: PNP and NPN structure, Fundamental of Operation and Characteristics of BJT, CB, CE and CC configurations, Early Effects, Break down Voltages, Transistor Switching Times, Eber - Moll model and datasheet parameters, BJT in Application – DTL logic family, TTL and ECL logic families **FIELD EFFECT TRANSISTORS (FET)**: Classification of FET, the Junction Field Effect Transistor, Voltage Variable Resistor, MOS Capacitor Structure Capacitance –Voltage Characteristics, MOSFETs: Types of MOSFET, fabrication, operation and V-I Characteristics, Datasheet. Application **SPECIAL DEVICES**: Tunnel diode, LED, LCD, LDR, PIN diode, Photo diode, Laser, solar cells, SCR, DIAC, TRIAC, HBT, HEMT, MESFET, FINFET.

#### Learning Resources

- 1. Streetman B.G., Banerjee, S.K, "Solid State Electronic Devices", 7th Edition, Pearson Education, 2016.
- 2. Adel S. Sedra and Kenneth C. Smith, "Microelectronic Circuits: Theory and Application", 7<sup>th</sup> Edition, Oxford University Press, 2017.
- 3. Albert Malvino and David J Bates ,"Electronic Principles" , 7<sup>th</sup> Edition, Mc Graw Hill , 2017.
- 4. NPTEL online Course on "Fundamentals of Semiconductor devices", Course Link: <u>https://onlinecourses.nptel.ac.in/noc19\_ee04/</u>

Madula	Tonia	No. of	Course
Noule	Горіс		Course
INO.		HOUIS	Outcome
1.	P-N JUNCTION DIODE		0.05
1.1	Open Circuit Analysis	1	CO5
1.2	P-N Junction Diode under forward and reverse bias	1	CO1
1.3	Current Components and V-I characteristics	1	CO1
1.4	Temperature dependence, transition and diffusion capacitance	1	CO1
1.4.1	Switching Characteristics,breakdown of junctions on reverse bias (Zener and avalanche breakdowns)	2	CO1
1.5	Diode datasheet	1	CO4
1.6	Applications Rectifier circuits, Voltage regulator,	3	CO1
<u> </u>	BIPOLAR JUNCTION TRANSISTOR (BJT)	4	005
2.1	PNP and NPN structure	1	C05
2.2	Fundamental of Operation and Characteristics of BJT, CB_CE and CC configurations	2	CO2
2.3	Early Effects. Break down Voltages	1	CO2
2.4	Transistor Switching Times, Eber - Moll model	2	CO2
0.5	dalasheel parameters	4	004
2.5		1	C04
2.6	BJT in Application - DTL logic family	1	CO2
2.7	I I L and ECL logic families	2	CO2
3.	FIELD EFFECT TRANSISTORS (FET)		
3.1	Classification of FET, Junction Field Effect Transistor	1	CO3
3.1.1	Voltage Variable Resistor	1	CO3
3.2	MOS Capacitor Structure Capacitance	1	CO3
3.2.1	Voltage Characteristics	1	CO3
3.2.2	MOSFETs: Types of MOSFET	1	CO3
3.2.3	Fabrication	1	CO3

**Course Contents and Lecture Schedule** 

3.2.4	operation	1	CO5
3.2.5	V-I Characteristics	1	CO3
3.2.6	Datasheet	1	CO4
3.3	Application	1	CO3
4.	SPECIAL DEVICES		
4.1	Tunnel diode, LED, LCD	1	CO5
4.2	LDR, PIN diode, Photo diode	1	CO5
4.3	Laser, solar cells	1	CO5
4.4	SCR, DIAC, TRIAC	1	CO5
4.5	HBT, HEMT	1	CO5
4.6	MESFET, FINFET	1	CO5
	Total Hours	36	

### **Course Designers:**

1.Dr. N.B. Balamurugan 2.Dr. V. Vinoth Thyagarajan 3.Dr. K. Vasudevan nbbalamurugan@tce.edu vvkece@tce.edu kvasudevan@tce.edu



18EC240	SEMICONDUCTOR PHYSICS	Category	L	Т	Ρ	Credit
1020210		ES	3	0	0	3

#### Preamble

The course aims to provide a sound understanding about the classification of electronic materials based on modern quantum theory. This course improves the analytical skill on the selection, identification and characteristics of semiconducting materials for appropriate applications. It also discusses the estimation of fundamental parameters such as Band gap, carrier concentration, Mobility and interaction with photon of semiconducting materials. **Prerequisite** 

#### NIL

#### Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage***
Number		in %
CO1	Compute the electrical properties of metals based on classical,	20%
	quantum and band theory of solids.	
CO2	Explain the electrical properties of materials through band gap	10%
CO3	Understand the basic properties of semiconductor based on	10%
	density of states	
CO4	Compute the carrier concentration and recombination of	20%
	semiconductors	
CO5	Demonstrate the interactive effects of photon on	20%
	Semiconductors	
CO6	Identify the appropriate techniques to characterize the	20%
	semiconducting materials	

\*\*\* Weightage depends on Bloom's Level, number of contact hours,

### CO Mapping with CDIO Curriculum Framework

CO		TCE				_earn	ing D	omair	Leve	el			CD	IO Cu	ricular	
#	P	roficie	ncy	C	ogniti	ve	Affec	tive	Psychomotor		or	Components				
	Scale													(X.Y.	Z)	
CO1	TPS	3		Ap	ply		Value	e	-			1.1,	2.1	.1, 2	.1.5,	2.4.3,
												2.4.6				
CO2	TPS	2		Ur	nderst	and	Resp	ond	-			1.1, 2.1.5, 2.4.3, 2.4.6				
CO3	TPS	2		Ur	nderst	and	Resp	ond	-			1.1, 2.1.5, 2.4.3, 2.4.6				
CO4	TPS	TPS3			ply		Value	e E	-			1.1, 2.1.1,2.1.5,2.4.3, 2.4.6				
CO5	TPS3			Ap	ply		Value	e	-			1.1, 2.1.1,2.1.5,2.4.3, 2.4.6				
CO6	TPS	2		Ur	nderst	and	Resp	ond	-			1.1, 2.1.5, 2.4.3, 2.4.6				
Марр	ing w	vith P	rogra	mme	Outc	ome	s and	Prog	ramm	ne Spe	cific	ς Οι	utcon	nes		
Cos	PO1	PO2	PO	PO	PO	PO	PO	PO	PO	PO1	PO	1	PO1	PSO	PSO	PSO
004			3	4	5	6	- /	8	9	0	1	_	2	Ĩ	2	3
CO1	M	M	M	L	-	-	-	-	-	-	-		-	-	-	-
CO2	Μ	L	L	L	-	-	-	-	-	-	-		-	-	-	-
CO3	Μ	L	L	L	-	-	-	-	-	-	-		-	-	-	-
CO4	М	М	М	Ĺ	-	-	-	-	-	-	-		-	-	-	-
CO5	М	М	Μ	L	-	-	-	-	-	-	-		-	-	-	-
CO6	М	L	L	L	-	-	-	-	-	-	-		-	-	-	-

S- Strong; M-Medium; L-Low

Assessment P	Assessment Fattern. Cognitive Domain												
Cognitive	Cont	inuous As Tests	sessment		Assign	Terminal							
Levels	1	2	3	1	2	3	Examinati						
							on						
Remember	20	20	20	0	0	0	20						
Understand	30	30	30	100	0	0	30						
Apply	50	50	50	0	100	100	50						
Analyse	0	0	0	0	0	0	0						
Evaluate	0	0	0	0	0	0	0						
Create	0	0	0	0	0	0	0						

### **Assessment Pattern: Cognitive Domain**

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment I	Assignment II	Assignment III
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	10	-	-

#### Sample Questions for Course Outcome Assessment Course Outcome 1(CO1):

- 1. Define Drift velocity
- 2. Describe the free electron theory of metals
- 3. Derive an expression for the electrical conductivity of metals
- 4. List out the failures of classical free electron theory
- 5. Explain the band theory of solids

#### Course Outcome 2 (CO2):

- 1. Calculate the drift velocity of the free electrons in a conductor of area 10<sup>-4</sup>m<sup>2</sup>, given the electron density to be 8x10<sup>28</sup>/m<sup>3</sup> when a current of 5A flows through it.
- 2. Calculate the electron density, if the drift velocity of electrons in a metal wire of diameter 5mm is 6x10<sup>-4</sup>m/s and the current is 10A.
- 3. Calculate the relaxation time of free electrons in a metal of resistivity 1.54x10<sup>-8</sup> ohm-m, if the metal has 5.8x10<sup>28</sup> electrons/m<sup>3</sup>. Identify the possible material and suggest the suitability for transformer winding applications.

#### Course Outcome 3(CO3):

- 1. Distinguish between intrinsic and extrinsic semiconductor
- 2. Explain the density of states in semiconductors
- 3. Discuss the carrier generation and recombination of charge carriers in semiconductors

#### Course Outcome 4(CO4):

- Calculate the drift current density in a semiconductor for a given electric field. Consider a germanium sample at T = 300°K with doping concentration of Na = 10<sup>16</sup> cm<sup>-3</sup>. Assume complete ionization and electron and hole mobilities are 3900 cm<sup>2</sup>/V⋅sec and 1900 cm<sup>2</sup>/V⋅sec. The applied electric field is E = 50 V/cm.
- 2. A piece of silicon is doped with Na = 2x10<sup>15</sup> cm<sup>-3</sup> and Nd = 1x10<sup>15</sup> cm<sup>-3</sup> a) what is the majority carrier? Is the silicon type n or type p? b) Find the electron and hole concentration and mobility at room temperature. c) We want increase the electron concentration to 1x10<sup>17</sup> cm<sup>-3</sup>. What is the additional dopant type and concentration? What is the new electron mobility?
- 3. The number of electron-hole pairs in intrinsic germanium (Ge) is given by:  $n_i$ = 9.7× 10<sup>15</sup> T<sup>3/2</sup> e<sup>-E /2KT</sup> [cm<sup>3</sup>], E<sub>g</sub> = 0.72 eV (a) What is the density of pairs at T = 20°C? (b) Will undoped Ge be a good conductor at 200°C? If so, why?

#### Course Outcome 5 (CO5):

1. Demonstrate the effect of photon on PV cell.

- 2. Illustrate the recombination of charge carriers on semiconductors under external photon.
- 3. Illustrate the mechanism of optical absorption on semiconductors with the help of beer lambert law.

#### Course Outcome 6(CO6):

- 1. Demonstrate the four probe method to calculate the sheet resistance and resitivity of solids.
- 2. Illustrate the Hall experiment to calculate the carrier concentration and mobility of semiconducting material.
- 3. Sequence the experimental procedure to calculate the electron and hole density and nature of a semiconducting material

#### Concept map:



#### Syllabus

**Electronic materials :** Introduction - Classical Free electron theory - Drift Velocity - Electrical Conductivity - Thermal Conductivity - Wiedemann Franz Law - Drawbacks - Quantum free electron theory - Band theory of solids - Blochs theorem - Kronig-Penny model - Direct and indirect band gaps - Energy bands in solids-Types of electronic materials: metals, semiconductors, and insulators - Application of low and high resistivity material.

**Semiconductors:** Intrinsic and extrinsic semiconductors, Density of states - Occupation probability - Fermi level - Effective mass - Dependence of Fermi level on carrier concentration and temperature - Carrier generation and recombination – Carrier transport: diffusion and drift - p-n junction - Metal-semiconductor junction (Ohmic and Schottky) – Applications - Laser diode and Photo diode. **Photon-semiconductor interaction** :Optical transitions in bulk semiconductors - Optical absorption-Absorption coefficient-Optical recombination - carrier lifetime-Photo response time –Emission –Spontaneous-stimulated emission-Joint density of states - Density of states for photons - Transition rates (Fermi's golden rule)- Optical loss and gain-Photovoltaic effect- Application of Solar cells. **Characterization of Semiconductors:** Four-point probe and van der Pauw measurements for carrier density – resistivity – hall Mobility - Hot-point probe measurement, Parameter extraction from diode I-V characteristics- Deep Level Transient Spectroscopy - band gap measurement by UV-Vis spectroscopy- absorption/transmission.

#### Learning Resources

- 1. M.A.Wahab, 'Solid state Physics', 3rd edition, Narosa Publications, 2015.
- 2. Charles Kittel, 'Introduction to solid state Physics', 8th edition, Wiley, 2012.
- 3. S. M. Sze, Semiconductor Devices: Physics and Technology, Wiley, 2008.
- 4. <u>https://ocw.mit.edu/courses/materials-science-and-engineering/3-091sc-introduction-to-solid-state-chemistry-fall-2010/electronic-materials/14-semiconductors/</u>
- 5. https://nptel.ac.in/courses/115102025/17

Module		No. of	Course
No.		Hours	Outcome
1.0	Electronic materials		
1.1	Introduction-Classical Free electron theory.	1	CO 1
1.2	Drift Velocity-Electrical Conductivity	1	CO 1
1.3	Thermal Conductivity	1	CO 1
1.4	Wiedemann Franz Law-drawback of classical	1	CO 1
	electron theory		
1.5	Quantum free electron theory-Band theory of	2	CO 1
	solids		
1.6	Bloch's theorem -Kronig-Penny model	2	CO 1
1.7	Direct and indirect band gaps - Energy bands	1	CO 2
	in solids		
1.8	Types of electronic materials: metals,	2	CO 2
	semiconductors, and insulators - Application of		
	low and high resistivity material.		
2.0	Semiconductors		
2.1	Intrinsic and extrinsic semiconductors	1	CO 3
2.2	Density of states - Occupation probability -	2	CO 3
	Fermi level-Effective mass		
2.3	Dependence of Ferm <mark>i level on</mark> carrier	2	CO 4
	concentration and temperature		
2.4	Carrier generation and recombination	2	CO 4
2.5	Carrier transport: diffusion and drift	1	CO 4
2.6	p-n junction - Metal-semiconductor junction	2	CO 4
	(Ohmic and Schottky)		
2.7	Applications – Laser diode and Photo diode	1	CO 3
3.0	Photon – semiconductor interaction		00.5
3.1	Optical transitions in bulk semiconductors	1	CO 5
3.2	Optical absorption-Absorption coefficient	1	CO 5
3.3	Optical recombination- carrier lifetime	1	CO 5
3.4	Photo response time – Emission	1	CO 5
3.5	Joint density of states - Density of states for	1	CO 5
0.0	pnotons Transition notes (Fermile noteber mile) - Ontion	4	00.5
3.0	Transition rates (Fermis golden rule)- Optical	1	05
2.7	IOSS and gain Destavaltais affect. Application of Salar calls	1	CO 5
3.7	Photovoltaic effect, Application of Solar cells.		0.05
4.0	Characterization of Semiconductors	0	<u> </u>
4.1	Four-point probe and van der Pauw	2	006
4.0	hell Mehility Llet point probe massurement	2	<u> </u>
4.2	Parameter extraction from diade 11/	<u> </u>	
4.3	characteristics	1	
1 1	Doop Lovel Transient Spectroscopy	1	CO 6
4.4	beep Level mansient Spectroscopy	1	
4.0	spectroscopy- absorption/transmission	I	
	speciroscopy- absorption/transmission		

### Course Contents and Lecture Schedule

#### Course Designers:

- hodphy@tce.edu
- 1. Dr.R.Vasuki 2. Dr.S.Rajathi, srphy@tce.edu
- 3. Mr.T.Mani Chandran stmanichandran@gmail.com

18EC260	DIGITAL SYSTEM DESIGN	Category	L	Т	Ρ	Credit
		PC	2	0	2	3

#### Preamble

The course "18EC260: Digital System Design" is offered as theory cum practical course in concurrent with the course on "Electronic Devices". The objective of this course is to give hands on training for the students to understand the theory of basic combinational and sequential circuits of digital systems. This course relies on extensive use of Hardware Description Language for describing and implementing digital logic designs on state-of-the-art FPGA.

## NIL

#### Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome Statement	Weightage***
Number		in %
CO1	Understand the significance of Digital information Systems	10
	and the structure of various number systems.	
CO2	Apply the principles of Boolean algebra to simplify the logic	10
	functions.	
CO3	Design simple combinational logic circuits using basic	15
	gates.	
CO4	Investigate the sequential behaviour of digital logic circuits	15
	using Finite State Machine	
CO5	Understand the memory architecture and their essential	10
	building blocks.	
CO6	Implement various combinational/sequential modules of	40
	digital system using HDL coding.	

\*\*\* Weightage depends on Bloom's Level, number of contact hours

CO Mapping with CDIO Curriculum Framework

00 1114														
CO	TCE	Learning Dom	nain Level		CDIO Curricular									
#	Proficiency	Cognitive	Affective	Psychomotor	Components									
	Scale				(X.Y.Z)									
CO1	TPS2	Understand	Respond	-	1.2.3, 2.4.6, 3.2.3									
CO2	TPS3	Apply	Value	Mechanism	1.2.3,2.1.1, 2.3.4,									
					2.4.6, 2.5.1, 3.1.1,									
					3.2.3, 4.5.1, 4.6.1									
CO3	TPS3	Apply	Value	Mechanism	1.2.3, 2.1.1, 2.3.4,									
					2.5.1, 3.1.1, 3.2.3,									
					4.5.1, 4.6.1									
CO4	TPS3	Analyse	Organise	Complex Overt	1.2.3, 2.1.1, 2.3.4,									
			_	Responses	2.5.1, 3.1.1, 3.2.3,									
					4.5.1, 4.6.1									
CO5	TPS2	Understand	Respond	Guided Response	1.2.3, 2.4.6, 3.2.3,									
CO6	TPS3	Analyse	Organise	Complex Overt	1.2.3, 2.1.1, 2.3.4,									
				Responses	2.5.1, 3.1.1, 4.5.1,									
					4.6.1									

Марр	Mapping with Programme Outcomes																		
Cos	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO1	PSO2	PSO2				
CO1	M	L		-	-	-	-	L	L	L	-	L	L	-	L				
CO2	S	Μ	L	-	S	-	-	L	L	L	-	L	M L L						
CO3	S	Μ	L	-	S	-	-	L	L	L	-	L	M	M L L					
CO4	S	M	L	L	S	-	-	L	L	L	-	L	M	L	L				
CO5	S	S	М	L	М	-	-	L	L	L	-	L	S	-	L				
CO6	S	S	Μ	L	S	-	-	L	L	L	-	L	S	L	L				
S- Str	S- Strong; M-Medium; L-Low																		
Asse	ssme	nt Pa	ttern:	Cog	nitive	Dom	ain												
Blo	om's	Cate	gory		Co	ntinuc	ous As	ssess	ment	Tests		Т	ermina	l Exam	ination				
	D				1			2		3									
	Rem	empe	r -		0			0		0			0				0		
	Unde	rstan	a		20					20			20						
	Ap	ріу			08			60		60	60			60					
	Ana	alyse			0			20				20							
	Eva				0			0		0				0					
A	Cr		<b>11</b>	Dave	0			0		0				0					
Asse	ssme		ttern:	PSyc	cnom	otor	1.			-			Due of						
Psyc	nome	otor S	KIII				1 mg	17	63				Pract	icai					
Perc	eptior	1							p1				-						
Set							-	2	PI				-						
Guid	ed Re	espon	se			T-A	12		S M	17			-						
	hanisi	n				N	100	- In	0	1			80						
Com	plex (	Overt	Resp	onses			Con.	Barry In	1		20								
Adap	Adaptation -																		
Origi	natior	<u>۱</u>					10	1.1	-				-						

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. Discuss the advantages of processing information in digital form.
- 2. Describe the software aspects of Digital design.
- 3. Convert the hexadecimal 64CD into binary, and then convert it from binary to octal

#### Course Outcome 2 (CO2):

- 1. Draw the logic diagram of the circuits that implements the original and simplified expressions of ABC+A'B+ABC'. Find the cost of both circuits.
- Simplify the given Boolean function using four variable Maps A'B'C'D'+AC'D'+B'CD'+A'BCD+AB'C

### Course Outcome 3 (CO3):

1. An 8×1 multiplexer has inputs A, B, and C connected to the selection input  $S_2$ , $S_1$  and  $S_0$  respectively. The data input  $I_0$  through  $I_7$  are as follows:

$$I_1 = I_2 = I_7 = 0$$
;  $I_3 = I_5 = 1$ ;  $I_0 = I_4 = D$  and  $I_6 = D'$ 

- Design a combinational circuit that converts four bit gray code to 4 bit binary. Implement the circuit using Exclusive-OR gates. Using case statement, write the verilog model of the circuit.
- A combinational circuit is specified by the following boolen functions: F1(A,B,C)=∑(1,4,6), F2(A,B,C)=∑(3,5), F3(A,B,C)=∑(2,4,6,7) Implement the circuit wth a decoder constructed with NAND gates and NAND or NOR gates connected to the decoder outputs. Minimize the number of inputs in the external gates.

#### Course Outcome 4 (CO4):

1. A sequential circuit with two D flipflops A and B, two inputs x and y, and the output z is specified by the following next state and output equations.

$$A(t+1) = xy'+xB$$

$$B(t+1) = xA+xB'$$
$$z = A$$

- (a) Draw the logic diagram of the circuit
- (b) List the state table for the sequential circuit.
- (c) Draw the corresponding state diagram.
- 2. Use as many as necessary of the following counter with minimal external gates to design a counter that counts from 0 to 20.



#### Course Outcome 5 (CO5):

- Investigate a 16×8 ROM that converts a four bit binary number to its corresponding twodigit BCD number by finding the truthtable. Each BCD may be represented using 4 bit. Draw the block diagram of the same memory.
- 2. Draw the block diagram of 8×4 ROM that implements the following Boolean function

 $A(x,y,z) = \sum (0,2,4,6)$  $B(x,y,z) = \sum (0,1,3,5)$  $C(x,y,z) = \sum (1,4)$  $D(x,y,z) = \sum (0,1,3,5,7)$  $C(x,y,z) = \sum (0,1,3,5,7)$  $C(x,y,z) = \sum (0,2,4,6)$  $C(x,y,z) = \sum (0,2,4,6)$ C(x,

#### Course Outcome 6 (CO6):

1. Implement the main components of an Digital clock



2. Implement the main components of an ALU



3. Implement the basic building blocks of digital communication system



#### **Concept Map**



### Syllabus

### Theory:

**Digital Information Processing**: Basis of Digital System, Software and Electronic aspects of Digital Design, Digital ICs, Number systems and Codes, Methods of base conversions, Code Converters and their Applications. **Boolean Algebra and Switching Functions**: Basic postulates and fundamental theorems of Boolean algebra; Standard representation of logic functions – Sum Of Product (SOP) and Product Of Sum (POS) forms; NAND and NOR Implementation - Simplification of switching functions – Karnaugh Maps and Quine-McCluskey tabular methods. **Combinational Logic Design:** Adders/subtractors, Fast adder, Magnitude comparator, Multiplexer Demultiplexer, Encoders, Decoders, Multiplier, and Parity generator, Standard IC Data Sheets and its Descriptions, HDL implementation of combinational circuits. **Sequential Logic Design:** Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF, Universal Shift register, Ripple and Synchronous counters, HDL Implementation of Sequential Circuits, Design of synchronous Finite State Machine. **Memories:** Read Only Memory, Programmable ROM, Read Access Memory: SRAM, and DRAM.

#### Practical:

- 1. Implementation of combinational circuits
  - a. Multiplexer and DeMultiplexer
  - b. Encoder and Decoder
- 2. Implementation of Arithmetic Circuits
  - a. Adder
  - b. Subtractor
  - c. Multiplier
  - d. Comparator
- 3. Implementation of code converters
  - a. Gray code to Excess-3 code.
  - b. BCD to Seven segment display
- 4. Implementation of sequential circuits
  - a. Universal Shift register
    - b. Counter

- 5. Implementation of Sequence generator in FSM approach.
- 6. Design and implement a final digital project of their choice, in areas such as games, music, digital filters, wireless communications, and graphics.

#### Learning Resources

- 1. John F Wakerly, "Digital Design Principles & Practices" 4<sup>th</sup> Edition, Prentice Hall, 2005.
- 2. M. Morris Mano and Michael D. Ciletti, "Digital Design: With an Introduction to the Verilog HDL", 5th Edition, Prentice Hall 2012.
- 3. Stephen D. Brown, and Zvonko Vranesic, "Fundamentals of Digital Logic with Verilog Design, 2nd Edition," McGraw Hill, June, 2007.
- 4. Thomas L. Floyd, Digital Fundamentals, 10th ed. Prentice Hall, 2009
- 5. William I. Fletcher," An Engineering Approach to Digital Design,1<sup>st</sup> Edition reprint 2015.
- 6. NPTEL course Digital Circuits: https://nptel.ac.in/courses/117106086/

Module No.	Торіс	No.of Lectures	CO
1	Digital Information Processing		
1.1	Basics of Digital Systems, Software and Electronic aspects of Digital Design, Digital ICs.	2	CO1
1.2	Number systems and Codes, Methods of base conversions	1	CO1
1.3	Code Converters and their Applications	1	CO1
2	Boolean Algebra and Switching Functions		
2.2	Basic postulates and fundamental theorems of Boolean algebra	1	CO2
2.3	Standard representation of logic functions - SOP and POS forms, NAND and NOR Implementation	1	CO2
2.4	Simplification of switching functions – Karnaugh Map	2	CO2
2.5	Quine-McCluskey Tabular methods	2	CO2
2.6	Practical – Simplification of Boolean functions	4	CO6
3	Combinational logic Design		
3.1	Adders/subtractors, fast adder, magnitude comparator	2	CO3
3.2	Multiplexer Demultiplexers, encoders, decoders	2	CO3
3.3	Multiplier, Parity generator.	2	CO3
3.4	Standard IC Data Sheets and its Descriptions	4	CO6
3.5	Practical - HDL implementation of combinational circuits	4	CO6
4	Sequential Logic Design		
4.1	Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF	2	CO4
4.2	Universal Shift register	2	CO4
4.3	Ripple and Synchronous counters	2	CO4
4.4	Design of synchronous FSM	2	CO4
4.5	Practical – HDL Implementation of Sequential Circuits	8	CO6
5	Memory and Programmable Logic Devices		
5.1	Read Only Memory	1	CO5
5.2	Programmable ROM	2	CO5
5.3	Read Access Memory -SRAM, and DRAM.	1	CO5
	Total	48	

#### Course Contents and Lecture Schedule

### **Course Designers:**

- 1. Dr.G.Ananthi
- 2. Dr.D.Gracia Nirmala Rani
- 3. Dr.K.Kalyani

<u>gananthi@tce.edu</u> gracia@tce.edu k kalyani@tce.edu

18EC270	EC270 CIRCUITS AND DEVICES LABORATORY	Category	L	Т	Ρ	Credit
		PC	0	0	1	1

#### Preamble

The goal is to supplement the theory courses '18EC230 Electronic Devices' and '18EC220 Network Theory' by giving a practical exposure of the operation of electric and electronic circuits to the students. The course also provides experience in analysing and testing of electric and electronic circuits using hardware implementation.

### Prerequisite

#### NIL

### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Experimental verifications of Kirchhoff's Laws	10
CO2	Experimental verifications of Network theorems	20
CO3	Simulate to study the transient and steady-state response of first	10
	order RL and RC circuits	
CO4	Experimental determination of Resonance frequency of Series	10
	and Parallel RLC Circuits.	
CO5	Demonstrate the I-V characteristics, Static and Dynamic	10
	resistance of PN Junction Diode and Zener diode	
CO6	Construction of Regulated DC power supply unit	20
C07	Demonstrate the I-V characteristics of BJT and MOSFET. Also	20
	the characteristics of opto-coupler built using LED and LDR	

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	rning Doma	ain Level	CDIO Curricular Components				
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)				
	Scale	_							
CO1	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,				
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,				
					4.6.2				
CO2	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,				
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,				
					4.6.2				
CO3	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,				
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,				
					4.6.2				
CO4	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,				
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,				
					4.6.2				
CO5	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,				
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,				
					4.6.2				
CO6	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,				
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,				
					4.6.2				
C07	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,				
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,				
					4.6.2				

#### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO	PO	PO	PSO1	PSO2	PSO3
••••										10	11	12			
CO1	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO2	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO3	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO4	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO5	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO6	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
C07	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L

#### S- Strong; M-Medium; L-Low

#### Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination						
Remember								
Understand								
Apply	70	70						
Analyse								
Evaluate								
Create	100							

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	A Sector Practical Component
Perception	- AL CARD A JA-
Set	Left and the second sec
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

#### List of Experiments/Activities with CO Mapping

- 1. Verifications of Kirchhoff's Voltage Law and Kirchhoff's Current Law.
- 2. Demonstrate the I-V characteristics, Transient response of PN Junction Diode and Zener diode.
- 3. Verifications of Thevenin's theorem and Norton's theorem.
- 4. Construct constant DC power supply unit using bridge rectifier and Zener diode regulator.
- 5. Verifications of Maximum power transfer theorem and Superposition theorem.
- 6. Demonstrate the I-V characteristics of BJT and MOSFET.
- 7. Transient and steady-state analysis of first order RL and RC circuits.
- 8. Demonstrate the characteristics of opto-coupler built using LED and LDR.
- 9. Determination of Resonance frequency of series and parallel RLC circuits.

#### Learning Resources

- 1. NPTEL Video Lecture on "Basic Electronics and Lab", weblink: https://nptel.ac.in/courses/122106025
- 2. MIT Video Lecture on "Circuits and Electronics", weblink: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002circuits-and-electronics-spring-2007/index.htm

#### **Course Designers:**

1.	Dr.V.Vinoth Thyagarajan	<u>vvkece@tce.edu</u>
2	Dr.V.R.Venkatasubramani	venthiru@tce.edu

2. Dr.V.R.Venkatasubramani

venthiru@tce.edu

18EC280	ELECTRONICS WORKSHOP	Category	L	Т	Ρ	Credit
		ES	0	0	1	1

#### Preamble

This workshop helps the students of electronic engineering and electronic professionals gain a full understanding of the basic of electronic components and instruments. The topics cover everything necessary as a prerequisite for their continued understanding in various circuits and systems in use in the coming courses. This course is for preparing students for engineering experience and practice through laboratory skill and experiments on PCB (Printed Circuit Board) designing is an integral part of each electronics products and this program is designed to make students capable to design their own projects PCB up to industrial grade In the laboratory, students learn by doing, by practicing engineering skills that they might perform in the future. After completion of the workshop for one semester, the course investigates the student's perception on the practical skills acquired. This course investigates students' perception on the practical skills acquired.

### Prerequisite

#### Nil

#### Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage***
Number		IN %
CO1	Identify various basic electronic components and packages and for understanding the operational principles of instruments, power supply and equipment	10
CO2	Experiment the connection of circuits in general board and specific Printed circuit board.	20
CO3	Develop a schematic circuit and acquire the knowledge for preparing necessary tools and customizing the tools for PCB design	20
CO4	Develop a PCB layout for the required specification, learn to use tools for layout preparation under various design constraints	30
CO5	Acquire the skills of soldering and desoldering in engineering practice and to learn the safety procedures	10
CO6	Test the assembled circuit in board with engineering IPC standards	10

\*\*\* Weightage depends on Bloom's Level, number of contact hours,

CO Mapping with CDIO Curriculum Framework

CO	TČE	Lea	rning Domaiı	n Level	CDIO Curricular
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale				(X.Y.Z)
CO1	TPS 2	Understand	Respond	Guided	1.1, 3.2.6
			_	Response	
CO2	TPS 3	Apply	Value	Mechanism	1.1, 2.1.1, 3.2.6
CO3	TPS 3	Apply	Value	Mechanism	1.1, 2.2.3, 3.2.6
CO4	TPS 3	Apply	Value	Mechanism	1.1, 2.3.1, 2.3.2, 3.2.6
CO5	TPS 3	Apply	Value	Mechanism	1.1, 2.5.1, 3.1.1, 3.2.6,
					4.1.5
CO6	TPS 4	Analyse	Organise	Complex	1.1, 3.2.1, 3.2.2, 3.2.6,
		-	-	Overt	4.2.3
				Responses	

### Mapping with Programme Outcomesand Programme Specific Outcomes

COs   P01   P02   P0   P0   P0   P0   P0   P0   P0   P0   P0   P1   P1   P31   P30   <																
3 4 5 6 7 8 9 0 1 2 1 2 3   CO1 M L - - - - L L L - - M - -   CO2 M L - - - - L L L - - M - -   CO2 M L - - - - L L L - - M - -   CO3 M L - - - - L L L - - - - - - - - - - - - M -	COs	PO1	PO2	PO	P01	P01	P01	PSO	PSO	PSO						
CO1 M L - - - L L L - - M - -   CO2 M L - - - - L L L - - M - -   CO2 M L - - - - L L L L - M - - -   CO3 M L - - - - L L L - M - - - Co3 M L - - - - L L L L - M - - - M M - L S - M				3	4	5	6	7	8	9	0	1	2	1	2	3
CO2 M L - - - L L L - - M - -   CO3 M L - - - L L L - - M - M - - - - - - - M M - - - - - - - M M - - - M M - - - M M - - - M M - - - M M - - - M M - - - M M - - - M M - - </td <td>CO1</td> <td>М</td> <td>L</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>-</td> <td>L</td> <td>L</td> <td>L</td> <td>-</td> <td>-</td> <td>Μ</td> <td>-</td> <td>-</td>	CO1	М	L	-	-	-	-	-	L	L	L	-	-	Μ	-	-
CO3   M   L   -   -   -   L   L   L   -   M   -   -   -   M   -   -   M   -   -   M   -   -   M   -   -   M   -   -   M   M   -   -   M   -   -   M   M   -   L   S   -   M     CO4   S   M   L   -   L   -   M   M   M   -   L   S   -   M     CO5   S   M   L   -   L   -   M   M   M   -   L   S   -   M     CO6   S   M   L   -   L   -   M   M   M   -   L   S   -   M	CO2	М	L	-	-	-	-	-	L	L	L	-	-	Μ	-	-
CO4   S   M   L   -   M   -   M   M   -   L   S   -   M     CO5   S   M   L   -   L   -   M   M   M   -   L   S   -   M     CO6   S   M   L   -   L   -   M   M   M   -   L   S   -   M	CO3	М	L	-	-	-	-	-	L	L	L	-	-	M	-	-
CO5   S   M   L   -   L   -   M   M   M   -   L   S   -   M     CO6   S   M   L   -   L   -   M   M   M   -   L   S   -   M	CO4	S	Μ	L	-	Μ	-	-	Μ	Μ	М	-	L	S	-	M
CO6 S M L - L - M M M - L S - M	CO5	S	Μ	L	-	L	-	-	Μ	М	М	-	L	S	-	M
	CO6	S	Μ	L	-	L	-	-	Μ	М	Μ	-	L	S	-	М

# S- Strong; M-Medium; L-Lowl AssessmentPattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember	0	0
Understand	10	10
Apply	10	10
Analyse	10	10
Evaluate	10	10
Create	15	15

#### AssessmentPattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	- ALI COMPANY -
Set	
Guided Response	-
Mechanism	10
Complex Overt Responses	10
Adaptation	10
Origination	15

### List of Experiments/Activities with CO Mapping

1.	Identification of components and packages(CO1)
	Experimenting with -
	Active and passive components:
	Resistor with various power rating, capacitors and inductors
	Through Hole Packages:
	Axial lead, Radial Lead, Single Inline Package(SIP), Dual Inline
	Package(DIP), Transistor Outline(TO), Pin Grid Array(PGA)
	Surface mount Packages:
	Metal Electrode Face(MELF),Leadless Chip Carrier(LCC),Small Outline
	Integrated Circuit(SOIC),Quad Flat Pack(QPF) and Thin QFP (TQFP),Ball
	Grid Array(BGA), Plastic Leaded Chip Carrier(PLCC)
2.	Exploration of instruments, power supply and equipment (CO1)
	Experimenting with analog (MI and MC types) and digital meters. Fixed power
	supply, various power supply, function generator and oscilloscope
3.	Experimenting with breadboard and dotted board connections (CO2)
	Experimenting with circuit boardsand its internal connection such as bread board and
	dotted boards
4.	Practising soldering and desoldering procedures (CO3)
	Experimenting withcircuit board connection by practising soldering and removing the

- components from the PCB by desoldering 5. Development of schematic circuit (CO3)
- Passed in BoS Meeting 08.12.2018

Experimenting with software tool for schematic capture and developing schematic by knowing the specification of the circuit and functionality of the tool. Practicing on available library of components and working through wiring and schematic designing and making new component symbols

6. Investigation of Printed circuit Board (CO4) Understanding and investigation of the following: Various PCB Substrates:Standard FR-4 Epoxy Glass, Multifuctional FR-4, Tetra Functional FR-4, Cyanate Aster, Plyimide Glass, Teflon Term and keyword:Footprint, Pad stacks, Vias, Tracks, Color of Layers, PCB Track Size Calculation Formula Track rules: Track Length, Track Angle, Rack Joints, Track Size

PCB tool terms: Schematic Entry, Netlisting, PCB Layout Designing, Prototype Designing, Design Rule Check(DRC), Design For Manufacturing(DFM), PCB Making, Printing, Etching, Drilling

### 7. Development of PCB Layout design(CO4)

Connecting the schematic from the software netlist, Selecting the Components Footprints as per design, Picking and placing the Component, Making New Footprints, assigning Footprint to components

### 8. Practising PCB fabrication(CO5)

Printing the design, etching, drilling, interconnecting and packaging electronic circuits (IPC) standards, gerber Generation, soldering and desoldering, component mounting, PCB testing.

IPC Standard for Schematic Design, Designing, Materials, PCB Fabrication

### 9. Assembling components and packing procedures(CO5)

For the given PCB the components are fixed and assembled with safety measure in terms of human and components

**10. Practicing circuit in PCB testing procedures (CO6)** Continuity testing of PCB without components and output signal measurement procedures with components

#### Learning Resources

- 1. Teachers Soft copy manual for Electronic components and symbols
- 2. https://img.ozdisan.com/content/library/IC\_Packages.pdf
- 3. CAD for Schematic and PCB Design Software.
- 4. Printed circuit board design techniques for EMC compliance, a handbook for designers 2<sup>nd</sup> edition. Mark I.Montrose, Wily publication 2016
- 5. http://www.ipc.org/4.0\_Knowledge/4.1\_Standards/OEM-Standards/IPC-OEM-Stds-A4-English-1111-ONLINE.pdf

#### Course Designer

1. Dr,S.Md. Mansoor Roomi

smmroomi@tce.edu khh@tce.edu

2. Dr.K.Hariharan

<b>18CHAA0</b>	ENVIRONMENTAL SCIENCES	Category	L	Т	Ρ	Credit
IUUIIAAU		ES	1	0	1	-

#### Preamble

The objective of this course is intended to make the students to understand the basic concepts of environment, ecology and pollution of the current environmental issues and to participate in various activities on conserving and protecting the environment.

Prerequisite NIL

### Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome	Weightage***
Number		in %
CO1	Describe the importance and progression of ecological system	15%
CO2	Explain the significance of natural resources	10%
CO3	Demonstrate the effects of pollution on environment and human beings	15%
CO4	Practice the suitable management method during disaster episode	10%
CO5	Explain the ethics and values related to Environment	15%
CO6	Describe the Traditional values and Impact of modernization on Environment	10%
C07	Carry out group activities	25%

\*\*\* Weightage depends on Bloom's Level, number of contact hours,

### CO Mapping with CDIO Curriculum Framework

CO	TCE		L	_earr	ning	Doma	in Leve	el		С	DIO Cu	rricular	Compo	onents
#	Proficien	icy	Cogniti	ve	Aff	fective	Psy	chomoto	or			(X.Y.	Z)	
	Scale		-											
CO1	TPS2		Understa	and	Re	espond	Gu	ded		1.1,2	2.3.1,2.	3.2,2.3.	4	
							Re	sponse						
CO2	TPS2		Understa	and	Re	espond	Gu	ded		1.1,2	2.3.1,2.	3.2,2.3.	4	
							Re	sponse						
CO3	TPS3		Apply		Va	lue	Me	chanism	n 1.1,2.1.1,2.1.5,2.4.1,4.1.				1,4.1.2	
CO4	TPS3		Apply		Value Mechanis			chanism	n	1.1,2	2.4.1,2.	4.7,4.1.	1,4.1.2	
CO5	TPS2		Understa	and	Re	espond	Gu	ded		1.1,2	2.5.1,2.	5.2,		
						-	Re	sponse						
CO6	TPS2		Understa	and	Re	espond	Gu	ded		1.1,2	2.4.7,2.	5.4,		
						-	Re	sponse						
C07	TPS4		Analyse		Or	ganise	Co	nplex		3.1.1	1,3.1.2,	3.1.3,3.	1.4,4.1.	1,4.1.2
				,		-	Ov	ert						
							Re	sponses	5					
Марр	ing with F	Prog	ramme	Outo	com	es an	d Prog	ramme	Sp	pecifi	ic Outc	omes		
Cos	PO1	PO2	PO3	PO	4	PO5	PO6	PO7	F	PO8	PO9	PO10	P011	PO12

Cos	PUI	PUZ	P03	P04	PU5	PU0	P07	PU0	PU9	POIU	PUIT	PUIZ
CO1	М	-	-	-	-	L	S	-	-	-	-	-
CO2	М	-	-	-	-	L	-	L	-	-	-	-
CO3	М	М	-	-	L	M	S	-	-	-	-	-
CO4	М	-	L	L	L	M	М	-	-	-	-	-
CO5	L	-	-	-	-	-	-	M	-	-	-	-
CO6	L	L	-	-	-	-	M	-	-	-	-	-
CO7	S	M	M	M	M	M	-	-	S	M	М	-

S- Strong; M-Medium; L-Low

Assessment P	attern: Cog	Initive Do	main				
Cognitive	Cont	inuous As Tests	sessment S		Assignr	Terminal	
Levels	1	2	3	1	2	3	Examinati on***
Remember	0	20	0				
Understand	0	40	0				Presentation
Apply	0	40	0				on Case
Analyse	0	0	0		INA		study report
Evaluate	0	0	0	1			
Create	0	0	0				

# Assignment: Marks will be given for the review I, II & III of case study presentation.

Case study presentation and evaluation

- Each group comprises of maximum three students
- Students will submit the case study report similar to final year project report

Evaluation of case study presentation is based on the approved rubrics

#### Method of Evaluation

a)lı	a)Internal assessment									
S.No	Description	Max.marks	Final							
			conversion							
1	CAT -II	50	40							
2	Assignment marks (from Review I,II & III)	3 X 10 =30	10							
		Total	50							

b) End semester examination – Case study presentation									
Marks per Individual									
20									
20									
20									
40									
100									

#### Model Titles for Case Study:

- 1. Environmental impacts of quarry industries in Melur Taluk.
- 2. A study on impacts of tanneries on ground water and soil guality in Dindigul district.
- 3. Effect of pharmaceutical industry on groundwater quality in poikaraipatty village, Alagar Kovil.
- 4. Solid waste and waste water management in TCE hostel.
- 5. Environmental effect of Kudankulam atomic power plant.
- 6. Case study on effect of Sterlite industry.
- 7. Effect on ground water and soil quality by dyeing industries in Tiruppur.
- 8. Effect of textile wastes in Karur District.
- 9. Segregation of waste and its recycling by Madurai Municipality at Vellakkal
- 10. Effect of fire work waste on atmosphere in Sivakasi region

#### Sample Questions for Course Outcome Assessment\*\*

#### Course Outcome 1(CO1):

- 1. Describe the Universal Energy flow model in an Ecosystem.
- 2. Discuss the conversion of one ecosystem into another ecosystem with example.
- 3. Explain the multidisciplinary nature of the environment.

#### Course Outcome 2 (CO2):

- 1. Summarize the importance of Natural resources to animals and human beings.
- 2. Describe the role of an individual in the conservation of Natural resources.

#### Course Outcome 3(CO3):

- 1. Demonstrate the effects and control measures of air pollution
- 2. Investigate the sources and management methods of e-waste.

#### Course Outcome 4(CO4):

- 1. Dramatize the mitigation methods adopted in severe cyclone affected areas.
- 2. Suggest the precautionary steps to prevent life from flood.

#### Course Outcome 5 (CO5):

- 1. Discuss the need for public awareness on environmental protection.
- 2. Identify the requirement for the equitable utilization of natural resources.

#### Course Outcome 6(CO6):

- 1. Describe the traditional value systems of India.
- 2. Recall the environmental related points discussed in our Indian Vedas.
- 3. List out the impacts of modernization on environment

#### Concept map:



### Syllabus

**Environment and Ecosystem -** Multidisciplinary nature of environment- Ecosystem- Energy flow in ecosystem-Ecological succession-Over exploitation of Natural resources-Role of an individual in conservation of natural resources. **Environmental pollution and control -** Environmental pollution – types, causes, effects and control measures - Disaster management strategies. **Environmental Ethics and Values -** Social issues and the environment -need for public awareness, Environmental Ethics- need for equitable utilization of natural resources- Traditional value systems in India, Impacts of modernization on Environment

#### Awareness and actual activities:

- ✓ Group meeting on water management, promotion of recycle use, reduction of waste,
- ✓ Plantation
- ✓ Cleanliness drive
- ✓ Drive on segregation of waste
- ✓ Energy saving
- ✓ Lectures by Environmentalist
- ✓ Slogan and poster making event

#### Learning Resources

- 1. Kaushik,A & Kaushik.C.P, Environmental Science and Engineering, 6<sup>th</sup> Edition, New Age International, 2018.
- 2. Erach Bharucha, Text book of Environmental studies for Undergraduate courses, 2<sup>nd</sup> Edtion, UGC, 2013.

- 3. Gilbert M.Masters, Introduction to Environmental Engineering and Sciences, 2<sup>nd</sup> Edition, Pearson, 2004.
- 4. Garg S.K & Garg, Ecological and Environmental studies, Khanna Publishrers, 2006.
- 5. Wright &Nebel, Environmental science towards a sustainable future, 8<sup>th</sup> Editon,Prentice Hall of Indial Ltd, 2002.
- 6. Documentary titled "HOME" by Yves Bertrand, Video Link: https://www.youtube.com/watch?v=jqxENMKaeCU

Course C			
Module	Торіс	No. of	Course
No.		Hours	Outcome
1.0	Environment and Ecosystem		
1.1	Multidisciplinary nature of environment-Ecosystem	1	CO1
1.2	Energy flow in ecosystem – Universal energy flow	1	CO1
	model		
1.3	Ecological succession	1	CO1
1.4	Over exploitation of Natural resources	1	CO2
1.5	Role of individual in conservation of natural resources	1	CO2
2.0	Environmental pollution and control		
2.1	Environmental pollution – types( Air, Water,soil,Marine),	2	CO3
2.2	causes (gaseous, liquid, solid, plastic, e-waste, biomedical waste and radiations),	2	CO3
2.3	Effects and control measures of Pollution	2	CO3
2.4	Disaster managements during cyclone, Tsunami, flood, draught and earthquake	2	CO4
3.0	Environmental Ethics and Values		
3.1	Social issues and the environment -need for public	1	CO5
3.2	Environmental Ethics- need for equitable utilization of natural resources	1	CO5
3.3	Traditional value systems in India,	1	CO6
3.4	Impacts of modernization on Environment	2	CO6
4.0	Awareness and actual activities		
4.1	Group meeting on water management, promotion of recycle use, reduction of waste	2	CO7
4.2	Plantation	1	CO7
4.3	Cleanliness drive	1	CO7
4.4	Drive on segregation of waste	1	CO7
4.5	Energy saving	1	CO7
4.6	Lectures by Environmentalist	1	CO7
4.7	Slogan and poster making event	Through	CO7
		online	

#### Course Contents and Lecture Schedule

#### **Course Designers:**

1. Dr.M.Kottaisamy

ny hodchem@tce.edu

2. Dr.S.Rajkumar rajkumarsubramanium@tce.edu



### Vision and Mission of the Department

### Vision:

To empower the Electronics and Communication Engineering students with technological excellence, professional commitment and social responsibility.

### Mission:

- ME1. Attaining academic excellence in Electronics and Communication Engineering through dedication to duty, innovation in learning and research, state of the art laboratories and industry driven skill development.
- ME2. Establishing suitable environment for the students to develop professionalism and face life challenges with ethical integrity.
- ME3. Nurturing the students to understand the societal needs and equip them with technical expertise to provide appropriate solutions.
- ME4. Providing breeding ground to obtain entrepreneurial skills and leadership qualities for self and social growth.

### Program Educational Objectives (PEOs):

- PEO1. Graduates will be capable of developing specification and design procedures, prototyping and test methodologies for modern electronics and communication systems and gadgets that perform analog and digital processing functions.
- PEO2. Graduates will be able to work and adapt to changes in allied areas of Electronics and Communication Engineering through personal success and life long learning.
- PEO3. Graduates will be able to identify technological requirements for the society and provide cost effective solutions.
  - These objectives will be evidenced by professional visibility (publications, presentations, inventions, patents and awards), entrepreneurial activities, international activities (participation in international conferences, collaborative research and employment abroad)

### Program Outcomes: Engineering Graduates will be able to:

- 1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- 2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- 3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- 4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- 5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- 6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- 8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- 9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- 10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- 11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- 12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

### Program Specific Outcomes:

Engineering Graduates will be able to

- PSO1. Design circuits and systems for complex engineering problems in Electronics and Communication and allied areas.
- PSO2. Apply research methodologies to provide solutions for contemporary problems in the areas including RF, Signal Processing, Image Processing, VLSI, Optical Communication, Networks and Embedded Systems for given specifications.
- PSO3. Actively contribute as a member or leader in diverse teams, and communicate effectively on complex engineering activities and involve in life-long learning, by applying reasoning and ethical principles.

### PEO- Mission Mapping:

	ME1	ME2	ME3	ME4
PEO1	S	М	М	L
PEO2	L	S	М	М
PEO3	М	L	S	М

#### **PEO-PO-PSO Mapping:**

	P 0 1	P 0 2	P 0 3	P 0 4	P 0 5	P O 6	P O 7	P O 8	P O 9	P O 10	P 0 11	P O 12	PS O 1	PS O 2	PS O 3
PEO 1															
PEO 2															
PEO 3															

### **PO-GA Mapping:**

	GA	GA	GA	GA	GA	GA	GA	GA	GA	GA1	GA1	GA1
	1	2	3	4	5	6	7	8	9	0	1	2
PO1						ST	2 D					
PO2					R		1 d					
PO3							PI					
PO4					N	Condition of the second	8 M	5				
PO5						N. S.	de la	1				
PO6					1							
PO7												
PO8					/		1					
PO9					1			S.				
PO1												
0												
PO1												
1												
PO1												
2												

### TCE PROFICIENCY SCALE (CDIO Curriculum Framework)

TCE Proficiency Scale (TPS)	Proficiency	Cognitive	Affective	Psychomotor
TPS1	To have been exposed to	Remember	Receive	Perception, Set
TPS2	To be able to interpret and imitate	Understand	Respond	Guided Response
TPS3	To be skilled in the practice or implement	Apply	Value	Mechanism
TPS4	To be able to participate in and contribute	Analyse	Organise	Complex Overt Responses
TPS5	To be able to judge and adapt	Evaluate	Organise	Adaptation
TPS6	To be able to lead and innovate	Create	Characterize	Origination

S.No	Category	Cre	dits
		Regular	Lateral
А	Foundation Courses	53 — 58	23-28
	Humanities and Social Science (HSS)	9 -11	6-8
	Basic Science (BS)	21	6
	Engineering Science (ES)	23 – 26	11-14
В	Professional Core Courses	55	45
С	Elective Courses	24 – 48	24-48
	Programme Specific Elective	12-24	12-24
	Programme Elective for Expanded Scope	6 – 12	6-12
	General Elective	3-6	3-6
	Foundation Elective	3-6	3-6
D	Project work, seminar, internship in industry or at	15	15
	Higher Learning institutions		
E	Mandatory Courses – Environment Science,	Non-Credit	Non-Credit
	Induction Programme, Indian Constitution,	(Not included	(Not included
	Essence of Indian Tradition knowledge,	for CGPA)	for CGPA)
	consumer Affairs ( as per UGC guideline)		
	Minimum Credits to be earned for the award of	160	120
	the Degree	(from A to D)	(from A to D)
		and the	and the
	A SA SA	successful	successful
	r l l	completion of	completion of
	Contraction of the second	Mandatory	Mandatory
		Courses	Courses

#### **Credit Distribution**

- General electives are courses offered by different departments that do not have any prerequisites and could be of interest to students of any branch
- All students have to undertake co-curricular and extra-curricular activities that include activities related to NCC, NSS, Sports, Professional Societies, participation in identified activities which promote the growth of Departments and the College.

### THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015 (A Govt. Aided Autonomous Institution affiliated to Anna University)

### CATEGORIZATION OF COURSES (CHOICE BASED CREDIT SYSTEM)

A. I		ON COURSES: Total Cre	edits t	o be	earne	ed: {	53-58
	a. Hum	anities and Social Science (09-11)					
S.No.	Course	Name of the Course	Nu	ımbe	er of		Credit
	Code		Ηου	irs / \	Neek		
			L	Т	P		
THEOF	٦Y						
1.	18EG140	English	2	-	-		2
2.	18EC610	Accounting and Finance	3	-	-		3
3.	18EC490	Project Management	3	-	-		3
THEO	RY CUM PR	ACTICAL					
1.	18EG460	Professional Communication	-	1	2		2
PRAC	TICAL						
1.	18EG170	English Laboratory	-	-	2		1
	b. Basio	c Science (21)					
S.No.	Course	Name of the Course	Nur	nber	of Ho	urs	Credit
	Code			/ W	/eek		
					т	D	-
		A Canada A SA		.	I	Г	
			<u> </u>		1		1
1.	TOWATTU	Engineering Calculus	3	'	1	-	4
2.	18PHB20	Physics	3		-	-	3
3.	18CHB30	Chemistry	3		-	-	3
4.	18MA210	Matrices and Ordinary Differential	2	.	1	-	3
		Equations					
5.	18EC310	Complex Analysis and Linear Algebra	2	<u> </u>	1		3
6.	18EC410	Optimization and Numerical Methods	2		1		3
PRAC	TICAL	1					-
1.	18PH180	Physics Laboratory	-		-	2	1
2.	18CH190	Chemistry Laboratory	-		-	2	1
	c. Engi	neering Science (23-26)					
S.No.	Course	Name of the Course	N	lumb	er of		Credit
	Code		Ho	urs /	Weeł	<b>(</b>	
			L	Т	P		
THEO	<u> YY</u>	1					
1.	18ES150	Engineering Exploration	3	-	-		3
2.	18EC240	Semiconductor Physics	3	-	-		3
3.	18EC630	Data Structures and Algorithms	2	-	-		2
4.	18XXPE0	Engineering Sciences Elective	3	-	-		3
THEOR	<u>RY CUM PR</u>	ACTICAL					
1.	18ME160	Engineering Graphics	3	-	2		4
2.	18EC360	Programming for Problem Solving	2	-	2		3
3.	18ES390	Design Thinking	1	-	2		2
4.	18ES590	System Thinking	1	-	1		2
PRAC	TICAL						
1.	18EC280	Electronics Workshop	-	-	2		1
2.	18ES290	Lateral Thinking	-	-	2		1

Degree: B.E. Programme: ECE

Batch: 2018-19 onwards

18EC670

Data

Laboratory

Structures

and

Algorithms

3.

\_

-

2

1

### **Engineering Sciences Elective**

S.No.	Course	Name of the Course	Ν	Number of		Credit				
	Code		Hc	ours /	Week					
			L	Т	Р					
THEOF	THEORY									
1.	18ECEA0	MEMS Technology	3	-	-	3				
2.	18ECEB0	Machine Learning for All	3	-	-	3				
3.	18ECEC0	IOT Sensors and Device	3	-	-	3				
4.	18ECED0	Blockchain Technology	3	-	-	3				
5.	18ECEE0	5G Wireless Networks	3	-	-	3				
THEOF	THEORY CUM PRACTICAL									
	-	-	-	-	-	-				

### **B. PROFESSIONAL CORE COURSES**

### Credits to be earned: 55

SI. No.	Course Code	Name of the Course	Number of Hours /		er of s /	Credit
		TOT	١	Nee	k	
			L	T	Р	
THEOR	Y		-			
1.	18EC220	Network Theory	2	1	-	3
2.	18EC230	Electronic Devices	3	-	-	3
3.	18EC320	RF Passive Devices and Circuits	2	1	-	3
4.	18EC330	Electronic Circuits	3	-	-	3
5.	18EC340	Signals and Systems	2	1	-	3
6.	18EC350	Microprocessors and Microcontrollers	2	1	-	3
7.	18EC420	RF Active Circuits	2	1	-	3
8.	18EC430	CMOS VLSI Systems	3	-	-	3
9.	18EC440	Signal Processing	2	1	-	3
10.	18EC510	Data Communication Networks	2	1	-	3
11.	18EC530	Analog and Digital Communication	2	1	-	3
		Systems				
12.	18EC620	Control Systems	2	1	-	3
13.	18EC710	Consumer Electronics	1	-	-	1
THEOR	Y CUM PRAC	TICAL				
14.	18EC260	Digital System Design	2	-	2	3
15.	18EC520	Antenna and Wave Propagation	2	-	2	3
16.	18EC560	Digital Image Processing	2	-	2	3
17.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTI	CAL					
18.	18EC270	Circuits and Devices Laboratory	-	-	2	1
19.	18EC370	Microprocessor and Microcontroller	-	-	2	1
		Laboratory				
20.	18EC380	Electronic Circuits Laboratory	-	-	2	1
21.	18EC470	RF Circuits Laboratory	-	-	2	1
22.	18EC480	Signal Processing Laboratory	-	-	2	1
23.	18EC570	Data Communication Networking	-	-	2	1
		Laboratory				
24.	18EC580	Analog and Digital Communications	-	-	2	1

C. EL	. ELECTIVE COURSES: Credit			ear	med:	24-48
a. Pr	ogramme Specifi	c Elective Credits t	o be	earr	ned:12	2-24
SI. No.	Course Code	Name of the Course	Number Hours / Week		er of s / k P	Credit
THEOR	Ý		_			
1.	18ECPA0	Computer Vision and Applications	3	-	-	3
2.	18ECPB0	Data Compression	3	-	-	3
3.	18ECPD0	Wireless Communication Systems	2	1	-	3
4.	18ECPF0	FPGA Based Digital System Design	3	-	-	3
5.	18ECPH0	Electronic Measurement and	3	-	-	3
6.	18ECPJ0	Network Security	3	-	-	3
7.	18ECPK0	Optical Communication	3	-	-	3
8.	18ECPM0	Planar Antennas for Wireless Applications	2	-	2	3
9.	18ECPN0	Electromagnetic Interference and Compatibility	3	-	-	3
10.	18ECPQ0	Statistical Signal Processing	2	1	-	3
11.	18ECPT0	Deep Learning For Speech Processing	2	1	-	3
12.	18ECPU0	VLSI Device Modeling	3	-	-	3
13.	18ECPY0	ASIC Design	3	-	-	3
14.	18ECPZ0	oT System and Applications	3	-	-	3
15.	18ECRA0	Real Time Embedded Systems	3	-	-	3
THEOR	Y CUM PRACTIC	AL		1	1	1
16.	18ECPC0	DSP Architecture and Programming	2	-	2	3
17.	18ECPE0	Biomedical Signal Processing	2	-	2	3
18.	18ECPG0	Analog System Design	2	-	2	3

b. Program	b. Programme Elective for Expanded Scope Credits t						6-12
SI. No.	Course Code	Name of the Course		Nu H L	mbe ours Vee T	er of s / k P	Credit

THEORY						
1.	18ECPL0	Medical Imaging and Processing	3	-	-	3
2.	18ECPP0	RF MEMS Design and Technology	3	-	-	3
3.	18ECPR0	LDPC and Polar Codes	2	1	-	3
4.	18ECPS0	Physical Channel Processing in 5G NR	2	1	-	3
5.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3
6.	18ECPW0	CAD for VLSI	3	-	-	3
7.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3
8.	18ECRC0	Multimedia Compression Techniques	3	1	-	4
9.	18ECRD0	Signal Processing in 5G NR	3	1	-	4
10.	18ECRE0	Algorithms for VLSI Design Automation	3	1	-	4
11.	18ECRF0	Low Power VLSI Design	3	1	-	4
12.	18EC1A0	Field Tests for a 5G Future	1	-	-	1
13.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1
14.	18EC1C0	Synchronization for 5G NR	1	-	-	1

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

15.	18EC1D0	Speech Signal Processing	1	-	-	1			
16.	18EC1E0	VLSI Implementation of	1	-	-	1			
		Communication Transceivers							
17.	18EC1F0	Embedded System Design	1	-	-	1			
THEORY CUM PRACTICAL									
	-	-	-	-	-	-			

c. General Elective

### Credits to be earned: 03-06

SI. No.	Course Code	Name of the Course	Number of Hours / Week		Credit	
			L	Т	Ρ	
THEORY						
1.	18ECGA0	Consumer Electronics	3	-	-	3
2.	18ECGB0	Multimedia Systems	3	-	-	3
3.	18ECGD0	Telecom Systems	3	-	-	3
4.	18ECGE0	Applied Image Processing	3	-	-	3

### d. Electives from foundation courses- HSS, BS, ES

### D. Project

### Credits to be earned: 15

Credits to be earned: 03-06

S.No.	Course Code	Name of the Course	Nu Hou	Number of Hours / Week		Credit
		and the second sec	L	Т	Р	
1.	18ES690	Engineering Design Project	2	-	4	3
2.	18ES790	Capstone Design Project	-	-	6	3
3.	18EC810	Project	-	-	18	9
		a second				

E. M	E. Mandatory Courses (Not included for CGPA)										
S.No.	Course	Name of the Course	Νι	ımbe	r of	Credit					
	Code		Hou	irs / V	Veek						
			L	Т	P						
THEOR	THEORY										
1.	18CHAA0	Environmental Sciences	-	-	2	0					
2.	18CHAB0	Constitution of India	-	-	2	0					
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0					
THEOR	Y CUM PRA	CTICAL									
-	-	-	-	-	-	-					
PRACT	PRACTICAL										
-	-	-	-	-	-	-					

Minimum credits to be earned for the award of the degree = 160

Batch: 2021-22 onwards

### THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015 (A Govt. Aided Autonomous Institution affiliated to Anna University)

### CATEGORIZATION OF COURSES (CHOICE BASED CREDIT SYSTEM)

Programme: ECE

F. F	F. FOUNDATION COURSES: Total Credits to be earned: 53-58									
	d. Huma	anities and Social Science (09-11)								
S.No.	Course	Name of the Course	Νι	umbe	r of		Credit			
	Code		Hou	ırs / \	Veek					
			L	Т	P					
THEOF	RY									
1.	18EG140	English	2	-	-		2			
2.	18EC610	Accounting and Finance	3	-	-		3			
3.	18EC490	Project Management	3	-	-		3			
THEOF	RY CUM PR	ACTICAL								
1.	18EG460	Professional Communication	-	1	2		2			
PRAC	TICAL									
1.	18EG170	English Laboratory	-	-	2		1			
	e. Basio	c Science (21)								
S.No.	Course	Name of the Course	Nur	nber	of Ho	urs	Credit			
	Code			/ W	eek					
				<u>і т</u>		D	_			
	<b>&gt;</b> V	A Canada A SA		•	•	1				
	18MA110	Engineering Calculus	3		1	_	4			
1.					-					
2.	18PHB20	Physics	3		-	-	3			
3.	18CHB30	Chemistry	3		-	-	3			
4.	18MA210	Matrices and Ordinary Differential	2	.	1	-	3			
5	18EC310	Complex Analysis and Linear Algebra	2	,	1		3			
6	18EC410	Ontimization and Numerical Methods	2	·	1		3			
PRAC				·	•					
1	18PH180	Physics Laboratory			-	2	1			
1.	18CH190	Chemistry Laboratory	-		-	2	1			
<u> </u>	f Engi	peering Science (23-26)				-	<u> </u>			
S No	Course	Name of the Course	N	lumb	er of		Credit			
0.110.	Code		Ho	urs /	Week		oroun			
				T	P	<u> </u>				
THEOF	ΥΥ					_				
1.	18ES150	Engineering Exploration	3	-	-		3			
2.	21EC240	Electronic Materials	3	_	-		3			
3.	18EC630	Data Structures and Algorithms	2	_	-		2			
4.	18XXPE0	Engineering Sciences Elective	3	_	-		3			
THEOF		ACTICAL		1	1					
1.	18ME160	Engineering Graphics	3	_	2		4			
2.	18EC360	Programming for Problem Solving	2	-	2		3			
3.	18ES390	Design Thinking	1	-	2		2			
4.	18ES590	System Thinking	1	-	1		2			
PRACT	TICAL			1						
1.	18EC280	Electronics Workshop	-	-	2		1			
2	18ES290	Lateral Thinking	-	-	2		1			

18EC670

Data

Laboratory

Structures

and

Algorithms

3.

Degree: B.E.

Approved in 61th Academic Council Meeting 03.07.2021

-

-

2

1

### **Engineering Sciences Elective**

S.No.	Course	Name of the Course	۸. I	Number of		Credit				
	Code		HC	urs /	Week					
			L	Т	Р					
THEOF	THEORY									
1.	18ECEA0	MEMS Technology	3	-	-	3				
2.	18ECEB0	Machine Learning for All	3	-	-	3				
3.	18ECEC0	IOT Sensors and Device	3	-	-	3				
4.	18ECED0	Blockchain Technology	3	-	-	3				
5.	18ECEE0	5G Wireless Networks	3	-	-	3				
THEOF	THEORY CUM PRACTICAL									
	-	-	-	-	-	-				

### G. PROFESSIONAL CORE COURSES

### Credits to be earned: 55

SI. No.	Course	Name of the Course	Number of			Credit
	Code	AT BAL	H	lours	s /	
		1 STRIN	۱ ۱	Nee	k	
			L	T	Р	
THEOR'	Ý					
25.	18EC220	Network Theory	2	1	-	3
26.	18EC231	Electronic Devices	3	-	-	3
27.	18EC320	RF Passive Devices and Circuits	2	1	-	3
28.	18EC330	Electronic Circuits	3	-	-	3
29.	18EC340	Signals and Systems	2	1	-	3
30.	18EC350	Microprocessors and Microcontrollers	2	1	-	3
31.	18EC420	RF Active Circuits	2	1	-	3
32.	18EC430	CMOS VLSI Systems	3	-	-	3
33.	18EC440	Signal Processing	2	1	-	3
34.	18EC510	Data Communication Networks	2	1	-	3
35.	18EC530	Analog and Digital Communication	2	1	-	3
		Systems				
36.	18EC620	Control Systems	2	1	-	3
37.	18EC710	Consumer Electronics	1	-	-	1
THEOR	Y CUM PRAC	TICAL				
38.	18EC260	Digital System Design	2	-	2	3
39.	18EC520	Antenna and Wave Propagation	2	-	2	3
40.	18EC560	Digital Image Processing	2	-	2	3
41.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTI	CAL					
42.	18EC270	Circuits and Devices Laboratory	-	-	2	1
43.	18EC370	Microprocessor and Microcontroller	-	-	2	1
		Laboratory				
44.	18EC380	Electronic Circuits Laboratory	-	-	2	1
45.	18EC470	RF Circuits Laboratory	-	-	2	1
46.	18EC480	Signal Processing Laboratory	-	-	2	1
47.	18EC570	Data Communication Networking	-	-	2	1
		Laboratory				
48.	18EC580	Analog and Digital Communications	-	-	2	1
		Laboratory				

H. EL	H. ELECTIVE COURSES: Cred		s to be earned: 24-48						
a. Pr	a. Programme Specific Elective Credits			to be earned:12-24					
SI. No.	Course Code	Name of the Course	Nu H	mbe lour: Nee	er of s / k	Credit			
	-		L	T	Р				
THEORY									
19.	18ECPA0	Computer Vision and Applications	3	-	-	3			
20.	18ECPB0	Data Compression	3	-	-	3			
21.	18ECPD0	Wireless Communication Systems	2	1	-	3			
22.	18ECPF0	FPGA Based Digital System Design	3	-	-	3			
23.	18ECPH0	Electronic Measurement and Instruments	3	-	-	3			
24.	18ECPJ0	Network Security	3	-	-	3			
25.	18ECPK0	Optical Communication	3	-	-	3			
26.	18ECPM0	Planar Antennas for Wireless Applications	2	-	2	3			
27.	18ECPN0	Electromagnetic Interference and Compatibility	3	-	-	3			
28.	18ECPQ0	Statistical Signal Processing	2	1	-	3			
29.	18ECPT0	Deep Learning for Speech Processing	2	1	-	3			
30.	18ECPU0	VLSI Device Modeling	3	-	-	3			
31.	18ECPY0	ASIC Design	3	-	-	3			
32.	18ECPZ0	IoT System and Applications	3	-	-	3			
33.	18ECRA0	Real Time Embedded Systems	3	-	-	3			
THEORY CUM PRACTICAL									
34.	18ECPC0	DSP Architecture and Programming	2	-	2	3			
35.	18ECPE0	Biomedical Signal Processing	2	-	2	3			
36.	18ECPG0	Analog System Design	2	-	2	3			

### b. Programme Elective for Expanded Scope Credits to be earned: 06-12

SI. No.	Course Code	Name of the Course	Number of Hours /		Credit				
	-		Week						
			L	Т	P				
THEORY									
18.	18ECPL0	Medical Imaging and Processing	3	-	-	3			
19.	18ECPP0	RF MEMS Design and Technology	3	-	-	3			
20.	18ECPR0	LDPC and Polar Codes	2	1	-	3			
21.	18ECPS0	Physical Channel Processing in 5G	2	1	-	3			
		NR							
22.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3			
23.	18ECPW0	CAD for VLSI	3	-	-	3			
24.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3			
25.	18ECRC0	Multimedia Compression Techniques	3	1	-	4			
26.	18ECRD0	Signal Processing in 5G NR	3	1	-	4			
27.	18ECRE0	Algorithms for VLSI Design	3	1	-	4			
		Automation							
28.	18ECRF0	Low Power VLSI Design	3	1	-	4			
29.	18EC1A0	Field Tests for a 5G Future	1	-	-	1			

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021
30.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1	
31.	18EC1C0	Synchronization for 5G NR	1	-	-	1	
32.	18EC1D0	Speech Signal Processing	1	-	-	1	
33.	18EC1E0	VLSI Implementation of	1	-	-	1	
		Communication Transceivers					
34.	18EC1F0	Embedded System Design	1	-	-	1	
THEORY CUM PRACTICAL							
	-	-	-	-	-	-	

d. General Elective Credits to be earned: 0					ed: 0	3-06
SI. No.	Course	Name of the Course	Number of			Credit
	Code		H	Hours /		
			Week			
			L	Т	Р	
THEORY	•					
5.	18ECGA0	Consumer Electronics	3	-	-	3
6.	18ECGB0	Multimedia Systems	3	-	-	3
7.	18ECGD0	Telecom Systems	3	-	-	3
8.	18ECGE0	Applied Image Processing	3	-	-	3

d. Electives from foundation courses- HSS, BS, ES Credits to be earned: 03-06

## I. Project

## Credits to be earned: 15

S.No.	Course	Name of the Course	Number of			Credit		
	Code	Sardin a	Hou	Hours / Week				
			L	Т	Р			
1.	18ES690	Engineering Design Project	2	-	4	3		
2.	18ES790	Capstone Design Project	-	-	6	3		
3.	18EC810	Project	-	-	18	9		

J. N	landatory Co	urses (Not included for CGPA)					
S.No.	Course	Name of the Course	Nu	umbe	r of	Credit	
	Code		Hou	ırs / V			
			L	Т	P		
THEOR	Y						
1.	18CHAA0	Environmental Sciences	-	-	2	0	
2.	18CHAB0	Constitution of India	-	-	2	0	
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0	
THEOR	Y CUM PRAG	CTICAL					
-	-	-	-	-	-	-	
PRACT	PRACTICAL						
-	-	-	-	-	-	-	

Minimum credits to be earned for the award of the degree = 160

c C ts		22	8	22	22	22
Audit Courses (Mandato ry Non- credit}	12	1	18CHAA0 Environm ental Sciences (0)		18CHAB0 Constituti on of India (0)	Essence of Indian Knowledg e (0)
Special Courses	11	1	18ES290 Lateral Thinking (1)	18ES390 Design Thinking (TCP) (2)	18EC490 Project Managem ent (3)	18ES590 System Thinking (2)
	10	18CH19 0 Chemist ry Lab. (1)			•	
Practical	9	18PH180 Physics Lab. (1)	18EC280 Workshop (1)	18EC380 Electronic Circuits Lab (1)	18EC480 Signal Processin g Lab (1)	18EC580 Analog and Digital Commn. Lab (1)
	8	18EG170 English Lab. (1)	18EC270 Circuits and Devices Lab (1)	18EC370 Microproc essor and Microcont roller Lab (1)	18EC470 RF Circuits Lab (1)	18EC570 Data Commn. Networkin g Lab `(1)
Theory cum Practical	7	18ME160 Engg Graphics (4)	18EC260 Digital System Design (3)	18EC360 Programmin g for Problem Solving (3)	18EG460 Professional Communicat ion (2)	18EC560 Digital Image Processing (3)
	9	L.			•	1
	5	18ES150 Engg Explorati on (3)	No.	18EC350 Micropro cessors and Microcont rollers (3)	18YYFX0 Foundati on Elective I (3)	18YYGX 0 Gen. Elective .I (3)
	4	18EG180 English (2)	18EC240** Semicondu ctor Physics (3)	18EC340 Signals and Systems (3)	18EC440 Signal Processing (3)	18ECPX0 Prog. Elective -I (3)
Theory	3	18CHB 30 Chemistry (3)	18EC230** Electronic Devices (3)	18EC330 Electronic Circuits (3)	18EC430 CMOS VLSI Systems (3)	18EC530 Analog and Digital Communicat ions (3)
	2	18PHB20 Physics (3)	18EC220 Network Theory (3)	18EC320 RF Passive Devices and Circuits (3)	18EC420 RF Active Circuits (3)	18EC520 Antenna and Wave Propagatio n (TCP) (3)
	1	18MA110 Engineering Calculus (4)	18MA210 Matrices and Ordinary Differential Equations (3)	18EC310 Complex Analysis and Linear Algebra (3)	18EC410 Optimization and Numerical Methods (3)	18EC510 Data Communicat ion Networks (3)
Se est er	5	_	=	≡	≥	>

SCHEDULING OF COURSES FOR 2018-19 onwards (B.E. ECE Programme)\*

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

B.E. (Electronics and Communication Engineering)

Cr edi ts		23	16	15
Audit Courses (Mandato ry Non- credit}	12	•	1	1
Special Courses	11	18ES690 Engineeri ng Design Project (3)	18ES790 Capstone Design (3) (3)	1
	10		1	18EC81 0 Project (9)
Practical	6	1	1	1
	8	18EC670 Data Structures and Algorithm s Lab (1)		1
Theory cum Practical	7	18EC660 Digital Communicat ion System Design (2)		-
	9	Engg Scienc es (3)		-
	5	18ECPX 0 Prog. Elective/ 18YYFX0 Foundati on Elective II (3)	18ECPX 0 Prog. Elec. VI/ 18YYFX0 General Elective (3)	-
	4	18ECPX0 Prog. (3) (3)	18ECPX0 Prog. Elec.V (3)	1
Theory	3	18EC630 Data Structures and Algorithms (2)	18ECPX0 Prog. Elec IV (3)	
	2	18EC620 Control Systems (3)	18ECPX0 Prog. Elec.III (3)	18XXPX0 Prog. Elec. VIII (3)
	1	18EC610 Accounting and Finance (3)	18EC710 Consumer Electronics (1)	18XXPX0 Prog. Elec. VII (3)
Se est er	5	⋝	T	IIN

Total Credits for Curricular Activities: 160 \*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & \*This schedule shows an optimal way of completing the B.E. Degree programme successfully in 4 Years 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

## THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI - 625 015

## B.E Degree (Electronics and Communication Engineering) Program

## COURSES OF STUDY

(For the students admitted from the Academic year 2018-19 onwards)

#### **FIRST SEMESTER**

Course code	Name of the Course	Category	Number of Hours / Week		Credits					
			L	Τ	Ρ					
THEORY	THEORY									
18MA110	Engineering Calculus	BS	3	1	-	4				
18PHB20	Physics	BS	3	I	-	3				
18CHB30	Chemistry	BS	3	I	-	3				
18EG140	English	HSS	2	I	-	2				
18ES150	Engineering Exploration	ES	3	I	-	3				
THEORY CL	IM PRACTICAL									
18ME160	Engineering Graphics	ES	3	I	2	4				
PRACTICAL										
18EG170	English Laboratory	HSS	-	-	2	1				
18PH180	Physics Laboratory	BS	-	I	2	1				
18CH190	Chemistry Laboratory	BS	-	-	2	1				
Total         17         1         8										

## SECOND SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week		Credits	
			L	Т		
THEORY						
18MA210	Matrices and Ordinary Differential	BS	2	1	-	3
	Equations					
18EC220	Network Theory	PC	2	1	-	3
18EC230**	Electronic Devices	PC	3	-	-	3
18EC240**	Semiconductor Physics	ES	3	-	-	3
THEORY CL	JM PRACTICAL					
18EC260	Digital System Design	PC	2	-	2	3
PRACTICAL	-					
18EC270	Circuits and Devices Laboratory	PC	-	-	2	1
18EC280	Electronics Workshop	ES	-	-	2	1
18ES290	Lateral Thinking	ES	-	-	2	1
Non-credit co	ourse (Mandatory) – Audit Course					
18CHAA0	Environment Sciences	ES	1	-	1	-
	Total		13	2	9	18

\*\*For students joined from 2021-22 onwards,

18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

## THIRD SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits
			L	Т	Ρ	
THEORY						
18EC310	Complex Analysis and Linear Algebra	BS	2	1	-	3
18EC320	RF Passive Devices and Circuits	PC	2	1	-	3
18EC330	Electronic Circuits	PC	3	-	-	3
18EC340	Signals and Systems	PC	2	1	-	3
18EC350	Microprocessors and Microcontrollers	PC	2	1	-	3
THEORY C						
18EC360	Programming for Problem Solving	ES	2	-	2	3
18ES390	Design Thinking	ES	1	-	2	2
PRACTICA	<u>L</u>					
18EC370	Microprocessor and Microcontroller Laboratory	PC	-	-	2	1
18EC380	Electronic Circuits Laboratory	PC	-	-	2	1
	Total		14	4	8	22
FOURTH SE	EMESTER					
			Number of			
Course	Name of the Course	Category	Nu	Imbei	r of	Credits
Course code	Name of the Course	Category	Nu Hou	imbei irs / V	r of Veek	Credits
Course code	Name of the Course	Category	Nu Hou L	imbei irs / V T	r of Veek P	Credits
Course code THEORY	Name of the Course	Category	Nu Hou L	Imbei Irs / V T	r of Veek P	Credits
Course code THEORY 18EC410	Name of the Course Optimization and Numerical Methods	Category BS	Nu Hou L	Imbei Irs / V T	r of Veek P -	Credits 3
Course code THEORY 18EC410 18EC420	Name of the Course Optimization and Numerical Methods RF Active Circuits	Category BS PC	Nu Hou L 2 2	Imbei Irs / V T 1 1	r of Veek P -	Credits 3 3
Course code THEORY 18EC410 18EC420 18EC430	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems	Category BS PC PC	Nu Hou L 2 3	Imbei Irs / V T 1 1 -	r of Veek P - -	Credits 3 3 3
Course code THEORY 18EC410 18EC420 18EC430 18EC440	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing	Category BS PC PC PC	Nu Hou 2 2 3 2	Imbei Irs / V T 1 - 1	r of Veek P - - -	Credits 3 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC420 18EC440 18YYFX0	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing Foundation Elective I	Category BS PC PC PC BS	Nu Hou 2 2 3 2 3	Imbei Irs / V T 1 1 - 1	r of Veek P - - - -	Credits 3 3 3 3 3 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490	Name of the CourseOptimization and Numerical MethodsRF Active CircuitsCMOS VLSI SystemsSignal ProcessingFoundation Elective IProject Management	Category BS PC PC PC BS HSS	Nu Hou 2 2 3 2 3 3 3 3	Imbei Irs / V T 1 - 1 - -	r of Veek P - - - - - -	Credits 3 3 3 3 3 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490 THEORY C	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL	Category BS PC PC PC BS HSS	Nu Hou L 2 3 2 3 3 3	Imbei Irs / V T 1 1 - 1 -	r of Veek P - - - - - - - - -	Credits 3 3 3 3 3 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC430 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460	Name of the CourseOptimization and Numerical MethodsRF Active CircuitsCMOS VLSI SystemsSignal ProcessingFoundation Elective IProject ManagementCUM PRACTICALProfessional Communication	Category BS PC PC BS HSS HSS	Nu Hou L 2 3 2 3 3 3 -	Imbei Irs / V T 1 1 - 1 - -	r of Veek P - - - - - - - 2	Credits 3 3 3 3 3 3 2
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460 PRACTICA	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication	Category BS PC PC PC BS HSS HSS	Nu Hou 2 2 3 2 3 3 -	Imbei Irs / V T 1 - 1 - - 1	r of Veek P - - - - - - 2	Credits 3 3 3 3 3 2 2
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         RF Circuits Laboratory	Category BS PC PC PC BS HSS HSS	Nu Hou 2 2 3 2 3 3 -	Imbei Irs / V T 1 1 - 1 - 1 - -	r of Veek P - - - - - 2	Credits 3 3 3 3 3 2 1
Course code THEORY 18EC410 18EC420 18EC430 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC470	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory	Category BS PC PC PC BS HSS HSS PC PC	Nu Hou L 2 3 2 3 3 - -	Imbei Irs / V T 1 1 - 1 - 1 - - - -	r of Veek P - - - - - - 2 2 2	Credits 3 3 3 3 3 2 1 1 1
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC480 AUDIT CO	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory         URSE - NON-CREDIT MANDATORY COM	Category BS PC PC PC BS HSS HSS PC PC JRSE	Nu Hou L 2 3 2 3 3 3 - -	Imbei Irs / V T 1 1 - 1 - 1 - 1 - -	r of Veek P - - - - - - 2 2 2	Credits 3 3 3 3 3 2 1 1 1
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC480 AUDIT CO 18CHAB0	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory         URSE - NON-CREDIT MANDATORY CON         Constitution of India	Category BS PC PC PC BS HSS HSS PC PC JRSE HSS	Nu Hou 2 2 3 2 3 3 - - - -	Imbei Irs / V T 1 1 - 1 - 1 - - - - -	r of Veek P - - - - - 2 2 2 2	Credits 3 3 3 3 3 2 1 1 0

## **FIFTH SEMESTER**

Course code	Name of the Course	Category	Number of Hours / Week		Credits				
			L	Т	Ρ				
THEORY	THEORY								
18EC510	Data Communication Networks	PC	2	1	-	3			
18EC530	Analog and Digital Communication	PC	2	1	-	3			
	Programme Elective -I	DE	3			3			
	Conoral Elective		2	-	-	3			
THEORY		GE	5	-	-	5			
18EC520	Antenna and Wave Propagation	PC	2	_	2	3			
1950560	Digital Imaga Processing		2	-	2	3			
10EC000	Digital image Processing	PC		-	2	3			
18ES590	System Thinking	ES	1	-	1*	2			
PRACTICA	NL								

18EC570	Data Communication Networking	PC	-	-	2	1				
1950590	Appled and Digital Communications	PC			2	1				
TOEC300		FC	-	-	2	I				
	Cooper of Indian Knowledge				0	0				
INCHACU		<u> пээ</u>	-	-		0				
	lotal		15	2	11	22				
*One hour p	er week is allotted for off the classroom w	ork								
SIXTH SEM	ESTER	1	1							
Course	Name of the Course	Category	Nu	Imbei	r of	Credits				
code			Hou	<u>rs / V</u>	Veek					
			L	T	Ρ					
THEORY										
18EC610	Accounting and Finance	HSS	3	-	-	3				
18EC620	Control Systems	PC	2	1	-	3				
18EC630	Data Structures and Algorithms	ES	2	-	-	2				
18ECPX0	Programme Elective-II	PE	3	-	-	3				
18YYZX0	Programme / Foundation Elective - I	PE/FE	3	-	-	3				
18ESEX0	Engineering Sciences Elective	ES	3	-	-	3				
THEORY C	CUM PRACTICAL									
18EC660	Digital Communication Transceiver	PC	1	-	2	2				
PRACTICA	\L									
18EC670	Data Structures and Algorithms	ES	-	-	2	1				
	Laboratory									
PROJECT										
18ES690	Engineering Design Project	Project	1	-	4	3				
	Total		18	1	8	23				

## SEVENTH SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week		Credits	
			L	Т	P	
THEORY						
18EC710	Consumer Electronics	PC	1	-	-	1
18ECPX0	Programme Elective -III	PE	3	-	-	3
18ECPX0	Programme Elective -IV	PE	3	-	-	3
18ECPX0	Programme Elective -V	PE	3	-	-	3
18YYZX0	Programme-VI / General Elective - II	PE/GE	3	-	-	3
THEORY C	CUM PRACTICAL					
-	-	-	-	-	-	-
PRACTICA	\L					
-	-	-	-	-	-	-
PROJECT						
18ES790	Capstone Design Project	Project	-	-	6	3
	Total		13	-	6	16

## **EIGHTH SEMESTER**

Course code	Name of the Course	Category	Nu Hou	mber rs / V	Credits	
			L	Т		
THEORY						
18ECPX0	Programme Elective -VII	PE	3	-	-	3
18ECPX0	Programme Elective -VIII	PE	3	-	-	3
THEORY C	CUM PRACTICAL					
-	-	-	-	-	-	-
PRACTICA	\L					
-	-	-	-	-	-	-
PROJECT						
18EC810	Project	Project	-	-	18	9
	Total		6	-	18	15

- BS : Basic Science
- HSS : Humanities and Social Science
- ES : Engineering Science
- PC : Programme Core
- PE : Programme Elective
- GE : General Elective
- FE : Foundation Elective
- L : Lecture
- T : Tutorial
- P : Practical

## Note:

- 1 Hour Lecture/week is equivalent to 1 Credit
- 1 Hour Tutorial/week is equivalent to 1 Credit
- 2 Hours Practical/week is equivalent to 1 Credit

## THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E Degree (Electronics and Communication Engineering) Program SCHEME OF EXAMINATIONS

(For the students admitted from the Academic Year 2018-19 onwards) **SECOND SEMESTER** 

Course	Name of the	Duration	Ν		Minimum	Marks	
code	Course	Torminal	Continuouo	Terminel	Max	Torminal	Tatal
			Continuous		Max.		Total
		Exam	Assessment	Exam**	Marks	Exam	
		In Hrs.					
THEORY	1						
18MA210	Matrices and	3	50	50	100	25	50
	Ordinary						
	Differential						
	Equations						
18EC220	Network	3	50	50	100	25	50
	Theory	_				_	
18EC230***	Electronic	3	50	50	100	25	50
	Devices						
18EC240***	Semiconductor	3	50	50	100	25	50
	Physics						
THEORY CU	M PRACTICAL	•				•	
18EC260	Digital System	3	50	50	100	25	50
	Design						
PRACTICAL	• • • •	•	•	•	•	•	
18EC270	Circuits and	3	50	50	100	25	50
	Devices						
	Laboratory						
18EC280	Electronics	3	50	50	100	25	50
	Workshop						
18ES290	Lateral	_	50	50	100	25	50
	Thinking						
AUDIT COUI	RSE - NON-CRED	IT MANDA	TORY COURS	E	1	1	1
18CHAA0	Environmental	-	50	50	100	25	50
	Sciences						

\*\*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

## THIRD SEMESTER

Course	Name of the	Duration			Minimum	Marks	
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY							
18EC310	Complex Analysis and Linear Algebra	3	50	50	100	25	50
18EC320	RF Passive Devices and Circuits	3	50	50	100	25	50
18EC330	Electronic Circuits	3	50	50	100	25	50
18EC340	Signals and Systems	3	50	50	100	25	50

18EC350	Microprocessors	3		50		50	100	25	50
	and Microcontrollers								
THEORY									
18EC360	Programming for	3		50		50	100	25	50
	Problem Solving								
18ES390	Design Thinking	-		50		50	100	25	50
PRACTICA	AL							1	1
18EC370	Microprocessor	3		50		50	100	25	50
	and Microcontrollor								
18EC380	Electronic	3		50		50	100	25	50
1020000	Circuits	J J		00			100	20	
	Laboratory								
FOURTH SI	EMESTER	·							
Course	Name of the	Duration of	of		I	Marks		Minimum	Marks
code	Course	End		0 "				for Pass	
		Semester		Continuous	*	End	Max.	End	Iotal
		Exam\		Assessmer	IT.	Semeste	er Marks	Semester	
THEORY									
18EC410	Optimization	3		50		50	100	25	50
1020110	and Numerical	U		00			100	20	00
	Methods								
18EC420	RF Active	3		50		50	100	25	50
	Circuits								
18EC430	CMOS VLSI	3		50		50 100		25	50
4050440	Systems	0		50		50	100	05	50
18EC440	Signal	3		50		50	100	25	50
18YYEX0	Foundation	3		50		50	100	25	50
	Flective I	0		50		00	100	20	50
18EC490	Project	3		50		50	100	25	50
	Management								
THEORY O	CUM PRACTICAL							•	
18EG460	Professional	-		50		50	100	25	50
	Communication								
PRACTICA		•		50		50	400	05	50
18EC4/0		3		50		50	100	25	50
1950490	Laboratory	2		50		50	100	25	50
10EC400	Processing	3		50		50	100	25	50
	Laboratory								
AUDIT CO	URSE - NON-CRE	DIT MANDA	ТС	RY COURS	E	1		1	I
18CHAB0	Constitution of	-		50		50	100	25	50
	India								

## **FIFTH SEMESTER**

						1	
Course code	Name of the Course	Duration of End	ſ	Varks		for Pass	Marks
		Semester Exam\ in Hrs.	Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY						•	•
18EC510	Data Communication Networks	3	50	50	100	25	50
18EC530	Analog and Digital Communication Systems	3	50	50	100	25	50
18ECPX0	Programme Elective -I	3	50	50	100	25	50
18YYGX0	General Elective - I	3	50	50	100	25	50
THEORY C		L. L			1	•	-
18EC520	Antennas and Wave Propagation	3	50	50	100	25	50
18EC560	Digital Image Processing	3	50	50	100	25	50
18ES590	System Thinking	-	50	50	100	25	50
PRACTICA	L					•	•
18EC570	Data Communication Networking Laboratory	3	50	50	100	25	50
18EC580	Analog and Digital Communications Laboratory	3	50	50	100	25	50
AUDIT COU	JRSE - NON-CREDI	T MANDATO	DRY COURSE			•	
18CHAC0	Essence of Indian Knowledge	-	50	50	100	25	50
SIXTH SEME	ESTER	1					
Course code	Name of the Course	Duration of End		Marks		Minimum for Pass	Marks
		Semester Exam\ in Hrs.	Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY	1			1			
18EC610	Accounting and Finance	3	50	50	100	25	50
18EC620	Control Systems	3	50	50	100	25	50
18EC630	Data Structures and Algorithms	3	50	50	100	25	50
18ECPX0	Programme Elective -II	3	50	50	100	25	50
18YYZX0	Programme / Foundation Elective - I	3	50	50	100	25	50

18ESEX0	Engineering	3	50	50	100	25	50
THEORY C							
18EC660	Digital	3	50	50	100	25	50
1020000	Communication	U	00	00		20	
	System Design						
PRACTICA	L				I		1
18EC670	Data Structures	3	50	50	100	25	50
	and Algorithms	_				_	
	Laboratory						
Project		•				•	
18ES690	Engineering	-	50	50	100	25	50
	Design Project						
SEVENTH S	EMESTER						
Course	Name of the	Duration	1	Marks		Minimum	Marks
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY		-					
18EC710	Consumer	3	50	50	100	25	50
(0505)(0	Electronics			=	100		
18ECPX0	Programme	3	50	50	100	25	50
			50	50	100	05	50
18ECPX0	Programme	3	50	50	100	25	50
	Dregromme	2	50	50	100	25	50
TOECFAU		3	50	50	100	25	50
187770		3	50	50	100	25	50
1011270		5	50	50		25	50
Project							I
18ES790	Capstone Design	_	50	50	100	25	50
1020100	Project			00	100	20	00
EIGTH SEME	ESTER				I		
Course	Name of the	Duration		Marks		Minimum	Marks
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY					•	•	
18ECPX0	Programme	PE	3	-	-	3	-
	Elective -VII						
18ECPX0	Programme	PE	3	-	-	3	50
	Elective -VIII						
Project							
18FC810	Project	-	50	50	100	25	50

\*Continuous Assessment evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\*End Semester Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of End semester examination marks.

\*\*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

18EC310	COMPLEX ANALYSIS AND LINEAR	Category	L	Т	Ρ	Credit
	ALGEBRA	BS	2	1	0	3

## Preamble

An engineering UG student needs to have some basic mathematical tools and techniques to apply in diverse applications in Engineering. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this, the course aims to give a thorough knowledge on complex analysis and vector spaces, students get to know about analytic functions, complex integration and dimensions and linear independence and work on any dimensional spaces. It helps to work in complex domain in their required field.

#### Prerequisite

NIL

## Course Outcomes

On the su	uccessful completion of the course, students will be able to	
CO#	Course Outcome Statement	Weightage in %
CO1.	Discuss about differentiation and C-R equations	10%
CO2.	Predict an analytic function, when its real or Imaginary part is	20%
	known. Calculate the Singularities and its corresponding	
	Residues for the given function.	
CO3.	Predict the suitable method to evaluate the Contour integration.	20%
CO4.	Use visualization, spatial reasoning, as well as geometric	10%
	properties and strategies to model, solve problems, and view	
	solutions, especially in $R^2$ and $R^3$ , as well as conceptually	
	extend these results to higher dimensions.	
CO5.	Use rank- nullity theorem to find where the object lies entirely.	20%
CO6.	Use orthogonal matrix to rotate objects in a two or three	20%
	dimensional space.	

## **CO Mapping with CDIO Curriculum Framework**

CO	TCE	Lear	ning Domain	Level	CDIO Curricular
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale	0			(X,Y,Z)
CO1	TPS2	Understand	Respond	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO2	TPS3	Apply	Value	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO3	TPS3	Apply	Value	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO4	TPS2	Understand	Respond	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO5	TPS3	Apply	Value	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO6	TPS3	Apply	Value	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1

COs	PO	PO	<b>P</b> O	PO	<b>DSU</b>	DSU	DSO								
003	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	S	S	S	М	S	-	S	S	-	-	-	S	-	-
CO2	S	S	S	М	М	S	L	S	S	-	-	-	S	-	-
CO3	S	S	S	S	М	S	-	S	S	-	-	-	S	-	-
CO4	S	S	S	S	М	S	М	S	S	-	-	-	S	-	-
CO5	S	S	S	S	М	S	М	S	S	-	-	-	S	-	-
CO6	S	S	S	S	М	S	М	S	S	-	-	-	S	-	-

## **Mapping with Programme Outcomes**

S- Strong; M-Medium; L-Low

**Assesment Pattern: Cognitive Domain** 

Cognitive Levels	Co As	ontinuo sessmo Tests	us ent		End Semester		
	1	2	3	1	2	3	Examination
Remember	10	10	10	-	-	-	0
Understand	20	20	20	A	-	-	30
Apply	70	70	70	100	100	100	70
Analyse	0	0	0	11	h 1 -	-	0
Evaluate	0	0	0	MG ACO	PA	-	0
Create	0	0	0		11-1	-	0

#### **Course Level Assessment Questions**

## Course Outcome 1 (CO1):

- 1. Identify whether  $\overline{z}$  is analytic or not?
- 2. Examine whether the following function satisfies C-R equations or not:  $u = x^2y - x$ ,  $v = y^2x - y$ .

## Course Outcome 2 (CO2)

- 1. Find the analytic function w = u + iv where  $u = e^{v} \cos x$
- 2. Find the image of the rectangular region in the z-plane bounded by the lines x=0, y=0,
   a. x=2 & y=1 under the transformation w = z+2-i
- 3. Expand in Laurent's series about z=0 , f(z) =  $(z-1)\sin(\frac{1}{z})$

4. Find the singularities of 
$$f(z) = \frac{z^2 + 4}{z^3 + 2z^2 + 2z}$$
 and the corresponding residues

#### Course Outcome 3 (CO3)

1. Evaluate 
$$\int_{0}^{\infty} \frac{x \sin x dx}{x^2 + a^2}$$
, by contour integration.

2. Evaluate 
$$\int_{-\infty}^{\infty} \frac{x^2 dx}{(x^2+1)(x^2+4)}$$

## Course Outcome 4 (CO4)

- 1. Show that  $R^{m \times n}$ , together with the usual addition and scalar multiplication of matrices, satisfies the eight axioms of a vector space.
- 2. Let  $x_1$ ,  $x_2$ , and  $x_3$  be linearly independent vectors in  $\mathbb{R}^n$  and let

 $y_1 = x_1 + x_2$ ,  $y_2 = x_2 + x_3$ ,  $y_3 = x_3 + x_1$ . Are  $y_1$ ,  $y_2$ ,  $y_3$  linearly independent? Prove your

#### answer.

## Course Outcome 5 (CO5)

- 1. Let S be the subspace of  $P_3$  consisting of all polynomials of the form  $ax^2 + bx + 2a + 3b$ . Find a basis for S.
- 2. Show that if U and V are subspaces of  $\mathbb{R}^n$  and  $U \cap V = \{0\}$ , then  $\dim(U+V) = \dim U + \dim V$ .
- 3. Let A and B be  $m \times n$  matrices. Show that  $rank(A+B) \le rank(A) + rank(B)$

## Course Outcome 6 (CO6)

- 1. Determine the distance from the point (2,0,0) to the plane x + 2y + 2z = 0.
- 2. Determine the least square solution of the system  $x_1 + x_2 = 3$ ,  $-2x_1 + 3x_2 = 1$ ,  $2x_1 x_2 = 2$ .
- 3. Show that the functions x and  $x^2$  are orthogonal in  $P_5$  with inner product defined by

$$\langle p,q \rangle = \sum_{i=1}^{n} p(x_i)q(x_i)$$
 where  $x_i = \frac{(i-3)}{2}$  for  $i = 1,2,...5$ .

**Concept Map** 



## Syllabus

**Complex Variable – Differentiation**: Differentiation, Cauchy-Riemann equations, Analytic functions, Harmonic functions, finding harmonic conjugate, Conformal mappings-standard transformations, Conformal transformations. **Complex Variable – Integration:** Cauchy theorem (without proof), Cauchy Integral formula (without proof), Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral. **Vector Spaces**: Vector space, Subspaces, linear independence of vectors, basis, dimension, Row space, Column space, Rank and nullity theorem. **Orthogonality**: Orthogonal subspaces, Least square problem, Inner product spaces, Orthonormal sets, The Gram-Schmidt orthogonalization process.

## Learning Resources

- 1. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., McGraw Hill, 2004.
- 2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36thEdition, 2010.
- 3. Steven.J.Leon, "Linear Algebra with Applications", 8<sup>th</sup> edition, Pearson, 2010.
- 4. David.C.Lay, "Linear Algebra and its applications", Pearson Addison Addison Wesley, 3<sup>rd</sup> edition, 2006.

## **Course Contents and Lecture Schedule**

Modul	Торіс	No. of Lecture	CO's
e No		Hours	
1	Complex Variable – Differentiation		
1.1	Differentiation, Cauchy-Riemann equations	1	CO1
1.2	Analytic functions	1	CO2
1.3	Harmonic functions, finding harmonic conjugate	2	CO2
1.4	Tutorial	1	
1.5	Conformal mappings-standard transformations	2	CO2
1.6	Conformal transformations	1	CO2
	Tutorial	1	
2	Complex Variable – Integration		
2.1	Cauchy theorem (without proof), Cauchy Integral formula (without proof)	1	CO3
2.2	Taylor's series, zeros of analytic functions, singularities	2	CO3
	Tutorial	1	
2.3	Laurent's series	2	CO3
2.4	Residues, Cauchy Residue theorem (without proof)	1	CO3
2.5	Evaluation of definite integral	2	CO3
	Tutorial	1	
3	Vector Spaces		
3.1	Vector space, Subspaces	2	CO4
3.2	Linear independence of vectors, basis, dimension	1	CO4
	Tutorial	1	
3.3	Row space, Column space	1	CO4
3.6	Rank and nullity theorem	2	CO5
	Tutorial	1	
4	Orthogonality		
4.1	Orthogonal subspaces	1	CO6
4.2	Least square problem	1	CO6
4.3	Inner product spaces	2	CO6
	Tutorial	1	
4.4	Orthonormal sets	1	CO6
4.5	The Gram-Schmidt orthogonalization process	2	CO6
	Tutorial	1	
	Total	36	

## Course Designers:

1. Dr.M.Mutharasan

2. Dr.S.P.Suriya Prabha

3. Mr.R.Sivakumar

mmmat@tce.edu suriyaprabha @tce.edu rsrmat@tce.edu

18	EC320

Category	L	Т	Ρ	Credit
PC	2	1	0	3

#### Preamble

This course aims to provide students with the technological skills needed in understanding the behaviour of two wire line, planar transmission lines and the design of RF passive circuits.

## Prerequisites

NIL

#### **Course Outcomes**

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Understand the RF front end in a GSM cellular phone and the	20
	allied RF signal parameters	
CO2	Understand and characterize transmission lines and calculate	10
	the transmission and reflection parameters	
CO3	Design and Develop a microstrip transmission line and its	10
	variants and its feed mechanisms	
CO4	Design and validate power divider and coupler	20
CO5	Design and validate filters for GSM frequencies	20
CO6	Apply the concepts of power divider, and filter to develop a	20
	duplexer for a GSM RF front end applications.	
	ALL CARDEN DA	

## **CO Mapping with CDIO Curriculum Framework**

CO	TCE	Learning Domain Level			CDIO Curricular
#	Proficiency	Cognitive	Affective	Psychomoto	Components
	Scale			r	(X.Y.Z)
CO1	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.4.7, 4.1.4
CO2	TPS2	Understand	Respond	-25.	1.2, 2.1.1, 2.4.7, 4.1.4
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4, 3.1.1,
					3.1.2, 3.1.4, 3.2.1, 3.2.6,
					3.2.4, 3.2.5, 3.2.6, 3.3.1,
					4.1.2 ,4.3.4, 4.4.3, 4.5.2,
					4.5.3, 4.5.5
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4, 3.1.1,
					3.1.2, 3.1.4, 3.2.1, 3.2.6,
					3.2.4, 3.2.5, 3.2.6, 3.3.1,
					4.1.2, 4.3.4, 4.4.3, 4.5.2,
					4.5.3, 4.5.5
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4, 3.1.1,
					3.1.2, 3.1.4, 3.2.1, 3.2.6,
					3.2.4, 3.2.5, 3.2.6, 3.3.1,
					4.1.2, 4.3.4, 4.4.3, 4.5.2,
					4.5.3, 4.5.5
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4,
					3.1.1, 3.1.2, 3.1.4, 3.2.1,
					3.2.6, 3.2.4, 3.2.5, 3.2.6,
					3.3.1, 4.1.2, 4.3.4, 4.4.3,
					4.5.2, 4.5.3, 4.5.5

## Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	M	L	-	-	-	L	-	L	L	-	-	-	M	-	L
CO2	M	L	-	-	-	L	-	L	L	-	-	-	M	-	L
CO3	S	Μ	L	-	М	L	-	Μ	М	-	-	-	M	-	М
CO4	S	Μ	L	-	М	L	-	Μ	М	-	-	-	M	-	М
CO5	S	Μ	L	-	М	L	-	Μ	М	-	-	-	M	-	М
CO6	S	М	L	-	М	L	-	М	М	-	-	-	М	-	М

S- Strong; M-Medium; L-Low

#### **Assessment Pattern: Cognitive Domain**

Cognitive Levels	Contir	nuous Ass Tests	sessment		Assignme	End Semester Examination			
	1	2	3	1	2	3			
Remember	20	20	20	0	0	0	0		
Understand	20	20	20	100	0	0	20		
Apply	60	60	60	0	50	25	80		
Analyse	0	0	0	0	0	0	0		
Evaluate	0	0	0	0	0	0	0		
Create	0	0	0	0	0	0	0		

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	for the second	-	-
Set	Salen V	-	-
Guided Response	-		-
Mechanism		50	75
Complex Overt Responses	C	-	-
Adaptation		-	-
Origination	-	-	-

一個人

#### **Course Level Assessment Questions**

## Course Outcome 1 (CO1)

- 1. Illustrate the behaviour of inductors and capacitors under high frequency circumstances
- 2. Calculate the following as desired: -20dBm to watts and 1nW to dBm
- 3. If the reflection coefficient is 0.4, calculate the VSWR.

## Course Outcome 2 (CO2)

- 1. A radio transmitter is connected to an antenna having an impedance of  $80+j40\Omega$  with a  $50\Omega$  coaxial cable. If the  $50\Omega$  transmitter can deliver 30W when connected to a  $50\Omega$  load, how much power delivered to the antenna?
- A 75Ω coaxial transmission line has a length of 2 cm and is terminated with a load impedance of 37.5+j75Ω. If the dielectric constant of the line is 2.56 and the frequency is 3.0 GHz, find the input impedance to the line, reflection coefficient at the load, the reflection coefficient at the input and the SWR on the line.
- 3. A lossless transmission line of electrical length I =  $0.3\lambda$  is terminated with a complex load impedance as shown below. Find the reflection coefficient at the load, the SWR on the line, the reflection coefficient at the input of the line and the input impedance to the line.

## Course Outcome 3(CO3)

- 1. Justify, why microstrip lines cannot support pure TEM mode of propagation.
- 2. Classify planar transmission lines with their mode of propagation and field Variations.
- 3. Design a micro strip for a 75ohm characteristic impedance and a 90 degree phase shift at 3.5 GHz. The substrate thickness is d = 0.127 cm with  $\mathcal{E}r = 2.20$ .

## Course Outcome 4(CO4)

- 1. A lossless T junction power divider has a source impedance of 50 ohms. Find the output characteristic impedances so that the input power is divided in a 2:1 ratio. Compute the reflection coefficients seen looking into the output ports.
- 2. A directional coupler has the scattering matrix given below. Find the return loss, coupling factor, directivity, insertion loss. Assume that the ports are terminated in matched loads.

	[ 0.1∠40°	0.944/90°	0.178∠180°	0.0056290° T
- 121	0.944/90°	0.1∠40°	0.0056∠90°	0.178∠180°
[2] =	0.178∠180°	0.0056/90°	0.1∠40°	0.944/90°
	0.0056/90°	0.178∠180°	0.944/90°	0.1∠40°

3. A 20 dBm power sorce is connected to the input of a directional coupler having a coupling factor of 20dB, a directivity of 35dB and an insertion of 0.5 dB. If all the ports are matched find the output powers (in dBm) at the through, coupled and isolated ports.

## Course Outcome 5(CO5)

- 1. Design a maximally flat low pass filter with a cut-off frequency of 2 GHz, impedance 50  $\Omega$ , and at least 15 dB insertion loss at 3 GHz.
- 2. Design a stepped impedance low pass filter having a maximally flat response and a cut off frequency of 2.5 GHz. It is necessary to have more than 20 dB insertion loss at 4 GHz, the filter impedance is  $50\Omega$ , the highest impedance is  $150\Omega$  and the lowest is  $10 \Omega$ .
- 3. Design a high-pass lumped-element filter with a 3 dB equal-ripple response, a cutoff frequency of 3 GHz, and at least 30 dB insertion loss at 2.0 GHz. The characteristic impedance is 75 ohms. Use CAD to plot the insertion loss versus frequency

## Course Outcome 6(CO6)

- 1. Design a bandpass filter having 0.5 dB equal ripple response with N=3.The Center frequency is 1GHz, the fractional bandwidth 10% and the impedance is 50  $\Omega$ .
- 2. Design a band pass filter with a single resonant circuit for a center frequency of 500MHz and a desired 3 dB bandwidth of 50 MHz. Use a  $50\Omega$  source and  $50\Omega$  load terminations. Also show the changes caused by finite component Q<sup>°</sup>s of 80 at 500MHz. Plot the response and show the changes from 450 MHz to 550 MHz.
- 3. Design a duplexer for GSM applications

#### Sample Assignments:

**Assignment 1:** Design and simulation of Microstrip line for a given impedance.

Assignment 2: Design, simulate, & measure the power divider, coupler and filter for GSM (or) Cellular applications..

Assignment 3: Mini Project: Design a duplexer for GSM (or) Cellular applications Concept Map



## Syllabus:

Introduction: Cellular phone architecture - blocks and functionalities. High frequency effects: RF/Microwaves versus DC or Low AC signals, Wave concepts - Wavelength and Frequency, EM Spectrum-frequency allocation for various applications, Power units - dB and dBm, dBm – Watt conversions, high frequency behaviour of electronic Components– Wire, Resistor, Capacitor, Inductor, Equivalent voltage and current at RF frequency, Impedance and matching, VSWR, reflection and transmission coefficient, S parameters of a two port network, Cascaded networks - Practical examples. RF front end - Sub systems transmission lines, active &, passive components, role of RF in communication with respect to modulation/demodulation - case study -GSM cellular application - air interface specifications - GSM, GSM upgrades to 4G - RF in 5G and IOT applications, Measurements using Spectrum analyser. Transmission Lines: Need for two wire Transmission Line, Lumped element circuit model for a transmission line- Wave propagation on a transmission line, Terminated lossless line & Quarter wave transformer, Types of transmission line - coaxial, waveguide, microstrip, stripline, coplanar waveguide, Synthesis of a transmission line for a given impedance. Synthesis of Microstrip transmission line for a given impedance. RF Resonators: Series and parallel resonant circuits, Loaded and unloaded Q, Transmission line resonators, Power dividers: Need for Power dividers, Basic properties of dividers, Equal and unequal power dividers. Couplers: Need for couplers, Basic properties of couplers, Principle and working of Quadrature 90° and Rat race 180° couplers. Design & Simulation of a power divider to split an incoming GSM signal from 930-960 MHz into two RF channels. Filters: Need for filters and practical applications, filter parameters, types of filters, Filter design by insertion loss method, finding the order of filter, Butterworth and Chebyshev filter transformations, Impedance and frequency scaling, lumped filters, Stepped impedance lowpass filter design. Design & Simulation of filters for GSM/5G wireless applications. Duplexers: Need for duplexers, specifications for a GSM front end, Layout, Design and simulation of a duplexer with power divider and filters for GSM. Identification of real world components and preparation of detailed schematics with loss and frequency Charts - Mini project.

## Learning Resources:

- 1. Matthew M. Radmanesh, "Radio frequency and Microwave Electronics Illustrated", Pearson Education Asia, 2001
- 2. David M. Pozar," Microwave Engineering," John Wiley & Sons, Fourth Edition, 2015.
- 3. Les Besser and Rowan Gilmore, "Practical RF circuit Design for Modern Wireless Systems- Passive circuits and Systems", Vol.1, Artech House Publishers, Boston, London 2008.
- 4. G L Matthaei, L Young, and E M T Jones ," Microwave filters, impedance matching networks and coupling structures", Artech House, 1985.
- Grish Kumar, microwave theory and techniques, NPTEL Video Lectures: https://www.youtube.com/watch?v=gH4bCRvBgBg&list=PLOzRYVm0a65dcxLJgO0uzQ 0Sad-57w37u&index=3

<u> </u>		I • •		
#	Торіс	Lect	Practi	CO
		ure	ce	Number
		Hour	Hour	
<u> </u>		riour	Tiour	
1	Introduction: Cellular phone architecture – blocks and	1	1	CO1
	functionalities			
2	High frequency effects: RF/Microwaves versus DC or	1	1	CO1
	Low AC signals, Wave concepts - Wavelength and			
	Frequency EM Spectrum-frequency allocation for			
	various applications			
2.2	<b>Power units</b> - dB and dBm, dBm – Watt conversions	1		CO1
2.3	High frequency behaviour of electronic Components-	1		CO1
	Wire, Resistor, Capacitor, Inductor.			
L		I		1

## **Course Contents and Lecture Schedule**

2.4	Equivalent voltage and current at RF frequency,	1		CO2
	Impedance and matching, VSWR, reflection and			
25	transmission coefficient	4		<u> </u>
2.5	<b>S parameters</b> of a two poil network, Cascaded networks	1		
	transmission lines active & passive components role of			
	RE in communication with respect to			
	modulation/demodulation			
26	Case study –GSM cellular application - air interface		2	CO2
	specifications - GSM, GSM upgrades to 4G – RF in 5G		-	
	and IOT applications. Measurements using Spectrum			
	analyser.			
3	Transmission Lines: Need for two wire Transmission	1	1	CO1, CO2,
	Line, Lumped element circuit model for a transmission			CO3
	line- Wave propagation on a transmission line,			
	Terminated lossless line & Quarter wave transformer,			
3.2	Types of transmission line – coaxial, waveguide,	1	2	CO3
	microstrip, stripline, coplanar waveguide, <b>Synthesis of</b>			
	Microstrip transmission line for a given impedance –			
	Assignment I			001.000
4	<b>RF Resonators:</b> Series and parallel resonant circuits,	1		C01, C02,
4.2	Loaded and unioaded Q, Transmission line resonators,.	2	1	
4.2	properties of dividers. Equal and upoqual power dividers	2		
	properties of dividers, Equal and direqual power dividers.			
43	Couplers: Need for couplers Basic properties of	1	1	
	couplers. Principle and working of Quadrature 90° and	-	-	CO3. CO4
	Rat race 180° couplers.			
4.4	Design & Simulation of a power divider to split an		2	CO4
	incoming GSM signal from 930-960 MHz into two RF			
	channels – Assignment II			
5	Filters: Need for filters and practical applications, filter	1		CO1, CO2,
	parameters, types of filters,			
5.2	Filter design by insertion loss method, finding the order	1	1	
	or liller, Bullerworth and Chebysnev liller			CO3,
			-	
5.3	Design of lumped filter model,	1	1	CO5
5.4	Stepped Impedance lowpass filter design.	1	1	005
5.5	Design & Simulation of filters for GSM/5G wireless		2	05
6	Duplovars: Nood for duplovors, specifications for a GSM	1		CO1 CO2
0	front end Layout model	'		
62	Design and simulation of a duplexer with power divider	1	1	CO6
0.2	and filters for GSM	•		
6.3	Identification of real world components and preparation	1		CO6
	of detailed schematics with loss and frequency Charts			
6.4	Mini project – Assignment III		2	CO6
Cou	rse Designers:			•

1. Dr.S.Raju

rajuabhai@tce.edu

- 2. Dr.S.Kanthamani skmece@tce.edu
- 3. Dr.A.Thenmozhi

thenmozhi@tce.edu

18EC330	ELECTRONIC CIRCUITS	Category	L	Т	Ρ	Credit
		PC	3	0	0	3

#### Preamble

Having attained the basic knowledge about the principle of operation of semiconductor electronic devices like diodes, transistors and elementary circuits in the second semester, this course will enable the students to learn about the use of transistors in analog circuits like single and multi stage amplifier, feedback amplifier, Differential amplifier, power amplifier and oscillators. It also gives information about the current mirror circuits used for biasing in Integrated Circuits and their applications in the field of electronics industry.

#### Prerequisite

18EC230 Electronic Devices

#### **Course Outcomes**

On the successful completion of the course students will be able to

COs	Course Outcome Statement	Weightage*** in %
CO1	Analyze Input resistance, Output resistance, Voltage gain, and Current gain of the Single stage amplifiers and Multistage Amplifiers	20
CO2	Analyze the low frequency response and high frequency response of Single stage and Multi stage amplifiers.	15
CO3	Derive and analyze the expressions for voltage gain, input impedance of voltage series, voltage shunt, current series and current shunt negative feedback amplifiers ,RC and LC Oscillators	20
CO4	Derive the equation for power output and conversion efficiency of Class A ,Class B and Class C of large signal amplifiers.	15
CO5	Analyze the open loop and closed loop response of OP-AMP	10
CO6	Understand and explain the operation of Instrumentation amplifier, A/D –D/A converters, Active filters	10
C07	Design of Multivibrators, ,Mixer circuits, VCO and PLL	10

\*\*\* Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

CO	TCE	L	earning Dor	nain Level	CDIO Curricular Components
#	Proficien	Cognitive	Affective	Psychomotor	(X.Y.Z)
	cy Scale	_			
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1,
					3.2.3, 4.5.5, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1,
					3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1,
					3.2.3, 4.5.5, 4.6.2
CO4	TPS4	Analyse	Organise	Complex Overt	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1,
				Responses	3.1.1, 3.2.3, 4.5.5, 4.6.2
CO5	TPS4	Analyse	Organise	Complex Overt	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1,
				Responses	3.1.1, 3.2.3, 4.5.5, 4.6.2
CO6	TPS4	Analyse	Organise	Complex Overt	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1,
		-	_	Responses	3.1.1, 3.2.3, 4.5.5, 4.6.2
C07	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1,
					3.1.1, 3.2.3, 4.5.5, 4.6.2

## Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	Μ	L	-	L	-	-	L	L	L	-	L	M	-	L
CO2	S	Μ	L	-	L	-	-	L	L	L	-	L	M	-	L
CO3	S	Μ	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	S	Μ	L	L	-	-	L	L	L	-	L	S	-	L
CO5	M	L	-	-	-	-	-	-	L	L	-	L	S	-	L
CO6	S	S	Μ	М	L	-	-	-	-	-	-	-	S	-	-
CO7	S	М	L	-	L	-	-	L	L	L	-	L	M	-	L

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

Cognitive	us Tests	A	Assignme	nt	End Semester		
Levels	1	2	3	1	2	3	Examination
Remember	20	0	0	-	-	-	0
Understand	20	20	20	-	-	-	20
Apply	60	50	40	100	50	-	40
Analyse	0	30	40	0	50	50	40
Evaluate	0	0	0	0	0	20	0
Create	0	0	0	0	0	0	0

## Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment 3
	FW CON MA
Perception	La La Maria
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

## Sample Questions for Course Outcome Assessment Course Outcome 1(CO1):

- 1. Design an common emitter amplifier with emitter degenerative resistance to operate between a 10K  $\Omega$  source and a 2K  $\Omega$  load with a gain of -8 V/V. the power supply available is 9V. Use an emitter current of 2 mA and a current of about one-tenth of that in the voltage divider that feeds the base, with the dc voltage at the base about one-third of the supply. The transistor  $\beta$ =100.
- 2. Design an audio amplifier (common emitter circuit) with an voltage gain of 10. The circuit uses a 12 V power supply. The input impedance of the amplifier should be about 15K, the same as the potentiometer from which the audio was taken. The impedance of the stereo amplifier's auxiliary input is about 50K.
- 3. Explain how h parameter can be obtained from the transistor characteristics.

## Course Outcome 2(CO2):

- 1. Determine the critical frequency of the bypass RC circuit for the amplifier in figure.( $r_e=12\Omega$ )
- 2. Determine the high frequency response of the amplifier.
- 3. Determine the low frequency response of the amplifier.

## Course Outcome 3(CO3):

- In a bridge rectifier, the input is from 230V, 50HZ mains. Calculate the d.c., the output voltage. If a capacitor of 1000µF is used as a filter with this rectifier while supplying a load of 2kΩ. Calculate the ripple factor and the output voltage.
- 2. Explain how FET can be used as an amplifier.

3. Derive the expression of the output voltage and explain how it can be varied for the feedback type series regulator.

## Course Outcome 4 (CO4):

- 1. Draw and explain the working of class C tuned amplifier
- 2. A certain B amplifier delivers 10W to the load. The output transform efficiency is 85% .A CRO connected across the load of 0,5  $\Omega$  in series with positive lead of the 24V power supply shows a peak voltage of 500mV. Determine the efficiency.
- 3. An ideal class B amplifier supplies power to a load of  $4\Omega$  connected through a step down transform with turns ratio 4:1 and efficiency of 90%.Calculate
  - (a) Maximum power delivered to load

(b) Power dissipation ratings of each transistor. Assume VCC=20V and gives turns ratio asN1/N2 .

## Course Outcome 5 (CO5):

- 1. Determine the output voltage of an op-amp for the input voltages of  $V_1$ =150 $\mu$ V, $V_2$ =140 $\mu$ V. The amplifier has a differential gain of 4000 and the value of CMRR is (i) 100 (ii)10<sup>5.</sup>
- 2. For a differential amplifier, the two sets of input are applied. The first set is V1=50μV and V2= -50μV and the second set is V1=1050μV and V2=950μV. If the CMRR is 100, calculate the percentage difference in the output voltage obtained for the two sets of the input signals. If now CMRR is improved to 10000, Calculate the percentage difference in the output voltage obtained for the two sets of the input signal.

## Course Outcome 6(CO6):

- 1. What is the main purpose of an instrumentation amplifier.
- 2. A certain op-amp has an open loop gain of 80,000.The maximum saturated output levels of this particular device are 12V. If a differential voltage of 0.15mV rms is applied between the input, what is the peak-to-peak value of the output?
- 3. How is the gain determined in a basic instrumentation amplifier? In a certain AD622 configuration, Rg=10KΩ.What is the voltage gain?

## Course Outcome 7(CO7):

- 1. Construct a 555 timer configured to run in the astablemode(oscillator). Determine the frequency of the output and the duty cycle.
- 2. Discuss aastable operation of the 555timer and explain how to use the 555 timer as a VCO?



## Syllabus

**Single Stage and Multistage Amplifiers:**Biasing Scheme, Compensation Techniques, Small Signal h-model analysis, Midband analysis, Low frequency analysis, Hybrid  $\pi$ equivalent circuit, High frequency analysis, **Feedback Amplifiers and Oscillators:**voltage/ current, series/shunt feedback, Oscillators:Colpitts, Hartley's, Phase shift, Wein bridge and crystal oscillators.**Power amplifiers :** Class A, B, AB, C **Operational Amplifier:**Ideal OP-AMP, Differential Amplifier, Constant Current Source(Current Mirror), Open and Closed loop Circuits,Inverting and Non-Inverting amplifiers, Voltage follower, Buffer circuit, DC Imperfections, Transient and Frequency dependent performance, Applications:Adder, Integrator and Differentiator, Comparator, Schmitt Trigger, Instrumentation Amplifier, Log and Anti-Log Amplifiers, A/D –D/A converters, Active Filters.**Multivibrators and Special Functional Circuits:** Monostable,Bistable,Astable multi vibrators using 555 timer,Mixer circuits,VCO and PLL.

## **Text Books**

- 1. Adel S. Sedra and Kenneth C. Smith, "Microelectronic Circuits: Theory and Application", 7<sup>th</sup> Edition, Oxford University Press, 2017.
- 2. SerigoFranco, "Design with Operational Amplifiers &Analog Integrated Circuits", 4<sup>th</sup> edition, McGraw Hill,2014.
- 3. Boylested&Nashelsky, "Electronic Devices and Circuit Theory", 11th edition, Pearson Education India, 2015.
- 4. BehzardRazavi, "Fundamentals of Microelectronics", 2<sup>nd</sup> Edition, Wiley, 2014.
- 5. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-012microelectronic-devices-and-circuits-fall-2009/readings/
- 6. NPTEL video lecture on "Analog Electronic Circuits" https://nptel.ac.in/courses/108102095/

## **Course Contents and Lecture Schedule**

Module	Торіс	No. of	Course
No.		Hours	Outcome
1.	SINGLE STAGE AND MULTISTAGE AMPLIFIERS		
1.1	Biasing Scheme,	1	CO1
1.2	Compensation Techniques	2	CO1
1.3	Small Signal h-model analysis	2	CO1
1.4	Midband analysis,	2	CO2
1.5	Low frequency analysis	1	CO2
1.6	Hybrid $\pi$ equivalent circuit	1	CO2
1.7	High frequency analysis	1	CO2
2.	FEEDBACK AMPLIFIERS AND OSCILLATORS		
2.1	voltage/ current feedback	2	CO3
2.2	series/shunt feedback	2	CO3
2.3	Oscillators: Colpitts, Hartley's	2	CO3
2.4	Phase shift, Wein bridge and crystal oscillators.	2	CO3
3.	POWER AMPLIFIERS		
3.1	Class A	1	CO4
3.2	Class B	1	CO4
3.3	Class AB	1	CO4
3.4	Class C	1	CO4
4.	OPERATIONAL AMPLIFIER		
4.1	Ideal OP-AMP, Differential Amplifier, Constant Current	2	CO5
	Source(Current Mirror)		
4.2	Open and Closed Loop Circuits, Inverting and Non-	1	CO5
	Inverting amplifiers		
4.3	Voltage follower, Buffer circuit, DC Imperfections	1	CO5
4.4	Transient and Frequency dependent performance	1	CO5

4.5	Adder, Integrator and Differentiator, Comparator	1	CO6
4.6	Schmitt Trigger, Instrumentation Amplifier,	2	CO6
4.7	Log and Anti-Log Amplifiers, A/D –D/A converters	1	CO6
	Active Filters		
5.	MULTIVIBRATORS AND SPECIAL FUNCTIONAL		
	CIRCUITS		
5.1	Monostable, Bistable, Astable multi vibrators using 555	2	CO7
	timer		
5.2	Mixer circuits	1	CO7
5.3	VCO and PLL	2	CO7
	Total Hours	36	

## **Course Designers:**

- 1. Dr. N.B. Balamurugan
- 2. Dr. V. Vinoth Thyagarajan
- 3. Dr.K.Kalyani
- 4. Dr.S.Rajaram
- 5. Dr.D.Gracia Nirmala Rani
- 6. Dr.V.R.Venkatasubramani
- nbbalamurugan@tce.edu vvkece@tce.edu k\_kalyani@tce.edu rajaram\_siva@tce.edu gracia@tce.edu venthiru@tce.edu



18EC340	SIGNALS AND SYSTEMS	Category	L	Т	Р	Credit
		PC	2	1	0	3

## Preamble

Signals and Systems arise in a wide variety of fields, and the ideas and techniques associated with these concepts play an important role in areas of science and technology as communications, aeronautics and astronautics, acoustics, seismology, biomedical engineering and speech processing. Signals are functions of one or more independent variables, contain information about the behaviour or nature of some phenomenon. Signals vary continuously in time or it is described only at discrete points in time. Systems respond to particular signals by producing other signals or some desired behaviour. Systems that respond to or process these signals leads naturally to two parallel frameworks for signal and system analysis, one for phenomena and processes that are described in continuous in time and one for those that are described in discrete in time. It introduces the students to analyze signals and systems and to design systems to enhance or restore signals that have been degraded in some way.

## Prerequisite

NIL

#### Course Outcomes

On the successful completion of the course students will be able to

CO#		Course O	utcome State	ement		Weightage in %			
CO1	Classify the	given determini	istic <mark>signal as</mark>	<mark>s conti</mark> nuous or dise	crete	10			
	periodic or a	periodic, even	or odd, and e	energy or power.					
CO2	Classify the	given system	in terms of	continuous or disc	crete	15			
	linearity, time	e invariance, ca	ausality and s	stability.					
CO3	Determine th	he time domai	n response	of a LTI System f	for a	15			
	given continu	uous time or dis	screte time in	put signal					
CO4	Determine the frequency domain representation of periodic 25								
0.05	and aperiodi	<u>c continuous ai</u>	nd discrete til	me signals		45			
005	Convert a continuous time signal into discrete time signal and 15								
C06	reconstruct the continuous time signal.								
COM Characterize LTT system using pole-zero locations in z-plane 20									
			arning Domai	n Level		CDIO Curricular			
	Proficiency	Cognitive		Psychomotor		Components			
<i><sup><i>π</i></sup></i>	Scale	Cognitive	Anconve			(X Y 7)			
CO1	TPS2	Understand	Respond	Perception and	1.2	2.1.1. 2.1.2. 2.4.1.			
				set	2.4.2	2, 2.4.5, 3.2.3, 3.2.5,			
0.00	<b>T</b> D00			<b>.</b>		<u> </u>			
002	TPS2	Understand	Respond	Perception and	1.2,	2.1.1, 2.1.2, 2.4.1,			
<u> </u>	TDO2	Apply		Set	2.4.2	<u>2, 2.4.5, 3.2.3, 3.2.5,</u>			
003	153	Арріу	value	Guided	1.2,	Z. I. I, Z. I.Z, Z. I.4, 5 0 4 1 0 4 0 0 4 5			
				response	2.1.0	), Z.4. I, Z.4.Z, Z.4.J, 2 2 2 5			
C:04	TPS3	Apply	Value	Guided	1.2.0	<u>,                                    </u>			
	11 00	трру	Value	response	215	5241242245			
				reepence	3.2.3	3. 3.2.5.			
CO5	TPS3	vlqqA	Value	Guided	1.2.	2.1.1. 2.1.2. 2.1.4.			
	_	11.5		response	2.1.5	5, 2.4.1, 2.4.2, 2.4.5,			
					3.2.3	3, 3.2.5,			
CO6	TPS3	Apply	Value	Guided	1.2,	2.1.1, 2.1.2, 2.1.4,			
				response	2.1.5	5, 2.4.1, 2.4.2, 2.4.5,			
L			<u> </u>		3.2.3	3, 3.2.5,			

## Mapping with Programme Outcomes and Programme Specific Outcomes

											<u> </u>				
COs	PO	PO	PSO	PSO	PSO										
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	M	L	-	-	L	-	-	L	L	L	-	L	L	-	L
CO2	M	L	-	-	L	-	-	L	L	L	-	L	L	-	L
CO3	S	Μ	L	-	L	-	-	L	L	L	-	L	L	-	L
CO4	S	Μ	L	-	L	-	-	L	L	L	-	L	L	-	L
CO5	S	М	L	-	L	-	-	L	L	L	-	L	L	-	L
CO6	S	М	L	-	L	-	-	L	L	L	-	L	L	-	L

#### S- Strong; M-Medium; L-Low

## **Assessment Pattern: Cognitive Domain**

Cognitive Levels	Contir	nuous Ass Tests	sessment		Assignmei	nt	End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	50	30	30	20
Apply	80	80	80	50	40	40	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### 

## Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	M.M		-
Set	here	-	-
Guided Response	South and the second se	-	-
Mechanism	-	30	30
Complex Overt Responses	-	-	-
Adaptation	C	<u> </u>	-
Origination		-	-

# Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. Show that any signal can be decomposed in to an even and odd component. Is the decomposition unique? Illustrate your arguments using the signal  $x[n] = e^{j\omega n}$
- 2. Show that  $\delta(n) = u(n) u(n-1)$
- 3. A discrete time signal x(n) is shown in figure. Sketch and label carefully each of the following signals.



## Course Outcome 2 (CO2):

- 1. For the each of the following systems, determine whether or not the system is 1. Linear and 2. Time invariant
  - a.  $y(n) = x(n)\cos(0.2\pi n)$
  - b. y(n) = Ax(n) + B, where A and B are constants.

2. Determine whether or not each of the following continuous time signals is periodic. If the signal is periodic, determine its fundamental period.

a. 
$$x(t) = 3\cos\left(4t + \frac{\pi}{3}\right)$$
  
b.  $x(t) = e^{j(\pi t - 1)}$ 

- 3. For each of the following input-output relationships, determine whether the corresponding system is linear, time invariant or both.
  - a.  $y(t) = t^2 x(t-1)$

b. 
$$y(n) = x(n+1) - x(n-1)$$

## Course Outcome 3 (CO3):

1. Consider the interconnection of LTI systems as shown in figure



- a. Express the overall impulse response in terms of  $h_1(n)$ ,  $h_2(n)$ ,  $h_3(n)$  and  $h_4(n)$ .
- b. Determine h(n) when  $h_1(n) = \{\frac{1}{2}, \frac{1}{4}, \frac{1}{2}\}$ ,  $h_2(n) = h_3(n) = \delta(n) + 2\delta(n-2) + \delta(n-4)$  and  $h_4(n) = \delta(n-2)$ . Determine the response of the system in part (b) if  $x(n) = \delta(n) + 3\delta(n-3) - 4\delta(n-5)$

2. Let 
$$x(t) = u(t-3) - u(t-5)$$
 and  $h(t) = e^{-3t}u(t)$ .  
a. Compute  $y(t) = x(t) * h(t)$   
b. Compute  $g(t) = \left(\frac{dx(t)}{dt}\right) * h(t)$ 

c. How is g(t) is related to y(t)?

3. Let  $x(n) = \delta(n) + 2\delta(n-1) - \delta(n-3)$  and  $h(n) = 2\delta(n+1) + 2\delta(n-1)$ . Compute and plot each of the following convolutions:

a.  $y_1 = (n) = x(n) * h(n)$ 

b. 
$$y_2 = (n) = x(n+2)*h(n)$$

c.  $y_3 = (n) = x(n+2) \cdot n(n)$ c.  $y_3 = (n) = x(n) \cdot h(n+2)$ 

## Course Outcome 4 (CO4):

1. A periodic signal 
$$x(t)$$
 is given by  $x(t) = 1 + 2\cos\left(300\pi t + \frac{\pi}{4}\right) + \sin\left(500\pi t\right)$ 

a.

- What is the period of x(t)?
  - b. Find the Fourier series coefficient of x(t) for  $-6 \le k \le 6$ .

- 2. Consider the square wave with 50 % duty cycle. Compute the exponential Fourier series and draw the spectrum for the square wave for 50 % duty cycle, having frequency of 25 Hz; then Synthesize the square wave from the Fourier coefficients for different harmonics and Describe Gibbs phenomenon
- 3. A periodic signal is represented by the Fourier Synthesis formula:  $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{j30\pi kt}$

where 
$$a_k = \begin{cases} \frac{1}{4+j2k} & k = -3, -2, -1, 0, 1, 2, 3 \\ 0 & |k| > 3 \end{cases}$$

a. Sketch the two sided spectrum of the signal. Label all complex amplitudes in polar form.

b. Determine the fundamental frequency and fundamental period of the signal. **Course Outcome 5 (CO5):** 

- 1. Consider the analog signal  $x_a(t) = 3\cos(2000\pi t) + 5\sin(6000\pi t) + 10\cos(12000\pi t)$ 
  - a. What is the Nyquist rate for this signal?
  - b. Assume now that we sample this sample using a sampling rate  $F_s = 5000$  samples/sec. What is the discrete time signal obtained after sampling?
  - c. What is the analog signal  $y_a(t)$  we can reconstruct from the samples if we use ideal interpolation?
- 2. The frequency which, under the sampling theorem, must be exceeded by the sampling frequency is called the Nyquist rate. Determine the Nyquist rate corresponding to each of the following signals:

a. 
$$x(t) = 1 + \cos(2000\pi t) + \sin(4000\pi t)$$

b. 
$$x(t) = \frac{\sin(4000\pi t)}{\pi t}$$
  
c.  $x(t) = \left(\frac{\sin(4000\pi t)}{\pi t}\right)^2$ 

3. Show that  $7\cos(8.4\pi n - 0.2\pi)$  is an alias of  $7\cos(0.4\pi n - 0.2\pi)$ 

#### Course Outcome 6 (CO6):

- 1. An LTI system is described by the difference equation  $y[n] = \frac{1}{4} [x[n] + x[n-1] + x[n-2] + x[n-3]].$ 
  - a) What is h[n], the impulse response of this system?
  - b) Determine the system function H(z) for this system.
  - c) Plot the poles and zeros of H(z) in the complex z -plane.
  - d) From H(z), obtain an expression for the frequency response  $H(e^{j\hat{\phi}})$  of this system
- 2. Compute the convolution x[n] of the signals

$$x_1[n] = \{1, -2, 1\}$$
  
$$x_2[n] = \begin{cases} 1, & 0 \le n \le 5\\ 0, & otherwise \end{cases}$$
 using the property of z-transform.



3. Find the region of convergence of z-transform of the sequence  $\left(\frac{5}{6}\right)^n u(n) - \left(\frac{6}{5}\right)^n u(-n-1)$ ?

#### Syllabus

Introduction: Standard Signals: Unit impulse, unit step, unit ramp, exponential, and sinusoidal signals, Sampling Process, Mathematical Representation of Continuous and discrete time signals, Types of signals: power, energy, periodic, even and odd, Basic System Properties: Linearity, Time Invariant, causality, stability and invertibility. Time Domain Characterisation of Continuous Time LTI system: Convolution Integral, Properties of continuous time LTI system, Causal continuous time LTI system described by differential equations. Frequency Domain Representation in Continuous Time Signals: Fourier series representation of continuous time periodic signals, properties of continuous time Fourier series, Fourier transform of continuous time aperiodic signals and periodic signals, properties of continuous time Fourier transform. Time Domain Characterisation of **Discrete Time LTI system:** Convolution sum, properties of discrete time LTI system, Causal discrete time LTI system described by difference equations. Frequency Domain Representation in Discrete Time Signals: Fourier series representation of discrete time periodic signals, properties of discrete time Fourier series, Discrete time Fourier transform, properties.z-Transform: z-Transform and linear systems, properties of z-Transform, Analysis and characterization of LTI system using z-Transform

## Learning Resources

- 1. Alan V.Oppenheim, Alan S.Willsky and S.Hamid Nawab, "Signals & Systems", Prentice-Hall of India, Second Edition, 2011.
- 2. James H.McClellen, Ronald W.Schafer, Mark A.Yoder ,"Signal Processing First", Pearson Education, 2003
- 3. Rodger E.Ziemer, William H.Tranter and D.Ronald Fannain "Signals & Systems Continuous and Discrete", Pearson Education, 2002.
- 4. Simon Haykin, Barry Van Veen," Signals and Systems", Wiely, 2<sup>nd</sup> Edition, 2002.
- 5. Sophocles J.Orfanidis "Introduction to Signal Processing", Prentice Hall, 1996.
- 6. Ashok Ambardar, "Digital Signal Processing: A Modern Introduction", Nelson Engineering, 2007
- 7. https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/index.htm
- 8. http://signalsandsystems.wikidot.com/video-lectures

Cour			
No.	Торіс	No. of	COs
		Lectures	
1	Introduction	4	001
1.1	and sinusoidal signals	1	01
1.2	Mathematical representation of continuous and discrete time	1	CO1
	signals		
1.3	Types of signals: Power energy, periodic, even and odd	1	CO1
1.4	System properties: Linearity, time invariant, causality, stability and invertibility	2	CO2
1.5	Tutorial	1	CO2
2	Time Domain Characterisation of Continuous time LTI system		
2.1	Convolution Integral	2	CO3
2.2	Properties of continuous time LTI system	1	CO3
2.3	Causal continuous time LTI system described by differential equations	1	CO3
2.4	Tutorial	1	CO3
3	Frequency Domain representation in continuous time signal		
3.1	Fourier series representation of continuous time periodic signals	1	CO4
3.2	properties of continuous time Fourier series	1	CO4
3.3	Fourier transform of continuous time aperiodic signals	2	CO4
3.4	Fourier transform of continuous time periodic signals	2	CO4
3.5	properties of continuous time Fourier transform	1	CO4
3.6	Tutorial	1	CO4
4	Sampling		
4.1	Impulse Train Sampling	1	CO5
4.2	Reconstruction of a signal from its samples using Interpolation	1	CO5
5	Time Domain Characterisation of Discrete time LTI system		
5.1	Convolution sum	1	CO3
5.2	properties of discrete time LTI system	1	CO3
5.3	Casual discrete time LTI system described by difference equations	1	CO3
5.4	Tutorial	1	CO3
6	Frequency Domain representation in discrete time signals		
6.1	Fourier series representation of discrete time periodic signals	1	CO4
6.2	properties of discrete time Fourier series	1	CO4
6.3	Discrete time Fourier transform	2	CO4
6.4	Properties	1	CO4
6.5	Tutorial	1	CO4
7	z-Transform		
7.1	z-Transform and linear systems	1	CO6
7.2	properties of z-Transform	2	CO6
7.3	Analysis and characterization of LTI system using z-Transform	2	CO6
7.4	Tutorial	1	CO6
	Total	36	
CALLE			

#### Course Contents and Lecture Schedule

## Course Designers:

1. Dr.S.J.Thiruvengadam

sjtece@tce.edu ganathi@tce.edu pgsvels@tce.edu

2. Dr.G.Ananthi 3. Dr.P.G.S.Velmurugan

Passed in BoS Meeting 11.05.2019

18EC350	MICROPROCESSORS AND	Category	L	Т	Ρ	Credit
	MICROCONTROLLERS	PC	2	1	0	3

## Preamble

The microprocessor has move out of giant air-conditioned rooms into closets, then onto desktops, and now into our laps and pockets. The rapid improvement in microprocessor architecture has come to both advances in the technology used to build computers and from innovation in computer design. The study of microprocessor architecture focuses on the structure and behaviour of the computer system and refers to the logical aspects of system implementation as seen by the engineer. The tremendous number of applications for embedded computing has given rise to high demand for engineers with experience in designing and implementing embedded systems with microcontroller. This course is also designed to provide an introduction to microcontroller architecture, internal and external peripherals, assembly language programming and embedded c programming. Students will be taught the basic use of a programming environment and how to develop the basic C programming for embedded application. This course highlights the general interfacing techniques and concepts through peripheral's data representation from input/output, and memory usage in the microcontroller in embedded C.

#### Prerequisite

18EC260-Digital System Design

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Classify the features in the evolution of Intel architecture and	20
	show its computer components	
CO2	Realize the need of the processor for computation by	15
	customizing the assembly level programming	
CO3	Apply the knowledge on writing program for the system call in	15
	operating system	
CO4	Apply the programming skill on accessing the timer and serial	15
	peripherals in ASM or in embedded C code	
CO5	Apply the effective implementation of the algorithm for the	15
	given process control in embedded C code	
CO6	Compute the number of machine cycles and T states taken by	20
	the program in ASM and embedded C code	

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Le	earning Doma	in Level	CDIO Curricular				
#	Proficiency	Cognitive	Affective	Psychomotor	Components				
	Scale	0			(X.Y.Z)				
CO1	TPS3	Apply	Value	-	1.2, 2.1.1, 2.1.2, 2.4.2,				
					2.4.6, 2.5.1, 3.1.1, 3.2.3,				
					4.5.5, 4.6.2				
CO2	TPS3	Apply	Value	-	1.2, 2.1.1, 2.1.2, 2.5.1,				
					3.1.1, 3.2.3, 4.5.5, 4.6.2				
CO3	TPS3	Apply	Value	-	1.2,, 2.1.1, 2.1.2, 2.5.1,				
					3.1.1, 3.2.3, 4.5.5, 4.6.2				
CO4	TPS4	Analyse	Organise	Complex Overt	1.2, 2.1.1, 2.1.2, 2.1.3,				
		_	_	Responses	2.5.1				
CO5	TPS4	Analyse	Organise	Complex Overt	1.2, 2.1.1, 2.1.2, 2.1.3,				
			-	Responses	2.5.1				
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.5.1				

## Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO	PÕ	PO	PO	PO	PO	PSO	PSO	PSO						
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	Μ	L	-	L	-	-	L	L	L	-	L	М	-	L
CO2	S	Μ	L	-	L	-	-	L	L	L	-	L	М	-	L
CO3	S	Μ	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	S	Μ	L	L	-	-	L	L	L	-	L	S	-	L
CO5	S	S	Μ	L	L	-	-	L	L	L	-	L	S	-	L
CO6	S	Μ	L	-	L	-	-	L	L	L	-	L	М	-	L

#### S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

Cognitive Levels	Contir	nuous Ass Tests	sessment		Assignme	nt	End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	60	60	100	70	70	60
Analyse	0	20	20	0	0	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

## Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	ALL CANADA	-	-
Set	La M - Canado	47 -	-
Guided Response	Les Les	-	-
Mechanism		30	30
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	1000		-

## Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. List the need of the microprocessor
- 2. How does 8086 generate physical address?
- 3. Compare logical and virtual address.

#### Course Outcome 2 (CO2):

- 1. How to write the ASM program for 8086? Show the template
- 2. Show the use of DB and DW assembler directive

## 3. List few of the assembler directive equivalent to compiler pre-processor like #define

#### Course Outcome 3 (CO3):

- 1. Develop an ASM code using "INT 10" interrupt with its various arguments
- 2. Show the ASM code for single loop delay program using interrupt
- 3. Exemplify the use of stack and stack pointer with the ASM code

#### Course Outcome 4 (CO4):

- 1. Develop embedded c code for accessing timer peripherals for the given time delay
- 2. Show the Embedded c code template for a cross compiler platform
- 3. Develop the embedded code to access the serial peripherals

#### Course Outcome 5 (CO5):

- 1. For the given flow chart of the process control system, develop a pseudo code
- 2. Develop an embedded c code for interfacing technique of external peripherals
- 3. How will you access the external peripherals with GPIO pins?

#### Course Outcome 6 (CO6):

1. Evaluate the time latency for the embedded c code for accessing timer peripherals for the given time delay

- 2. Examine the number of machine cycles and T states taken for the given ASM program
- 3. Observe the comment the stack overflow for the nested function call in a given program

## Sample Assignments:

- 1. Accessing input and output devices in x86 kit or computer using various BIOS interrupts. Develop the document for often used BIOS interrupts in printf and scanf function in C
- In your own way of understating , create the document for 8085 architecture along with its instructions and develop ASM codes single precision and double precision arithmetic operations
- 3. Implement the unique idea of a given process control system in 8051 microcontroller hardware for the given requirement.(Additional hardware can be used).Developing hardware edge device for IoT framework for the given requirement

#### Concept Map



#### Syllabus

Computer organization and architecture: Architecture, Structure and Function, Computer components, function, and bus interconnection. Instruction sets and pipelines characteristics and functions. Evolution of the Intel x86 architecture. CISC and RISC Machines. Memory management: Cache and virtual memory paging.8086 microprocessor: architecture, instruction sets, addressing modes and assembler directives, stacks and interrupts. Assembly language programming for data transfer and arithmetic computations .Microcontrollers: 8051 architecture, programming model, instructions sets and addressing modes. Memory organization, stack structure and Interrupts. Assembly level program for arithmetic operations. Internal-peripherals: GPIO Timer architecture and modes of operation, Timer peripheral programming, UART and modes of operation. UART programming by polling and interrupt driven. External peripherals interfacing: Port expansion with 8255. ADC, DAC, Keyboard interfacing. Display interfacing LED 7 segment and LCD module. SPI and I2C protocols and devices. Programming in C: Cross compiler C -programming structure, Data types, memory models, infinite loops and handling interrupts in C. C-Programming for LED, LCD display, temperature sensor with ADC, Measuring pulse width and frequency.

## Learning Resources

- William Stallings "Computer Organization and architecture designing for performance" 8<sup>th</sup> Edition-Prentice hall -2017
- 2. K. Ray, K. M. Bhurchandi "Advanced Microprocessors and Peripherals Architecture, Programming and Interface" – Tata McGraw Hill – 2017
- 3. Kenneth J. Ayala, The 8051 Microcontroller. Architecture, Programming and Applns, West publishing company 2016

## 4. NPTEL video lecture by Dr.S.RAMAN

IITMhttps://www.youtube.com/watch?v=leWKvuZVUE8

5. Teacher Handout

Cour	se Contents and Lecture Schedule		
No.	Торіс	No. of Hours	Cos
1	Computer organization and architecture		
1.1	Introduction to organization and architecture	1	CO1
1.2	Architecture, Structure and Function, Computer components, function, and bus interconnection.	1	CO1
1.3	Instruction set: Formats and components	2	CO1
1.4	Pipelines characteristics and functions.	2	CO1
1.5	Evolution of the Intel x86 architecture CISC and RISC	1	CO1
1.6	Cache and virtual memory paging	1	CO1
2	8086 microprocessor	11	
2.1	Architecture and programming model, Memory Buses	1	CO2
2.2	Instruction sets formats and machine cycles	1	CO2
2.3	Instructions seta	1	CO2
2.4	Addressing modes & Assembler directives.	1	CO2
2.5	Stack and its operations & Interrupts	1	CO2
2.6	Assembly language programming for data transfer	1	CO2
2.7	Assembly language programming arithmetic computations	1	CO2
3	Microcontrollers		
3.1	8051 architecture, programming model,	1	CO3
3.2	8051 Memory organization	1	CO3
3.3	Instructions sets: Data MOV groups	1	CO3
3.4	Instructions sets: Arithmetic and logical, branch	1	CO3
3.5	Machine cycle and delay computation	1	CO3
3.6	addressing modes	1	CO3
3.7	Stack structure and Interrupts.	1	CO3
3.8	ASM Program- Data transfer	1	CO3
3.9	ASM Program-Arithmetic and logical computation	1	CO3
4	Internal-peripherals:	1 1	
4.1	GPIO Pin outs and Timer architecture modes of operation	2	CO4
4.2	Timer peripheral programming	2	CO4
4.3	UART and modes of operation	1	CO4
4.4	UART programming by polling and interrupt driven	2	CO4
5.	External peripherals interfacing:		
5.1	Port expansion with 8255	1	CO5
5.2	Interfacing with ADC and DAC	1	CO5
5.3	Keyboard interfacing, Lead per key and Matrix	2	CO5
5.4	Display interfacing: 7 segment and LCD module	2	CO5
5.5	SPI and I2C protocols and devices		
6	Programming in Embedded C:		
6.1	Cross compiler C-programming structure, memory models, infinite	2	CO6
6.2	C Programming for LED LCD display, temperature senser with	2	006
0.2	ADC, Measuring pulse width and frequency.	J J	000
	Total Hours	48	

#### Course Designers:

- 1. Dr.K.Hariharan
- 2. Dr.E.Murugavalli

khh@tce.edu murugavalli@tce.edu

18EC360	PROGRAMMING FOR PROBLEM	Category	L	Т	Ρ	Credit
	SOLVING	BS	2	0	0 2	3

## Preamble

This course aims to provide students with an understanding on the role of computation in problem solving. It focuses on problem analysis, algorithm development, top-down design, modular programming, debugging and testing. The students will learn the required background programming knowledge, including stream I/O, loops, functions, structures, arrays, pointers and memory management.

## Prerequisite

#### NIL

## Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage
		in %
CO1	Use various constructs of a programming language like decision	30
	making, looping, modularity and recursion in problem solving	
CO2	Develop algorithms to perform sorting, searching and text processing.	25
CO3	Use pointers and derived data types like structures and union in	20
	solving complex problems.	
CO4	Write programs to create text and database files.	10
CO5	Apply problem solving methodology in implementing mathematical and	15
	engineering problems.	

## CO Mapping with CDIO Curriculum Framework

CO	TCE	Learr	ning Domain	n Level	CDIO Curricular Components				
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)				
	Scale								
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.3.1,				
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.3.1, 2.4.3,				
					2.4.4				
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.3.1, 2.4.3,				
					2.4.4				
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.3.1, 2.4.3,				
					2.4.4				
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.3.1, 2.4.3,				
					2.4.4, 2.5.1, 3.1.1, 3.1.2				

## Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	М	М	-	S	-	-	-	S	М	-	-	М	-	L
CO2	S	М	М	-	S	-	-	-	S	М	-	-	М	-	L
CO3	S	М	М	-	S	-	-	-	S	М	-	-	М	-	L
CO4	S	М	М	-	S	-	-	-	S	М	-	-	М	-	L
CO5	S	М	М	-	S	-	-	-	S	М	-	-	М	-	L

S- Strong; M-Medium; L-Low
Assessment Pattern: Cognitive Domain									
Cognitive	Conti	End Semester Examination							
Levels	1	2	3						
Remember	0	0	0						
Understand	30	30	30						
Apply	70	70	70	Lab Examination					
Analyse	0	0	0						
Evaluate	0	0	0						
Create	0	0	0						

#### Assessment Pattern: Psychomotor

Psychomotor Skill		Practical
Perception		-
Set		-
Guided Response		-
Mechanism		80
Complex Overt Responses		20
Adaptation	mon	-
Origination	( all a	-

# Sample Questions for Course Outcome Assessment

#### Course Outcome 1 (CO1):

- 1. A manufacturer would like to have a device for a car that will turn on a light when the temperature is between 34 and 40 degrees Fahrenheit (F) and sound a warning signal when the outside temperature is 34 degrees F or below. The light and the sound are never going simultaneously. Write a solution to this problem.
- 2. Write a function for finding the power of a number using recursion and without using recursion.

#### Course Outcome 2 (CO2):

- 1. America and Britain are "two nations divided by a common language." The noticeable difference between American and British English is vocabulary. A blogger stared writing an article using American English and now he want to change it to British English. He found that the words {vacation, apartment} has to be changed to {holidays, flat}. Develop an algorithm and implement it, so that his problem is solved.
- 2. Given a list of temperature measured in Madurai city over a period of 15 days, develop an algorithm to print the minimum, maximum, median and average temperature over the given period. (median is the middle value in the sorted list)

#### Course Outcome 3 (CO3):

- 1. Write a program to dynamically allocate memory for a 1-D array and sort it.
- 2. Write a program that concatenates two linked lists of characters. The program should include function concatenate that takes pointers to both lists as arguments and concatenates the second list to the first list.

#### Course Outcome 4 (CO4):

- 1. A data file named 'employee.dat' to be created with the following details: employee ID. how many days (s)he worked, and how many hours (s)he worked in each day. a program to create a data file, read the above file and output the employee ID and average work hour per day.
- 2. Write a program to copy the content of file 'source.txt' into another file named 'dest.txt' in encrypted format. Open the destination file and print its content on screen. [use offset cipher for encryption. Offset each character with 3. E.g 'abc' is encrypted as 'def']

#### Course Outcome 5 (CO5):

1. Consider a casual FIR filter of order M with impulse response h(n),  $n = 0.1, 2, \dots$  M and input signal x(n), n=0,1,2,....L-1. Write a program to calculate the convolution of the length L input x with order M filter h using direct form. Let h=[1,2,-1,1] x=[1,1,2,1,2,2,1,1]

$$y(n) = \sum_{m=\max(0,n-L+1)}^{\min(n,M)} h(m)x(n-m)$$

2. Write a program to solve linear algebraic equation using Gauss elimination method. **Concept Map** 



#### Syllabus

Problem Solving Methodology: problem specification and analysis, algorithm design, flowchart, programs, program testing and verification **Basics of Programming:** data types and its representation, variables, keywords, Operators, operator precedence, types of Control Structures: Selection structure, expression, looping Structure Modular **Programming and Functions:** Function declaration, function definition, function call-call by value - call by reference, storage classes, variable scope, use of stacks in function call, Recursive functions, library functions Array and string handling algorithms: 1-D, 2-D array declaration, initialization, using arrays as function arguments, strings sorting: selection sort, bubble sort, searching: linear and binary search, text processing: key word search, text editing. Memory management & Pointers: use of malloc-realloc-free- heaps in memory management, Pointers and memory addressing, Arrays and pointer arithmetic, Pointers and Functions, Pointers to pointers, pointer and string arrays, Void and function pointers **Derived** data types: structures- Arrays of Structures – Passing Structures to Functions – Structure Pointers – Structures within Structures, union, bitfield, enumeration, typedef **File Handling**: read, write and update text files - file structure for database management

#### List of Experiments:

- 1. Programs to explore fundamental programming constructs
  - a. Find the size of the processor, range of all primary data types.
  - b. Use of different types of operators and expressions.
- 2. Programs using decision making, case control and looping statements.

24 Hrs

- a. Print twin prime numbers in a given range
- b. Finding greatest common divisor using Euclid's method
- c. Trigonometric series generation
- 3. Programs using 1-D and 2-D arrays
  - a. Bubble and insertion sort algorithms
  - b. Matrix multiplication
- 4. Programs using strings
  - a. Linear pattern search
  - b. Text editing
- 5. Programs using recursive and non-recursive functions
  - a. Binary search
  - b. Finding nth Fibonacci number
- 6. Programs for dynamic memory management and pointer arithmetic
- 7. Programs to create database files using file structures
- 8. Solving numerical methods/engineering problems (sample)

CO5

- a. Finding roots of a linear equation using bisection method
- b. Numerical integration by trapezoidal method
- c. Linear convolution
- d. Bitwise operations to set specific bit fields

#### Learning Resources

- 1. Kernighan, Brian, and Dennis Ritchie. "*The C Programming Language*", 2nd ed. Upper Saddle River, NJ: Prentice Hall, 1988.
- 2. Paul Deitel, Harvey Deitel, "C: How to program", 7<sup>th</sup> ed., ", Pearson Education, 2013
- 3. George S. Tselikis, Nikolaos D. Tselikas, "C: From Theory to Practice", 2<sup>nd</sup> Ed., CRC Press, 2017
- 4. R. G. Dromey, "How to Solve It By Computer", PearsonEducation, 1982
- 5. William H. Press, Saul A. Teukolsky, "Numerical Recipes in C:The Art of Scientific Computing", 2<sup>nd</sup> ed., Cambridge University Press, 2002
- 6. Adam Hoover, "System Programming *with C and Unix", 1 ed.,* Pearson Education, Inc., 2010
- 7. Randal E. Bryant and David R. O'Hallaron, *Computer Systems: A Programmer's Perspective, Third Edition*, Pearson, 2016
- 8. NPTEL course on problem solving through C, https://nptel.ac.in/courses/106105171/

#### **Course Contents and Lecture Schedule**

No.	Торіс	No. of	COs
		Hours	
1	Problem Solving Methodology		
1.1	problem specification and analysis, algorithm design, flowchart,	1	CO1
	programs, program testing and verification		
2	Basics of Programming		
2.1	data types and its representation, variables, keywords,	1	CO1
2.2	Operators, operator precedence, types of expressions	1	CO1
2.3	Control Structures: Selection structure - looping Structure	2	CO1
3	Modular Programming and Functions		
3.1	Function declaration, function definition, function call-call by value	2	CO1
	- call by reference, storage classes, variable scope, use of stacks		
	in function call		
3.2	Recursive functions	1	CO1
3.3	library functions	1	CO1
4	Arrays and Array handling algorithms		
4.1	1-D, 2-D array declaration, initialization, using arrays as function	2	CO2
	arguments, strings		
4.2	Sorting: selection sort, bubble sort	1	CO2

4.3	Searching: linear and binary search	1	CO2
4.4	text processing: key word search, text editing	1	CO2
5.	Memory management & Pointers		
5.1	Memory management functions: malloc, calloc, realloc, free - use	1	CO3
	of heap in memory management		
5.2	Pointers and memory addressing, Arrays and pointer arithmetic	1	CO3
5.3	Pointers and Functions, Pointers to pointers	1	CO3
5.4	Pointer and string arrays, Void and function pointers	1	CO3
6	Derived data types		
6.1	Structures- Arrays of Structures - Passing Structures to Functions	1	CO3
6.2	Structure Pointers – Structures within Structures	1	CO3
6.3	Union, bitfield, enumeration, typedef	1	CO3
7.	File Handling		
7.1	read, write and modify text files	2	CO4
7.2	file structure for database management	1	CO4
	Theory	24	
	Practical	24	
	Total	48	

# **Course Designers:**

- 1. Dr.S. Ponmalar
- 2. Dr.B.SathyaBama
- spmece@tce.edu
- ama sbece@tce.edu

18EC370	MICROPROCESSOR AND	Category	L	Т	Ρ	Credit
	MICROCONTROLLER LABORATORY	PC	0	0	2	1

#### Preamble

This course is designed to realize and to do practical experimentation on the theory course '18EC350 Microprocessors and Microcontrollers'. The purpose of this course is to give hands on training to the students in understanding and practicing the embedded C programming concepts and algorithms. This course will improve the embedded system design capability of the students. On successful completion with full involvement in the experimentation of the course, the knowledge will lead to the students to become entrepreneur in the start-up company.

#### Prerequisite

NIL

#### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage
		111 70
CO1	Write, assemble, debug, link and execute assembly program in the	10
	given 8086 simulator for transferring data from one space to another,	
	arithmetic computation and accessing IOs using BIOS interrupts	
CO2	Analyze the segment memory space, number of machine cycles and	10
	execution time taken for the given program or flow chart in the	
	simulation tool	
CO3	Use appropriate methods for accessing internal and external	20
	peripherals such as Timers, Serial peripheral and GPIO in assembly	
	and C programming	
CO4	Apply access methodologies to ADC and DAC in assembly and C	20
	programming	
CO5	Design a flow chart and develop the code for processes control system	20
CO6	Analyze the memory requirements and number of clocks and delay for	20
L	the system by implementing the application in 8051 target board	

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	rning Doma	in Level	CDIO Curricular Components
#	Proficiency Scale	Cognitive	Affective	Psychomotor	(X.Y.Z)
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes															
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO2	S	Μ	L	-	S	-	-	L	S	S		-	S	-	L
CO3	S	Μ	L	-	S	-	-	L	S	S		-	S	-	L
CO4	S	Μ	L	-	S	-	-	L	S	S		-	S	-	L
CO5	S	Μ	L	-	S	-	-	L	S	S		-	S	-	L
CO6	S	Μ		-	S	-	-	L	S	S		•	S	-	L
S- Str	ong; l	M-Me	dium;	L-Lov	N										
Asse	ssme	nt Pa	ttern	: Cog	nitive	Dom	nain								
	C	ogniti	ve			Model Examination				End Semester Examination					
		Level	S												
	Re	emem	ber												
	Ur	nderst	and												
		Appl	у			70			70						
		Analy	se												
	E	Evalua	ate												
		Creat	te					m							
Asse	ssme	nt Pa	ttern	: Psyc	chom	otor									
Psyc	home	otor S	skill				100	17	P	ractic	al Coi	mpon	ent		
Perc	eptior	า						團	PI						
Set							5	S.	PI	Å					
							and the second s	COMPAREMENT.	100 PT 1 PT 1						

Set	A Sala					
Guided Response	ru - M					
Mechanism	30					
Complex Overt Responses	Concern and					
Adaptation						
Origination						
List of Experiments/Activities with CO Menning						

#### List of Experiments/Activities with CO Mapping

- 1. Develop an assembly program in 8086 simulator for copying data from one space to another space of the same or different segments (CO1)
  - Develop a user defined function for the given objective at the time of lab hour
  - Assembling and observing memory allocations for each segments used in the ASM code
  - Debugging the code in "step by step" and "GO" options
  - Inputting and showing the output in the simulator for the developed function
- 2. Develop and reverse an assembly level program in 8086 simulator BIOS interrupts
- (CO1)
  - Develop an ASM code for accessing IO devices such as display and keyboard using BIOS interrupts
  - Disassemble the c code with printf and scanf statement and list the BIOS interrupts used
  - List and tabulate other BIOS interrupts with its executives
- 3. Develop an assembly level program in 8086 simulator for performing given arithmetic computation (CO2)
  - Develop a user defined function for the given objective at the time of lab hour
  - Inputting and showing the output in the simulator for the developed function
  - Examine the memory space size of each segments used in the ASM code
  - · List and tabulate the measured machine cycles, clock cycles and execution time
- 4. Programming in cross compiler Keil for 8051microcontroller (CO3)
  - Assembling and simulating an ASM code for accessing GPIO and external memory
  - Develop the user define function to a switches connected in PORT1 and outputting the data to the LEDs connected in PORT0 using appropriate argument and return type

- Methods to invoke break points and step by step execution of the code
- Calculating the delay for the given clock frequency
- 5. Embedded C programming in cross compiler Keil for 8051 microcontroller (CO3)
  - Compiling and simulating the embedded C code for performing the computation like root of the equation, and perform convolution operation.
  - an arithmetic computation
  - Methods to invoke break points and step by step execution of the C code
  - Calculating the delay for the given clock frequency
- 6. Developing the C program for accessing GPIO and Timer peripherals in 8051 boards (CO3)
  - Develop an user function for a software delay "SoftDelay\_ms(no of milli-seconds)" and use this function for blinking the LEDs in Port 0
  - Plot the error in the delay function when the argument changes from 1 to 1000 in the order of 100
  - Develop an user function for a hardware delay "HardDelay\_ms(no of milli-seconds)" and use this function for blinking the LEDs in Port 0
  - Plot the error in the delay function when the argument changes from 1 to 1000 in the order of 100
- 7. Invoking interrupt services in the Embedded C programming and to realize it in 8051 target board (CO4)
  - Control the LEDs in PORT-0 by the external interrupts INT0 and INT1
- Blink the LEDs using Timer peripheral interrupt which runs periodic time of intervals
- 8. Establishing serial communication between target board and computer (CO3)
  - Develop an user function in the C code for serial transmission with defined baud rate to transmit a character and a string as an arguments. Use interrupt driven and polling methods
  - Develop an user function in the C code for serial reception with defined baud rate to transmit a character and a string as an arguments. Use interrupt driven method
- 9. Accessing analog signal into the 8051 system through ADC (CO4)
  - Develop the C code for accessing external ADC through parallel or serial communication and show the result in LEDs or in serial transmission
  - Access the ADC and display the send data to LEDs
  - Show the analog input data in CRO
- 10. Design a setup for a display system to display the data in 7 segment LED (CO5)
  - Develop the LUT for 7 segment pattern to display the list of characters including blank
  - The Number X is displayed and incremented up to 9 for every period of time and it is updated in a single display
  - The number X range from 0 to 9999 is displayed for every period of time and it is updated in a single display. BCD conversion is done before displaying
  - For all the above objective , user defined function is required
- 11. Design a setup for a display system to display the numbers and characters in LCD module (CO6)
  - Develop a function to display the array of stored alpha numeric string in LCD module
  - The arguments are needed to control the display position and clear the LCD
  - The text sent by PC is displayed in LCD module in 8051 target board

#### Case study implementation and prototyping:

- 1. **Implement a** on performing a simulation of a process control system
  - a. Develop an ASM code for accessing simulation packages such as traffic control, temperature and motor control
  - b. List and tabulate what are the BIOS interrupts used in this executives
- 2. Implement a case study on prototyping of access control system
  - a. considering switches as discrete sensor switch are fixed in the door to detect the person entry and exit and LEDs are considered to be the actuators, develop the C code for accessing actuators by reading the sensor conditions
- 3. Implement a case study on prototyping of process control system

- a. Use temperature sensor LM35/LDR/Thermistor/thermocouple/IR sensors and develop a process control with relay output
- b. Servo motor/Brushless DC motor(BLDC) and stepper motor control
- c. RGB LED control with climatic intensity condition

# Learning Resources

- 1. NPTEL Video Lecture on "Microprocessor and Microcontroller", weblink: https://onlinecourses.nptel.ac.in/noc19\_ee11/course
- 2. Virtual Lab on "Real Time Embedded System", weblink: https://nptel.ac.in/courses/108102045/24

#### Course Designers: 1. Dr.K.Hariharan

- khh@tce.edu
- 2. Dr.E.Murugavalli murugavalli@tce.edu



18EC380	ELECTRONIC CIRCUITS LABORATORY	Category	L	Т	Ρ	Credit
		PC	0	0	2	1

#### Preamble

The goal is to supplement the theory courses '18EC330 Electronic Circuits' by giving a practical exposure of the operation of linear and non linear electronic circuits to the students. The linear mode of operation of the active devices was demonstrated with the amplifier, oscillator and filter circuits. The non linear mode of operation is demonstrated with switching applications. The course also provides experience in analysing and testing of electronic circuits using simulation software and hardware implementation.

#### Prerequisite

18EC230: Electron Devices, 18EC280: Circuits and Devices Laboratory

#### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Design a single stage and two stage transistor amplifier for the given specification.	20
CO2	Analyse the frequency response of the amplifier with and without feedback based on gain and bandwidth.	20
CO3	Identify the parameters given in the datasheet of operational amplifier IC.	10
CO4	Demonstrate the inverting and non-inverting mode of operation of the operational amplifer.	10
CO5	Create low frequency and high frequency sinusoidal oscillations using operational amplifier.	10
CO6	Analyse the frequency response of analog filters (LPF, HPF and BPF) using the TI ASLKv analog kit.	10
C07	Demonstrate the nonlinear mode operation of active devices.	10
CO8	Explain the power amplification and efficiency calculation of class B power amplifier.	10

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	rning Doma	ain Level	CDIO Curricular Components
#	Profi.	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale				
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2,
					2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2,
					2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2,
					2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2,
					2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2,
					2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2,
					2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
C07	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2,
					2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO8	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2,
					2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2

# Mapping\ with Programme Outcomes and Programme Specific Outcomes

								<u>.</u>							
COs	PO	PO	PO	PO	PO	PSO	PSO	PSO							
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO2	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO3	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO4	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO5	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO6	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO7	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO8	S	М	L	-	S	-	-	L	S	S	Ĺ	-	S	-	L

S- Strong; M-Medium; L-Low

#### **Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	End Semester Examination
Remember		
Understand		
Apply	100	100
Analyse		
Evaluate	m	
Create		

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	The second
Set	
Guided Response	Cu Cu
Mechanism	100
Complex Overt Responses	
Adaptation	Contraction of the second seco
Origination	

#### List of Experiments/Activities with CO Mapping

- 1. Design, simulation and hardware realization of Single Stage amplifier for given specification and its frequency analysis. (using BJT)
- 2. Design and hardware realization of Multistage Amplifier for given specification and its frequency analysis. (using BJT)
- 3. Hardware realization of different types of feedback amplifiers and infer the effect of feedback on gain and frequency of the amplifier.(using BJT)
- 4. Study the AC and DC characteristics of Operational amplifier and implement the inverting and non-inverting mode of operation. (using TL082)
- 5. Design, Simulation and Hardware realisation of sinusoidal waveform generators. RC Oscillators – RC phase shift and wien bridge. (using IC741)
- 6. Design, Simulation and Hardware realisation of sinusoidal waveform generators. LC Oscillators – Hartley and Colpitts. (using IC741)
- 7. Design and hardware implementation of Low pass, High pass and Band pass filter using operational amplifier. (using TI ASLKV kit)
- 8. Design and implementation of Non linear analog circuit, Astable and Monostable multivibrator using NE555 timer IC.
- 9. Simulation and hardware realization of Class B power amplifier and calculation of its efficiency
- 10. Mini project

#### Learning Resources

3. NPTEL Video Lecture on "Basic Electronics and Lab", weblink: https://nptel.ac.in/courses/122106025 4. MIT Video Lecture on "Circuits and Electronics", weblink: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002circuits-and-electronics-spring-2007/index.htm

#### **Course Designers:**

- 1. Dr. N.B. Balamurugan
- 2. Dr. V. Vinoth Thyagarajan
- 3. Dr.K.Kalyani
- 4. Dr.S.Rajaram
- 5. Dr.D.Gracia Nirmala Rani
- 6. Dr.V.R.Venkatasubramani

nbbalamurugan@tce.edu vvkece@tce.edu k\_kalyani@tce.edu rajaram\_siva@tce.edu gracia@tce.edu venthiru@tce.edu



18ES390	DESIGN THINKING	Category	L	Т	Ρ	Credit
		ES	1	I	2	2

#### Preamble

Design has been defined as a "systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints". Human-centered design is defined as a process and a set of techniques used to create new solutions for the world. Solutions include products, services, environments, organizations, and modes of interaction. The reason this process is called "human-centered" is because it starts with the people we are designing for. This course facilitates the development of students' professional skills through their team engagement in developing conceptual design for a local community problem.

#### Prerequisite Nil

### Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage
Number	The second se	in %
CO1	Identify a specific social need to be addressed	20
CO2	Identify stakeholder's requirements for the societal project	20
CO3	Develop measurable criteria in which design concepts can be	10
	evaluated	
CO4	Develop prototypes of multiple concepts using user's feedback	30
CO5	Select the best design solution among the potential solutions with its	20
	functional decomposition	

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	rning Doma	in Level	CDIO Curricular Components				
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)				
	Scale			-					
CO1	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 3.1.2, 3.2.3,				
					3.2.6, 4.1.2				
CO2	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.2, 2.5.1, 2.5.2,				
					3.1.2, 3.2.3, 3.2.6, 4.1.2				
CO3	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.3, 3.1.2, 3.2.3,				
					3.2.6, 4.1.2, 4.3.1				
CO4	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.4, 3.1.2, 3.2.3,				
					3.2.6, 4.1.2, 4.4.1				
CO5	TPS5	Evaluate	Organise	Adaptation	1.1, 1.2, 2.1.5, 3.1.2, 3.2.3,				
			-		3.2.6, 4.1.2, 4.4.1				

#### Mapping with Programme Outcomes and Programme Specific Outcomes

	<u> </u>	U										
COs	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	Μ	L	-	-	M	М	M	L	М	М	S
CO2	S	Μ	L	-	-	M	М	M	L	М	М	S
CO3	S	Μ	L	-	-	M	М	M	L	М	М	S
CO4	S	Μ	L	-	М	M	М	M	L	М	М	S
CO5	S	S	М	L	М	М	М	М	L	М	М	S

S- Strong; M-Medium; L-Low

#### Assessment Pattern: Cognitive Domain

Phases	Deliverables	Marks	Course Outcomes							
Cont	inuous Assessment									
Review 1 – Problem Identification	Technical Report	10	CO1 and CO2							
Review 2 – Specification Development	Technical Report	20	CO3							
Review 3 -Conceptual Design	Technical Report	20	CO4 and CO5							
End-Semester Examination										
Demonstration	Prototype	60	CO1, CO2, CO3,							
Poster Presentation	Poster	40	CO4 and CO5							

- Reports are to be submitted at each review. The report and presentation will be evaluated based on Rubrics
- Demonstration and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.



#### Syllabus

**1.0 Project Identification:** Needs Assessment, Stakeholder Identification, Stakeholder Requirement Project Time Constraint.

**2.0 Specification Development:** Description Problem Environment, Creation of Stakeholder's Profiles Development of Low-cost Prototypes, Development of Task-Analysis, Comparison with Benchmark Products, Development of Customer Specification, Development of Evaluation Criteria,

**3.0 Conceptual Design:** Conduct of Functional Decomposition, Brainstroming of possible solutions, Creation of Prototypes for Multiple Concepts, Refinement of Design Specification on users' feedback, Evaluation of Potential Solutions, Selection of best design.

#### Learning Resources

- 1. Learning Material prepared by TCE faculty members
- 2. https://www.ideo.com/
- 3. https://engineering.purdue.edu/EPICS

Course	Contents and Lecture Schedule			
Module	Торіс	No. o	f Hours	Course
No.		In-Class	Hands-on	Outcome
1.	Project Identification: Introduction to Human-	1	-	CO1
	Centered Design			
1.1	Needs Assessment	1	2	CO1
1.2	Identification of Stakeholders	1	2	CO2
1.3	Identification of Stakeholder Requirements		2	CO2
1.4	Project Time Constraint	1	2	CO2
2.	Specification Development			
2.1	Description Problem Environment	1	2	CO3
2.2	Creation of Stakeholder's Profiles		2	CO3
2.3	Development of Low-cost Prototypes	1	2	CO3
2.4	Development of Task-Analysis	1	2	CO3
2.5	Comparison with Benchmark Products	1	2	CO3
2.6	Development of Customer Specification		2	CO3
2.7	Development of Evaluation Criteria	1	2	CO3
3.	Conceptual Design			
3.1	Conduct of Functional Decomposition	1	2	CO4
3.2	Brainstroming of possible solutions	1	2	CO5
3.3	Creation of Prototypes for Multiple Concepts	1	2	CO5
3.4	Refinement of design Specification on users'		2	CO6
	feedback	1		
3.5	Evaluation of Potential Solutions	1	2	CO6
3.6	Selection of best design		2	CO6
	Total	12	34	

# Course Contents and Lecture Schedule

# **Course Designers:**

Dr.S.J.Thiruvengadam
 Dr.S.Saravana Perumaal

sjtece@tce.edu

sspmech@tce.edu

# **CURRICULUM AND SYLLABI** FOR **B.E. DEGREE (ELECTRONICS AND COMMUNICATION ENGINEERING)** PROGRAMME FOURTH SEMESTER FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2018-2019 ONWARDS THIAGARAJAR COLLEGE OF ENGINEERING (A Govt Aided Autonomous Institution Affiliated to Anna University) MADURAI - 625 015, TAMILNADU

### Vision and Mission of the Department

#### Vision:

To empower the Electronics and Communication Engineering students with technological excellence, professional commitment and social responsibility.

#### Mission:

- ME1. Attaining academic excellence in Electronics and Communication Engineering through dedication to duty, innovation in learning and research, state of the art laboratories and industry driven skill development.
- ME2. Establishing suitable environment for the students to develop professionalism and face life challenges with ethical integrity.
- ME3. Nurturing the students to understand the societal needs and equip them with technical expertise to provide appropriate solutions.
- ME4. Providing breeding ground to obtain entrepreneurial skills and leadership qualities for self and social growth.

## Program Educational Objectives (PEOs):

- PEO1. Graduates will be capable of developing specification and design procedures, prototyping and test methodologies for modern electronics and communication systems and gadgets that perform analog and digital processing functions.
- PEO2. Graduates will be able to work and adapt to changes in allied areas of Electronics and Communication Engineering through personal success and life long learning.
- PEO3. Graduates will be able to identify technological requirements for the society and provide cost effective solutions.
  - These objectives will be evidenced by professional visibility (publications, presentations, inventions, patents and awards), entrepreneurial activities, international activities (participation in international conferences, collaborative research and employment abroad)

#### Program Outcomes: Engineering Graduates will be able to:

- 1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- 2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- 3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- 4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- 5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- 6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- 8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- 9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- 10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- 11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- 12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

# Program Specific Outcomes:

Engineering Graduates will be able to

- PSO1. Design circuits and systems for complex engineering problems in Electronics and Communication and allied areas.
- PSO2. Apply research methodologies to provide solutions for contemporary problems in the areas including RF, Signal Processing, Image Processing, VLSI, Optical Communication, Networks and Embedded Systems for given specifications.
- PSO3. Actively contribute as a member or leader in diverse teams, and communicate effectively on complex engineering activities and involve in life-long learning, by applying reasoning and ethical principles.

# PEO- Mission Mapping:

	ME1	ME2	ME3	ME4
PEO1	S	М	М	L
PEO2	L	S	М	М
PEO3	М	L	S	М

#### **PEO-PO-PSO Mapping:**

	P 0 1	P 0 2	P 0 3	P 0 4	P 0 5	P O 6	P O 7	P O 8	P O 9	P O 10	P 0 11	P O 12	PS O 1	PS O 2	PS O 3
PEO 1															
PEO 2															
PEO 3															

#### **PO-GA Mapping:**

	GA	GA	GA	GA	GA	GA	GA	GA	GA	GA1	GA1	GA1
	1	2	3	4	5	6	7	8	9	0	1	2
PO1						ST	2 D					
PO2					R		1 d					
PO3							PI					
PO4					N	Condition of the second	S Y	5				
PO5						E State	de la	1				
PO6					1							
PO7												
PO8					/		1					
PO9					1			S				
PO1												
0												
PO1												
1												
PO1												
2												

# TCE PROFICIENCY SCALE (CDIO Curriculum Framework)

TCE Proficiency Scale (TPS)	Proficiency	Cognitive	Affective	Psychomotor
TPS1	To have been exposed to	Remember	Receive	Perception, Set
TPS2	To be able to interpret and imitate	Understand	Respond	Guided Response
TPS3	To be skilled in the practice or implement	Apply	Value	Mechanism
TPS4	To be able to participate in and contribute	Analyse	Organise	Complex Overt Responses
TPS5	To be able to judge and adapt	Evaluate	Organise	Adaptation
TPS6	To be able to lead and innovate	Create	Characterize	Origination

S.No	Category	Cre	dits
		Regular	Lateral
А	Foundation Courses	53 — 58	23-28
	Humanities and Social Science (HSS)	9 -11	6-8
	Basic Science (BS)	21	6
	Engineering Science (ES)	23 – 26	11-14
В	Professional Core Courses	55	45
С	Elective Courses	24 – 48	24-48
	Programme Specific Elective	12-24	12-24
	Programme Elective for Expanded Scope	6 – 12	6-12
	General Elective	3-6	3-6
	Foundation Elective	3-6	3-6
D	Project work, seminar, internship in industry or at	15	15
	Higher Learning institutions		
E	Mandatory Courses – Environment Science,	Non-Credit	Non-Credit
	Induction Programme, Indian Constitution,	(Not included	(Not included
	Essence of Indian Tradition knowledge,	for CGPA)	for CGPA)
	consumer Affairs ( as per UGC guideline)		
	Minimum Credits to be earned for the award of	160	120
	the Degree	(from A to D)	(from A to D)
		and the	and the
	A SA SA	successful	successful
	r l l	completion of	completion of
	Contraction of the second	Mandatory	Mandatory
		Courses	Courses

#### **Credit Distribution**

- General electives are courses offered by different departments that do not have any prerequisites and could be of interest to students of any branch
- All students have to undertake co-curricular and extra-curricular activities that include activities related to NCC, NSS, Sports, Professional Societies, participation in identified activities which promote the growth of Departments and the College.

# THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015 (A Govt. Aided Autonomous Institution affiliated to Anna University)

# CATEGORIZATION OF COURSES (CHOICE BASED CREDIT SYSTEM)

A. I	A. FOUNDATION COURSES: Total Credits to be earned: 53-58								
	a. Hum	anities and Social Science (09-11)							
S.No.	Course	Name of the Course	Nu	ımbe	er of		Credit		
	Code		Ηου	irs / \	Neek				
			L	Т	P				
THEOF	٦Y								
1.	18EG140	English	2	-	-		2		
2.	18EC610	Accounting and Finance	3	-	-		3		
3.	18EC490	Project Management	3	-	-		3		
THEO	RY CUM PR	ACTICAL							
1.	18EG460	Professional Communication	-	1	2		2		
PRAC	TICAL								
1.	18EG170	English Laboratory	-	-	2		1		
	b. Basio	c Science (21)							
S.No.	Course	Name of the Course	Nur	nber	of Ho	urs	Credit		
	Code			/ W	/eek				
					т	D	-		
		A Canada A SA		.	I	Г			
			<u> </u>		1		1		
1.	TOWATTU	Engineering Calculus	3	·	1	-	4		
2.	18PHB20	Physics	3		-	-	3		
3.	18CHB30	Chemistry	3		-	-	3		
4.	18MA210	Matrices and Ordinary Differential	2	2   1			3		
		Equations							
5.	18EC310	Complex Analysis and Linear Algebra	2	<u> </u>	1		3		
6.	18EC410	Optimization and Numerical Methods	2		1		3		
PRAC	TICAL	1					-		
1.	18PH180	Physics Laboratory	-		-	2	1		
2.	18CH190	Chemistry Laboratory	-		-	2	1		
	c. Engi	neering Science (23-26)							
S.No.	Course	Name of the Course	N	lumb	er of		Credit		
	Code		Ho	urs /	Weeł	<b>(</b>			
			L	Т	P				
THEO	<u> YY</u>	1							
1.	18ES150	Engineering Exploration	3	-	-		3		
2.	18EC240	Semiconductor Physics	3	-	-		3		
3.	18EC630	Data Structures and Algorithms	2	-	-		2		
4.	18XXPE0	Engineering Sciences Elective	3	-	-		3		
THEOR	<u>RY CUM PR</u>	ACTICAL							
1.	18ME160	Engineering Graphics	3	-	2		4		
2.	18EC360	Programming for Problem Solving	2	-	2		3		
3.	18ES390	Design Thinking	1	-	2		2		
4.	18ES590	System Thinking	1	-	1		2		
PRAC	TICAL								
1.	18EC280	Electronics Workshop	-	-	2		1		
2.	18ES290	Lateral Thinking	-	-	2		1		

Degree: B.E. Programme: ECE

Batch: 2018-19 onwards

18EC670

Data

Laboratory

Structures

and

Algorithms

3.

\_

-

2

1

# **Engineering Sciences Elective**

S.No.	Course	Name of the Course	Ν	Number of		Credit	
	Code		Hc	ours /	Week		
			L	Т	Р		
THEOF	RY						
1.	18ECEA0	MEMS Technology	3	-	-	3	
2.	18ECEB0	Machine Learning for All	3	-	-	3	
3.	18ECEC0	IOT Sensors and Device	3	-	-	3	
4.	18ECED0	Blockchain Technology	3	-	-	3	
5.	18ECEE0	5G Wireless Networks	3	-	-	3	
THEOF	THEORY CUM PRACTICAL						
	-	-	-	-	-	-	

# **B. PROFESSIONAL CORE COURSES**

# Credits to be earned: 55

SI. No.	Course Code	Name of the Course	Nu H	Number of Hours /		Credit
		TOT	١	Nee	k	
			L	T	Р	
THEOR	Y		-			
1.	18EC220	Network Theory	2	1	-	3
2.	18EC230	Electronic Devices	3	-	-	3
3.	18EC320	RF Passive Devices and Circuits	2	1	-	3
4.	18EC330	Electronic Circuits	3	-	-	3
5.	18EC340	Signals and Systems	2	1	-	3
6.	18EC350	Microprocessors and Microcontrollers	2	1	-	3
7.	18EC420	RF Active Circuits	2	1	-	3
8.	18EC430	CMOS VLSI Systems	3	-	-	3
9.	18EC440	Signal Processing	2	1	-	3
10.	18EC510	Data Communication Networks	2	1	-	3
11.	18EC530	Analog and Digital Communication	2	1	-	3
		Systems				
12.	18EC620	Control Systems	2	1	-	3
13.	18EC710	Consumer Electronics	1	-	-	1
THEOR	Y CUM PRAC	TICAL				
14.	18EC260	Digital System Design	2	-	2	3
15.	18EC520	Antenna and Wave Propagation	2	-	2	3
16.	18EC560	Digital Image Processing	2	-	2	3
17.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTI	CAL					
18.	18EC270	Circuits and Devices Laboratory	-	-	2	1
19.	18EC370	Microprocessor and Microcontroller	-	-	2	1
		Laboratory				
20.	18EC380	Electronic Circuits Laboratory	-	-	2	1
21.	18EC470	RF Circuits Laboratory	-	-	2	1
22.	18EC480	Signal Processing Laboratory	-	-	2	1
23.	18EC570	Data Communication Networking	-	-	2	1
		Laboratory				
24.	18EC580	Analog and Digital Communications	-	-	2	1

C. EL	C. ELECTIVE COURSES: Credits			to be earned: 24-48			
a. Pr	ogramme Specifi	c Elective Credits t	o be	earr	ned:12	2-24	
SI. No.	Course Code	Name of the Course	Nu H	mbe lour: Nee T	er of s / k P	Credit	
THEOR	Ý		_				
1.	18ECPA0	Computer Vision and Applications	3	-	-	3	
2.	18ECPB0	Data Compression	3	-	-	3	
3.	18ECPD0	Wireless Communication Systems	2	1	-	3	
4.	18ECPF0	FPGA Based Digital System Design	3	-	-	3	
5.	18ECPH0	Electronic Measurement and	3	-	-	3	
6.	18ECPJ0	Network Security	3	-	-	3	
7.	18ECPK0	Optical Communication	3	-	-	3	
8.	18ECPM0	Planar Antennas for Wireless Applications	2	-	2	3	
9.	18ECPN0	Electromagnetic Interference and Compatibility	3	-	-	3	
10.	18ECPQ0	Statistical Signal Processing	2	1	-	3	
11.	18ECPT0	Deep Learning For Speech Processing	2	1	-	3	
12.	18ECPU0	VLSI Device Modeling	3	-	-	3	
13.	18ECPY0	ASIC Design	3	-	-	3	
14.	18ECPZ0	oT System and Applications	3	-	-	3	
15.	18ECRA0	Real Time Embedded Systems	3	-	-	3	
THEOR	Y CUM PRACTIC	AL		1	1	1	
16.	18ECPC0	DSP Architecture and Programming	2	-	2	3	
17.	18ECPE0	Biomedical Signal Processing	2	-	2	3	
18.	18ECPG0	Analog System Design	2	-	2	3	

b. Programme Elective for Expanded Scope Credits to					o be earned: 06-12		
SI. No.	Course Code	Name of the Course		Nu H L	mbe ours Vee T	er of s / k P	Credit

THEORY	THEORY							
1.	18ECPL0	Medical Imaging and Processing	3	-	-	3		
2.	18ECPP0	RF MEMS Design and Technology	3	-	-	3		
3.	18ECPR0	LDPC and Polar Codes	2	1	-	3		
4.	18ECPS0	Physical Channel Processing in 5G NR	2	1	-	3		
5.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3		
6.	18ECPW0	CAD for VLSI	3	-	-	3		
7.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3		
8.	18ECRC0	Multimedia Compression Techniques	3	1	-	4		
9.	18ECRD0	Signal Processing in 5G NR	3	1	-	4		
10.	18ECRE0	Algorithms for VLSI Design Automation	3	1	-	4		
11.	18ECRF0	Low Power VLSI Design	3	1	-	4		
12.	18EC1A0	Field Tests for a 5G Future	1	-	-	1		
13.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1		
14.	18EC1C0	Synchronization for 5G NR	1	-	-	1		

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

15.	18EC1D0	Speech Signal Processing	1	-	-	1	
16.	18EC1E0	VLSI Implementation of	1	-	-	1	
		Communication Transceivers					
17.	18EC1F0	Embedded System Design	1	-	-	1	
THEORY CUM PRACTICAL							
	-	-	-	-	-	-	

c. General Elective

# Credits to be earned: 03-06

SI. No.	Course Code	Name of the Course	Number of Hours / Week		Credit	
			L	Т	Ρ	
THEORY						
1.	18ECGA0	Consumer Electronics	3	-	-	3
2.	18ECGB0	Multimedia Systems	3	-	-	3
3.	18ECGD0	Telecom Systems	3	-	-	3
4.	18ECGE0	Applied Image Processing	3	-	-	3

# d. Electives from foundation courses- HSS, BS, ES

# D. Project

# Credits to be earned: 15

Credits to be earned: 03-06

S.No.	Course Code	Name of the Course	Nu Hou	Number of Hours / Week		Credit
		the second second	L	Т	Р	
1.	18ES690	Engineering Design Project	2	-	4	3
2.	18ES790	Capstone Design Project	-	-	6	3
3.	18EC810	Project	-	-	18	9
		a second				

E. M	E. Mandatory Courses (Not included for CGPA)								
S.No.	Course	Name of the Course	Νι	ımbe	Credit				
	Code		Hou	Hours / Week					
			L	Т	P				
THEOR	THEORY								
1.	18CHAA0	Environmental Sciences	-	-	2	0			
2.	18CHAB0	Constitution of India	-	-	2	0			
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0			
THEOR	Y CUM PRA	CTICAL							
-	-	-	-	-	-	-			
PRACTICAL									
-	-	-	-	-	-	-			

Minimum credits to be earned for the award of the degree = 160

Batch: 2021-22 onwards

# THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015 (A Govt. Aided Autonomous Institution affiliated to Anna University)

# CATEGORIZATION OF COURSES (CHOICE BASED CREDIT SYSTEM)

Programme: ECE

F. FOUNDATION COURSES: Total Credits to be earned: 53-58									
	d. Huma	anities and Social Science (09-11)							
S.No.	Course	Name of the Course	Νι	umbe	r of		Credit		
	Code		Hou	ırs / \	Veek				
			L	Т	P				
THEOF	RY								
1.	18EG140	English	2	-	-		2		
2.	18EC610	Accounting and Finance	3	-	-		3		
3.	18EC490	Project Management	3	-	-		3		
THEORY CUM PRACTICAL									
1.	18EG460	Professional Communication	-	1	2		2		
PRAC	TICAL								
1.	18EG170	English Laboratory	-	-	2		1		
	e. Basio	c Science (21)							
S.No.	Course	Name of the Course	Nur	nber	of Ho	urs	Credit		
	Code			/ W	eek				
					ТР		-		
	<b>&gt;</b> V	A Canada A SA		•	•	1			
	18MA110	Engineering Calculus	3		1	_	4		
1.					-				
2.	18PHB20	Physics	3		-	-	3		
3.	18CHB30	Chemistry	3		-	-	3		
4.	18MA210	Matrices and Ordinary Differential	2	2 1		-	3		
5	18EC310	Complex Analysis and Linear Algebra	2	,	1		3		
6	18EC410	Ontimization and Numerical Methods	2	·	1		3		
PRAC				·	•				
1	18PH180	Physics Laboratory			-	2	1		
1.	18CH190	Chemistry Laboratory	-		-	2	1		
<u> </u>	f Engi	peering Science (23-26)				-	<u> </u>		
S No	Course	Name of the Course	N	lumb	er of		Credit		
0.110.	Code		Ho	urs /	Week		oroun		
				T	P	<u> </u>			
THEOF	ΥΥ					_			
1.	18ES150	Engineering Exploration	3	-	-		3		
2.	21EC240	Electronic Materials	3	_	-		3		
3.	18EC630	Data Structures and Algorithms	2	_	-		2		
4.	18XXPE0	Engineering Sciences Elective	3	_	-		3		
THEOF		ACTICAL		1	1				
1.	18ME160	Engineering Graphics	3	_	2		4		
2.	18EC360	Programming for Problem Solving	2	-	2		3		
3.	18ES390	Design Thinking	1	-	2		2		
4.	18ES590	System Thinking	1	-	1		2		
PRACT	TICAL			1					
1.	18EC280	Electronics Workshop	-	-	2		1		
2	18ES290	Lateral Thinking	-	-	2		1		

18EC670

Data

Laboratory

Structures

and

Algorithms

3.

Degree: B.E.

Approved in 61th Academic Council Meeting 03.07.2021

-

-

2

1

# **Engineering Sciences Elective**

S.No.	Course	Name of the Course	۸. I	Number of		Credit	
	Code		HC	urs /	Week		
			L	Т	Р		
THEOF	RY						
1.	18ECEA0	MEMS Technology	3	-	-	3	
2.	18ECEB0	Machine Learning for All	3	-	-	3	
3.	18ECEC0	IOT Sensors and Device	3	-	-	3	
4.	18ECED0	Blockchain Technology	3	-	-	3	
5.	18ECEE0	5G Wireless Networks	3	-	-	3	
THEORY CUM PRACTICAL							
	-	-	-	-	-	-	

# G. PROFESSIONAL CORE COURSES

# Credits to be earned: 55

SI. No.	Course	Name of the Course	Nu	Number of		Credit
	Code	AT DA	H	lours	s /	
		1 STRIN	۱ ۱	Nee	k	
			L	T	Р	
THEOR'	Ý					
25.	18EC220	Network Theory	2	1	-	3
26.	18EC231	Electronic Devices	3	-	-	3
27.	18EC320	RF Passive Devices and Circuits	2	1	-	3
28.	18EC330	Electronic Circuits	3	-	-	3
29.	18EC340	Signals and Systems	2	1	-	3
30.	18EC350	Microprocessors and Microcontrollers	2	1	-	3
31.	18EC420	RF Active Circuits	2	1	-	3
32.	18EC430	CMOS VLSI Systems	3	-	-	3
33.	18EC440	Signal Processing	2	1	-	3
34.	18EC510	Data Communication Networks	2	1	-	3
35.	18EC530	Analog and Digital Communication	2	1	-	3
		Systems				
36.	18EC620	Control Systems	2	1	-	3
37.	18EC710	Consumer Electronics	1	-	-	1
THEOR	Y CUM PRAC	TICAL				
38.	18EC260	Digital System Design	2	-	2	3
39.	18EC520	Antenna and Wave Propagation	2	-	2	3
40.	18EC560	Digital Image Processing	2	-	2	3
41.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTI	CAL					
42.	18EC270	Circuits and Devices Laboratory	-	-	2	1
43.	18EC370	Microprocessor and Microcontroller	-	-	2	1
		Laboratory				
44.	18EC380	Electronic Circuits Laboratory	-	-	2	1
45.	18EC470	RF Circuits Laboratory	-	-	2	1
46.	18EC480	Signal Processing Laboratory	-	-	2	1
47.	18EC570	Data Communication Networking	-	-	2	1
		Laboratory				
48.	18EC580	Analog and Digital Communications	-	-	2	1
		Laboratory				

H. EL	H. ELECTIVE COURSES: Cred		to be earned: 24-48				
a. Pr	ogramme Specif	c Elective Credits t	o be	be earned:12-24			
SI. No.	Course Code	Name of the Course	Number of Hours / Week		er of s / k	Credit	
	-		L	T	Р		
THEORY	Y	-				-	
19.	18ECPA0	Computer Vision and Applications	3	-	-	3	
20.	18ECPB0	Data Compression	3	-	-	3	
21.	18ECPD0	Wireless Communication Systems	2	1	-	3	
22.	18ECPF0	FPGA Based Digital System Design	3	-	-	3	
23.	18ECPH0	Electronic Measurement and Instruments	3	-	-	3	
24.	18ECPJ0	Network Security	3	-	-	3	
25.	18ECPK0	Optical Communication	3	-	-	3	
26.	18ECPM0	Planar Antennas for Wireless Applications	2	-	2	3	
27.	18ECPN0	Electromagnetic Interference and Compatibility	3	-	-	3	
28.	18ECPQ0	Statistical Signal Processing	2	1	-	3	
29.	18ECPT0	Deep Learning for Speech Processing	2	1	-	3	
30.	18ECPU0	VLSI Device Modeling	3	-	-	3	
31.	18ECPY0	ASIC Design	3	-	-	3	
32.	18ECPZ0	IoT System and Applications	3	-	-	3	
33.	18ECRA0	Real Time Embedded Systems	3	-	-	3	
THEORY	Y CUM PRACTIC	AL					
34.	18ECPC0	DSP Architecture and Programming	2	-	2	3	
35.	18ECPE0	Biomedical Signal Processing	2	-	2	3	
36.	18ECPG0	Analog System Design	2	-	2	3	

# b. Programme Elective for Expanded Scope Credits to be earned: 06-12

SI. No.	Course Code	Name of the Course	Number o Hours /		er of s /	Credit
	-		N	Nee	k	
			L	Т	Р	
THEORY	/					
18.	18ECPL0	Medical Imaging and Processing	3	-	-	3
19.	18ECPP0	RF MEMS Design and Technology	3	-	-	3
20.	18ECPR0	LDPC and Polar Codes	2	1	-	3
21.	18ECPS0	Physical Channel Processing in 5G	2	1	-	3
		NR				
22.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3
23.	18ECPW0	CAD for VLSI	3	-	-	3
24.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3
25.	18ECRC0	Multimedia Compression Techniques	3	1	-	4
26.	18ECRD0	Signal Processing in 5G NR	3	1	-	4
27.	18ECRE0	Algorithms for VLSI Design	3	1	-	4
		Automation				
28.	18ECRF0	Low Power VLSI Design	3	1	-	4
29.	18EC1A0	Field Tests for a 5G Future	1	-	-	1

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

30.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1		
31.	18EC1C0	Synchronization for 5G NR	1	-	-	1		
32.	18EC1D0	Speech Signal Processing	1	-	-	1		
33.	18EC1E0	VLSI Implementation of	1	-	-	1		
		Communication Transceivers						
34.	18EC1F0	Embedded System Design	1	-	-	1		
THEORY CUM PRACTICAL								
	-	-	-	-	-	-		

d. Genera	I Elective	Credits t	to be earned: 03-06				
SI. No.	Course	Name of the Course	Number of		Credit		
	Code		H	lours	s /		
			۱ ۱	Week			
			L	Т	Р		
THEORY							
5.	18ECGA0	Consumer Electronics	3	-	-	3	
6.	18ECGB0	Multimedia Systems	3	-	-	3	
7.	18ECGD0	Telecom Systems	3	-	-	3	
8.	18ECGE0	Applied Image Processing	3	-	-	3	

d. Electives from foundation courses- HSS, BS, ES Credits to be earned: 03-06

# I. Project

# Credits to be earned: 15

S.No.	Course	Name of the Course	Number of			Credit				
	Code	Sardin a	Hours / Week							
			L	Т	Р					
1.	18ES690	Engineering Design Project	2	-	4	3				
2.	18ES790	Capstone Design Project	-	-	6	3				
3.	18EC810	Project	-	-	18	9				

J. N	J. Mandatory Courses (Not included for CGPA)									
S.No.	Course	Name of the Course	Nu	umbe	r of	Credit				
	Code		Hou	ırs / V	Veek					
			L	Т	P					
THEOR	THEORY									
1.	18CHAA0	Environmental Sciences	-	-	2	0				
2.	18CHAB0	Constitution of India	-	-	2	0				
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0				
THEOR	Y CUM PRAG	CTICAL								
-	-	-	-	-	-	-				
PRACTICAL										
-	-	-	-	-	-	-				

Minimum credits to be earned for the award of the degree = 160

Cr edi ts		22	8	22	22	22
Audit Courses (Mandato ry Non- credit}	12	1	18CHAA0 Environm ental Sciences (0)		18CHAB0 Constituti on of India (0)	Essence of Indian Knowledg e (0)
Special Courses	11	1	18ES290 Lateral Thinking (1)	18ES390 Design Thinking (TCP) (2)	18EC490 Project Managem ent (3)	18ES590 System Thinking (2)
	10	18CH19 0 Chemist ry Lab. (1)			•	
Practical	9	18PH180 Physics Lab. (1)	18EC280 Workshop (1)	18EC380 Electronic Circuits Lab (1)	18EC480 Signal Processin g Lab (1)	18EC580 Analog and Digital Commn. Lab (1)
	8	18EG170 English Lab. (1)	18EC270 Circuits and Devices Lab (1)	18EC370 Microproc essor and Microcont roller Lab (1)	18EC470 RF Circuits Lab (1)	18EC570 Data Commn. Networkin g Lab `(1)
Theory cum Practical	7	18ME160 Engg Graphics (4)	18EC260 Digital System Design (3)	18EC360 Programmin g for Problem Solving (3)	18EG460 Professional Communicat ion (2)	18EC560 Digital Image Processing (3)
	9	L.			•	1
	5	18ES150 Engg Explorati on (3)	No.	18EC350 Micropro cessors and Microcont rollers (3)	18YYFX0 Foundati on Elective I (3)	18YYGX 0 Gen. Elective .I (3)
	4	18EG180 English (2)	18EC240** Semicondu ctor Physics (3)	18EC340 Signals and Systems (3)	18EC440 Signal Processing (3)	18ECPX0 Prog. Elective -I (3)
Theory	3	18CHB 30 Chemistry (3)	18EC230** Electronic Devices (3)	18EC330 Electronic Circuits (3)	18EC430 CMOS VLSI Systems (3)	18EC530 Analog and Digital Communicat ions (3)
	2	18PHB20 Physics (3)	18EC220 Network Theory (3)	18EC320 RF Passive Devices and Circuits (3)	18EC420 RF Active Circuits (3)	18EC520 Antenna and Wave Propagatio n (TCP) (3)
	1	18MA110 Engineering Calculus (4)	18MA210 Matrices and Ordinary Differential Equations (3)	18EC310 Complex Analysis and Linear Algebra (3)	18EC410 Optimization and Numerical Methods (3)	18EC510 Data Communicat ion Networks (3)
Se est er	5	_	=	≡	≥	>

SCHEDULING OF COURSES FOR 2018-19 onwards (B.E. ECE Programme)\*

Passed in BoS Meeting 22.06.2021

Approved in 61th Academic Council Meeting 03.07.2021

B.E. (Electronics and Communication Engineering)

Cr edi ts		23	16	15
Audit Courses (Mandato ry Non- credit}	12	•	1	1
Special Courses	11	18ES690 Engineeri ng Design Project (3)	18ES790 Capstone Design (3) (3)	1
	10		1	18EC81 0 Project (9)
Practical	6	1	1	1
	8	18EC670 Data Structures and Algorithm s Lab (1)		1
Theory cum Practical	7	18EC660 Digital Communicat ion System Design (2)		-
	9	Engg Scienc es (3)		-
	5	18ECPX 0 Prog. Elective/ 18YYFX0 Foundati on Elective II (3)	18ECPX 0 Prog. Elec. VI/ 18YYFX0 General Elective (3)	-
	4	18ECPX0 Prog. (3) (3)	18ECPX0 Prog. Elec.V (3)	1
Theory	3	18EC630 Data Structures and Algorithms (2)	18ECPX0 Prog. Elec IV (3)	
	2	18EC620 Control Systems (3)	18ECPX0 Prog. Elec.III (3)	18XXPX0 Prog. Elec. VIII (3)
	1	18EC610 Accounting and Finance (3)	18EC710 Consumer Electronics (1)	18XXPX0 Prog. Elec. VII (3)
esta Se		⋝	T	IIN

Total Credits for Curricular Activities: 160 \*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & \*This schedule shows an optimal way of completing the B.E. Degree programme successfully in 4 Years 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

# THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI - 625 015

#### B.E Degree (Electronics and Communication Engineering) Program

# COURSES OF STUDY

(For the students admitted from the Academic year 2018-19 onwards)

#### **FIRST SEMESTER**

Course code	Name of the Course	Category	Nu of I V	Number of Hours / Week		Credits
			L	Τ	Ρ	
THEORY						
18MA110	Engineering Calculus	BS	3	1	-	4
18PHB20	Physics	BS	3	I	-	3
18CHB30	Chemistry	BS	3	I	-	3
18EG140	English	HSS	2	I	-	2
18ES150	Engineering Exploration	ES	3	I	-	3
THEORY CL	IM PRACTICAL					
18ME160	Engineering Graphics	ES	3	I	2	4
PRACTICAL						
18EG170	English Laboratory	HSS	-	-	2	1
18PH180	Physics Laboratory	BS	-	I	2	1
18CH190	Chemistry Laboratory BS				2	1
	Total		17	1	8	22

#### SECOND SEMESTER

Course code	Name of the Course	Category	Nu	Number of Hours / Week		Credits
			L	Т	Ρ	
THEORY						
18MA210	Matrices and Ordinary Differential	BS	2	1	-	3
	Equations					
18EC220	Network Theory	PC	2	1	-	3
18EC230**	Electronic Devices	PC	3 -			3
18EC240**	Semiconductor Physics	ES	3			3
THEORY CL	JM PRACTICAL					
18EC260	Digital System Design	PC	2	-	2	3
PRACTICAL	-					
18EC270	Circuits and Devices Laboratory	PC	-	-	2	1
18EC280	Electronics Workshop	ES	-	-	2	1
18ES290	Lateral Thinking	ES	-	-	2	1
Non-credit co	ourse (Mandatory) – Audit Course					
18CHAA0	Environment Sciences	ES	1	-	1	-
		13	2	9	18	

\*\*For students joined from 2021-22 onwards,

18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

# THIRD SEMESTER

Course code	Name of the Course	Category	Nu Hou	imbei Irs / V	r of Veek	Credits	
			L	Т	Ρ		
THEORY	·			•			
18EC310	Complex Analysis and Linear Algebra	BS	2	1	-	3	
18EC320	RF Passive Devices and Circuits	PC	2	1	-	3	
18EC330	Electronic Circuits	PC	3	-	-	3	
18EC340	Signals and Systems	PC	2	1	-	3	
18EC350	Microprocessors and Microcontrollers	PC	2	1	-	3	
THEORY C							
18EC360	Programming for Problem Solving	ES	2	-	2	3	
18ES390	Design Thinking	ES	1	-	2	2	
PRACTICA	<u>L</u>						
18EC370	Microprocessor and Microcontroller Laboratory	PC	-	-	2	1	
18EC380	Electronic Circuits Laboratory	PC	C 2			1	
	Total		14	4	22		
FOURTH SE	EMESTER						
Course Name of the Course							
Course	Name of the Course	Category	Νι	Imbei	r of	Credits	
Course code	Name of the Course	Category	Nu Hou	imbei i <mark>rs / V</mark>	r of Veek	Credits	
Course code	Name of the Course	Category	Nu Hou L	imbei irs / V   T	r of Veek P	Credits	
Course code THEORY	Name of the Course	Category	Nu Hou L	Imbei Irs / V T	r of Veek P	Credits	
Course code THEORY 18EC410	Name of the Course Optimization and Numerical Methods	Category BS	Nu Hou L	Imbei Irs / V T	r of Veek P -	Credits 3	
Course code THEORY 18EC410 18EC420	Name of the Course Optimization and Numerical Methods RF Active Circuits	Category BS PC	Nu Hou L 2 2	Imbei Irs / V T 1 1	r of Veek P -	Credits 3 3	
Course code THEORY 18EC410 18EC420 18EC430	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems	Category BS PC PC	Nu Hou L 2 3	Imbei Irs / V T 1 1 -	r of Veek P - -	Credits 3 3 3	
Course code THEORY 18EC410 18EC420 18EC430 18EC440	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing	Category BS PC PC PC	Νι Ηου L 2 3 2	Imbei Irs / V T 1 - 1	r of Veek P - - -	Credits 3 3 3 3 3	
Course code THEORY 18EC410 18EC420 18EC420 18EC440 18YYFX0	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing Foundation Elective I	Category BS PC PC PC BS	Nu Hou 2 2 3 2 3	Imbei Irs / V T 1 1 - 1 -	r of Veek P - - - -	Credits 3 3 3 3 3 3 3 3 3	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing Foundation Elective I Project Management	Category BS PC PC PC BS HSS	Nu Hou 2 2 3 2 3 3 3 3	Imber Irs / V T 1 - 1 - -	r of Veek P - - - - - -	Credits 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490 THEORY C	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL	Category BS PC PC PC BS HSS	NL Hou 2 2 3 2 3 3 3	Imbei Irs / V T 1 1 - 1 -	r of Veek P - - - - - - - - -	Credits 3 3 3 3 3 3 3 3 3	
Course code THEORY 18EC410 18EC420 18EC430 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication	Category BS PC PC BS HSS HSS	NL Hou L 2 3 2 3 3 3 -	Imbei Irs / V T 1 - 1 - - -	r of Veek P - - - - - - - 2	Credits 3 3 3 3 3 3 2	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460 PRACTICA	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication	Category BS PC PC PC BS HSS HSS	NL Hou 2 2 3 2 3 3 3 -	Imbei Irs / V T 1 - 1 - - 1	r of Veek P - - - - - - 2	Credits 3 3 3 3 3 3 2 2	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460 PRACTICA 18EC470	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         L         RF Circuits Laboratory	Category BS PC PC PC BS HSS HSS	NL Hou 2 2 3 2 3 3 -	Imbei Irs / V T 1 1 - 1 - 1 - -	r of Veek P - - - - - 2	Credits 3 3 3 3 3 2 1	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC480	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory	Category BS PC PC PC BS HSS HSS PC PC	NL Hou L 2 2 3 2 3 3 - -	Imbei Irs / V T 1 1 - 1 - 1 - - -	r of Veek P - - - - - - 2 2 2	Credits 3 3 3 3 3 2 1 1 1	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC480 AUDIT CO	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory         URSE - NON-CREDIT MANDATORY COI	Category BS PC PC PC BS HSS HSS PC PC JRSE	NL Hou L 2 3 2 3 3 3 - -	Imbei Irs / V T 1 - 1 - - 1 - -	r of Veek P - - - - - - 2 2 2	Credits 3 3 3 3 3 2 1 1 1	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC480 AUDIT CO 18CHAB0	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory         URSE - NON-CREDIT MANDATORY COU         Constitution of India	Category BS PC PC PC BS HSS HSS HSS JRSE HSS	NL Hou 2 2 3 2 3 3 - - - -	Imbei Irs / V T 1 - 1 - 1 - - - - - - -	r of Veek P - - - - - - 2 2 2 2	Credits 3 3 3 3 3 3 2 1 1 0	

# **FIFTH SEMESTER**

Course code	Name of the Course	Category	Nu Hou	Number of Hours / Week		Credits
			L	Т	P	
THEORY						
18EC510	Data Communication Networks	PC	2	1	-	3
18EC530	Analog and Digital Communication	PC	2	1	-	3
18ECPX0	Programme Elective -I	PE	3	-	-	3
18YYGX0	General Elective - I	GE	3	-	-	3
THEORY C	UM PRACTICAL	•				
18EC520	Antenna and Wave Propagation	PC	2	-	2	3
18EC560	Digital Image Processing	PC	2	-	2	3
18ES590	System Thinking	ES	1	1 - 1*		2
PRACTICA	NL .					

18EC570	Data Communication Networking	PC	-	-	2	1
1950590	Analog and Digital Communications	PC			2	1
TOEC300		FC	-	-	2	I
AUDIT CO	URSE - NUN-CREDIT MANDATURT CC					0
INCHACU		192	-	-	2	0
	lotal		15	2	11	22
*One hour p	er week is allotted for off the classroom w	ork				
SIXTH SEM	ESTER	1	1			
Course	Name of the Course	Category	Nu	Impe	r of	Credits
code			Hou	<u>irs / V</u>	Veek	
			L	T	Ρ	
THEORY						
18EC610	Accounting and Finance	HSS	3	-	-	3
18EC620	Control Systems	PC	2	1	-	3
18EC630	Data Structures and Algorithms	ES	2	-	-	2
18ECPX0	Programme Elective-II	PE	3	-	-	3
18YYZX0	Programme / Foundation Elective - I	PE/FE	3	-	-	3
18ESEX0	Engineering Sciences Elective	ES	3	-	-	3
THEORY C	CUM PRACTICAL					
18EC660	Digital Communication Transceiver	PC	1	-	2	2
PRACTICA	NL					
18EC670	Data Structures and Algorithms	ES	-	-	2	1
	Laboratory					
PROJECT						
18ES690	Engineering Design Project	Project	1	-	4	3
	Total		18	1	8	23

# SEVENTH SEMESTER

Course code	Name of the Course	Category	Nu Hou	Number of Hours / Week		Credits	
			L	Т	P		
THEORY							
18EC710	Consumer Electronics	PC	1	-	-	1	
18ECPX0	Programme Elective -III PE 3 -				-	3	
18ECPX0	Programme Elective -IV	PE	3	-	-	3	
18ECPX0	Programme Elective -V	PE	3	-	-	3	
18YYZX0	Programme-VI / General Elective - II	PE/GE	3	-	-	3	
THEORY C	CUM PRACTICAL						
-	-	-	-	-	-	-	
PRACTICA	\L						
-	-	-	-	-	-	-	
PROJECT							
18ES790	Capstone Design Project	Project	-	-	6	3	
	Total		13	-	6	16	

#### **EIGHTH SEMESTER**

Course code	Name of the Course	Category	Number of Hours / Week		Credits	
			L	Т	Ρ	
THEORY						
18ECPX0	Programme Elective -VII	PE	3	-	-	3
18ECPX0	Programme Elective -VIII	PE	3	3		3
THEORY C	CUM PRACTICAL					
-	-	-	-	-	-	-
PRACTICA	\L					
-	-	-	-	-	-	-
PROJECT						
18EC810	Project	Project	-	18		9
	Total		6 - 18		15	

- BS : Basic Science
- HSS : Humanities and Social Science
- ES : Engineering Science
- PC : Programme Core
- PE : Programme Elective
- GE : General Elective
- FE : Foundation Elective
- L : Lecture
- T : Tutorial
- P : Practical

#### Note:

- 1 Hour Lecture/week is equivalent to 1 Credit
- 1 Hour Tutorial/week is equivalent to 1 Credit
- 2 Hours Practical/week is equivalent to 1 Credit

#### THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E Degree (Electronics and Communication Engineering) Program SCHEME OF EXAMINATIONS

(For the students admitted from the Academic Year 2018-19 onwards) **SECOND SEMESTER** 

Course	Name of the	Duration	Ν		Minimum	Marks	
code	Course	Torminal	Continuouo	Terminel	Max	Torminal	Tatal
			Continuous		Max.		Total
		Exam	Assessment	Exam**	Marks	Exam	
		In Hrs.					
THEORY	1						
18MA210	Matrices and	3	50	50	100	25	50
	Ordinary						
	Differential						
	Equations						
18EC220	Network	3	50	50	100	25	50
	Theory	_				_	
18EC230***	Electronic	3	50	50	100	25	50
	Devices						
18EC240***	Semiconductor	3	50	50	100	25	50
	Physics						
THEORY CU	M PRACTICAL	•				•	
18EC260	Digital System	3	50	50	100	25	50
	Design						
PRACTICAL		•	•	•	•	•	
18EC270	Circuits and	3	50	50	100	25	50
	Devices						
	Laboratory						
18EC280	Electronics	3	50	50	100	25	50
	Workshop						
18ES290	Lateral	_	50	50	100	25	50
	Thinking						
AUDIT COUI	RSE - NON-CRED	IT MANDA	TORY COURS	E	1	1	1
18CHAA0	Environmental	-	50	50	100	25	50
	Sciences						

\*\*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

#### THIRD SEMESTER

Course	Name of the	Duration			Minimum	Marks	
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY							
18EC310	Complex Analysis and Linear Algebra	3	50	50	100	25	50
18EC320	RF Passive Devices and Circuits	3	50	50	100	25	50
18EC330	Electronic Circuits	3	50	50	100	25	50
18EC340	Signals and Systems	3	50	50	100	25	50

18EC350	Microprocessors	3		50		50	100	25	50
	and Microcontrollers								
THEORY									
18EC360	Programming for	3		50		50	100	25	50
	Problem Solving								
18ES390	Design Thinking	-		50		50	100	25	50
PRACTICA	AL							T	1
18EC370	Microprocessor	3		50		50	100	25	50
	and Microcontrollor								
18EC380	Electronic	3		50		50	100	25	50
1020000	Circuits	J J		00			100	20	
	Laboratory								
FOURTH SI	EMESTER	·							•
Course	Name of the	Duration of	of		I	Marks		Minimum	Marks
code	Course	End		0 "				for Pass	
		Semester		Continuous	*	End	Max.	End	Iotal
		Exam\		Assessmer	IT.	Semeste	er   Marks	Semester	
THEORY									
18EC410	Optimization	3		50		50	100	25	50
1020110	and Numerical	U		00				20	00
	Methods								
18EC420	RF Active	3		50		50	100	25	50
	Circuits								
18EC430	CMOS VLSI	3		50		50	100	25	50
4050440	Systems	0		50		50	100	05	50
18EC440	Signal	3		50		50	100	25	50
18YYEX0	Foundation	3		50		50	100	25	50
	Flective I	0		50		00	100	20	50
18EC490	Project	3		50		50	100	25	50
	Management								
THEORY O	CUM PRACTICAL							•	
18EG460	Professional	-		50		50	100	25	50
	Communication								
PRACTICA		•		50		50	400	05	50
18EC470		3		50		50	100	25	50
1950490	Signal	2		50		50	100	25	50
1020400	Processing	3		50		50	100	25	50
	Laboratory								
AUDIT CO	URSE - NON-CRE	DIT MANDA	ТС	RY COURS	E	I	1	1	
18CHAB0	Constitution of	-		50		50	100	25	50
	India								

# **FIFTH SEMESTER**

						1	
Course code	Name of the Course	Duration of End	ſ	Varks		for Pass	Marks
		Semester Exam\ in Hrs.	Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY						•	•
18EC510	Data Communication Networks	3	50	50	100	25	50
18EC530	Analog and Digital Communication Systems	3	50	50	100	25	50
18ECPX0	Programme Elective -I	3	50	50	100	25	50
18YYGX0	General Elective - I	3	50	50	100	25	50
THEORY C	UM PRACTICAL					•	•
18EC520	Antennas and Wave Propagation	3	50	50	100	25	50
18EC560	Digital Image Processing	3	50	50	100	25	50
18ES590	System Thinking	-	50	50	100	25	50
PRACTICA	L	•		•		•	•
18EC570	Data Communication Networking Laboratory	3	50	50	100	25	50
18EC580	Analog and Digital Communications Laboratory	3	50	50	100	25	50
AUDIT COU	JRSE - NON-CREDI	T MANDATO	DRY COURSE			•	
18CHAC0	Essence of Indian Knowledge	-	50	50	100	25	50
SIXTH SEME	ESTER	1	•				
Course code	Name of the Course	Duration of End		Marks		Minimum for Pass	Marks
		Semester Exam\ in Hrs.	Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY	1			1			
18EC610	Accounting and Finance	3	50	50	100	25	50
18EC620	Control Systems	3	50	50	100	25	50
18EC630	Data Structures and Algorithms	3	50	50	100	25	50
18ECPX0	Programme Elective -II	3	50	50	100	25	50
18YYZX0	Programme / Foundation Elective - I	3	50	50	100	25	50
18ESEX0	Engineering	3	50	50	100	25	50
------------	-----------------	----------	-------------	----------	-------	----------	-------
THEORY C							
18EC660	Digital	3	50	50	100	25	50
1020000	Communication	U	00	00		20	
	System Design						
PRACTICA	L				I		1
18EC670	Data Structures	3	50	50	100	25	50
	and Algorithms	_				_	
	Laboratory						
Project		•				•	
18ES690	Engineering	-	50	50	100	25	50
	Design Project						
SEVENTH S	EMESTER						
Course	Name of the	Duration	1	Marks		Minimum	Marks
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY		-					
18EC710	Consumer	3	50	50	100	25	50
(0505)(0	Electronics			=	100		
18ECPX0	Programme	3	50	50	100	25	50
			50	50	100	05	50
18ECPX0	Programme	3	50	50	100	25	50
	Dregromme	2	50	50	100	25	50
TOECFAU		3	50	50	100	25	50
187770		3	50	50	100	25	50
1011270		5	50	50		25	50
Project							I
18ES790	Capstone Design	_	50	50	100	25	50
1020100	Project			00	100	20	00
EIGTH SEME	ESTER				I		
Course	Name of the	Duration		Marks		Minimum	Marks
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY					•	•	
18ECPX0	Programme	PE	3	-	-	3	-
	Elective -VII						
18ECPX0	Programme	PE	3	-	-	3	50
	Elective -VIII						
Project							
18FC810	Project	-	50	50	100	25	50

\*Continuous Assessment evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\*End Semester Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of End semester examination marks.

\*\*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

18EC410	OPTIMIZATION AND NUMERICAL	Category	L	Т	Ρ	Credit
	METHODS	BS	2	1	0	3
	·					

An engineering UG student needs to have some basic mathematical tools and techniques to apply in diverse applications in Engineering. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Optimization is a scientific approach to decision making that seeks to best design and operate a system, usually under conditions requiring the allocation of scarce resources. Various techniques of optimization have been dealt on the title "Operations Research". Because of the complexity of most realworld optimization problems, it has been necessary to reduce the complexity of the problem by either simplifying the problem or constraining it by making reasonable assumptions. Students will get exposure to such knowledge on operations research and numerical methods.

# Prerequisite

NIL

#### **Course Outcomes**

On th	e successful completion of the course, students will be able to											
CO#	Course Outcome Statement	Weightage in %										
CO1	Compute the solution for the IVPs in ODE using single step methods.	10%										
CO2	Compute the solution for the IVPs in ODE using multistep methods and the solution for the Boundary value problems in ODE.	20%										
CO3	Solving partial differential equation using Numerical methods.	20%										
CO4	Formulate mathematical models of Linear Programming (LP)	10%										
CO5	Solve Linear Programming Problems (LPP) by appropriate techniques (i.e. Graphical, Simplex method) and evaluate the behaviour under different range of parameters.	20%										
CO6	Examine the performance characteristics such as time and cost in solving shortest route, flow, transportation and assignment problems with an appropriate model	20%										

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lear	ning Domain	Level	CDIO Curricular									
#	Proficiency	Cognitive	Affective	Psychomotor	Components									
	Scale			-	(X,Y,Z)									
CO1	TPS2	Understand	Respond	-	1.1.1, 2.1.3, 2.1.5, 3.1.3,									
			-		4.1.1									
CO2	TPS3	Apply	Value	-	1.1.1, 2.1.3, 2.1.5, 3.1.3,									
					4.1.1									
CO3	TPS3	Apply	Value	-	1.1.1, 2.1.3, 2.1.5, 3.1.3,									
					4.1.1									
CO4	TPS2	Understand	Respond	-	1.1.1, 2.1.3, 2.1.5, 3.1.3,									
					4.1.1									
CO5	TPS3	Apply	Value	-	1.1.1, 2.1.3, 2.1.5, 3.1.3,									
					4.1.1									
CO6	TPS3	Apply	Value	-	1.1.1, 2.1.3, 2.1.5, 3.1.3,									
					4.1.1									

Mappi	Mapping with Programme Outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	S	S	S	М	S		S	S	-	-	-	S	-	-
CO2	S	S	S	М	М	S	L	S	S	-	-	-	S	-	-
CO3	S	S	S	S	М	S		S	S	-	-	-	S	-	-
CO4	S	S	S	S	М	S	М	S	S	-	-	-	S	-	-
CO5	S	S	S	S	М	S	М	S	S	-	-	-	S	-	-
CO6	S	S	S	S	М	S	М	S	S	-	-	-	S	-	-

S- Strong; M-Medium; L-Low

#### Assesment Pattern: Cognitive Domain

Cognitive	Contir	nuous Asse	essment	As	signment	End	
Levels	1	2	3	1	2	3	Examination
Remember	10	10	10	-	-	-	0
Understand	20	20	20	-	-	-	30
Apply	70	70	70	100	100	100	70
Analyse	0	0	0		-	-	0
Evaluate	0	0	0	N-A	-	-	0
Create	0	0	0	( R-)	-	-	0
		1 0 1					

#### **Course Level Assessment Questions**

## Course Outcome 1 (CO1):

- A company produces two types of goods A and B that require gold and silver. Each unit of type A requires 3 grams of silver and 1 gram of gold while B requires 1 grams of silver and 2 grams of gold. The company can produce 9 grams of silver and 8 grams of gold. If each unit of type A brings a profit of Rs.40 and that of type B Rs.50, determine the number of units of each type that should be produced to maximize the profit. Formulate the LP Model and find the optimal product mix and the corresponding profit of the company using simplex method.
- 2. A firm produces two products A and B on which the profits earned per unit are Rs.3 and Rs.4, respectively. They are processed on two machines M1 and M2. Product A requires one minute of processing time on M1 and two minutes on M2, while B requires one minute on M1 and one minute on M2. Machine, M1 is available for not more than 7 hours 30 minutes, while machine M2 available for 10 hours during any working day. Formulate the problem as LPP to find the number of units of products A and B to be manufactured to get maximum profit and solve this LPP using the result of the its dual problem.

#### Course Outcome 2 (CO2):

- 1. Solve the following problem graphically
- Maximize Z = 60  $x_1$  + 40 $x_2$  subject to 2  $x_1$  +  $x_2 \le 60$ ; X<sub>1</sub>  $\le 25$ ; X<sub>2</sub>  $\le 35$ ; X<sub>1</sub> $\ge 0$ ;  $x_2 \ge 0$ 2. Solve by simplex method: Maximize Z =  $x_1 - x_2 + 3x_3$  subject to  $2x_1 + x_2 + x_3 \le 10$ ;  $2x_1 - x_2 + 3x_3$
- $\mathbf{x}_3 \le 2$ ;  $2\mathbf{x}_1 2\mathbf{x}_2 + 3\mathbf{x}_3 \ge 0$ ;  $\mathbf{x}_1$ ,  $\mathbf{x}_2$ ,  $\mathbf{x}_3$  all  $\ge 0$

#### Course Outcome 3 (CO3):

1. The owner of a small machine shop has four mechanics available to assign jobs for the day. Five jobs are offered with expected profit for each mechanic on each job as follows.

				500	13		
		Α	В	C	Ľ	)	E
	1	62	78	50	111	82	
Mashinoa	2	71	84	61	73	59	
Machines	3	87	92	111	71	81	
	4	48	64	87	77	80	

Find by using the assignment method the assignment of mechanics of the job that will recent in a maximum profit. Which job should be declined.

2. Solve the following transportation problem.

		То		Available
From	А	В	С	
Ι	50	30	220	1
I	90	45	170	3
=	250	200	50	4
Requirement	4	2	2	

# Course Outcome 4 (CO4):

- 1. Using Euler's method, solve numerically the equation y' = x + y, y(0) = 1, for x = 0.0 (0.2) (0.1). Check your answer with the exact solution.
- 2. By means of Taylor series expansion find y at x = 0.1 & 0.2, given  $\frac{dy}{dx} 2y = 3e^x$ , y(0) = 0.

# Course Outcome 5 (CO5):

- 1. Given  $y'+xy^2 + y = 0$ , y(0) = 1, find the value of y(0.2) by using Runge-Kutta method of fourth order.
- 2. Using Milne's method find y(4.4) given  $5xy'+y^2 2 = 0$  given y(4) =1; y(4.1) =1.0049; y(4.2) = 1.0097 and y(4.3) = 1.0143.

# Course Outcome 6 (CO6):

- 1. Solve  $u_{xx} + u_{yy} = 0$  over the square mesh of side 4 units; satisfying the following conditions.u(x, 0) = 3x for  $0 \le x \le 4$ ; u(x, 4) =  $x^2$  for  $0 \le x \le 4$ ; u(0, y) = 0 for  $0 \le y \le 4$ ; u(4, y) = 12 + y for  $0 \le y \le 4$ .
- 2. Solve  $\frac{\partial^2 u}{\partial x^2} 2 \cdot \frac{\partial u}{\partial t} = 0$  given u(0, t) = 0, u(4, t) = 0, u(x, 0) = x(4 x). Assume h = 1. Find the values of u upto t = 5.
- 3. Solve  $y_{tt} = 4y_{xx}$  subject to the conditions y(0, t) = 0, y(2, t) =, y(x, 0) = x(2 x),  $\frac{\partial y}{\partial y}(x, 0) = 0$ . Do for the conditions y(0, t) = 0, y(2, t) = 0, y(x, 0) = x(2 - x),
  - $\frac{\partial y}{\partial x}(x,0) = 0$ . Do 4 steps. Find values upto 2 decimal accuracy.

# Concept Map



# Syllabus

**Numerical Solution for Ordinary Differential Equation:** Picards method, Eulers method, modified Eulers method, Runge Kutta method of fourth order - Predictor- corrector method: Milne's method. Solving simultaneous first order differential equation. Solving boundary value problems : finite difference method. Numerical Solution for Partial Differential Equation: Classification of second order partial differential equation-Solution of elliptic equation, - Solution of parabolic equation by bender method and Solution of hyberbolic equation. Linear Programming: Formulation - Graphical Method and Simplex Method – Primal Vs. Dual relationships. Transportation problems: Transportation problems and solutions - Assignment problems – Solution using Hungarian Method.

#### Learning Resources

- 1. S.S. Sastry, Introductory methods of numerical analysis, PHI, 4<sup>th</sup> Edition, 2005.
- 2. P.Kandasamy, K.Thilagavathy, K.Gunavathi, Numerical Methods, S. Chand & Company, 2<sup>nd</sup> Edition, Reprint 2012.
- 3. Hamdy A. Taha, "Operations Research An Introduction", 7th Edition, MacMillan Co., 2010.
- 4. Frederick Hillier, Gerald Lieberman, "Introduction to Operations Research" Tenth Edition, Tata McGraw Hill, 2015.

Module No	Торіс	Lecture Hours	CO's		
1	Numerical solution for ordinary differential equation				
1.1	Picards method, Euler's method, Modified Euler's method	2	CO1		
1.2	Runge Kutta method of fourth order	2	CO1		
	Tutorial	1			
1.3	Predictor- corrector method: Milne's method	2	CO2		
1.4	Finite difference method	1	CO2		
	Tutorial	1			
2	Numerical solution for partial differential equation				
2.1	Classification of second order partial differential equation	1	CO3		
2.2	Solution of elliptic equation	2	CO3		
	Tutorial	1			
2.3	Solution of parabolic equation by bender method	2	CO3		
2.4	Solution of hyberbolic equation	2	CO3		
	Tutorial	1			
3	Linear Programming:				
3.1	Formulation	1	CO4		
3.2	Graphical Method	2	CO5		
3.3	Simplex Method	2	CO5		
	Tutorial	1			
3.4	Primal Vs. Dual relationships.	2	CO5		
	Tutorial	1			
4	Transportation problems				
4.1	Transportation problems and solutions	3	CO6		
	Tutorial	1			
4.2	Assignment problems	2	CO6		
4.3	Solution using Hungarian Method	2	CO6		
	Tutorial	1			
	Total	36			

#### **Course Contents and Lecture Schedule**

**Course Designers:** 

- 1. Dr.M.Mutharasan
- 2. Dr.S.P.Suriya Prabha
- 3. Mr.R.Sivakumar

mmmat@tce.edu suriyaprabha@tce.edu rsrmat@tce.edu

Passed in BoS Meeting 11.05.2019

18EC420	RF ACTIVE CIRCUITS	Category	L	Т	Ρ	Credit
		PC	2	1	0	3

This course aims to provide students with the technological skills needed in understanding the behaviour of active circuits and analyze the system level parameters of the RF front end.

#### Prerequisite

18EC320 RF Passive Devices and Circuits

#### Course Outcomes

On the successful completion of the course, students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Understand the fundamentals of maximum power transfer, stability criteria, Oscillation criteria, heterodyning criteria.	20
CO2	Design and implementation of Matching network in different platforms for maximum power transfer between two microwave circuits.	20
CO3	Design and develop linear amplifier for the GSM applications	20
CO4	Design an oscillator for the given specifications.	15
CO5	Design a mixer for the given specifications.	15
CO6	Calculate the RF System level power budget for the given receiver architecture.	10
Mann	ing with Programme Outcomes	

#### Mapping with Programme Outcomes

COs	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO						
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	М	L	-	-	L	-	1	-	F	-	-	L	L	-	L
CO2	S	M	L	-	Μ	L	- /-	М	М	M	L	L	М	М	L
CO3	S	M	L	-	Μ	L	-	М	М	М	L	L	М	М	L
CO4	S	M	L	-	Μ	L	-	Μ	М	M	L	L	М	М	L
CO5	М	L	-	-	Μ	L	-	Μ	М	M	-	L	М	-	L
CO6	М	L	-	-	L	-	-	-	L	-	-	L	L	-	L

# S- Strong; M-Medium; L-Low

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lear	ning Domain	Level	CDIO Curricular
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale	-		-	(X.Y.Z)
CO1	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.4.7, 4.1.4
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4,
					3.1.1, 3.1.2, 3.1.4, 3.2.1,
					3.2.6, 3.2.4, 3.2.5, 3.2.6,
					3.3.1, 4.1.2, 4.3.4, 4.4.3,
					4.5.2, 4.5.3, 4.5.5
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4,
					3.1.1, 3.1.2, 3.1.4, 3.2.1,
					3.2.6, 3.2.4, 3.2.5, 3.2.6,
					3.3.1, 4.1.2, 4.3.4, 4.4.3,
					4.5.2, 4.5.3, 4.5.5
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4,
					3.1.1, 3.1.2, 3.1.4, 3.2.1,
					3.2.6, 3.2.4, 3.2.5, 3.2.6,
					3.3.1, 4.1.2, 4.3.4, 4.4.3,
					4.5.2, 4.5.3, 4.5.5

CO	TCE		Lear	ning Domaii	n Level		CDIO	Curricular	
#	Proficie	ncy 🗌	Cognitive Affective		Psych	omotor	Components		
	Scale	e	-		-		(>	(.Y.Z)	
CO5	TPS3		Apply	Value	Mecha	inism	1.2, 2.4.7,	2.5.1, 2.5.4,	
							3.1.1, 3.1.2	, 3.1.4, 3.2.1,	
							3.2.6, 3.2.4	, 3.2.5, 3.2.6,	
							3.3.1, 4.1.2	, 4.3.4, 4.4.3,	
							4.5.2, 4.5.3,	4.5.5	
CO6	TPS2		Understand	Respond	-		1.2, 2.1.1, 2.	4.7, 4.1.4	
Asses	sment P	attern	: Cognitive I	Domain					
Cog	gnitive	Con	tinuous Ass	essment		Assigni	nent	End Semester	
Le	evels		Tests					Examination	
		1	2	3	1	2	3		
Reme	mber	20	0	20	0	0	0	0	
Under	stand	20	20	20	100	0	0	20	
Apply		60	80	60	0	50	50	80	
Analys	se	0	0	0	0	0	0	0	
Evalue	ato	0	0	0	0	0	0	0	

Assessment Pattern: Psychomotor							
Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3				
Perception		<u> </u>	-				
Set	A SAL	fa -	-				
Guided Response	THE SECTION		-				
Mechanism		50	50				
Complex Overt Responses	San Burney	-	-				
Adaptation	_	-	-				
Origination		-	-				
Course Level Assessment Questions							

0

0

0

0

0

# Course Outcome 1 (CO1):

0

Create

0

- 1. What are the factors needed to develop a matching network? What is a stub?
- 2. What are the drawbacks of L section matching? Why double stubs are preferred?
- 3. An amplifier uses a transistor having the following S parameters ( $Z_0=50 \Omega$ )  $S_{11}=0.61 \angle -170^{\circ}$ ,  $S_{12}=0.06 \angle 70^{\circ}$ ,  $S_{21}=2.3 \angle 80^{\circ}$ ,  $S_{22}=0.72 \angle -25^{\circ}$ . The input of the transistor is connected to a source with  $V_s=2 V$ (peak) and  $Z_s=25 \Omega$ . and the output of the transistor is connected to a load of  $Z_L=100 \Omega$ . What is the power gain, the available power gain, the transducer power gain and the unilateral transducer power gain.

#### Course Outcome 2 (CO2):

- 1. For a load impedance ZL=  $15+j10 \Omega$ , design two single stub shunt tuning networks to match this load to a 50  $\Omega$  line. Assume the load is matched at 2 GHz and the load consists of a resistor and inductor in series.
- 2. Design a single stub shunt tuner to match a load impedance ZL=60-j80  $\Omega$  to a 50 $\Omega$  line. The stubs are to be short circuited stubs. Assume that this load consists of a series resistor and capacitor and the match frequency is 2 GHz.
- 3. Design a lumped element matching network at 1 GHz that would transform ZL=  $0.2+j0.2 \Omega$  into a 50  $\Omega$  transmission line.

#### Course Outcome 3 (CO3):

- 1. The S parameters for the HP HFET-102 GaAS FET at 2 GHz with the bias voltage Vgs=0 are given as follows:
  - S11=0.894 $\angle$ 60.6°, S21=3.122 $\angle$ 123.6°, S12=0.020 $\angle$ 62.4°, S22=0.781 $\angle$ 27.6°. Determine the stability of this transistor by calculating K and  $|\Delta|$  and plot the stability circles.

- 2. A GaAs FET has the following scattering and noise parameters at 6 GHz (Z0=50  $\Omega$ ): S11=0.6  $\angle 60^{\circ}$ , S12=0,S21=2.0  $\angle 81^{\circ}$ , S22=0.7  $\angle 60^{\circ}$ , Fmin= 2. dB, Fopt=0.62  $\angle 100^{\circ}$  and RN=20  $\Omega$ . Design an amplifier to have a gain of 6 dB, and the minimum noise figure possible with this gain. Use open circuited shunt stubs in the matching sections.
- 3. Design an amplifier for maximum gain at 4 Ghz using single stub matching sections. The GaAs FET has the following specifications: S11=0.72  $\angle$  116°, S21=2.60  $\angle$  76°, S12=0.03  $\angle$  57°, S22=0.73  $\angle$  54°, Ts= 0.872  $\angle$  123°, TL= 0.876  $\angle$  61°, Z0= 50 ohms.

#### Course Outcome 4 (CO4):

- 1. One oscillator has a Q of 5, another a Q of 50. Which oscillator reaches steady-state conditions first ? Which oscillator can be quenched more quickly ? Are these results intuitive ? Can you think a mechanical system that behaves the same way ?
- Design a transistor oscillator at 4 GHz using a GaAs MESFET in a common gate configuration, with a 5 nH inductor in series with the gate to increase the instability. Choose a load network to match to a 50 \_ load, and an appropriate terminating network at the input to the transistor. The scattering parameters of the transistor in a common source configuration are: S11=0.72∠116°,,S21=2.60∠76°,S12=0.03∠57°,S22=0.73∠54°,Ts=0.872∠123°,TL= 0.876∠61°,Z0= 50 ohms.
- Design a transistor oscillator at 1.9 GHz using a silicon BJT in a common emitter configuration driving a 50 ohms load on the drain side. The scattering parameters are as follows: : S11=0.72∠116°, S21=2.60∠76°, S12=0.03 ∠57°, S22=0.73∠54°, Ts= 0.872 ∠123°, TL= 0.876∠61°, Z0= 50 ohms. Choose Γ<sub>L</sub> for Γ<sub>in</sub> >> 1, design appropriate load and terminating networks.

# Course Outcome 5 (CO5):

- 1. An RF input signal at 900MHz is down- converted in a mixer to an IF frequency of 80MHz. What are the two possible LO frequencies, and the corresponding image frequencies?
- 2. An input level signal composed of two closely spaced frequencies ( $\omega_1$ ,  $\omega_2$ ) is applied to a mixer along with an LO frequency at  $\omega_0$ . Calculate and sketch the resulting output spectrum due to the v<sup>2</sup> term of the mixer response equation.
- 3. Consider a single ended mixer having the following port VSWR values at 15GHz:  $(VSWR)_{RF} = 2.5; (VSWR)_{IF} = 3.5; L_h = 3 dB.$  The diode used in the mixer has:  $R_j = 100 \Omega$ ,  $R_s = 2 \Omega$  and  $C_j = 0.2 pF$ . What is the conversion loss of the mixer?

# Course Outcome 6 (CO6):

- Consider a 50Ω cable, LNA and another amplifier are cascaded together. Their gain and Noise figures are G<sub>1</sub>= -3dB, NF<sub>1</sub>= 3dB; G<sub>2</sub>= -20dB, NF<sub>2</sub>= 1.5dB; G<sub>3</sub>=13dB, NF<sub>3</sub>= 4dB. Compute the overall noise figure.
- 2. An amplifier with a bandwidth of 1GHz has a gain of 15d dB and a noise temperature of 250°K. If it is used as a preamplifier in a cascade, preceding a microwave amplifier of 20 dB gain and 5 dB noise figure, determine the overall noise temperature.
- 3. For a wideband amplifier operating over 3-5GHz with gain 10dB, output power 10dbm and noise figure 4 dB at room temperature, find the output noise power
- 4. An amplifier with a gain of 12dB, a bandwidth of 150 MHz and a noise figure of 4 dB feeds a receiver with a noise temperature of 900K.Find the noise figure and equivalent noise temperature of the overall system.

#### Sample Assignments

- 1. Assignment-1: Presentation of linear amplifiers for the GSM applications
- 2. **Assignment-2:** Commercially available oscillator for GSM Transceiver applications
- 3. Assignment-3: Design a down converter for GSM application



#### Syllabus

Introduction- Review of Cellular phone architecture, Transmitter/Receiver System, Operation mechanisms, UP/ down Conversion: Frequency translation and harmonics. RF front end, Role of Amplifiers, Mixers and oscillators.

Consideration in Active networks: Introduction to diodes and Transistors – PIN Diodes, Schottky diodes, BJT and FET.

Matching Network – Need for Impedance matching, Smith chart, Design of matching circuits using lumped elements, Matching network design using distributed element, Choice of shortor open circuited stubs, Design steps for single stub matching.

**Stability considerations** - stability circles, K-  $\Delta$  Test,  $\mu$  test, Gain considerations - power gain concepts, A special case: unilateral transistor, Unilateral case (maximum gain and constant gain circles)

**Noise consideration-**Definition and sources, Definition of noise figure, Noise figure of cascade networks, Constant noise figure circles.

**RF/Microwave Linear Amplifiers:** Functionality, Types of amplifiers Amplifier parameters-Gain, Noise figure, Compression, Third order Intercept. Small-signal amplifiers- DC-bias circuit design and amplifiers DC-bias RF/MW circuit design, GSM receiver LNA Specifications Design of narrowband amplifier (NBA) design, Design of maximum gain amplifier (MGA) design, Design of low-noise amplifier (LNA) design

**RF/Microwave Oscillator:** Introduction-Oscillator versus amplifier design, Oscillation conditions, Two-port NR oscillator, Condition of stable oscillations, Design of transistor oscillators, Commercially available oscillator for GSM wireless Transceiver Applications

**RF/Microwave Mixers:** Introduction, Mixer types-up converter, Mixer parameters: Conversion loss for SSB mixers-diode loss, mismatch loss and harmonic loss - conversion loss and noise figure, Single ended mixer, Balanced mixer.

**Receiver architecture and System level power budgeting -** Receiver Architecture: Diode detectors and heterodyne, Noise Figure and power budgets for a GSM Down convertor

**Mini project: Design of a down converter for GSM application –** System level calculation and simulations.

#### Learning Resources:

1. Matthew M. Radmanesh, "Radio frequency and Microwave Electronics Illustrated", Pearson Education Asia, 2001.

- 2. David M Pozar: Microwave and RF design of wireless systems, John Wiley & Sons, 2001.
- 3. David M. Pozar," Microwave Engineering," John Wiley & Sons, Fourth Edition, 2015
- 4. Les Besser and Rowan Gilmore, "Practical RF circuit Design for Modern Wireless Systems- Passive circuits and Systems", Vol.1, Artech House Publishers, Boston, London 2008.
- 5. Joy Laskar, Babak Matinpour, Sudipto Chakraborty, "Modern Receiver Front- Ends Systems, Circuits, and Integration", Wiley- Interscience, 2004.
- 6. https://onlinecourses.nptel.ac.in/noc18\_ee22
- 7. https://www.udemy.com/courses

# **Course Contents and Lecture Schedule**

SI.No	Торіс	Lecture	Practice Hours	COs
1	Introduction- Review of Cellular phone	1	1	CO1
•	architecture	•	•	001
1.1	Transmitter/Receiver System, Operation mechanisms,	1	1	CO1
	harmonics			
1.2	RF front end, Role of Amplifiers, Mixers and oscillators	1		CO1
2	Consideration in Active networks: Introduction to diodes and Transistors – PIN Diodes, Schottky diodes, BJT and FET.	1		CO1
3	Matching Network – Need for Impedance matching, Smith chart	1	1	CO2
3.2	Design of matching circuits using lumped elements	1	1	CO2
3.3	Matching network design using distributed element - Choice of short- or open circuited stubs	1		CO2
3.4	Design steps for single stub matching	1	1	CO2
4	<b>Stability considerations</b> - stability circles, Gain considerations - K- $\Delta$ Test, $\mu$ test	1	1	CO1
4.2	power gain concepts, A special case: unilateral transistor, Unilateral case (maximum gain and constant gain circles)	1		C01
5	<b>Noise consideration</b> -Definition and sources, Definition of noise figure, Noise figure of cascade networks.	1		CO1
5.2	Constant noise figure circles	1		CO1
6	<b>RF/Microwave Linear Amplifiers:</b> Functionality, Types of amplifiers Amplifier parameters- Gain, Noise figure, Compression, Third order Intercept.	1	1	CO1, CO3
6.2	Small-signal amplifiers- DC-bias circuit design and amplifiers DC-bias RF/MW circuit design, GSM receiver LNA Specifications	1		CO1, CO3
6.3	Design of narrowband amplifier (NBA) design,	1	1	CO3
6.4	Design of maximum gain amplifier (MGA) design,		1	CO3
6.5	Design of low-noise amplifier (LNA) design		1	CO3
	<b>Assignment 1:</b> Presentation of linear amplifiers for the GSM applications		1	CO3
7	<b>RF/Microwave Oscillator:</b> Introduction-Oscillator versus amplifier design, Oscillation conditions, Two-	1		CO1, CO4
7.0	port INR Oscillator, Condition of stable oscillations,	<u> </u>	1	<u> </u>
1.2	Assignment 2 Commercially available oscillator for	<b>∠</b>	   1	CO4

B.E.(Electronics and Communication Engineering), 2018-19

SI.No	Торіс	Lecture Hours	Practice Hours	COs
	GSM wireless Transceiver Applications			
8	<b>RF/Microwave Mixers:</b> Introduction, Mixer types-up converter, Mixer parameters: Conversion loss for SSB mixers-diode loss, mismatch loss and harmonic loss - conversion loss and noise figure,	1		CO1, CO5
8.2	Single ended mixer, Balanced mixer.	1		CO5
9	<b>Receiver architecture and System level power</b> <b>budgeting -</b> Receiver Architecture: Diode detectors and heterodyne, Noise Figure and power budgets for a GSM Down convertor	1	1	CO6
9.2	Mini project – Design of a down converter for GSM application – System level calculation and simulations. Assignment III		2	CO6

- Course Designers: 1. Dr.S.Raju 2. Dr.S.Kanthamani
  - 3. Dr.A.Thenmozhi

rajuabhai@tce.edu skmece@tce.edu thenmozhi@tce.edu



18EC430	CMOS VLSI SYSTEMS	Category	L	Т	Ρ	Credit
		PC	3	0	0	3

The course aims at understanding the basic concepts of Digital CMOS VLSI circuit by studying logic design, physical structure and fabrication of MOS devices and how they are combined to build systems for efficient data processing.

#### Prerequisite

18EC330 : Electronics Circuits

#### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement Weightage in %					
CO1	Construct CMOS logic circuits and Layouts.	20				
CO2	Examine the electrical characteristics of CMOS logic circuits.	15				
CO3	Examine the electronic aspects of CMOS logic circuits.	20				
CO4	Understand VLSI design flow and fabrication of CMOS integrated circuits	15				
CO5	Combinational Circuit Design using Advanced CMOS logic design techniques	15				
CO6	Construct CMOS VLSI system components	15				

# CO Mapping with CDIO Curriculum Framework

CO	TCE	Le	arning Doma	in Level	CDIO Curricular Components
#	Proficiency	Cognitiv	Affective	Psychomotor	(X.Y.Z)
	Scale	е	No.		
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.2, 3.1.1, 4.5.1,
					4.6.1
CO2	TPS3	Apply	Value	-	1.2, 2.1.1, 2.1.2, 3.1.1, 4.5.1,
			1-3-		4.6.1
CO3	TPS3	Apply	Value	-	1.2,, 2.1.1, 2.1.2, 3.1.1, 3.2.3,
					4.5.1, 4.6.1
CO4	TPS4	Unders	Respond	-	1.2, 2.1.1, 2.1.2, 4.5.1, 4.6.1
		tand			
CO5	TPS4	Apply	Value	Mechanism	1.2, 2.1.1, 2.5.1, 4.5.1, 4.6.1
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.5.1, 4.5.1, 4.6.1

# Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	S	М	L	L	-	-	-	-	-	-	-	М	-	-
CO2	S	S	М	L	-	-	-	-	-	-	-	-	М	-	-
CO3	S	S	М	L	-	-	-	-	-	-	-	-	М	-	-
CO4	S	М	L	-	-	-	-	-	-	-	-	-	L	-	-
CO5	S	S	М	М	L	-	-	-	-	-	-	-	М	-	-
CO6	S	S	М	М	L	-	-	-	-	-	-	-	М	-	-

S- Strong; M-Medium; L-Low

Assessment P	attern: C	cognitive	Domain				
Cognitive Levels	ive Continuous Assessment Assignment s Tests						End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	100	100	0	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	100
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	- monto	-	-

# Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

- Design a CMOS logic circuit that implements the function F = (a+b.c+a.b.c)' using seriesparallel logic. The objective is to minimize the transistor count.
- 2. Using transmission gates, design a 2:1 MUX circuit.
- 3. Draw the CMOS Gates to realize the function: F = a + b.c + a.b.c. Find a Common Euler Path for both PUN and PDN. Use the Common Euler Path to draw Stick Diagram.

# Course Outcome 2 (CO2):

1. Construct the RC switch Model for the FET layout specifications. Assume a power supply voltage of 3 V.

L'= 0.5 µm	Lo = 0.05 µm
$V_{ton} = 0.6 v$	$k'n = 150 \mu A/V^2$
$C_{ox} = 2.70 \times 10^{-15} \text{ F/}\mu\text{m}^2$	C <sub>i</sub> = 0.86 x 10 <sup>-15</sup> F/µm <sup>2</sup>
C <sub>jsw</sub> = 0.24 x 10 <sup>-15</sup> F/µm <sup>2</sup>	X= 2 microns, W= 6 microns

- 2. Derive the Expression for MOS threshold voltage and MOS Drain current.
- 3. Construct the voltage transfer characteristics of an electrically symmetric CMOS inverter that is build in a process where

$$V_{\tau} = \pm 0.5 \text{ V}$$
 W = 4 µm L = 0.25 µm k' = 130 µ $\Delta/V^2$ 

$$V_{-} = -0.6 V$$
 W = 4 µm 1 - 0.25 µm k' = 65 µA/V<sup>2</sup>

 $V_{Tp}$  = -0.6 V,  $W_p$ =4µm,  $L_p$ =0.25µm,  $k'_p$  = 65 µA/V and a power supply of  $V_{DD}$ =3V is used.

# Course Outcome 3(CO3):

- 1. An inverter uses FETs with  $b_n = 2.1 \text{mA/v}^2$  and  $b_p = 1.8 \text{mA/v}^2$ . The threshold voltages are given as  $V_{tn} = 0.6 \text{ V}$  and  $V_{tp} = -0.7 \text{V}$  and the power supply has a value of 5V.The parasitic capacitance at the output node is  $C_{out} = 74 \times 10^{-15} \text{ F}$ .
  - a. Find the mid-point Voltage  $V_m$  and values of  $R_n$  and  $R_p$ .
  - b. Calculate the rise time and fall time when  $C_L = 0$
  - c. Calculate the rise time and fall time when  $C_L$  = 115 x 10 <sup>-15</sup> F
  - d. Plot rise time and fall time as functions of  $C_L$ .
- 2. A interconnect has the geometry with  $T_{ox} = 0.9\mu m$ ,  $w = 0.35\mu m$  and t = 1.10 $\mu m$ . The interconnect line has a sheet resistance of Rs = 0.04 ohms.
  - a. Find the value of 'c' predicted by the empirical expression that includes fringing.
  - b. Find the values of  $R_{line}$  and  $C_{line}$  if the line is 48um long.

3. Construct an m=7 RC ladder equivalent for the line, then use the model to determine time constant.

#### Course Outcome 4 (CO4):

- 1. List the steps in CMOS fabrication?
- 2. Explain the process of photolithography.
- 3. What do you understand by synthesis in VLSI Design process?

#### Course Outcome 5 (CO5):

- 1. Consider the OAI Logic Function g = (a+b).(c+d).e. Design the Clocked CMOS Logic circuit and then construct a basic layout for the circuit.
- 2. Draw the Pseudo-nmos circuit for the functions
  - i) F= (a+(c.[x+(y.z)]))' ii) h=( ( a+b+c).x + y.z)'
- 3. Design a 2/4 active high decoder using only transmission gates in the main logic paths.

#### Course Outcome 6 (CO6):

- 1 Design a NAND3 gate using an 8:1 MUX.
- 2. Design a CMOS logic gate circuit the implements the function F = (a+b.c+a.b.c)' using series-parallel logic. The objective is to minimize the transistor count.
- 3 Design a 6T SRAM memory cell

#### Sample Assignments



#### Concept Map



#### Syllabus

**CMOS Logic and Layout Design:** MOSFETs as Switches, Logic Gates and their static CMOS implementation, Transmission Gate Circuits, Stick Diagram and Layout Design Rules, Layout of Basic Structures, FET sizing, Physical structure of MOSFETs,. **Electrical Characteristicsof CMOS Logic:** MOS Threshold Voltage Equation, nFET Current-Voltage Equations, The FET RC Model, DC Characteristics of CMOS Inverter. **Electronics Analysis of CMOS Logic:** Switching Characteristics, Logical Effort, Analysis of Complex Logic Gates, Power Dissipation, Interconnect Delay Model, Crosstalk and Interconnect Scaling. **Fabrication of CMOS Integrated Circuits:** VLSI Design Flow, Integrated Circuit Fabrication Process: Oxidation, Diffusion, Ion Implantation, Photolithography and Twin-tub CMOS Process.**Advanced CMOS Logic Circuits:** Mirror Circuits, Pseudo- nMOS, Tri-state Circuits, Clocked CMOS, Dynamic CMOS and Dual Rail Logic Networks.**CMOSVLSI** 

**System Components:** Multiplexors, Binary Decoders, Priority Encoders, Latches, D Flip-Flop, Registers, Full Adder, Binary Multiplier, SRAM, DRAM and Logic Arrays. **Learning Resources** 

- 1. N. Weste and David Harris," CMOS VLSI Design : A circuits and systems perspective" 4<sup>th</sup> Edition, Pearson, 2015.
- 2. N. Weste and K. Eshraghian, "Principles of CMOS VLSI Design", Second Edition, Addison-Wesley, 1993.
- 3. Uyemura, John P, "Introduction to VLSI Circuits and Systems". Wiley & Sons, 8th Reprint 2009.
- 4. Jan M. Rabaey, "Digital Integrated Circuits: A Design Perspective", Prentice Hall, Second Edition, 2006.
- 5. R. Jacob Baker, "CMOS: Circuit Design, Layout, and Simulation", Wiley-IEEE, Revised Second Edition, 2008.
- 6. Pucknell, "Basic VLSI Design", Prentice Hall, 1995.
- 7. Wayne Wolf, "Modern VLSI Design: System on Chip", Pearson Education, 2002.
- 8. MIT Open courseware: http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-374-analysis-and-design-of-digital-integrated-circuits/.
- 9. Dr.Nandita Dasgupta, VLSI Design, NPTEL Video Lectures: http://www.nptelvideos.in/2012/12/vlsi-design.html

## **Course Contents and Lecture Schedule**

No.	Торіс	No.of Hours	COs
1	CMOS Logic and Layout Design		
1.1	MOSFETs as Switches	1	CO1
1.2	Logic Gates and their static CMOS implementation	1	CO1
1.3	Transmission Gate Circuits	1	CO1
1.4	Stick Diagram and Layout Design Rules	2	CO1
1.5	Layout of Basic Structures	1	CO1
1.6	FET sizing	1	CO1
1.7	Physical structure of MOSFETs	1	CO1
2	Electrical Characteristics of CMOS logic:		
2.1	MOS Threshold Voltage Equation	1	CO2
2.2	nFET Current-Voltage Equations	1	CO2
2.3	The FET RC Model	2	CO2
2.4	DC Characteristics of the CMOS Inverter.	2	CO2
3	Electronic Analysis of CMOS Logic:		
3.1	Switching Characteristics	2	CO3
3.2	Logical Effort	1	CO3
3.3	Analysis of Complex Logic Gates	1	CO3
3.4	Power Dissipation	1	CO3
3.5	Interconnect Delay Model	1	CO3
3.6	Crosstalk and Interconnect Scaling	1	CO3
4	Fabrication of CMOS Integrated Circuits:		
4.1	VLSI Design Flow	0.5	CO4
4.2	Integrated Circuit Fabrication Process	0.5	CO4
4.3	Oxidation	0.5	CO4
4.4	Diffusion	0.5	CO4
4.5	Ion Implantation	0.5	CO4
4.6	Photolithography and Twin-tub CMOS Process	1	CO4
5	Advanced CMOS Logic Circuits		
5.1	Mirror Circuits	0.5	CO5

B.E.(Electronics and Communication Engineering), 2018-19

5.2	Pseudo-nMOS	0.5	CO5			
5.3	Tri - State Circuits	0.5	CO5			
5.4	Clocked CMOS	1	CO5			
5.5	Dynamic CMOS	1	CO5			
5.6	Dual - Rail Logic Networks	1	CO5			
6	CMOSVLSI System Components					
6.1	Multiplexors	0.5	CO6			
6.2	Binary Decoders	0.5	CO6			
6.3	Priority Encoders	0.5	CO6			
6.4	Latches	0.5	CO6			
6.5	D Flip-Flop	0.5	CO6			
6.6	Registers	0.5	CO6			
6.7	Full adder	1	CO6			
6.8	Binary Multiplier	1	CO6			
6.9	SRAM, DRAM and logic arrays	2	CO6			
	TOTAL 36					

# Course Designers:

- 1. Dr.S.Rajaram
- rajaram\_siva@tce.edu venthiru@tce.edu
- Dr.V.R.Venkatasubramani
  Dr.N.B.Balamurugan
- Dr. N.B.Balamurugan
  Dr. V.VinothThyagarajan
- nbb<mark>alamuruga</mark>n@tce.edu vvkece@tce.edu
- 4. Dr.D.GraciaNirmala Rani
- 5. Dr.K.Kalyani
- gracia@tce.edu
- k\_kalyani@tce.edu

Passed in BoS Meeting 11.05.2019

18EC440	SIGNAL PROCESSING	Category	L	Т	Ρ	Credit
		PC	2	1	0	3

Signal processing is concerned with the representation, transformation and manipulation of signals and the information they contain. It is an area of science and engineering that has developed rapidly over the past few decades. The novel algorithms by Cooley and Tukey (1965) for efficient computation of Fourier transform provided a new point of view towards a discrete time signal processing. This course aims at the analysis and design of signal processing systems and computational techniques.

#### Prerequisite

18EC340 Signals and Systems

#### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Compute DFT and IDFT coefficients of a given discrete time	15
	sequence using Fast Fourier Transform algorithms	
CO2	Design Linear phase FIR digital filters using windowing and	15
	frequency sampling methods	
CO3	Design IIR digital filters from analog filters namely Butterworth, and	20
	Chebyshev for a given specification 🗋 🦳 🎽	
CO4	Draw the implementation structure of FIR and IIR discrete time	10
	systems using block diagram and signal flow graph representation.	
CO5	Compute statistical parameters like mean, correlation and power	20
	spectral density of a given random variable or random processes at	
	the output of a LTI system	
CO6	Design LTI systems for noise reduction & signal enhancement,	20
	linear prediction and analyzing the effects of finite precision	
	representation of system coefficients and truncation/rounding of	
	intermediate computation.	

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Le	earning Doma	CDIO Curricular	
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale				(X.Y.Z)
CO1	TPS3	Apply	Value	Guided	1.2, 2.1.1, 2.1.2, 2.1.4,
				response	2.1.5, 2.4.1, 2.4.2, 2.4.5,
					3.2.3, 3.2.5,
CO2	TPS3	Apply	Value	Guided	1.2, 2.1.1, 2.1.2, 2.1.4,
				response	2.1.5, 2.4.1, 2.4.2, 2.4.5,
					3.2.3, 3.2.5,
CO3	TPS3	Apply	Value	Guided	1.2, 2.1.1, 2.1.2, 2.1.4,
				response	2.1.5, 2.4.1, 2.4.2, 2.4.5,
					3.2.3, 3.2.5,
CO4	TPS3	Apply	Value	Guided	1.2, 2.1.1, 2.1.2, 2.1.4,
				response	2.1.5, 2.4.1, 2.4.2, 2.4.5,
					3.2.3, 3.2.5,
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3,
					2.1.4, 2.1.5, 2.4.1, 2.4.2,
					2.4.5, 3.2.3, 3.2.5,
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3,
					2.1.4, 2.1.5, 2.4.1, 2.4.2,
					2.4.5, 3.2.3, 3.2.5,

Марр	Mapping with Programme Outcomes and Programme Specific Outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	М	L	-	L	-	-	М	M	М	-	L	M	-	М
CO2	S	М	L	-	L	-	-	М	M	М	-	L	M	-	М
CO3	S	М	L	-	L	-	-	М	M	М	-	L	M	-	М
CO4	S	М	L	-	L	-	-	М	M	М	-	L	M	-	М
CO5	S	М	L	-	L	-	-	М	Μ	М	-	L	M	М	М
CO6	S	М	L	-	L	-	-	М	М	М	-	L	М	М	M

# S- Strong; M-Medium; L-Low

# **Assessment Pattern: Cognitive Domain**

Cognitive Levels	Contir	uous Ass Tests	sessment		Assignme	End Semester Examination	
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	50	30	30	20
Apply	80	80	80	50	40	40	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### **Assessment Pattern: Psychomotor**

Assignment-1	Assignment-2	Assignment-3
AL CAN	-	-
L' LL - Contra		-
to the second		-
Ser Cu D	30	30
-	-	-
-	-	-
p-s-max	<u> </u>	-

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

1. a. Determine the Fourier transform 
$$X(\omega)$$
 of the signal  $x(n) = \{1, 2, 3, 2, 1, 0\}$ 

b. Compute the 6 point DFT V(k) of the signal  $v(n) = \{3, 2, 1, 0, 1, 2\}$ 

- c. Is there any relation between  $X(\omega)$  and V(k)?
- 2. Consider the sequences

$$x_1(n) = \{0, 1, 2, 3, 4\}, \quad x_2(n) = \{0, 1, 0, 0, 0\}, s(n) = \{1, 0, 0, 0, 0\}$$

- a. Determine a sequence y(n) so that  $Y(k) = X_1(k)X_2(k)$ .
- b. Is there a sequence  $x_3(n)$  such that  $S(k) = X_1(k)X_3(k)$ ?
- 3. Determine the eight point DFT of the signal  $x(n) = \{1, 1, 1, 1, 1, 1, 0, 0\}$  using DIF and DIT algorithms.

# Course Outcome 2 (CO2):

1. A FIR linear phase, digital low pass filter is to be designed with a cutoff frequency

of  $\frac{\pi}{4}$  rad.

- i) Determine the coefficients of a 7-tap filter based on the windowing technique with a Hamming window
- ii) Determine and plot the magnitude and phase response of the filter.
- iii) What will happen to the magnitude response if the taps of the filter increases to 11.

2. Design an FIR low pass filter satisfying the specifications  $0.95 < H(e^{j\omega}) < 1.05, 0 \le |\omega| \le 0.25\pi$ 

$$-0.1 < H(e^{j\omega}) < 0.1, \quad 0.35\pi \le |\omega| \le \pi$$

By applying a window w[n] to the impulse response  $h_d[n]$  for the ideal discrete time low pass filter with cutoff  $\omega_c = 0.3\pi$ . Which of the window can be used to meet the specification? For each window that you claim will satisfy this specification, give the minimum length M+1 required for the filter.

3. Determine the unit sample response h[n] of a linear phase FIR filter of length M = 4 for which the frequency response at  $\omega = 0$  and  $\omega = \pi/2$  is specified as  $H_r(0) = 1$ ,

$$H_r\left(\frac{\pi}{2}\right) = \frac{1}{2}$$

#### Course Outcome 3 (CO3):

- 1. For the analog transfer function  $H_a(s) = \frac{2}{(s+1)(s+2)}$ , Determine H(z) if T=1 Sec, by means of the impulse invariant method.
- 2. Convert the analog filter with system transfer function  $H_a(s) = \frac{(s+0.1)}{(s+0.1)^2+9}$

in to digital IIR bilinear transformation.

3. Determine the order and poles of a type I Chebyshev lowpass filter that has a 1dB ripple in the passband, a cutoff frequency of  $1000\pi$ , a stopband frequency of  $\Omega_s = 2000\pi$  and attenuation of 40dB or more for  $\Omega > \Omega_s$ 

#### Course Outcome 4 (CO4):

1. Determine a direct form realization for the following linear phase filters:

a. 
$$h[n] = \{1, 2, 3, 4, 3, 2, 1\}$$
  
b.  $h[n] = \{1, 2, 3, 3, 2, 1\}$ 

- 2. Consider an FIR filter with system function  $H(z) = 1 + 2.88z^{-1} + 3.4048z^{-2} + 1.74z^{-3} + 0.4z^{-4}$ . Sketch the direct form and lattice realizations of the filter and determine in detail the corresponding input-output equations. Is the system minimum phase?
- 3. Determine all the FIR filters which are specified by the lattice parameters  $K_1 = \frac{1}{2}$ ,

$$K_2 = 0.6$$
,  $K_3 = -0.7$  and  $K_4 = \frac{1}{3}$ 

# Course Outcome 5 (CO5):

1. Consider the sinusoidal process  $X(t) = A\cos(2\pi f_c t)$  where the frequency  $f_c$  is constant and the amplitude A is uniformly distributed:  $f_A(a) = \begin{cases} 1, & 0 \le a \le 1 \\ 0, & otherwise \end{cases}$ .

Determine whether or not this process is strictly stationary.

- 2. Prove the following two properties of the autocorrelation function  $R_X(\tau)$  of a random process X(t):
  - a. If X(t) contains a DC component equal to A, then  $R_X(\tau)$  will contain a constant component equal to  $A^2$ .

- b. If X(t) contains a sinusoidal component, then  $R_X(\tau)$  will also contain a sinusoidal component of the same frequency
- 3. Consider two linear filters connected in cascade as shown in Figure. Let X(t) be a stationary process with autocorrelation function  $R_X(\tau)$ . The random process appearing at the first filter output is V(t) and the second filter output Y(t).
  - d. Find the autocorrelation function of Y(t).
  - e. Find the cross correlation function  $R_{VY}(\tau)$  of V(t) and Y(t).

#### Course Outcome 6 (CO6):

- 1. Design a 2-pole resonator with peak  $f_0 = 500Hz$  and width  $\Delta f = 32Hz$  operating at a sampling rate of  $f_s = 10kHz$ . Draw its magnitude response and Impulse response.
- 2. Design a peaking digital IIR filter operating at a rate of 10kHz that has a peak at 1.75kHz and 3dB width of 500Hz. Then redesign it such that 500Hz represents its 10 dB width. For the 3 dB width care, determine also the corresponding complementary notch filter.
- 3. Consider the four comb filters: y(n) = x(n) + x(n-8), y(n) = x(n) x(n-8),

y(n) = x(n) + x(n-8) + x(n-16), y(n) = x(n) - x(n-8) + x(n-16). Determine their transfer functions and their impulse responses. Place their zeros on the z-plane relative to the unit circle. Sketch their magnitude responses. How are they similar or different? Draw their canonical realization forms using 8-fold delays  $z^{-8}$ . Write the corresponding sample processing algorithms both in their linear and circular buffer versions.



#### Syllabus

**Discrete Fourier Transform (DFT):** Fourier representation of Finite duration sequences, Properties of DFT, Linear Convolution using DFT, Direct computation of the DFT, Decimation-in Time and Decimation in frequency FFT algorithms.

**FIR Filter Design Techniques:** Filter specifications, Design of FIR filters by Windowing, Frequency sampling method, Basic network structures for FIR filters: Direct, cascade, lattice and Linear phase FIR form

**IIR Filter Design Techniques:** Filter specifications, Design of Discrete time IIR filters from continuous time filters: Impulse invariance, Bilinear transformation techniques, Discrete time Butterworth and Chebyshev filters, Basic structures for IIR filters: Direct, cascade, parallel, lattice and lattice-ladder.

**Random signals:** Probabilistic concept, random variables, statistical averages, random process: definition, stationary process, mean, correlation and covariance functions, ergodic process, transmission of random process through LTI systems, power spectral density, Gaussian process, noise, narrow band noise.

**Applications:** Filter design based on Pole/zero: First order filters, Parametric resonators and equalizers, Notch and Comb filters, Effects of coefficient quantization, effects of roundoff noise in digital filters, noise reduction and signal enhancement, linear prediction

#### Learning Resources

- 1. Alan V.Oppenheim, Ronald W. Schafer, "Discrete time signal processing", Prentice Hall, Third Edition, 2009.
- 2. John G.Proakis and Dimitris G.Manolakis, "Digital Signal Processing Principles, Algorithms and Applications", Prentice-Hall of India, Fourth Edition, 2006.
- 3. Sophocles J.Orfanidis "Introduction to Signal Processing", Prentice Hall, 1996.
- 4. Sanjit K.Mitra "Digital Signal Processing: A computer based approach" McGraw Hill Education; 4 edition 2013.
- 5. Richard G. Lyons, "Understanding Digital Signal Processing" Third Edition, Pearson Education India, 2011.
- https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/studymaterials/
- 7. https://freevideolectures.com/course/2317/digital-signal-processing-iit-delhi
- **Course Contents and Lecture Schedule**

No.	Торіс	No. of	COs
	Contra 1	Lectures	
1	Discrete Fourier Transform (DFT)		
1.1	Fourier representation of Finite duration sequences	1	CO1
1.2	Properties of DFT	1	CO1
1.3	Linear Convolution using DFT,	1	CO1
1.4	Direct computation of the DFT: Decimation-in Time and	2	CO1
1.5	Decimation in frequency FFT algorithms.	2	CO1
2	FIR Filter Design Techniques		
2.1	Filter specifications	1	CO2
2.2	Design of FIR filters by Windowing	1	CO2
2.3	Frequency sampling method	1	CO2
3	IIR Filter Design Techniques		
3.1	Filter specifications	1	CO3
3.2	Design of Discrete time IIR filters from continuous time filters: Impulse invariance,	2	CO3
3.3	Bilinear transformation techniques,	1	CO3
3.4	Butterworth filter design	1	CO3
3.5	Chebyshev Filter design	2	CO3
4	Filter Structures		
4.1	Basic structures for IIR filters: Direct, cascade, parallel,	1	CO4
4.2	lattice and lattice-ladder	1	CO4
4.3	Basic network structures for FIR filters: Direct, cascade,	1	CO4
4.4	Lattice and Linear phase FIR form	1	CO4

5	Random signals		
5.1	Probabilistic concept, random variables, statistical averages,	1	CO5
5.2	Random process: definition, stationary process, mean, correlation and covariance functions,	2	CO5
5.3	Ergodic process,	1	CO5
5.4	Transmission of random process through LTI systems,	2	CO5
5.5	Power spectral density, Gaussian process, noise, narrow band noise.	2	CO5
6	Applications		
6.1	Filter design based on Pole/zero: First order filters	1	CO6
6.2	Parametric resonators and equalizers	1	CO6
6.3	Notch and Comb filters	1	CO6
6.4	transmission of random process through LTI systems	1	CO6
6.5	noise reduction and signal enhancement	1	CO6
6.6	linear prediction	2	CO6
	Total	36	

# Course Designers:

- 1. Dr.S.J.Thiruvengadam
- 2. Dr.M.N.Suresh
- 3. Dr.P.G.S.Velmurugan

sjtece@tce.edu mnsece@tce.edu pgsvels@tce.edu



18EG460	PROFESSIONAL COMMUNICATION	Category	L	Т	Ρ	Credit
		HSS	0	1	2	2

This course helps the students to achieve effective language proficiency for their professional, social and interpersonal communication skills, hence increasing their employability and career skills.

#### Prerequisite

Basic English Knowledge

#### Course Outcomes

#### On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage***
		in %
CO1	Listen, watch, understand and respond to talks, conversations, etc by native and neutral speakers on science, general context, and from ETS test samples with confidence.	22%
CO2	Present ideas, express opinions/comments, practice presentation, and converse in discussions on a variety of technical and non-technical domains without fear	39%
CO3	Read and comprehend passages/texts from various topics – general and reasoning, to respond precisely through reading techniques, besides getting awareness on competitive exam lexicon/verbal exercises for career prospects	17%
CO4	Write journal abstracts/projects and business correspondences with clarity, accuracy, intelligibility, and precision.	22%
*** We	eightage depends on Bloom's Level, number of contact hours	

# CO Mapping with CDIO Curriculum Framework

CO	TCE	Le	arning Dom	nain Level	CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale	-			
CO1	TPS2	Understand	Respond	Guided Response	2.4.2, 2.4.6, 3.2.1, 3.2.2,
CO2	TPS3	Apply	Value	Mechanism	3.1.3, 3.1.2, 3.2.4, 3.2.5,3.2.6
CO3	TPS2	Understand	Respond	Guided Response	2.4.6, 2.4.5, 3.2.1,
CO4	TPS3	Apply	Value	Mechanism	2.4.3, 3.2.1, 3.2.3, 3.2.5

# Mapping with Programme Outcomes and Programme Specific Outcomes

_															
COs	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	-	-	-	L	S	-	M	-	-	-
CO2	-	-	-	-	-	-	-	-	S	S	-	M	-	-	-
CO3	-	-	-	-	-	-	-	-	М	S	-	M	-	-	-
CO4	-	-	-	-	-	-	-	-	М	S	-	М	-	-	-

# S- Strong; M-Medium; L-Low

#### Assessment Pattern:

**Internal:** No Continuous Assessment Test CAT) will be conducted. Students' performance will be continuously assessed in various classroom activities in Listening, Speaking, Reading and Writing for 50 marks as detailed below:

Listening Test	- 10
Speaking Test (Group Discussion and Technical Presentation)	- 20
Written Test(Objective/Descriptive to be tested for 40 marks and	
converted to 20 marks)	- 20

External (Practical):	
Group Discussion	- 20
Personal Interview / Situational Conversation (BEC speaking based)	- 20
Listening Test	- 20
Reading/Writing –Computerised or Paper-based Test /General Aptitude Test	
– Objective type	- 40

#### List of Experiments/Activities with CO Mapping

S.No	Activities	Ho T	urs P	С	O Ma	appin	9
1	Listening, Reading and Writing based on Extensive Reading	2		CO1		CO3	CO4
2	Listening exercises at lab - online resources		2	CO1			
3	Developing Listening skills (BEC / IELTS / TOEIC / TOEFL)		2	CO1			
4	GD/Mock interview/Presentation Intro at lab through online		2	CO1			
5	GD Practice at classroom in groups		4	CO1	CO2		
6	Presentation on Technical / general topics – from dailies &	1	4		CO2		
7	Mock interview practice at classroom	1	4	CO1	CO2		
8	Comprehension Descriptive and Reasoning	2	2			CO3	
9	General Aptitude Practice – Vocabulary Development / Sentence completion / Error spotting /Analogy / Reasoning	3	2			CO3	CO4
10	Business Correspondence - BEC Writing Task II	2					CO4
11	Basics of Technical Writing/ Project Reports		2		CO2		
12	Preparation of Resume	1					CO4

#### Learning Resources

Reference Books:

- 1. Cappel, Annette and Sharp, Wendy, Cambridge English: Objective First, 4<sup>th</sup> Ed., CUP,
- 2. New Delhi, 2013.
- 3. Cusack, Barry. Improve Your IELTS Listening and Speaking Skills (With CD)
- 4. Paperback, Mcmillan, 2007.
- 5. Bates, Susan TOEFL iBT Exam Paperback Oxford, 2012.
- 6. Hart, Guy Brook. Cambridge English Business Benchmark: 2 Ed., CUP 2014

#### Websites:

- 1. https://ielts-up.com (IELTS LSRW Practice Tests)
- 2. www.cambridgeenglish.org (BEC LSRW)
- 3. www.etsglobal.org (TOEIC Preparation)
- 4. www.examenglish.com (Online Exams for international ESL Exams)
- www.testpreppractice.net (GRE Tests -Vocabulary /Analogy / Sentence Completion / Reading)

#### 6. https://www.freshersworld.com (Placement Papers)

# **Extensive Reading:**

Coelho, Paulo. The Alchemist, Harper Publication, 2018.

# **Course Designers:**

- 1. Dr.A.Tamilselvi, Convenor
- 2. Dr S.Rajaram
- 3. Mr.R.Vinoth
- 4. Dr.G.Jeya Jeevakani
- 5. Ms.R.Manibala

18EC470	RF CIRCUITS LABORATORY	Category	L	Т	Ρ	Credit
		PC	0	0	2	1

The objective of this course is to design, simulate and validate the characteristics of RF active, passive circuits and wireless boards.

# Prerequisite

18EC320 RF Passive devices and circuits, 18EC420 RF Active Circuits

#### Course Outcomes

On the successful completion of the course, students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Design and validate a matching network	20
CO2	Design, simulate and test the characteristics of microwave	10
	passive devices such as coupler, filter	
CO3	Design and validate linear amplifier for GSM frequencies	10
CO4	Analyze the mixer parameters	20
CO5	Perform the RF signal measurements	20
CO6	Understand the usage of spectrum and network analyzer	20
	pping with CDIO Curriculum Framowork	

# CO Mapping with CDIO Curriculum Framework

	ICE	Lear	ning Domain	Level	CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4, 2.4.2, 2.4.3, 2.4.4, 2.4.5, 2.4.6, 2.4.7, 2.5.1, 2.5.2, 3.1.2, 3.1.4, 3.2.3, 3.2.4, 4.1.7,4.2.3,4.4.1,4.4.3,4.4.6
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4,      2.4.2, 2.4.3, 2.4.4, 2.4.5,      2.4.6, 2.4.7, 2.5.1,2.5.2,      3.1.2, 3.1.4, 3.2.3, 3.2.4,      4.1.7,4.2.3,4.4.1,4.4.3,4.4.6
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4,      2.4.2, 2.4.3, 2.4.4, 2.4.5,      2.4.6, 2.4.7, 2.5.1,2.5.2,      3.1.2, 3.1.4, 3.2.3, 3.2.4,      4.1.7,4.2.3,4.4.1,4.4.3,4.4.6
CO4	TPS4	Analyse	Oraganize	Complex overt responses	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4,      2.4.2, 2.4.3, 2.4.4, 2.4.5,      2.4.6, 2.4.7, 2.5.1,2.5.2,      3.1.2, 3.1.4, 3.2.3, 3.2.4,      4.1.7,4.2.3,4.4.1,4.4.3,4.4.6
CO5	TPS2	Understand	Respond	Guided response	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4,      2.4.2, 2.4.3, 2.4.4, 2.4.5,      2.4.6, 2.4.7, 2.5.1,2.5.2,      3.1.2, 3.1.4, 3.2.3, 3.2.4,      4.1.7,4.2.3,
CO6	TPS2	Understand	Respond	Guided response	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4,      2.4.2, 2.4.3, 2.4.4, 2.4.5,      2.4.6, 2.4.7, 2.5.1,2.5.2,      3.1.2, 3.1.4, 3.2.3, 3.2.4,      4.1.7,4.2.3,

Mapp	Mapping with Programme Outcomes and Programme Specific Outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	Μ	L	-	S	-	-	L	S	S	L	-	S	М	M
CO2	S	Μ	L	-	S	-	-	L	S	S	L	-	S	М	M
CO3	S	Μ	L	-	S	-	-	L	S	S	L	-	S	М	M
CO4	S	Μ	L	L	S	-	-	L	S	S	L	-	M	М	M
CO5	Μ	L	-	-	M	-	-	L	M	Μ	L	-	L	L	M
CO6	М	L	-	-	М	-	-	L	М	М	L	-	L	L	М

#### S- Strong; M-Medium; L-Low nt Pattern: Cognitive Domain

Assessment rattern. oogi		
Cognitive Levels	Model Examination	End Semester Examination
Remember		
Understand		
Apply	60	60
Analyse	10	10
Evaluate		
Create		

# Assessment Pattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	A Sala
Set	THE SHARE
Guided Response	
Mechanism	20
Complex Overt Responses	10
Adaptation	
Origination	

#### List of Experiments:

- 1. Study of Spectrum and Network analyzers
- 2. Design and Validation of a matching network.
- 3. Design, development and validation of a Low pass filter.
- 4. Design and Simulation of a coupler.
- 5. Design and Simulation of a linear amplifier.
- (Gain, RL,1dB compression, II<sup>nd</sup> and III<sup>rd</sup> order harmonics)
- 6. Harmonic balance simulation of a linear amplifier.
- 7. Measurement of mixer parameters.

#### 8. RF parameter measurement of a WLAN board

#### Learning Resources

- 1. https://www.coursehero.com/file/32950114/ADS-cookbookpdf/
- 2. David M. Pozar," Microwave Engineering," John Wiley & Sons, Fourth Edition, 2015
- 3. Les Besser and Rowan Gilmore, "Practical RF circuit Design for Modern Wireless Systems- Passive circuits and Systems", Vol.1, Artech House Publishers, Boston, London 2008.
- 4. https://www.udemy.com/courses

#### Course Designers:

- 1. Dr.S.Raju rajuabhai@tce.edu
- 2. Dr.S.Kanthamani skmece@tce.edu
- 3. Dr.A.Thenmozhi thenmozhi@tce.edu

18EC480	SIGNAL PROCESSING LABORATORY	Category	L	Т	Ρ	Credit
		PC	0	0	2	1

This course is designed to complement the course 18EC340 Signals and Systems and 18EC440 Signal Processing. The purpose of this course is to give hands on training to the students in understanding the theory of signals and systems and practicing the algorithms used in digital signal processing. This will improve the understanding capability of the signal and system theory and simulation capability of the signal processing algorithms.

# Prerequisite

18EC340 Signals and Systems

# Course Outcomes

On the	On the successful completion of the course students will be able to						
CO#	Course Outcome Statement	Weightage in %					
CO1	Analyze time and frequency domain response of discrete time	10					
	LTI systems						
CO2	Analyze the effects of sampling theorem through DFT and FFT	20					
CO3	Analyze the filter concepts through pole zero placement and the	20					
	effects of quantization error in the filter coefficients						
CO4	Design FIR and IIR filter for the given specification and simulate	10					
	the frequency response						
CO5	Analyze the upsampling and downsampling process through	10					
	simulation						
CO6	Simulate a random sequence for the given distribution	10					
CO7	Apply signal processing principle for removing noise in speech	20					
	and image						
CO Ma	pping with CDIO Curriculum Eromowork						

CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	rning Doma	ain Level	CDIO Curricular Components			
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)			
	Scale							
CO1	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,			
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,			
					4.6.2			
CO2	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,			
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,			
					4.6.2			
CO3	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,			
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,			
					4.6.2			
CO4	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,			
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,			
					4.6.2			
CO5	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,			
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,			
					4.6.2			
CO6	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,			
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,			
					4.6.2			
C07	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3,			
					2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3,			
					4.6.2			

Марр	Mapping with Programme Outcomes and Programme Specific Outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	М	L	-	S	-	-	L	S	S	L	-	S	-	L
CO2	S	М	L	-	S	-	-	L	S	S	L	-	S	-	L
CO3	S	М	L	-	S	-	-	L	S	S	L	-	S	-	L
CO4	S	М	L	-	S	-	-	L	S	S	L	-	S	-	L
CO5	S	М	L	-	S	-	-	L	S	S	L	-	S	-	L
CO6	S	М	L	-	S	-	-	L	S	S	L	-	S	-	L
C07	S	М	L	-	S	-	-	L	S	S	L	-	S	-	L

#### S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	End Semester Examination							
Remember									
Understand									
Apply	70	70							
Analyse									
Evaluate	2								
Create	ATONA								

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	A Sector
Set	MA STATISTICS
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

#### List of Experiments/Activities with CO Mapping

- 1. Introduction to MATLAB
- 2. Time and Frequency response of Discrete Time LTI systems
- 3. Fourier Series Analysis and Synthesis
- 4. Sampling and DFT Spectral Analysis.
- 5. Z-transforms, Pole-Zero Diagrams, BIBO Stability
- 6. FIR Filter Design
- 7. IIR Filter Design
- 8. Multi rate signal processing
- 9. Random variable and Random process
- 10. Signal Processing Applications

#### Learning Resources

- 1. Buck, Daniel, Singer, "Computer Explorations in Signals and Systems Using MATLAB", Prentice Hall, 2nd Ed., 2001.
- 2. Vinay K. Ingle, John G.Proakis, "Digital Signal Processing using MATLAB" Cengage Learning, Third Edition, 2012.

sjtece@tce.edu

#### **Course Designers:**

- Dr.S.J.Thiruvengadam 1.
- 2. Dr.P.G.S.Velmurugan pgsvels@tce.edu

HSS 3 0 0 3	18EC490	PROJECT MANAGEMENT	Category	L	Т	Ρ	Credit
			HSS	3	0	0	3

Project management has been proven to be the most effective method of delivering products within cost, schedule, and resource constraints. It provides the skills to ensure that the projects are completed on time and on budget while giving the user the product, they expect. This course gives strong working knowledge of the basics of project management and be able to immediately use that knowledge to effectively manage work projects.

# Prerequisite

#### Nil

#### **Course Outcomes**

On the successful completion of the course, students will be able to

COs	Course outcomes										W	eightag	e (%)			
CO1	Explain the importance of project management and methodologies										s 15	5%				
CO2	Prepare a project proposal and apply methods for project planning										ing 20	1%		1		
	and	analy	SIS	1		41.					I	<u>Ct</u>		.0/		_
003		y met	noas	to ex	amine	e the	risk	and	social	cost	bene	tit wn		9%		
<u> </u>	Idont	ify th	ing a	ical n	u oth a	nd tir	no in	coho	duling		ot of	nroio	ot 20	0/		-
	activ	ities		icai p	ama		ne in	SUILE	uunni	yas		proje		70		
CO5	Expla	ain re	esour	ce al	locatio	on ar	nd lev	velling	g and	the the	use	of F	PM 15	5%		
	softw	/are				A	AG		A PI	4						
CO6	Outli	ne the	e imp	ortanc	ce and	d varie	ous a	ctivitie	es dur	ing p	roject	closu	ıre   15	5%		
	and p	orepa	re a p	roject	repoi	t		20		<u></u>						
СОМ	appin	g wit	h CDI	O Cu	rricul	um F	rame	work			1					
CO	T	CE			Learı	ning E	Domai	n Lev	el		CDI	O Cu	rricular	Compo	nents	
#	Prof	icienc	y   Co	ognitiv	/e	Affe	ective	Ps	ychon	notor	(X.Y	′.Z)				
	S	cale														
<u>CO1</u>	TPS	2		Inders	stand	Re	spond		-		2.3.	1, 2.5	.2, 4.2.	1.2.1,4.3.4		
CO2	TPS	3		Арр	ly	Val	ue		-		2.3.	2, 2	2.4.3,	2.5.4,	3.2.3	5,
	-							_			3.2.	4,4.3	4			
<u>CO3</u>		3		App	ly	Va	ue	_	-		2.1.	4, 2.4	.4, 4.1.	5,4.3.4		
<u>CO4</u>	IPS	3	<u> </u>	<u>App</u>	ly .		ue	_	-		2.4	<u>3, 2.4</u>	4,4.3.4	•		
<u>CO5</u>	TPS	2		Inders	stand	Re	spond		-		3.2.	<u>4,4.3.</u>	4			
<u>CO6</u>	IPS	3	_   L	Inders	stand	Re	spond		-		2.1.	5, 3.2	.3, 3.2.4	4, 4.3.4		
Марр	ing w	ith Pr	ogra	mme	Outco	omes										ĩ
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	-	-	-	-	-	-	-	М	M - M S M					М	ļ	
CO2	-	-	-	-	-	-	-	М	-	М	S	-	-	-	М	
CO3	-	-	-	-	-	-	-	М	-	M	S	-	-	-	М	l

Μ

Μ

Μ

\_

-

\_

CO6 -S- Strong; M-Medium; L-Low

\_

\_

\_

\_

\_

\_

\_

\_

\_

\_

\_

\_

\_

\_

CO4

CO5

\_

-

-

S

S

S

\_

\_

\_

\_

\_

\_

\_

\_

\_

Μ

Μ

Μ

Μ

Μ

М

\_

-

-

Cognitive	Continuous Te	As	signme	nts	Case study Presentation			
Levels	1	2	1	2	3	with Technical Report		
Remember	10	10	-	-	-	0		
Understand	60	40	-	-	-	20		
Apply	30	50	100	100	100	80		
Analyse	0	0				0		
Evaluate	0	0				0		
Create	0	0				0		

# Assessment Pattern\*

\*Revised in 62<sup>nd</sup> Academic Council Meeting dated 29.01.2022

Sample Questions for Course Outcome Assessment

# Course Outcome 1 (CO1):

- 1. Identify the suitable project management methodology for an organization change in an Engineering college.
- 2. Explain the necessity of project management.
- 3. Explain in detail about any two project management methodologies with examples.

# Course Outcome 2 (CO2):

- 1. Prepare a project proposal for the new technical function to be organized by you.
- 2. The sales of a certain product during a fourteen-year period have been as follows: Find the least squares regression line for the data given.

Period	Sales	Period	Sales
1	2000	8	4000
2	2200	9	3900
3	2100	10	4000
4	2300	11	4200
5	2500	12	4300
6	3200	13	4900
7	3600	14	5300

3. Consider a scenario that you are organizing an Electrical Association event on software contest. Do SWOT analysis for this assignment. Explain the outcome of the analysis.

# Course Outcome 3 (CO3)

- 1. Prepare a work breakdown structure for a shifting a software company from one location to another and illustrate the need of WBS
- 2. Do the UNIDO-SCBA analysis for the new government road projects.
- 3. Demonstrate the risks associated in a electronics project implementation.

# Course Outcome 4 (CO4)

- 1. Create a customer database for the Modesto league baseball team. Draw a project network Complete the forward and backward pass, compute activity slack, and identify the critical path. How long will this project take? How sensitive is the network schedule? Calculate the free slack and total slack for all noncritical activities.
- 2. The network shows information related to a project that involves merging two marketing firms. Determine the Earliest start and finish time, Latest start time and completion time for each activity. List the critical activities and determine the project completion duration.



#### **Course Outcome 5 (CO5)**

- 1. Explain resource allocation in detail
- 2. Discuss various PM software that are being used widely.
- 3. Explain about the resource levelling

#### **Course Outcome 6 (CO6)**

- 1. Discuss the key elements to be included in project report.
- 2. Develop a project report for the given problem scenario.
- 3. List out the various activities to be considered in project closure.

#### Concept Map



#### Syllabus

**Understanding Projects and Project management**: Definition of Project & Project Management. Life cycle of Project. Project Management Methodologies and tools. **Project Selection & Appraisal:** Project ideas generation, Pre-Feasibility Analysis -SWOT Feasibility Analysis-Market& Demand appraisal, Technical appraisal, Risk analysis- Sensitivity analysis & Scenario Analysis. Economic Feasibility -SCBA-UNIDO approach. Preparing a detailed Project Proposal (Executive Summary). **Project Planning& Execution**: Attributes & Definition of planning. WBS. Time Planning - PERT/CPM/Trade off. Material Planning - Procurement logistics & storage. Machines & Technology planning. Human Resource Planning in Project Organization. Quality Assurance Plan. Planning of Risk Management. Resource Allocation & Resource Levelling. Introduction & use of PM software. **Project Closure & Termination:** Inspection. Testing. Transportation. Commissioning. Trial Run. Documentation required for Project Handover. Preparing a Project Report for Future Reference, Templates. **Case Studies** 

#### Learning Resources

- 1. Prasanna Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation and Review, Mc Graw Hill, 8th edition, 2015
- 2. Project planning and control using PERT and CPM, Dr.P.C.Punmia, Lakshmi publications, 2006
- 3. Project Management- A Managerial Approach to Planning, Scheduling, and Controlling Harold Kerzner, 10th edition John Wiley & Sons, Inc.
- 4. Project Management Institute (PMBOK) Guide, 5th Edition

-			
S.No.	Торіс	No. of	COs
		Lectures	
1	Understanding Projects and Project management:		
1.1	Definition of Project & Project Management.	1	CO1
1.2	Life cycle of Project.	1	CO1
1.3	Project Management Methodologies	2	CO1
1.4	Project Management tools	1	CO1
2	Project Selection & Appraisal:		
2.1	Project ideas generation, Pre-Feasibility Analysis -SWOT.	2	CO2
2.2	Feasibility Analysis-Market& Demand appraisal,	2	CO2
2.3	Technical appraisal	1	CO2
2.4	Risk analysis (Sensitivity analysis & Scenario Analysis).	2	CO3
2.5	Economic Feasibility (SCBA-UNIDO approach).	2	CO3
2.6	Preparing a detailed Project Proposal (Executive Summary).	1	CO2
3	Project Planning& Execution:		
3.1	Attributes & Definition of planning. WBS.	1	CO2
3.2	Time Planning (PERT).	3	CO4
3.3	CPM/Trade off	3	CO4
3.4	Material Planning (Procurement logistics & storage), Machines & Technology planning.	1	CO5
3.5	Human Resource Planning (Project Organization).	1	CO5
3.6	QAP	1	CO5
3.7	Planning of Risk Management.	1	CO3
3.8	Resource Allocation & Resource Leveling.	1	CO5
3.9	Introduction & use of PM software.	2	CO5
4	Project Closure & Termination:		
4.1	Inspection. Testing. Transportation.	1	CO6
4.2	Commissioning. Trial Run.	1	CO6
4.3	Documentation required for Project Handover.	1	CO6
4.4	Preparing a Project Report for Future Reference.	1	CO6
5	Case Studies	3	CO6
	Total	36	

#### **Course Contents and Lecture Schedule**

# **Course Designers**

1. Dr.S.J.Thiruvengadam

2. Dr.V.R.Venkatasubramani

sjtece@tce.edu venthiru@tce.edu

Category	L	Т	Ρ	Credit
AC	2	0	0	0

On the successful completion of the course, the students will be able to explain the basic features and fundamental principles of Constitution of India. The Constitution of India is the supreme law of India. Parliament of India cannot make any law which violates the Fundamental Rights enumerated under the Part III of the Constitution. The Parliament of India has been empowered to amend the Constitution under Article 368, however, it cannot use this power to change the "basic structure" of the constitution, which has been ruled and explained by the Supreme Court of India in its historical judgments. The Constitution of India reflects the idea of "Constitutionalism" – a modern and progressive concept historically developed by the thinkers of "liberalism" – an ideology which has been recognized as one of the most popular political ideology and result of historical struggles against arbitrary use of sovereign power by state. The historic revolutions in France, England, America and particularly European Renaissance and Reformation movement have resulted into progressive legal reforms in the form of "constitutionalism" in many countries. The Constitution of India was made by borrowing models and principles from many countries including United Kingdom and America.

The Constitution of India is not only a legal document but it also reflects social, political and economic perspectives of the Indian Society. It reflects India's legacy of "diversity". It has been said that Indian constitution reflects ideals of its freedom movement; however, few critics have argued that it does not truly incorporate our own AICTE Model Curriculum for Mandatory Courses & Activities (Non-Credit) for Undergraduate Degree in Engineering & Technology ancient legal heritage and cultural values. No law can be "static" and therefore the Constitution of India has also been amended more than one hundred times. These amendments reflect political, social and economic developments since the year 1950. The Indian judiciary and particularly the Supreme Court of India has played an historic role as the guardian of people. It has been protecting not only basic ideals of the Constitution. The judicial activism of the Supreme Court of India and its historic contributions has been recognized throughout the world and it gradually made it "as one of the strongest court in the world"

# **Course Outcome:**

On the successful completion of the course students will be able to

CO1	Explain the meaning of the constitution law and constitutionalism and Historical perspective of the Constitution of India	Understand
CO2	Explain the salient features and characteristics of the Constitution of India, scheme of the fundamental rights and the scheme of the Fundamental Duties and its legal status	Understand
CO3	Explain the Directive Principles of State Policy, Federal structure and distribution of legislative and financial powers between the Union and the States, and Parliamentary Form of Government in India	Understand
CO4	Explain the amendment of the Constitutional Powers and Procedure, the historical perspectives of the constitutional amendments in India, and Emergency Provisions.	Understand
CO5	Explain the Local Self Government – Constitutional Scheme in India, Scheme of the Fundamental Right to Equality,	Understand
CO6	Explain the scheme of the Fundamental Right to certain Freedom under Article 19, and Scope of the Right to Life and Personal Liberty under Article 21	Understand

# Manning with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	L	-	-	-	М	-	М	-	L	-	-
CO2	M	L	-	-	-	M	-	М	-	L	-	-
CO3	M	L	-	-	-	M	-	М	-	L	-	-
CO4	M	L	-	-	-	M	-	М	-	L	-	-
CO5	M	L	-	-	-	M	-	М	-	L	-	-
CO6	Μ	L	-	-	-	Μ	-	Μ	-	L	-	-

S- Strong; M-Medium; L-Low

# **Svllabus**

- 1. Meaning of the constitution law and constitutionalism
- 2. Historical perspective of the Constitution of India
- 3. Salient features and characteristics of the Constitution of India
- 4. Scheme of the fundamental rights
- 5. The scheme of the Fundamental Duties and its legal status
- 6. The Directive Principles of State Policy Its importance and implementation
- 7. Federal structure and distribution of legislative and financial powers between the Union and the States
- 8. Parliamentary Form of Government in India The constitution powers and status of the President of India
- 9. Amendment of the Constitutional Powers and Procedure
- 10. The historical perspectives of the constitutional amendments in India
- 11. Emergency Provisions : National Emergency, President Rule, Financial Emergency
- 12. Local Self Government Constitutional Scheme in India
- 13. Scheme of the Fundamental Right to Equality
- 14. Scheme of the Fundamental Right to certain Freedom under Article 19
- 15. Scope of the Right to Life and Personal Liberty under Article 21

Bloom's category	Continuous Te	Seminar		
Dieenie outogery	1	2	-	
Remember	40	40	0	
Understand	60	60	100	
Apply	0	0	0	
Analyze	0	0	0	
Evaluate	0	0	0	
Create	0	0	0	

# . . .

References

- 1. Durga Das Basu, 'Introduction to The Constitution of India', LexisNexis Butterworths Wadhwa, 20th Edition, Reprint 2011.
- 2. Constitution of India, National Portal of India, Web link: https://www.india.gov.in/mygovernment/constitution-india

# **Course Designers:**

1. Adapted from AICTE Model Curriculum for Undergraduate Degree Courses in Engineering & Technology, Volume-II, January 2018.

# **CURRICULUM AND SYLLABI** FOR **B.E. DEGREE (ELECTRONICS AND COMMUNICATION ENGINEERING)** PROGRAMME FIFTH SEMESTER FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2018-2019 ONWARDS THIAGARAJAR COLLEGE OF ENGINEERING (A Govt Aided Autonomous Institution Affiliated to Anna University) MADURAI - 625 015, TAMILNADU

# Vision and Mission of the Department

# Vision:

To empower the Electronics and Communication Engineering students with technological excellence, professional commitment and social responsibility.

# Mission:

- ME1. Attaining academic excellence in Electronics and Communication Engineering through dedication to duty, innovation in learning and research, state of the art laboratories and industry driven skill development.
- ME2. Establishing suitable environment for the students to develop professionalism and face life challenges with ethical integrity.
- ME3. Nurturing the students to understand the societal needs and equip them with technical expertise to provide appropriate solutions.
- ME4. Providing breeding ground to obtain entrepreneurial skills and leadership qualities for self and social growth.

# Program Educational Objectives (PEOs):

- PEO1. Graduates will be capable of developing specification and design procedures, prototyping and test methodologies for modern electronics and communication systems and gadgets that perform analog and digital processing functions.
- PEO2. Graduates will be able to work and adapt to changes in allied areas of Electronics and Communication Engineering through personal success and life long learning.
- PEO3. Graduates will be able to identify technological requirements for the society and provide cost effective solutions.
  - These objectives will be evidenced by professional visibility (publications, presentations, inventions, patents and awards), entrepreneurial activities, international activities (participation in international conferences, collaborative research and employment abroad)
## Program Outcomes: Engineering Graduates will be able to:

- 1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- 2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- 3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- 4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- 5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- 6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- 8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- 9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- 10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- 11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- 12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## Program Specific Outcomes:

Engineering Graduates will be able to

- PSO1. Design circuits and systems for complex engineering problems in Electronics and Communication and allied areas.
- PSO2. Apply research methodologies to provide solutions for contemporary problems in the areas including RF, Signal Processing, Image Processing, VLSI, Optical Communication, Networks and Embedded Systems for given specifications.
- PSO3. Actively contribute as a member or leader in diverse teams, and communicate effectively on complex engineering activities and involve in life-long learning, by applying reasoning and ethical principles.

## PEO- Mission Mapping:

	ME1	ME2	ME3	ME4
PEO1	S	М	М	L
PEO2	L	S	М	М
PEO3	М	L	S	М

### **PEO-PO-PSO Mapping:**

	P 0 1	P 0 2	P 0 3	P 0 4	P 0 5	P O 6	P O 7	P O 8	P O 9	P O 10	P 0 11	P O 12	PS O 1	PS O 2	PS O 3
PEO 1															
PEO 2															
PEO 3															

## **PO-GA Mapping:**

	GA	GA	GA	GA	GA	GA	GA	GA	GA	GA1	GA1	GA1
	1	2	3	4	5	6	7	8	9	0	1	2
PO1						ST	2 D					
PO2					R		1 d					
PO3							PI					
PO4					N	Condition of the second	S Y	5				
PO5						E State	de la	1				
PO6					1							
PO7												
PO8					/		1					
PO9					1			S.				
PO1												
0												
PO1												
1												
PO1												
2												

## TCE PROFICIENCY SCALE (CDIO Curriculum Framework)

TCE Proficiency Scale (TPS)	Proficiency	Cognitive	Affective	Psychomotor
TPS1	To have been exposed to	Remember	Receive	Perception, Set
TPS2	To be able to interpret and imitate	Understand	Respond	Guided Response
TPS3	To be skilled in the practice or implement	Apply	Value	Mechanism
TPS4	To be able to participate in and contribute	Analyse	Organise	Complex Overt Responses
TPS5	To be able to judge and adapt	Evaluate	Organise	Adaptation
TPS6	To be able to lead and innovate	Create	Characterize	Origination

S.No	Category	Cre	dits
		Regular	Lateral
А	Foundation Courses	53 — 58	23-28
	Humanities and Social Science (HSS)	9 -11	6-8
	Basic Science (BS)	21	6
	Engineering Science (ES)	23 – 26	11-14
В	Professional Core Courses	55	45
С	Elective Courses	24 – 48	24-48
	Programme Specific Elective	12-24	12-24
	Programme Elective for Expanded Scope	6 – 12	6-12
	General Elective	3-6	3-6
	Foundation Elective	3-6	3-6
D	Project work, seminar, internship in industry or at	15	15
	Higher Learning institutions		
E	Mandatory Courses – Environment Science,	Non-Credit	Non-Credit
	Induction Programme, Indian Constitution,	(Not included	(Not included
	Essence of Indian Tradition knowledge,	for CGPA)	for CGPA)
	consumer Affairs ( as per UGC guideline)		
	Minimum Credits to be earned for the award of	160	120
	the Degree	(from A to D)	(from A to D)
		and the	and the
	A SA SA	successful	successful
	r l l	completion of	completion of
	Contraction of the second	Mandatory	Mandatory
		Courses	Courses

### **Credit Distribution**

- General electives are courses offered by different departments that do not have any prerequisites and could be of interest to students of any branch
- All students have to undertake co-curricular and extra-curricular activities that include activities related to NCC, NSS, Sports, Professional Societies, participation in identified activities which promote the growth of Departments and the College.

## THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015 (A Govt. Aided Autonomous Institution affiliated to Anna University)

## CATEGORIZATION OF COURSES (CHOICE BASED CREDIT SYSTEM)

A. I	A. FOUNDATION COURSES: Total Credits to be earned: 53-58										
	a. Hum	anities and Social Science (09-11)									
S.No.	Course	Name of the Course	Nu	ımbe	er of		Credit				
	Code		Ηου	irs / \	Neek						
			L	Т	P						
THEOF	٦Y										
1.	18EG140	English	2	-	-		2				
2.	18EC610	Accounting and Finance	3	-	-		3				
3.	18EC490	Project Management	3	-	-		3				
THEO	RY CUM PR	ACTICAL									
1.	18EG460	Professional Communication	-	1	2		2				
PRAC	TICAL										
1.	18EG170	English Laboratory	-	-	2		1				
	b. Basio	c Science (21)									
S.No.	Course	Name of the Course	Nur	nber	of Ho	urs	Credit				
	Code			/ W							
				ΙΤ			-				
		A Canada A SA		.	I	Г					
			<u> </u>		1		1				
1.	TOWATTU	Engineering Calculus	3	·	1	-	4				
2.	18PHB20	Physics	3		-	-	3				
3.	18CHB30	Chemistry	3		-	-	3				
4.	18MA210	Matrices and Ordinary Differential	2	.	1	-	3				
		Equations									
5.	18EC310	Complex Analysis and Linear Algebra	2	<u> </u>	1		3				
6.	18EC410	Optimization and Numerical Methods	2		1		3				
PRAC	TICAL	1					-				
1.	18PH180	Physics Laboratory	-		-	2	1				
2.	18CH190	Chemistry Laboratory	-		-	2	1				
	c. Engi	neering Science (23-26)									
S.No.	Course	Name of the Course	N	lumb	er of		Credit				
	Code		Ho	urs /	Weeł	<b>(</b>					
			L	Т	P						
THEO	<u> YY</u>	1									
1.	18ES150	Engineering Exploration	3	-	-		3				
2.	18EC240	Semiconductor Physics	3	-	-		3				
3.	18EC630	Data Structures and Algorithms	2	-	-		2				
4.	18XXPE0	Engineering Sciences Elective	3	-	-		3				
THEOR	<u>RY CUM PR</u>	ACTICAL									
1.	18ME160     Engineering Graphics     3     -     2						4				
2.	18EC360	Programming for Problem Solving	2	-	2		3				
3.	18ES390	Design Thinking	1 - 2				2				
4.	18ES590	System Thinking	1	-	1		2				
PRAC	TICAL										
1.	18EC280	Electronics Workshop	-	-	2		1				
2.	18ES290	Lateral Thinking	-	-	2		1				

Degree: B.E. Programme: ECE

Batch: 2018-19 onwards

18EC670

Data

Laboratory

Structures

and

Algorithms

3.

\_

-

2

1

## **Engineering Sciences Elective**

S.No.	Course	Name of the Course	Ν	lumb	er of	Credit
	Code		Hc	ours /	Week	
			L	Т		
THEOF	RY					
1.	18ECEA0	MEMS Technology	3	-	-	3
2.	18ECEB0	Machine Learning for All	3	-	-	3
3.	18ECEC0	IOT Sensors and Device	3	-	-	3
4.	18ECED0	Blockchain Technology	3	-	-	3
5.	18ECEE0	5G Wireless Networks	3	-	-	3
THEOF	RY CUM PRA	ACTICAL				
	-	-	-	-	-	-

## **B. PROFESSIONAL CORE COURSES**

## Credits to be earned: 55

SI. No.	Course Code	Name of the Course	Number of Hours /			Credit
		TOT	١	Nee	k	
			L	T	Р	
THEOR	Y		-			
1.	18EC220	Network Theory	2	1	-	3
2.	18EC230	Electronic Devices	3	-	-	3
3.	18EC320	RF Passive Devices and Circuits	2	1	-	3
4.	18EC330	Electronic Circuits	3	-	-	3
5.	18EC340	Signals and Systems	2	1	-	3
6.	18EC350	Microprocessors and Microcontrollers	2	1	-	3
7.	18EC420	RF Active Circuits	2	1	-	3
8.	18EC430	CMOS VLSI Systems	3	-	-	3
9.	18EC440	Signal Processing	2	1	-	3
10.	18EC510	Data Communication Networks	2	1	-	3
11.	18EC530	Analog and Digital Communication	2	1	-	3
		Systems				
12.	18EC620	Control Systems	2	1	-	3
13.	18EC710	Consumer Electronics	1	-	-	1
THEOR	Y CUM PRAC	TICAL				
14.	18EC260	Digital System Design	2	-	2	3
15.	18EC520	Antenna and Wave Propagation	2	-	2	3
16.	18EC560	Digital Image Processing	2	-	2	3
17.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTI	CAL					
18.	18EC270	Circuits and Devices Laboratory	-	-	2	1
19.	18EC370	Microprocessor and Microcontroller	-	-	2	1
		Laboratory				
20.	18EC380	Electronic Circuits Laboratory	-	-	2	1
21.	18EC470	RF Circuits Laboratory	-	-	2	1
22.	18EC480	Signal Processing Laboratory	-	-	2	1
23.	18EC570	Data Communication Networking	-	-	2	1
		Laboratory				
24.	18EC580	Analog and Digital Communications	-	-	2	1

C. EL	C. ELECTIVE COURSES: Credits					to be earned: 24-48					
a. Pr	ogramme Specifi	c Elective Credits t	o be	earr	ned:12	2-24					
SI. No.	Course Code	Name of the Course	Nu H	mbe lour: Nee T	er of s / k P	Credit					
THEOR	Ý		_								
1.	18ECPA0	Computer Vision and Applications	3	-	-	3					
2.	18ECPB0	Data Compression	3	-	-	3					
3.	18ECPD0	Wireless Communication Systems	2	1	-	3					
4.	18ECPF0	FPGA Based Digital System Design	3	-	-	3					
5.	18ECPH0	Electronic Measurement and	3	-	-	3					
6.	18ECPJ0	Network Security	3	-	-	3					
7.	18ECPK0	Optical Communication	3	-	-	3					
8.	18ECPM0	Planar Antennas for Wireless Applications	2	-	2	3					
9.	18ECPN0	Electromagnetic Interference and Compatibility	3	-	-	3					
10.	18ECPQ0	Statistical Signal Processing	2	1	-	3					
11.	18ECPT0	Deep Learning For Speech Processing	2	1	-	3					
12.	18ECPU0	VLSI Device Modeling	3	-	-	3					
13.	18ECPY0	ASIC Design	3	-	-	3					
14.	18ECPZ0	oT System and Applications	3	-	-	3					
15.	18ECRA0	Real Time Embedded Systems	3	-	-	3					
THEOR	Y CUM PRACTIC	AL		1	1	1					
16.	18ECPC0	DSP Architecture and Programming	2	-	2	3					
17.	18ECPE0	Biomedical Signal Processing	2	-	2	3					
18.	18ECPG0	Analog System Design	2	-	2	3					

b. Programme Elective for Expanded Scope Credits to						be earned: 06-12			
SI. No.	Course Code	Name of the Course		Nu H L	mbe ours Vee T	er of s / k P	Credit		

THEORY						
1.	18ECPL0	Medical Imaging and Processing	3	-	-	3
2.	18ECPP0	RF MEMS Design and Technology	3	-	-	3
3.	18ECPR0	LDPC and Polar Codes	2	1	-	3
4.	18ECPS0	Physical Channel Processing in 5G NR	2	1	-	3
5.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3
6.	18ECPW0	CAD for VLSI	3	-	-	3
7.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3
8.	18ECRC0	Multimedia Compression Techniques	3	1	-	4
9.	18ECRD0	Signal Processing in 5G NR	3	1	-	4
10.	18ECRE0	Algorithms for VLSI Design Automation	3	1	-	4
11.	18ECRF0	Low Power VLSI Design	3	1	-	4
12.	18EC1A0	Field Tests for a 5G Future	1	-	-	1
13.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1
14.	18EC1C0	Synchronization for 5G NR	1	-	-	1

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

15.	18EC1D0	Speech Signal Processing	1	-	-	1		
16.	18EC1E0	VLSI Implementation of	1	-	-	1		
		Communication Transceivers						
17.	18EC1F0	Embedded System Design	1	-	-	1		
THEORY CUM PRACTICAL								
	-	-	-	-	-	-		

c. General Elective

## Credits to be earned: 03-06

SI. No.	Course Code	Name of the Course	Number of Hours / Week		Credit	
			L	Т	Ρ	
THEORY						
1.	18ECGA0	Consumer Electronics	3	-	-	3
2.	18ECGB0	Multimedia Systems	3	-	-	3
3.	18ECGD0	Telecom Systems	3	-	-	3
4.	18ECGE0	Applied Image Processing	3	-	-	3

## d. Electives from foundation courses- HSS, BS, ES

## D. Project

## Credits to be earned: 15

Credits to be earned: 03-06

S.No.	Course Code	Name of the Course	Nu Hou	Number of Hours / Week		Credit
		and the second sec	L	Т	Р	
1.	18ES690	Engineering Design Project	2	-	4	3
2.	18ES790	Capstone Design Project	-	-	6	3
3.	18EC810	Project	-	-	18	9
		a second				

E. M	E. Mandatory Courses (Not included for CGPA)									
S.No.	Course	Name of the Course	Νι	ımbe	r of	Credit				
	Code		Hou	Hours / Week						
			L	Т	P					
THEOR	THEORY									
1.	18CHAA0	Environmental Sciences	-	-	2	0				
2.	18CHAB0	Constitution of India	-	-	2	0				
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0				
THEOR	Y CUM PRA	CTICAL								
-	-	-	-	-	-	-				
PRACTICAL										
-	-	-	-	-	-	-				

Minimum credits to be earned for the award of the degree = 160

Batch: 2021-22 onwards

## THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015 (A Govt. Aided Autonomous Institution affiliated to Anna University)

## CATEGORIZATION OF COURSES (CHOICE BASED CREDIT SYSTEM)

Programme: ECE

F. F	OUNDATIC	ON COURSES: Total Cro	edits t	o be	earne	ed: {	53-58
	d. Huma	anities and Social Science (09-11)					
S.No.	Course	Name of the Course	Νι	umbe	r of		Credit
	Code		Hou	ırs / \	Veek		
			L	Т	P		
THEOF	RY						
1.	18EG140	English	2	-	-		2
2.	18EC610	Accounting and Finance	3	-	-		3
3.	18EC490	Project Management	3	-	-		3
THEOF	RY CUM PR	ACTICAL					
1.	18EG460	Professional Communication	-	1	2		2
PRAC	TICAL						
1.	18EG170	English Laboratory	-	-	2		1
	e. Basio	c Science (21)					
S.No.	Course	Name of the Course	Nur	nber	of Ho	urs	Credit
	Code			/ W	eek		
							-
	$\nabla \nabla$	A Canada A SA		•	•	1	
	18MA110	Engineering Calculus	3		1	_	4
1.					-		
2.	18PHB20	Physics	3		-	-	3
3.	18CHB30	Chemistry	3		-	-	3
4.	18MA210	Matrices and Ordinary Differential	2	2		-	3
5	18EC310	Complex Analysis and Linear Algebra	2	,	1		3
6	18EC410	Ontimization and Numerical Methods	2	·	1		3
PRAC				·	•		
1	18PH180	Physics Laboratory			-	2	1
1.	18CH190	Chemistry Laboratory	-		-	2	1
<u> </u>	f Engi	peering Science (23-26)				-	<u> </u>
S No	Course	Name of the Course	N	lumb	er of		Credit
0.110.	Code		Ho	urs /	Week		oroun
				T	P	<u> </u>	
THEOF	ΥΥ					_	
1.	18ES150	Engineering Exploration	3	-	-		3
2.	21EC240	Electronic Materials	3	_	-		3
3.	18EC630	Data Structures and Algorithms	2	_	-		2
4.	18XXPE0	Engineering Sciences Elective	3	_	-		3
THEOF		ACTICAL		1	1		
1.	18ME160	Engineering Graphics	3	_	2		4
2.	18EC360	Programming for Problem Solving	2	-	2		3
3.	18ES390	Design Thinking	1	-	2		2
4.	18ES590	System Thinking	1	-	1		2
PRACT	TICAL			1			
1.	18EC280	Electronics Workshop	-	-	2		1
2	18ES290	Lateral Thinking	-	-	2		1

18EC670

Data

Laboratory

Structures

and

Algorithms

3.

Degree: B.E.

Approved in 61th Academic Council Meeting 03.07.2021

-

-

2

1

## **Engineering Sciences Elective**

S.No.	Course	Name of the Course	Number of		er of	Credit			
	Code		HC	urs /	Week				
			L	Т	Р				
THEOF	THEORY								
1.	18ECEA0	MEMS Technology	3	-	-	3			
2.	18ECEB0	Machine Learning for All	3	-	-	3			
3.	18ECEC0	IOT Sensors and Device	3	-	-	3			
4.	18ECED0	Blockchain Technology	3	-	-	3			
5.	18ECEE0	5G Wireless Networks	3	-	-	3			
THEOF	THEORY CUM PRACTICAL								
	-	-	-	-	-	-			

## G. PROFESSIONAL CORE COURSES

## Credits to be earned: 55

SI. No.	Course	Name of the Course	Number of		er of	Credit
	Code	AT DA	H	Hours /		
		1 STRIN	۱ ۱	Nee	k	
			L	T	Р	
THEOR'	Ý					
25.	18EC220	Network Theory	2	1	-	3
26.	18EC231	Electronic Devices	3	-	-	3
27.	18EC320	RF Passive Devices and Circuits	2	1	-	3
28.	18EC330	Electronic Circuits	3	-	-	3
29.	18EC340	Signals and Systems	2	1	-	3
30.	18EC350	Microprocessors and Microcontrollers	2	1	-	3
31.	18EC420	RF Active Circuits	2	1	-	3
32.	18EC430	CMOS VLSI Systems	3	-	-	3
33.	18EC440	Signal Processing	2	1	-	3
34.	18EC510	Data Communication Networks	2	1	-	3
35.	18EC530	Analog and Digital Communication	2	1	-	3
		Systems				
36.	18EC620	Control Systems	2	1	-	3
37.	18EC710	Consumer Electronics	1	-	-	1
THEOR	Y CUM PRAC	TICAL				
38.	18EC260	Digital System Design	2	-	2	3
39.	18EC520	Antenna and Wave Propagation	2	-	2	3
40.	18EC560	Digital Image Processing	2	-	2	3
41.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTI	CAL					
42.	18EC270	Circuits and Devices Laboratory	-	-	2	1
43.	18EC370	Microprocessor and Microcontroller	-	-	2	1
		Laboratory				
44.	18EC380	Electronic Circuits Laboratory	-	-	2	1
45.	18EC470	RF Circuits Laboratory	-	-	2	1
46.	18EC480	Signal Processing Laboratory	-	-	2	1
47.	18EC570	Data Communication Networking	-	-	2	1
		Laboratory				
48.	18EC580	Analog and Digital Communications	-	-	2	1
		Laboratory				

H. EL	ECTIVE COURS	SES: Credits	to be	ear	ned:	24-48
a. Pr	ogramme Specif	c Elective Credits t	o be	earr	ed:12	-24
SI. No.	Course Code	Name of the Course	Nu H	mbe lour: Nee	er of s / k	Credit
	-		L	T	Р	
THEORY	Y	-				-
19.	18ECPA0	Computer Vision and Applications	3	-	-	3
20.	18ECPB0	Data Compression	3	-	-	3
21.	18ECPD0	Wireless Communication Systems	2	1	-	3
22.	18ECPF0	FPGA Based Digital System Design	3	-	-	3
23.	18ECPH0	Electronic Measurement and Instruments	3	-	-	3
24.	18ECPJ0	Network Security	3	-	-	3
25.	18ECPK0	Optical Communication	3	-	-	3
26.	18ECPM0	Planar Antennas for Wireless Applications	2	-	2	3
27.	18ECPN0	Electromagnetic Interference and Compatibility	3	-	-	3
28.	18ECPQ0	Statistical Signal Processing	2	1	-	3
29.	18ECPT0	Deep Learning for Speech Processing	2	1	-	3
30.	18ECPU0	VLSI Device Modeling	3	-	-	3
31.	18ECPY0	ASIC Design	3	-	-	3
32.	18ECPZ0	IoT System and Applications	3	-	-	3
33.	18ECRA0	Real Time Embedded Systems	3	-	-	3
THEORY	Y CUM PRACTIC	AL				
34.	18ECPC0	DSP Architecture and Programming	2	-	2	3
35.	18ECPE0	Biomedical Signal Processing	2	-	2	3
36.	18ECPG0	Analog System Design	2	-	2	3

## b. Programme Elective for Expanded Scope Credits to be earned: 06-12

SI. No.	Course Code	Name of the Course	Nu H	mbe ours	er of s /	Credit
	-		N	Nee	k	
			L	Т	Р	
THEORY	/					
18.	18ECPL0	Medical Imaging and Processing	3	-	-	3
19.	18ECPP0	RF MEMS Design and Technology	3	-	-	3
20.	18ECPR0	LDPC and Polar Codes	2	1	-	3
21.	18ECPS0	Physical Channel Processing in 5G	2	1	-	3
		NR				
22.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3
23.	18ECPW0	CAD for VLSI	3	-	-	3
24.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3
25.	18ECRC0	Multimedia Compression Techniques	3	1	-	4
26.	18ECRD0	Signal Processing in 5G NR	3	1	-	4
27.	18ECRE0	Algorithms for VLSI Design	3	1	-	4
		Automation				
28.	18ECRF0	Low Power VLSI Design	3	1	-	4
29.	18EC1A0	Field Tests for a 5G Future	1	-	-	1

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

30.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1		
31.	18EC1C0	Synchronization for 5G NR	1	-	-	1		
32.	18EC1D0	Speech Signal Processing	1	-	-	1		
33.	18EC1E0	VLSI Implementation of	1	-	-	1		
		Communication Transceivers						
34.	18EC1F0	Embedded System Design	1	-	-	1		
THEORY CUM PRACTICAL								
	-	-	-	-	-	-		

d. General Elective Credits				earn	ed: 0	3-06
SI. No.	Course	Name of the Course	Nu	Number of		Credit
	Code		H	lours	s /	
			۱ ۱	Week		
			L	Т	Р	
THEORY	•					
5.	18ECGA0	Consumer Electronics	3	-	-	3
6.	18ECGB0	Multimedia Systems	3	-	-	3
7.	18ECGD0	Telecom Systems	3	-	-	3
8.	18ECGE0	Applied Image Processing	3	-	-	3

d. Electives from foundation courses- HSS, BS, ES Credits to be earned: 03-06

## I. Project

# Credits to be earned: 15

S.No.	Course	Name of the Course	Number of			Credit					
	Code	San Barris	Hours / Week								
			L	Т	Р						
1.	18ES690	Engineering Design Project	2	-	4	3					
2.	18ES790	Capstone Design Project	-	-	6	3					
3.	18EC810	Project	-	-	18	9					

J. N	J. Mandatory Courses (Not included for CGPA)									
S.No.	Course	Name of the Course	Nu	umbe	r of	Credit				
	Code		Hou	Hours / Week						
			L	Т	P					
THEOR	Y									
1.	18CHAA0	Environmental Sciences	-	-	2	0				
2.	18CHAB0	Constitution of India	-	-	2	0				
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0				
THEOR	Y CUM PRAG	CTICAL								
-	-	-	-	-	-	-				
PRACTICAL										
-	-	-	-	-	-	-				

Minimum credits to be earned for the award of the degree = 160

c C ts		22	8	22	22	22
Audit Courses (Mandato ry Non- credit}	12	1	18CHAA0 Environm ental Sciences (0)		18CHAB0 Constituti on of India (0)	Essence of Indian Knowledg e (0)
Special Courses	11	1	18ES290 Lateral Thinking (1)	18ES390 Design Thinking (TCP) (2)	18EC490 Project Managem ent (3)	18ES590 System Thinking (2)
	10	18CH19 0 Chemist ry Lab. (1)			•	
Practical	9	18PH180 Physics Lab. (1)	18EC280 Workshop (1)	18EC380 Electronic Circuits Lab (1)	18EC480 Signal Processin g Lab (1)	18EC580 Analog and Digital Commn. Lab (1)
	8	18EG170 English Lab. (1)	18EC270 Circuits and Devices Lab (1)	18EC370 Microproc essor and Microcont roller Lab (1)	18EC470 RF Circuits Lab (1)	18EC570 Data Commn. Networkin g Lab `(1)
Theory cum Practical	7	18ME160 Engg Graphics (4)	18EC260 Digital System Design (3)	18EC360 Programmin g for Problem Solving (3)	18EG460 Professional Communicat ion (2)	18EC560 Digital Image Processing (3)
	9	L.			•	1
	5	18ES150 Engg Explorati on (3)	No.	18EC350 Micropro cessors and Microcont rollers (3)	18YYFX0 Foundati on Elective I (3)	18YYGX 0 Gen. Elective .I (3)
	4	18EG180 English (2)	18EC240** Semicondu ctor Physics (3)	18EC340 Signals and Systems (3)	18EC440 Signal Processing (3)	18ECPX0 Prog. Elective -I (3)
Theory	3	18CHB 30 Chemistry (3)	18EC230** Electronic Devices (3)	18EC330 Electronic Circuits (3)	18EC430 CMOS VLSI Systems (3)	18EC530 Analog and Digital Communicat ions (3)
	2	18PHB20 Physics (3)	18EC220 Network Theory (3)	18EC320 RF Passive Devices and Circuits (3)	18EC420 RF Active Circuits (3)	18EC520 Antenna and Wave Propagatio n (TCP) (3)
	1	18MA110 Engineering Calculus (4)	18MA210 Matrices and Ordinary Differential Equations (3)	18EC310 Complex Analysis and Linear Algebra (3)	18EC410 Optimization and Numerical Methods (3)	18EC510 Data Communicat ion Networks (3)
		≥	>			

SCHEDULING OF COURSES FOR 2018-19 onwards (B.E. ECE Programme)\*

Passed in BoS Meeting 22.06.2021

Approved in 61th Academic Council Meeting 03.07.2021

B.E. (Electronics and Communication Engineering)

Cr edi ts		23	16	15
Audit Courses (Mandato ry Non- credit}	12	•	1	1
Special Courses	11	18ES690 Engineeri ng Design Project (3)	18ES790 Capstone Design (3) (3)	1
Practical	10		1	18EC81 0 Project (9)
	6	1	1	1
	8	18EC670 Data Structures and Algorithm s Lab (1)		1
Theory cum Practical	7	18EC660 Digital Communicat ion System Design (2)		-
	9	Engg Scienc es (3)		-
	5	18ECPX 0 Prog. Elective/ 18YYFX0 Foundati on Elective II (3)	18ECPX 0 Prog. Elec. VI/ 18YYFX0 General Elective (3)	-
	4	18ECPX0 Prog. (3) (3)	18ECPX0 Prog. Elec.V (3)	1
Theory	3	18EC630 Data Structures and Algorithms (2)	18ECPX0 Prog. Elec IV (3)	
	2	18EC620 Control Systems (3)	18ECPX0 Prog. Elec.III (3)	18XXPX0 Prog. Elec. VIII (3)
	1	18EC610 Accounting and Finance (3)	18EC710 Consumer Electronics (1)	18XXPX0 Prog. Elec. VII (3)
Se est er	5	⋝	T	IIN

Total Credits for Curricular Activities: 160 \*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & \*This schedule shows an optimal way of completing the B.E. Degree programme successfully in 4 Years 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

## THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI - 625 015

### B.E Degree (Electronics and Communication Engineering) Program

## COURSES OF STUDY

(For the students admitted from the Academic year 2018-19 onwards)

#### **FIRST SEMESTER**

Course code	Name of the Course	Category	Number of Hours / Week		er rs / k	Credits
			L	Τ	Ρ	
THEORY						
18MA110	Engineering Calculus	BS	3	1	-	4
18PHB20	Physics	BS	3	I	-	3
18CHB30	Chemistry	BS	3	I	-	3
18EG140	English	HSS	2	I	-	2
18ES150	Engineering Exploration	ES	3	I	-	3
THEORY CL	IM PRACTICAL					
18ME160	Engineering Graphics	ES	3	I	2	4
PRACTICAL						
18EG170	English Laboratory	HSS	-	-	2	1
18PH180	Physics Laboratory	BS	-	I	2	1
18CH190	Chemistry Laboratory	BS	-	-	2	1
	Total		17	1	8	22

### SECOND SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week		r of ; / ;	Credits
			L	Т	Ρ	
THEORY						
18MA210	Matrices and Ordinary Differential	BS	2	1	-	3
	Equations					
18EC220	Network Theory	PC	2	1	3	
18EC230**	Electronic Devices	PC	3	-	-	3
18EC240**	18EC240** Semiconductor Physics ES				-	3
THEORY CL	JM PRACTICAL					
18EC260	Digital System Design	PC	2	-	2	3
PRACTICAL	-					
18EC270	Circuits and Devices Laboratory	PC	-	-	2	1
18EC280	Electronics Workshop	ES	-	-	2	1
18ES290	Lateral Thinking	ES	-	-	2	1
Non-credit co	ourse (Mandatory) – Audit Course					
18CHAA0	Environment Sciences	ES	1	-	1	-
	Total		13	2	9	18

\*\*For students joined from 2021-22 onwards,

18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

## THIRD SEMESTER

Course code	Name of the Course	Category	y Number of Hours / Week			Credits
			L	Т	Ρ	
THEORY						
18EC310	Complex Analysis and Linear Algebra	BS	2	1	-	3
18EC320	RF Passive Devices and Circuits	PC	2	1	-	3
18EC330	Electronic Circuits	PC	3	-	-	3
18EC340	Signals and Systems	PC	2	1	-	3
18EC350	Microprocessors and Microcontrollers	PC	2	1	-	3
THEORY C						
18EC360	Programming for Problem Solving	ES	2	-	2	3
18ES390	Design Thinking	ES	1	-	2	2
PRACTICA	<u>L</u>					
18EC370	Microprocessor and Microcontroller Laboratory	PC	-	-	2	1
18EC380	Electronic Circuits Laboratory	PC	-	-	2	1
	Total		14	4	8	22
FOURTH SE	EMESTER					
			Number of			
Course	Name of the Course	Category	Nu	Imbei	r of	Credits
Course code	Name of the Course	Category	Nu Hou	imbei irs / V	r of Veek	Credits
Course code	Name of the Course	Category	Nu Hou L	imbei irs / V T	r of Veek P	Credits
Course code THEORY	Name of the Course	Category	Nu Hou L	Imbei Irs / V T	r of Veek P	Credits
Course code THEORY 18EC410	Name of the Course Optimization and Numerical Methods	Category BS	Nu Hou L	Imbei Irs / V T	r of Veek P -	Credits 3
Course code THEORY 18EC410 18EC420	Name of the Course Optimization and Numerical Methods RF Active Circuits	Category BS PC	Nu Hou L 2 2	Imbei Irs / V T 1 1	r of Veek P -	Credits 3 3
Course code THEORY 18EC410 18EC420 18EC430	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems	Category BS PC PC	Nu Hou L 2 3	Imbei Irs / V T 1 1 -	r of Veek P - -	Credits 3 3 3
Course code THEORY 18EC410 18EC420 18EC430 18EC440	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing	Category BS PC PC PC	Nu Hou 2 2 3 2	Imbei Irs / V T 1 - 1	r of Veek P - - -	Credits 3 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC420 18EC440 18YYFX0	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing Foundation Elective I	Category BS PC PC PC BS	Nu Hou 2 2 3 2 3	Imbei Irs / V T 1 1 - 1 -	r of Veek P - - - -	Credits 3 3 3 3 3 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490	Name of the CourseOptimization and Numerical MethodsRF Active CircuitsCMOS VLSI SystemsSignal ProcessingFoundation Elective IProject Management	Category BS PC PC PC BS HSS	Nu Hou 2 2 3 2 3 3 3 3	Imbei Irs / V T 1 - 1 - -	r of Veek P - - - - - -	Credits 3 3 3 3 3 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490 THEORY C	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL	Category BS PC PC PC BS HSS	Nu Hou L 2 3 2 3 3 3	Imbei Irs / V T 1 1 - 1 -	r of Veek P - - - - - - - - -	Credits 3 3 3 3 3 3 3 3 3
Course code THEORY 18EC410 18EC420 18EC430 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460	Name of the CourseOptimization and Numerical MethodsRF Active CircuitsCMOS VLSI SystemsSignal ProcessingFoundation Elective IProject ManagementCUM PRACTICALProfessional Communication	Category BS PC PC BS HSS HSS	Nu Hou L 2 3 2 3 3 3 -	Imbei Irs / V T 1 1 - 1 - -	r of Veek P - - - - - - - 2	Credits 3 3 3 3 3 3 2
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460 PRACTICA	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication	Category BS PC PC PC BS HSS HSS	Nu Hou 2 2 3 2 3 3 -	Imbei Irs / V T 1 - 1 - - 1	r of Veek P - - - - - - 2	Credits 3 3 3 3 3 2 2
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         RF Circuits Laboratory	Category BS PC PC PC BS HSS HSS	Nu Hou 2 2 3 2 3 3 -	Imbei Irs / V T 1 1 - 1 - 1 - -	r of Veek P - - - - - 2	Credits 3 3 3 3 3 2 1
Course code THEORY 18EC410 18EC420 18EC430 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC470	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory	Category BS PC PC PC BS HSS HSS PC PC	Nu Hou L 2 3 2 3 3 - -	Imbei Irs / V T 1 1 - 1 - 1 - - -	r of Veek P - - - - - - 2 2 2	Credits 3 3 3 3 3 2 1 1 1
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC480 AUDIT CO	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory         URSE - NON-CREDIT MANDATORY COM	Category BS PC PC PC BS HSS HSS PC PC JRSE	Nu Hou L 2 3 2 3 3 3 - -	Imbei Irs / V T 1 1 - 1 - 1 - 1 - -	r of Veek P - - - - - - 2 2 2	Credits 3 3 3 3 3 2 1 1 1
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC480 AUDIT CO 18CHAB0	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory         URSE - NON-CREDIT MANDATORY CON         Constitution of India	Category BS PC PC PC BS HSS HSS PC PC JRSE HSS	Nu Hou 2 2 3 2 3 3 - - - -	Imbei Irs / V T 1 1 - 1 - 1 - - - - -	r of Veek P - - - - - 2 2 2 2	Credits 3 3 3 3 3 2 1 1 0

## **FIFTH SEMESTER**

Course code	Name of the Course	Category	Number of Hours / Week		r of Veek	Credits
			L	Т	Ρ	
THEORY						
18EC510	Data Communication Networks	PC	2	1	-	3
18EC530	Analog and Digital Communication	PC	2	1	-	3
	Programme Elective -I	DE	3			3
	Conoral Elective		2	-	-	3
THEORY		GE	5	-	-	5
18EC520	Antenna and Wave Propagation	PC	2	_	2	3
1950560	Digital Imaga Processing		2	-	2	3
1020300		PC		-	2	3
18ES590	System Thinking	ES	1	1   -   1*   2		
PRACTICA	NL					

18EC570	Data Communication Networking	PC	-	-	2	1		
1950590	Appled and Digital Communications	PC			2	1		
TOEC300		FC	-	-	2	I		
	Cooper of Indian Knowledge				0	0		
INCHACU		<u> пээ</u>	-	-		0		
	lotal		15	2	11	22		
*One hour p	er week is allotted for off the classroom w	ork						
SIXTH SEM	ESTER	1	1					
Course	Name of the Course	Category	Nu	Imbei	r of	Credits		
code	de				Veek			
			L	T	Ρ			
THEORY								
18EC610	Accounting and Finance	HSS	3	-	-	3		
18EC620	Control Systems	PC	2	1	-	3		
18EC630	Data Structures and Algorithms	ES	2	-	-	2		
18ECPX0	Programme Elective-II	PE	3	-	-	3		
18YYZX0	Programme / Foundation Elective - I	PE/FE	3	-	-	3		
18ESEX0	Engineering Sciences Elective	ES	3	-	-	3		
THEORY C	CUM PRACTICAL							
18EC660	Digital Communication Transceiver	PC	1	-	2	2		
PRACTICA	\L							
18EC670	Data Structures and Algorithms	ES	-	-	2	1		
	Laboratory							
PROJECT								
18ES690	Engineering Design Project Project 1 - 4							
Total 18 1 8 2								

## SEVENTH SEMESTER

Course code	Name of the Course	Category	Nu Hou	ımbeı Irs / V	r of Veek	Credits	
			L	Т	P		
THEORY							
18EC710	Consumer Electronics PC 1						
18ECPX0	Programme Elective -III	PE	3	-	- 3		
18ECPX0	Programme Elective -IV	PE	3	-	-	3	
18ECPX0	Programme Elective -V	PE	3	-	-	3	
18YYZX0	Programme-VI / General Elective - II	PE/GE	3	-	-	3	
THEORY C	CUM PRACTICAL						
-	-	-	-	-	-	-	
PRACTICA	\L						
-	-	-	-	-	-	-	
PROJECT							
18ES790	Capstone Design Project	Project	-	-	6	3	
	Total		13	-	6	16	

### **EIGHTH SEMESTER**

Course code	Name of the Course	Category	y Number of Hours / Week		<sup>.</sup> of Veek	Credits				
			L	Т	Ρ					
THEORY	THEORY									
18ECPX0	Programme Elective -VII	PE	3	-	-	3				
18ECPX0	Programme Elective -VIII	PE	3	-	3					
THEORY CUM PRACTICAL										
-	-	-	-	-	-	-				
PRACTICA	\L									
-	-	-	-	-	-	-				
PROJECT										
18EC810	Project	Project	-	-	18	9				
Total 6 - 18 1										

- BS : Basic Science
- HSS : Humanities and Social Science
- ES : Engineering Science
- PC : Programme Core
- PE : Programme Elective
- GE : General Elective
- FE : Foundation Elective
- L : Lecture
- T : Tutorial
- P : Practical

### Note:

- 1 Hour Lecture/week is equivalent to 1 Credit
- 1 Hour Tutorial/week is equivalent to 1 Credit
- 2 Hours Practical/week is equivalent to 1 Credit

## THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E Degree (Electronics and Communication Engineering) Program SCHEME OF EXAMINATIONS

(For the students admitted from the Academic Year 2018-19 onwards) **SECOND SEMESTER** 

Course	Name of the	Duration	Ν		Minimum	Marks	
code	Course	Torminal	Continuouo	Terminel	Max	Torminal	Tatal
			Continuous		Max.		Total
		Exam	Assessment	Exam**	Marks	Exam	
		In Hrs.					
THEORY	1						
18MA210	Matrices and	3	50	50	100	25	50
	Ordinary						
	Differential						
	Equations						
18EC220	Network	3	50	50	100	25	50
	Theory	_				_	
18EC230***	Electronic	3	50	50	100	25	50
	Devices						
18EC240***	Semiconductor	3	50	50	100	25	50
	Physics						
THEORY CU	M PRACTICAL	•				•	
18EC260	Digital System	3	50	50	100	25	50
	Design						
PRACTICAL	• • • •	•	•	•	•	•	
18EC270	Circuits and	3	50	50	100	25	50
	Devices						
	Laboratory						
18EC280	Electronics	3	50	50	100	25	50
	Workshop						
18ES290	Lateral	_	50	50	100	25	50
	Thinking						
AUDIT COUI	RSE - NON-CRED	IT MANDA	TORY COURS	E	1	1	1
18CHAA0	Environmental	-	50	50	100	25	50
	Sciences						

\*\*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

### THIRD SEMESTER

Course	Name of the	Duration			Minimum	Marks	
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY							
18EC310	Complex Analysis and Linear Algebra	3	50	50	100	25	50
18EC320	RF Passive Devices and Circuits	3	50	50	100	25	50
18EC330	Electronic Circuits	3	50	50	100	25	50
18EC340	Signals and Systems	3	50	50	100	25	50

18EC350	Microprocessors	3		50		50	100	25	50
	and Microcontrollers								
THEORY									
18EC360	Programming for	3		50		50	100	25	50
	Problem Solving								
18ES390	Design Thinking	-		50		50	100	25	50
PRACTICA	AL							1	1
18EC370	Microprocessor	3		50		50	100	25	50
	and Microcontrollor								
18EC380	Electronic	3		50		50	100	25	50
1020000	Circuits	J J		00			100	20	
	Laboratory								
FOURTH SI	EMESTER	·							
Course	Name of the	Duration of	of		I		Minimum	Marks	
code	Course	End					for Pass		
		Semester		Continuous	*	End	Max.	End	Iotal
		Exam\		Assessmer	IT.	Semeste	er Marks	Semester	
THEORY									
18EC410	Optimization	3		50		50	100	25	50
1020110	and Numerical	U		00			100	20	00
	Methods								
18EC420	RF Active	3		50		50	100	25	50
	Circuits								
18EC430	CMOS VLSI	3		50		50	100	25	50
4050440	Systems	0		50		50	100	05	50
18EC440	Signal	3		50		50	100	25	50
18YYEX0	Foundation	3		50		50	100	25	50
	Flective I	0		50		00	100	20	50
18EC490	Project	3		50		50	100	25	50
	Management								
THEORY O	CUM PRACTICAL							•	
18EG460	Professional	-		50		50	100	25	50
	Communication								
PRACTICA		•		50		50	400	05	50
18EC4/0		3		50		50	100	25	50
1950490	Laboratory	2		50		50	100	25	50
10EC400	Processing	3		50		50	100	25	50
	Laboratory								
AUDIT CO	URSE - NON-CRE	DIT MANDA	TO	RY COURS	E	1		1	I
18CHAB0	Constitution of	-		50		50	100	25	50
	India								

## **FIFTH SEMESTER**

						1	
Course code	Name of the Course	Duration of End	ſ	Varks		for Pass	Marks
		Semester Exam\ in Hrs.	Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY						•	•
18EC510	Data Communication Networks	3	50	50	100	25	50
18EC530	Analog and Digital Communication Systems	3	50	50	100	25	50
18ECPX0	Programme Elective -I	3	50	50	100	25	50
18YYGX0	General Elective - I	3	50	50	100	25	50
THEORY C		L. L		L	1	•	-
18EC520	Antennas and Wave Propagation	3	50	50	100	25	50
18EC560	Digital Image Processing	3	50	50	100	25	50
18ES590	System Thinking	-	50	50	100	25	50
PRACTICA	L					•	•
18EC570	Data Communication Networking Laboratory	3	50	50	100	25	50
18EC580	Analog and Digital Communications Laboratory	3	50	50	100	25	50
AUDIT COU	JRSE - NON-CREDI	T MANDATO	DRY COURSE			•	
18CHAC0	Essence of Indian Knowledge	-	50	50	100	25	50
SIXTH SEME	ESTER	1					
Course code	Name of the Course	Duration of End		Marks		Minimum for Pass	Marks
		Semester Exam\ in Hrs.	Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY	1			1			
18EC610	Accounting and Finance	3	50	50	100	25	50
18EC620	Control Systems	3	50	50	100	25	50
18EC630	Data Structures and Algorithms	3	50	50	100	25	50
18ECPX0	Programme Elective -II	3	50	50	100	25	50
18YYZX0	Programme / Foundation Elective - I	3	50	50	100	25	50

18ESEX0	Engineering	3	50	50	100	25	50
THEORY C							
18EC660	Digital	3	50	50	100	25	50
1020000	Communication	U	00	00		20	
	System Design						
PRACTICA	L				I		1
18EC670	Data Structures	3	50	50	100	25	50
	and Algorithms	_				_	
	Laboratory						
Project		•				•	
18ES690	Engineering	-	50	50	100	25	50
	Design Project						
SEVENTH S	EMESTER						
Course	Name of the	Duration	1	Marks		Minimum	Marks
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY		-					
18EC710	Consumer	3	50	50	100	25	50
(0505)(0	Electronics			=	100		
18ECPX0	Programme	3	50	50	100	25	50
			50	50	100	05	50
18ECPX0	Programme	3	50	50	100	25	50
	Dregromme	2	50	50	100	25	50
TOECFAU		3	50	50	100	25	50
187770		3	50	50	100	25	50
1011270		5	50	50		25	50
Project							I
18ES790	Capstone Design	_	50	50	100	25	50
1020100	Project			00	100	20	00
EIGTH SEME	ESTER				I		
Course	Name of the	Duration		Marks		Minimum	Marks
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY					•	•	
18ECPX0	Programme	PE	3	-	-	3	-
	Elective -VII						
18ECPX0	Programme	PE	3	-	-	3	50
	Elective -VIII						
Project							
18FC810	Project	-	50	50	100	25	50

\*Continuous Assessment evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\*End Semester Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of End semester examination marks.

\*\*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

18EC510	DATA COMMUNICATION NETWORKS	Category	L	Т	Ρ	Credit
		PC	2	1	0	3

### Preamble

The goal of this course is to introduce the students to state-of-the-art network protocols and architectures. This course includes networking technologies such as Ethernet, Wireless local area network, and wireless personal area network, multiple access technologies, unicast and multicast routing algorithms, subnetting of internetworking, and error/congestion/flow control techniques. This course also covers the QoS Provisioning and network security. **Prerequisite** 

## NIL

### Course Outcomes

On the successful completion of the course students will be able to

COs	Course Outcome Statement	Weightage*** in %
CO1	Build a reliable Data networks using LAN technologies such as ETHERNET, WLAN and WPAN	20
CO2	Apply the unicast and multicast routing algorithms for autonomous Networks	25
CO3	Analyze the concepts of reliable data transfer and congestion control of TCP	15
CO4	Analyze the performance parameters such as delay, throughput of a network.	15
CO5	Understand the client/server model and key application layer protocols	10
CO6	Apply cryptographic algorithms and security mechanisms for secured networks	15
*** \ \ /	a subtain a damagada an Diagonta Langal number of a suta at having	

\*\*\* Weightage depends on Bloom's Level, number of contact hours,

CO Mapping with CDIO Curriculum Framework

CO		TCE			L	earni	ng Do	main	Level				CDIO	Curricu	lar	
#	Pro	ficien	icy [	Cog	nitive	A	fectiv	ve	Psyc	chomo	otor		Com	ponent	S	
	5	Scale	-	0					,				(X	(.Y.Z)		
CO1		<b>FPS3</b>		Apply		Va	alue		Mech	nanisr	n	1.2.2.1.1.2.1.2.2.4.2				
					. ,							2.4	6. 2.5.1	1. 3.1.1	3.2.3.	
												4.5	5.4.6.2	2	,,	
CO2	-	FPS3		A	oply	Va	alue		Mech	nanisr	n	12	211	2122	251	
002	'			, i	spiy				meer	amor		31	1 3 2 3	3 4 5 5	462	
CO3	- 1	TPS3		Unde	rstan	d Va	alue		Mech	nanisr	n	12	211	2122	251	
	'			onac	/ oturn				Meer	amor		31	1 3 2 3	2.1.2,2	462	
CO4	- 1			Δn	alveo		raanie		Com	nlov (	Wort					
004		11 04				Door	251		۷.۱.۷, ۱	2.1.3,						
COF	+ -			<b>A</b>					Cam		5 Ducent	2.0.	011	242	242	
005		1754		Ana	Analyse Organise Complex O		Jven	1.2,	∠. I. I, ₁	Z. I.Z, <i>i</i>	2.1.3,					
000	-								Resp	onse	S	2.3.1				
006		1953		Unde	erstan	d Va	alue		Mecr	anism [ 1.2, 2.1.1, 2.1.2, 2.5.1						
Mappi	ng w	ith Pr	ogra	amme	Outco	omes	and	Prog	ramm	e Spe	<b>Sitic</b>	Outc	omes	1		
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	S	М	L	-	L	-	-	L	L	L	-	L	M	-	L	
CO2	S	М	L	-	L	-	-	L	L	L	-	L	М	-	L	
CO3	S	М	L	-	L	-	-	L	L	L	-	L	М	-	L	
CO4	S	S	М	L	L	-	-	L	L	L	-	L	S	-	L	

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	РО 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO5	S	S	М	L	L	-	-	L	L	L	-	L	S	-	L
CO6	S	М	L	-	L	-	-	L	L	L	-	L	М	-	L

## S- Strong; M-Medium; L-Low

#### Assessment Pattern: Cognitive Domain

Cognitive Levels	Contin	uous Ass Tests	sessment		Assignme	End Semester Examination	
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	50	40	30	0	0	0	30
Apply	50	40	40	100	100	100	40
Analyse	0	20	30	0	0	0	30
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	AN	-	-
Guided Response		-	-
Mechanism		-	-
Complex Overt Responses		1	-
Adaptation	TAL SOME	PA-	-
Origination			-

### Sample Questions for Course Outcome Assessment\*

### Course Outcome 1 (CO1):

- 1. Outline the features of IEEE 802.3 protocol?
- 2. Justify why do you require a limit on the minimum size of Ethernet frame?
- 3. Write about the Bluetooth Technology and list out the applications and limitations.

### Course Outcome 2 (CO2):

- 1. Outline the need of DVMRP?
- 2. Outline shortest path algorithm. Explain with suitable diagrams and examples?
- 3. For the given network, find the global distance vector table when.



- i) Each node knows only the distances to its immediate neighbours.
- ii) Each node has reported information it had in the preceding step (i) to its immediate neighbours.
- iii) Step (ii) is repeated.

### Course Outcome 3 (CO3):

- 1. How is congestion controlled? Deduct various congestion control techniques.
- 2. Find the 4-bit CRC code for the data bit sequence 10011011100 using the polynomial x 4+x2+1.
- 3. Draw a timeline diagram for the sliding window algorithm with SWS = RWS = 3 frames, For the following two situations, use a timeout interval of about 2 X RTT (a) Frame 4 is lost and (b) Frames 4-6 are lost.

### Course Outcome 4 (CO4):

1. For 1 MB file over a 1Gbps network with RTT 100ms, find out the Transfer time and Throughput of the link.

- 2. Consider a point–to-point link 50km in length. At what bandwidth would the propagation delay equal transmit delay for 100byte packets? Calculate bandwidth for 512byte packet.
- 3. Suppose a 128 Kbps pt. to pt. link is set up between earth and rover on mars. The distance from earth to mars is approximately 55 Gm and data travels over the link at the speed of light.
  - Calculate minimum RTT for link
  - Calculate the delay bandwidth product for the link

### Course Outcome 5 (CO5):

- 1. Illustrate the various steps involved in the use of non-persistent connection of HTTP.
- 2. Assess the importance of Push and Pull Protocols.
- 3. Illustrate the sequence of events and the respective protocols involved while accessing a web page from a machine when it is connected with internet for first time.

#### Course Outcome 6 (CO6):

- 1. Design the key generation process of DES?
- 2. Estimate the encryption and decryption values for the RSA algorithm parameters. P=7, Q=11, E=17, M=8?
- 3. Evaluate the design goals of firewalls

#### Concept Map



### Syllabus

FUNDAMENTALS & LINK LAYER: Building a network - Requirements - Layering and protocols - Internet Architecture - Network software - Performance ; Link layer Services -Framing - Error Detection and AR, Flow control – Stop and wait and sliding window protocol. MEDIA ACCESS & INTER NETWORKING: Media access control - Ethernet - CSMA/CD-802.3 Physical Properties, Encoding - Wireless LANs – CSMA/CA-802.11, Spread Spectrum techniques and Distribution systems, WPAN - Bluetooth, Zigbee, Internetworking - IP, subnetting CIDR, ARP, DHCP,ICMP. ROUTING: Routing - RIP, OSPF, metrics - Switch basics – Global Internet - BGP, IPv6, Multicast – addresses – multicast routing -DVMRP, PIM. IPv6, Mobile IP. TRANSPORT LAYER: Overview of Transport layer - UDP -Reliable byte stream (TCP) - Connection management - Flow control - Retransmission -TCP Congestion control - Congestion avoidance - DECbit, RED NETWORK **PERFORMANCE**– Throughput, Bandwidth and Latency, High speed networks, Application performance needs. APPLICATION LAYER: Traditional applications-Electronic Mail -SMTP, POP3, IMAP, MIME - HTTP - Web Services - DNS - SNMP. NETWORK **SECURITY:** Cryptography – DES and RSA, Secured Communication – Security services, VPN. Firewall

#### Learning Resources

- 1. Larry L. Peterson, Bruce S. Davie, "Computer Networks: A Systems Approach", Fifth Edition, Morgan Kaufmann Publishers, 2011.
- 2. James F. Kurose, Keith W. Ross, "Computer Networking A Top-Down Approach Featuring the Internet", Fifth Edition, Pearson Education, 2009.
- 3. Nader. F. Mir, "Computer and Communication Networks", Prentice Hall Publishers, 2010.

- 4. Ying-Dar Lin, Ren-Hung Hwang, Fred Baker, "Computer Networks: An Open Source Approach", Mc Graw Hill Publisher, 2011.
- 5. Behrouz A. Forouzan, "Data communication and Networking", Fourth Edition, Tata McGraw Hill,2011.
- 6. Web Page http://www.cse.iitd.ernet.in/~vinay/courses/CSL858.html
- 7. Web Page mythili@cse.iitb.ac.in
- 8. https://onlinecourses.nptel.ac.in/noc18\_cs38/preview
- 9. https://nptel.ac.in/courses/106105183/

Cour	se contents and Lecture Schedule	-	•
No.	Торіс	No. of	COs
		Hours	
1	FUNDAMENTALS & LINK LAYER	-	-
1.1	Building a network – Requirements	1	CO1
1.2	Layering and protocols - Internet Architecture	1	CO1
1.3	Network software – Performance	2	CO1
1.4	Link layer Services - Framing	1	CO1
1.5	Error Detection	2	CO1
1.6	Flow control	2	CO1
1.7	Media access control - Ethernet (802.3)	2	CO2
1.8	Wireless LANs – 802.11	1	CO2
1.9	Bluetooth, Zigbee	1	CO2
2			
2.1	Switching and bridging components	1	CO2
2.2	Basic Internetworking-IP, subnetting	2	CO2
2.3	CIDR, ARP, DHCP,ICMP	2	CO2
2.4	Routing (RIP, OSPF, metrics)	2	CO3
2.5	Switch basics – Global Internet (Areas, BGP, IPv6)	2	CO3
2.6	Multicast – addresses – multicast routing (DVMRP, PIM)	2	CO3
2.7	IPv6, Mobile IP	2	CO3
3	TRANSPORT LAYER		
3.1	Overview of Transport layer - UDP	1	CO4
3.2	Reliable byte stream (TCP)	1	CO4
3.3	Connection management - Flow control, Retransmission	1	CO4
3.4	TCP Congestion control - Congestion avoidance (DECbit, RED)	2	CO4
4	NETWORK PERFORMANCE	1	1
4.1	Throughput, Bandwidth and Latency	2	CO5
4.2	High speed networks, Application performance needs	3	CO5
5.	APPLICATION LAYER		
5.1	Traditional applications-Electronic Mail(SMTP, POP3,IMAP, MIME)	2	CO6
5.2	HTTP,HTTPS – Web Services	1	CO6
5.3	DNS – SNMP	2	CO6
6	NETWORK SECURITY		
6.1	Cryptography – DES and RSA	2	CO6
6.2	Secured Communication – Security services, VPN	1	C06
6.3	Firewall	1	C06
	Total Hours	36	

- Course Designers: 1. Dr.T.Aruna
- taece@tce.edu dan manimsk@tce.edu
- Dr.M.S. K. Manikandan
   Dr. E. Murugavalli

Passed in BoS Meeting 11.05.2019

- manimsk@tce.edu murugavalli@tce.edu

18EC520	ANTENNAS AND WAVE PROPAGATION	Category	L	Т	Ρ	Credit
		PC	2	0	2	3

### Preamble

One of the main competencies that a present day RF engineer has to acquire is the capability to design antennas for wireless applications such as cellular and navigational applications. Antennas are important component in making wireless communication a reality. This course is essential to review EM theory and understand the fundamental principles of Antenna theory, and wave propagation with a lucid explanation of the basic concepts and equations. This course explains how antenna converts the electric and magnetic energy in to a propagating wave and vice versa. This course also explains the various types of transmitting and receiving antennas including arrays which are used for conventional broadcasting and antennas such as helix, spiral antennas used for wireless applications. The course also focus on simple design procedures and practical approach to simulate, prototype for a given wireless specification and measure the parameters of antenna for popular applications.

#### Prerequisite

18EC320: RF Passive Devices and Circuits, 18EC420: RF Active Circuits

## Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage***
		in %
CO1	Understand the role of antenna in real world applications and study	15
	the antenna parameters.	
CO2	Understand the concepts of wire, loop, aperture antennas and arrays	20
	and the radiation pattern of various antenna.	
CO3	Design, develop and validate Microstrip antenna for cellular base	15
	station applications	
CO4	Design, develop and validate PIFA for cellular handset applications	15
CO5	To understand the role of polarization in navigation and design,	15
	develop and validate circularly polarized antenna for GPS applications	
CO6	Explain the role of atmospheric layers in radio wave propagation	10
CO7	Apply Friss equation in link budget analysis	10

\*\*\* Weightage depends on Bloom's Level, number of contact hours

## **CO Mapping with CDIO Curriculum Framework**

CO	TCE	Lea	arning Domai	n Level	CDIO Curricular						
#	Proficiency	Cognitive	Affective	Psychomotor	Components						
	Scale	0		, , , , , , , , , , , , , , , , , , ,	(X.Y.Z)						
CO1	TPS2	Understand	Respond	Guided	1.2, 2.1.1						
			-	Response							
CO2	TPS2	Understand	Respond	Guided	1.2, 2.1.1,						
			-	Response							
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.5, 3.1,						
					4.4.1, 4.5.1-4.5.4						
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.5, 3.1,						
					4.4.1, 4.5.1-4.5.4						
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.2, 3.1,						
					4.5.1-4.5.4						
CO6	TPS2	Understand	Respond	Guided	1.2, 2.1.1,						
				Response							
CO7	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.5, 2.4.2,						
					3.1., 4.4.1, 4.5.1-4.5.4						

Map	ping	with Prog	gramme	Outcomes and	Programme	Specific (	Dutcomes
-----	------	-----------	--------	--------------	-----------	------------	----------

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	L	L	-	-	-	-	-	Μ	-	-	М	S	-	М
CO2	S	Μ	L	-	-	-	-	-	M	-	-	M	S	-	М
C03	S	Μ	Μ	L	S	Μ	M	L	M	Μ	М	M	S	М	М
CO4	S	Μ	Μ	L	S	Μ	M	L	M	Μ	М	M	S	Μ	М
CO5	S	Μ	Μ	L	S	L	L	L	M	Μ	М	M	S	Μ	М
CO6	S	L	L	-	-	L	L	L	M	-	-	M	S	М	М
C07	S	L	Μ	-	L	L	L	L	М	М	М	М	S	L	М

#### S- Strong; M-Medium; L-Low

#### Assessment Pattern: Cognitive Domain

Cognitive	Contir	nuous Assessr	End Semester	
Levels	1	2	3	Examination
Remember	40	20	20	10
Understand	40	40	20	30
Apply	20	40	60	60
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

#### Assessment Pattern: Psychomotor

Psychomotor Skill		Practical
Perception	ALL COMPANY	-
Set	HI	-
Guided Response	have a start of the	-
Mechanism	South the	80
Complex Overt Responses		20
Adaptation		-
Origination		-

### **Course Level Assessment Questions:**

#### Course Outcome (CO1)

- 1. Define beam width
- 2. What Is Meant By Effective Height?
- 3. Why high-gain antennas are normally used for EME (moon bounce) communications?

### Course Outcome (CO2)

- 1. Why loop antennas are called as magnetic dipole?
- 2. List The Applications Of Helical Antenna?
- 3. What Is The Condition On Phase For The End Fire Array With Increased Directivity?

#### Course Outcome (CO3)

- 1. What kind of "radiation" is used by mobile phones and base stations?
- 2. Suggest and design suitable planar antenna system for the given specification:
  - Center Frequency 800MHz
  - Dielectric constant 3.38
  - Thickness 1.52mm
  - VSWR 2:1
- 3. Is it safe to be close to base station antennas?

#### Course Outcome (CO4)

- 1. What are the constraints in designing antenna for mobile handset?
- 2. What are the exposure levels from mobile phones?
- 3. Design a planar inverted F antenna operating in Cellular GSM lower band.

### Course Outcome (CO5):

- 1. What is the need for circular polarization in GPS navigation?
- 2. What is the reason for sending two transmissions in the same band?
- 3. Design a circularly polarized antenna to operate at 1.575GHz.

#### Course Outcome (CO6):

- 1. What are the atmospheric factors that affect the propagation of radio waves?
- 2. How does the earth affect ground wave and space wave propagation?
- 3. How are VHF signals propagated within the range of the visible horizon?

#### Course Outcome (CO7):

- 1. The output power of a 900MHz mobile phone base station transmitter is 100w. It is connected to an antenna having a gain of 15.Calculate the power delivered to the receiver kept at a distance of 25km. Gain of the receiver antenna is 20.
- 2. In a microwave link, two identical antennas operating at 10GHz are used with power gain of 40db, If the transmitted power is 1KW, find the received power for the range of link of 30km.
- 3. Consider a mobile radio system at 900-MHz carrier frequency, and with 25-kHz bandwidth. It is affected only by thermal noise (temperature of the environment E = 300F). Antenna gains at the TX and RX sides are 8 dB and -2 dB, respectively. Losses in cables, combiners, etc. at the TX are 2 dB. The noise figure of the RX is 7 dB. The 3-dB bandwidth of the signal is 25 kHz. The required operating SNR is 18 dB and the desired range of coverage is 2 km. The breakpoint is at 10-m distance; beyond that point, the path loss exponent is 3.8. The fading margin is 10 dB. What is the minimum TX Power?

#### **Concept Map:**



#### Syllabus:

#### Theory:

**Fundamentals of Antennas**: Review of the fundamentals of Electromagnetics and RF system, Antenna definition, Antenna in real world applications: Cellular phone, Case study (Base station and handset) principle of radiation, Radiation from current element, Thin wire antenna, dipole, Parameters- Return loss, Radiation pattern, Beamwidth, side lobes, Power Density, intensity, beam width, Directivity, Efficiency, Gain, bandwidth, polarization-Effective aperture, field regions, Types of antennas

**Thin Wire , Loop and aperture antennas**: Infinitesimal dipole-small dipole, finite length dipole, Half wavelength dipole, working principles of Wire antennas: Folded dipole, loop antenna, Arrays: Two element array- Broadside and Endfire, N element array, Pattern multiplication, planar arrays, Yagi -Uda and Log periodic array Aperture antennas: Horn and parabolic reflectors.

**Antennas for Cellular applications:** Specifications, design of Microstrip patch antenna (MPA), Cellular base station- design, feeding techniques, patch array.. Cellular handset: Planar Inverted F antenna (PIFA), design and reception of signals using Spectrum analyser

**Antennas for Navigational applications:** GPS Spec, Role of circular polarization in navigation, Principle of circular polarization, circularly polarized antennas, working principle of spiral, helix, design techniques for circular polarization MPA, tunning.

**Wave propagation**: Fundamentals of EM wave propagation, wave propagation in different environment (Ground wave, sky wave and tropospheric wave propagation, (indoor, and urban), parameters, Friss equation, Link budget analysis, Cellular link calculations.

### Practical:

- 1. Design and characterization of wire antennas: monopole, dipole and FM reception
- 2. Radiation pattern measurement of Yagi-Uda Antenna and TV signal reception
- 3. Design and simulation Patch antenna for cellular Base station
- 4. Prototype and testing of antenna for cellular station application
- 5. Development of PIFA for cellular application
- 6. Simulation and prototyping of antenna for cellular handset
- 7. Design and simulation antenna for GPS application
- 8. Range measurement of PIFA using Link Budget measurement
- 9. Internal assessment test-EMF survey in college campus

### Learning Resources:

- 1. C. A. Balanis, "Antenna Theory and Design", 3rd Ed., John Wiley & Sons., 2005.
- 2 John D.Kraus, "Antennas for all Applications", Tata McGraw Hill ,2002
- 3 W. L. Stutzman, and G. A. Thiele, "Antenna Theory and Design", 2nd Ed., John Wiley & Sons., 1998.
- 4 C. A. Balanis, "Antenna Theory and Design", 4<sup>th</sup> Ed., John Wiley & Sons., 2016.
- 5 F.E.Terman, "Electronic and Radio Engineering", Mc Graw Hill, 1985.
- 6 A.R. Harish and M.Sachidananda, "Antenna and wave propagation", Oxford University Press., 2007
- 7 NPTEL Course Antenna and wave propagation: https://nptel.ac.in/courses/ 108101092/
- 8 WWW.amanogawa.con
- 9 www, orbanmicrowave.com
- 10 Course handouts prepared by RF Special interest Group, TCE

### **Course Contents and Lecture Schedule**

Module No	Topics	No. of Lectures	COs
1.	<b>Fundamentals of Antennas:</b> Introduction to PO, CO of the course, overview of the course Review of the fundamentals of Electromagnetics and RF system, ,	1	CO1
2.	Antenna definition, Antenna in real world applications: Cellular phone, Case study (Base station and handset), principle of radiation, Radiation from current element, Thin wire antenna, dipole	1	CO1
3.	,Parameters- Return loss, Radiation pattern, Beamwidth, side lobes,	1	CO1
4.	Power Density, intensity, beam width, Directivity, Efficiency, Gain, bandwidth,	1	CO1
5.	polarization-Effective aperture, field regions, Types of antennas Assignment 1	1	CO1
6.	Thin Wire, Loop and aperture antennas: Infinitesimal dipole-small dipole, finite length dipole, Half wavelength dipole,	2	CO2
7.	working principles of Wire antennas: Folded dipole, loop antenna	1	CO2
8.	Arrays: Two element array- Broadside and Endfire, N element array, Pattern multiplication, planar arrays	1	CO2
9.	Yagi -Uda and Log periodic array Aperture antennas: Horn and parabolic reflectors.	1	CO2
10.	<b>Antennas for Cellular applications:</b> Specifications, design of Microstrip patch antenna (MPA), Cellular base station-design, feeding techniques, patch array.	2	CO3
11.	Cellular handset: Planar Inverted F antenna (PIFA), design and reception of signals using Spectrum analyser	2	CO3
12.	<b>Antennas for Navigational applications:</b> GPS Spec, Role of circular polarization in navigation, Principle of circular polarization, antennas types	2	CO4
13.	Working principle of spiral, helix, design techniques for circular polarization MPA, tunning.	2	CO4
	Assignment 2		
14.	<b>Wave propagation</b> : Fundamentals of EM wave propagation, wave propagation in different environment (Ground wave, ,	2	CO6
15.	sky wave and tropospheric wave propagation, (indoor, and urban), parameters	2	CO6
16.	Friss equation, Link budget analysis, Cellular link calculations.	2	CO6
	Assignment 3	24	
	<u> </u>	24	

Course Designers:

- Dr.V.Abhaikumar
- 1. 2. Dr.B.Manimegalai

vak@tce.edu

- naveenmegaa@tce.edu

18EC530	ANALOG AND DIGITAL	Category	L	Т	P	Credit
	COMMUNICATION SYSTEMS	PC	2	1	0	3

#### Preamble

The course "18EC520: Analog and Digital Communication Systems" is offered in the fifth semester and is the first course on communication systems. This course aims at designing Analog and Digital communication systems that are used for the transmission of information from source to destination. A detailed quantitative framework for analog and digital transmission techniques is addressed.

#### Prerequisite

14EC340 Signals and Systems, 14EC440 Signal Processing

### **Course Outcomes**

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Characterize the different analog modulation schemes in time	10
	and frequency domains.	
CO2	Analyze the performance of analog modulation schemes in the presence of additive white Gaussian noise.	10
CO3	Describe the principle of pulse modulation techniques namely PAM, PPM PCM, DPCM and DM	10
CO4	Determine the minimum number of bits per symbol required to represent the source and the maximum rate at which reliable communication can take place over the channel	20
CO5	Detect and correct the errors introduced in the channel using error control coding schemes.	15
CO6	Design the baseband pulse for ISI free transmission over finite bandwidth channels	10
CO7	Apply estimation and detection theory for the development of digital communication transmitters and receivers for various digital modulation schemes and analyze their BER performances	25

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	arning Doma	in Level	CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale				
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.2, 2.4.5,
					2.4.6, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS4	Analyze	Organise	Complex	1.2, 2.1.1, 2.1.2, 2.4.2, 2.4.5,
				Overt	3.1.1, 3.2.3, 4.5.3, 4.5.5, 4.6.2
				Responses	
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.2, 2.4.5,
					2.5.1, 3.2.3
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.4, 2.4.2,
					2.4.5, 4.4.1,4.4.3
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.4, 2.4.2,
					2.4.5, 4.4.1, 4.4.3
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.14, 2.1.5,
					2.4.2, 2.4.5, 4.4.3
C07	TPS4	Analyze	Organise	Complex	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5,
			_	Overt	2.4.2, 2.4.5, 2.5.1, 3.2.5, 4.4.3,
				Responses	4.5.3, 4.5.5, 4.6.2

## Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1.	S	М	L	-	-	-	-	-	L	L	-	L	S	L	L
CO2.	S	S	Μ	L	-	-	-	-	L	L	-	L	S	L	L
CO3.	M	L	-	-	-	-	-	-	L	L	-	L	S	Μ	L
CO4	S	Μ	L	-	-	-	-	-	L	L	-	L	S	L	L
CO5	S	Μ	L	-	-	-	-	-	L	L	-	L	S	Μ	L
CO6	S	М	L	-	-	-	-	-	L	L	-	L	S	Μ	L
C07	S	S	Μ	L	-	-	-	-	L	L	-	L	S	М	L

S- Strong; M-Medium; L-Low

### **Assessment Pattern: Cognitive Domain**

Cognitive Levels	Contir	nuous Ass Tests	sessment		Assignme	nt	End Semester Examination
	1	2	3	1	2	3	
Remember	10	10	10	0	0	0	10
Understand	10	10	20	0	0	0	10
Apply	80	60	60	100	70	50	60
Analyse	0	20	20	0	0	20	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	L'H-	27 -	-
Set	400-	-	-
Guided Response	ANGU L	-	-
Mechanism	-	30	30
Complex Overt Responses	· / · · · ·	-	-
Adaptation	Constant and	· ·	-
Origination	-	-	-
	<b>A</b> 1		

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. Using the message signal  $m(t) = 1/(1+t^2)$ , determine the modulated waves for the following methods of modulation,
  - a. Amplitude modulation with 50 percent modulation
  - b. Double sideband suppressed carrier modulation
  - c. Single side band modulation with only the upper side band transmitted.
  - d. Single side band modulation with only the lower side band transmitted.
- 2. The single tone modulating signal,  $m(t) = A_m \cdot \cos(2\pi f_m t)$  is used to generate the VSB
  - a. signal

 $s(t) = (1/2).a.A_m.A_c.\cos[2\pi(f_c + f_m)t] + (1/2).A_m.A_c(1-a).\cos[2\pi(f_c - f_m)t]$ 

- b. where, 'a' is a constant, less than unity, representing the attenuation of the upper side frequency.
- c. Find the Quadrature component of the VSB signal s(t).
- d. The VSB signal, plus the carrier  $A_c \cdot \cos(2\pi f_c t)$ , is passed through an envelope detector. Determine the distortion produced by the Quadrature component.
- e. What is the value of constant, 'a' for which this distortion reaches its worst possible condition?.

3. An angle modulated signal with carrier frequency,  $\omega_c = 2\pi * 10^5$  is described by  $\phi_{EM}(t) = 10.\cos(\omega_c t + 5.\sin 3000t + 10.\sin 2000\pi t)$ . Find the power of the modulated signal, frequency deviation,  $\Delta f$ , deviation ratio,  $\beta$  and phase distortion,  $\Delta \phi$ 

## Course Outcome 2 (CO2):

- 1. Why is De-Emphasis used in FM?
- 2. A DSB SC modulated signal is transmitted over a noisy channel, with the power spectral density of the noise being as shown in the figure. The message bandwidth is 4 kHz and the carrier frequency is 200 kHz. Assuming that the average power of the modulated wave is 10 watts, determine the output signal to noise ratio of the receiver.



3. Determine the improvement in post detection signal to noise ration in FM receiver with pre –emphasis and de-emphasis circuits in dB.

### Course Outcome 3 (CO3):

- 1. The speech signal is transmitted over a PCM channel with 8-bit accuracy. Assume the speech is base band limited to 3.6 KHz. Determine the bit rate.
- 2. A sinusoidal signal  $x(t) = a_o \cos(2\pi f_o t)$  is applied to a delta modulator that operates with a sampling period, T<sub>s</sub> and step size,  $\Delta = 2\delta$ .
  - (a) Find the expression for amplitude,  $a_0$  to avoid slope overload distortion.
  - (b) Compute the maximum permissible value of the output signal power.
  - (c) Compute the variation of Quantization noise in delta modulation.
  - (d) Find the maximum value of output signal to noise ratio.
- 3. A PCM System uses a uniform quantizer followed by a 8 bit binary encoder. The bit rate of the system is 64 Mbps. What is the maximum message bandwidth for which the system operates satisfactorily?

### Course Outcome 4 (CO4):

- 1. Consider a discrete memoryless source with source alphabet ,  $S = \{s_o, s_1, s_2\}$  and source statistics {0.7,0.15,0.15}. Calculate the entropy of the source. Calculate the entropy of the second order extension of the source.
- 2. Define average mutual information and average self information.
- 3. Why the theory of information is relevant for understanding the principles of digital communication systems?

## Course Outcome 5 (CO5):

- 1. The parity check bits of a (7,3) linear block code are generated by  $c_4 = d_1 + d_2, c_5 = d_2 + d_3, c_6 = d_1 + d_2 + d_3, c_7 = d_1 + d_3$ , where d<sub>1</sub>, d<sub>2</sub>, and d<sub>3</sub> are the message digits.
  - a. Find the Generator Matrix and Parity Check Matrix for this code
  - b. Find the minimum weight of this code.
- 2. Find the error correcting capabilities of this code.A systematic (6,3) linear block code has  $\begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 \end{bmatrix}$

the generator matrix  $\begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$ . Construct the Standard array and determine the

correctable error patterns and their corresponding syndromes.

3. The (3,1) convolutional encoder is shown in figure.1. Assume that four information bits  $\begin{pmatrix} x_1 & x_2 & x_3 & x_4 \end{pmatrix}$ , followed by two zero bits, have been encoded and sent via a binary symmetric channel. The received sequence is (111 111 111 111 111 111). Find the most likely data sequence using Viterbi decoding algorithm.



Figure 1

### Course Outcome 6 (CO6):

1. What is the advantage of using partial response signals? For the duobinary pulse

$$x(nT) = \begin{cases} 1, & \text{for } n = 0, 1 \\ 0 & \text{otherwise} \end{cases}$$
, write the equation for the overall signal (transmitter

followed by channel and receiver) and its spectrum.

- 1. Prove the Nyquist condition for zero ISI in digital communication system. Discuss the effect of choosing symbol rate (1/T) greater than, equal to and less than twice the bandwidth (2W).
- **2.** The binary data stream [00 10 11 0] is applied to duo-binary system. Construct the duo-binary coder output and corresponding receiver output. Assume that there is Pre-Coder at the input.

### Course Outcome 7 (CO7):

- 1. Consider a random variable  $\chi \in \{x_1 = -1, x_2 = +1\}$ . Given an observation of the random variable y = x + n; where *n* is a zero mean Gaussian random variable with variance,  $\sigma^2$  independent of *x*. The decision regions of the ML detector at the receiver subsystem is given as  $y = \left(\frac{x_1 + x_2}{2}\right) + \frac{\sigma^2}{x_1 x_2} \cdot \ln \left| \frac{p(x_2 = +1)}{p(x_1 = -1)} \right|$ . Now suppose  $\sigma^2 = 0.5$  and y = -0.1, find the decision for the following cases with apriori probabilities, (i)  $p(x_1) = p(x_2) = 0.5$  (ii)  $p(x_1) = 0.2$  &  $p(x_2) = 0.8$ .
- Using Gram Schmidt Orthogonalization procedure, find the set of orthonormal basis for FSK modulation scheme.
- 3. Compare the BER performance of BPSK, BASK and BFSK modulation scheme.





### Syllabus

**Analog Communication Systems:** Amplitude Modulation, Double Side Band Suppressed Carrier Modulation, Single side band Modulation, Vestigial Side band Modulation, Super heterodyne Receiver, Frequency Division Multiplexing, Angle Modulation Systems: Narrow band and wideband FM, Generation and demodulation of FM waves, Phase Modulation systems, Noise Analysis.

**Analog to Digital Transition Systems:** Pulse Amplitude Modulation, Pulse Position Modulation, Pulse Code Modulation, DPCM, Delta Modulation, Time Division Multiplexing

**Information Theory:** Uncertainty, Information and entropy, source coding theorem, Discrete Memoryless channels, Mutual Information, Channel capacity, Channel coding theorem, Differential entropy, Mutual Information and channel capacity theorem

**Error control coding:** Linear block codes, cyclic codes, convolutional codes, Trellis coded Modulation

**Baseband Pulse transmission:** Inter Symbol Interference problem, Nyquist criterion, Raised cosine pulse, partial response signals

**Passband Transmission:** Gram-Schmidt Orthogonalization Procedure, Detection of known signals in noise, Correlation receiver, Matched Filter receiver, Binary Amplitude Shift Keying, Binary Phase Shift Keying, Binary Frequency Shift Keying, QAM, BER Analysis

**Spread Spectrum Modulation:** Pseudo noise sequences, Discrete sequence spread spectrum with coherent BPSK, Signal space dimensionality and processing gain, Frequency hop spread spectrum modulation

### Learning Resources

- 1. Simon Haykin and Michael Moher, "Communication systems" John Wiley & Sons, Fifth Edition, 2016
- 2. Simon Haykin and Michael Moher, "An Introduction to Analog and Digital Communications", John Wiley & Sons, second Edition, 2006.
- 3. Leon W. Couch II, "Digital and Analog Communication Systems", Prentice Hall, 1997
- 4. Sam Shanmugam, "Digital and Analog Communication Systems", 2<sup>nd</sup> ed, John Wiley, 1992.
- 5. B. Carlson, "Introduction to Communication systems", 3<sup>rd</sup> Edition, McGraw Hill, 1989
- 6. NPTEL Course Digital Communication: https://nptel.ac.in/courses/117101051/

#### **Course Contents and Lecture Schedule**

Module	Торіс	No. of
No.		Lectures
1	Analog Communication Systems	
1.1	Amplitude Modulation	1
1.2	Double Side band Suppressed Carrier Modulation	1
1.3	Single side band Modulation	1
1.4	Vestigial Side band Modulation	1
1.5	Super heterodyne Receiver	1
1.6	Frequency Division Multiplexing	1
	Angle Modulation Systems:	
1.7	Narrow band and Wideband Frequency Modulation	1
1.8	Generation and Demodulation of FM waves	1
1.9	Phase Modulation systems	1
1.10	Noise analysis	2
2	Analog to Digital Transition Systems	
2.1	Pulse Amplitude Modulation and Pulse Position Modulation	1
2.2	Pulse Code Modulation	1
2.3	Digital Pulse Code Modulation	1
2.4	Delta Modulation	1

2.5	Time Division Multiplexing	1
3	Information Theory	
3.1	Uncertainty, Information and entropy	1
3.2	source coding theorem	1
3.3	Discrete Memoryless channels	1
3.4	Mutual Information, Channel capacity	1
3.5	Channel coding theorem	1
3.6	Differential entropy, Mutual Information and Channel capacity	2
	theorem	
4	Error Control Coding	
4.1	Linear block codes	1
4.2	cyclic codes	1
4.3	convolutional codes	2
4.4	Trellis coded Modulation	1
5	Baseband Pulse transmission	
5.1	Inter Symbol Interference problem, Nyquist criterion	2
5.2	Raised cosine pulse, partial response signals	1
6	Passband Transmission	
6.1	Gram-Schmidt Orthogonalization Procedure	1
6.2	Detection of known signals in noise	1
6.3	Correlation receiver, Matched Filter receiver	1
6.4	Binary Amplitude Shift Keying	1
6.5	Binary Phase Shift Keying	1
6.6	Binary Frequency Shift Keying	1
6.7	QAM	1
6.8	BER Analysis	1
7	Spread Spectrum Modulation	
7.1	Pseudo noise sequences	1
7.2	Discrete sequence spread spectrum with coherent BPSK	1
7.3	Signal space dimensionality and processing gain	1
7.4	Frequency hop spread spectrum modulation	1
	Total	41
Course Designers:		

- 1. Dr.S.J.Thiruvengadam
- sjtece@tce.edu
- 2. Dr.M.N.Suresh
- 3. Dr.K.Rajeswari
- mnsece@tce.edu rajeswari@tce.edu
- 4. Dr.V.N.SenthilKumaran
- vnsenthilkumaran@tce.edu
| 18EC560 | DIGITAL IMAGE PROCESSING | Category | L | Т | Р | Credit |
|---------|--------------------------|----------|---|---|---|--------|
|         |                          | PC       | 2 | 0 | 2 | 3      |

## Preamble

The purpose of this course is to provide the basic concepts and methodologies for Digital Image Processing in three different levels. At the lower-level, the course introduces the terminology of image processing, image acquisition, digitization, formation, storage and the relationship between pixels. Further, it provides the image enhancement by improving the contrast and noise removal in spatial domain and applications of transformations for enhancement and coding. In the middle-level, it addresses region based segmentation, representation and description processes to extract meaningful information with geometrical operations. Morphological processing is introduced to clean up and cluster such regions for real world image processing applications.

## Prerequisite

14EC340 Signals and Systems, 14EC440 Signal Processing

## Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome Statement	Weightage
	m the	in %
CO	Demonstrate the digital image acquisition, digitization, formation,	15
1	storage and the relationship between pixels.	
CO	Enhance the visual perception of the digital imagery from	15
2	contrast/brightness degradation and by removing noise in spatial	
	domain.	
CO	Apply image transformations such as Fourier and DCT for image	20
3	enhancement and coding.	
CO	Extract regions of interest from an image using region based	15
4	segmentation by region splitting, merging and watershed segmentation	
CO	Represent the segmented boundary by chain code and shape numbers	15
5	and describe it using shape number, Fourier and Euler number with	
	structural and geometric operations.	
CO	Apply image processing algorithms to solve real-world image	20
6	processing problems such as number plate detection, Counting cars	
	based on color, Cyst detection in MRI/CT, Non-destructive testing with	
	IR, thermal images and Change detection.	

CO Mapping with CDIO Curriculum Framework

CO	TCE	Lear	ning Doma	in Level	CDIO Curricular					
#	Profi. Scale	Cognitive	Affectiv	Psychomoto	Components					
			е	r	(X.Y.Z)					
CO1	TPS2	Understan	Respond	Guided	1.2, 2.4.6, 2.5.1, 4.1.1, 4.1.2					
		d		Response						
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.2.3, 3.1, 3.2.3, 3.3.1,					
					4.1.1, 4.1.2, 4.3.2, 4.5.3					
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.2.3, 3.1, 3.2.3, 3.3.1,					
					4.1.1, 4.1.2, 4.3.2, 4.5.3					
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.2.3, 3.1, 3.2.3, 3.3.1,					
					4.3.2, 4.5.3					
CO5	TPS2	Apply	Value	Mechanism	1.2, 2.2.3, 3.1, 3.2.3, 3.3.1,					
					4.3.2, 4.5.3					
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.3, 2.1.5, 2.2.3, 2.3.1,					
					2.4.6, 2.5.1, 3.1, 3.3.1, 4.1.1,					
					4.1.2, 4.3.2, 4.5.3					

Mapp	Mapping with Programme Outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	M	L	-	-	M	-	-	L	L	L	-	-	L	-	L
CO2	S	S	М	L	Μ	М	-	L	Μ	М	-	L	L M S L		
CO3	S	S	Μ	L	Μ	L	L	L	M	Μ	-	L	M	S	L
CO4	S	S	Μ	L	Μ	L	-	L	M	Μ	-	L	M	М	L
CO5	S	S	Μ	L	Μ	Μ	L	L	M	Μ	-	L	M	S	L
CO6	S	S	Μ	L	S	Μ	Μ	L	Μ	М	-	L	S	S	М
S- Str	ong; I	M-Me	dium;	L-Lo	W										
Asse	Assessment Pattern: Cognitive Domain														
	Cog	nitive	)		Co	ntinuo	ous A	ssess	ment	Tests	6		End S	Semest	er
	Le	vels			1			2		3		Examination			
	Rem	embe	r		10			10		10		10			
	Understand				10			10		10		10			
	Apply			80		80 80					80				
	Ana	alyse			0 0 0					0					
	Eva	luate			0			0		0				0	
	Cr	eate			0		100	0		0				0	
Asse	ssme	nt Pa	ttern	: Psy	chom	otor									
Psyc	home	otor S	Skill				150	HER (	1				Praction	cal	
Perc	eptior	n -													
Set			AL GARDAN					Δ.			-				
Guid	led Re	espon	se			C	20		A.	97	-				
Mec	hanisi	m				E.		20		1	80				
Com	plex (	Overt	Resp	onses	;		No.	Burg	2				20		
Adap	otatior	า					-	_					-		
Oria	natio	n					1			-					

## Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

- 1. Distinguish CT and MRI imaging techniques and List the Pros and Cons.
- 2. Consider the image segment shown.
  - Let  $v = \{0,1\}$ , and obtain the shortest 8 and m-path between p and q. If a particular path does not exist between these two points state the reason. Repeat the same for  $v \{1,2\}$ .
    - 3210(q)
    - 2120
    - 1111
  - (p) 1012
- 3. Illustrate two dimensional sampling (down sample to 2X2) and 4 bit (16 gray levels) quantization for the following 8 bit sub image and state the reasons for the effects due to these processes?

255	255	255	255	255	255	255	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	255	255	255	255	255	255	255

## Course Outcome 2 (CO2):

1. Justify whether the image is poor in contrast. Identify the category of contrast. Is there any possibility to apply histogram equalization for the enhancement? If Yes, Justify and apply Histogram equalization for the following 6 bit image segment of size 6X6? Write the inference on image segment before and after equalization.

35	55	60	55	40	60
55	35	35	60	60	52
60	48	45	55	38	48
51	40	60	45	40	40
49	40	60	35	35	55
62	48	55	62	45	35

- 2. Demonstrate the following gray-level transformations for image enhancement via i) Gamma correction
  - ii) Gray level slicing
  - iii) Contrast Stretching
- 3. Suggest a suitable filter to remove noise but still preserve edges. Give the transfer function of it.

## Course Outcome 3 (CO3):

- 1. Illustrate the procedure step by step for JPEG image compression and write the significance of DCT.
- 2. Apply Discrete Fourier Transform for the following image data?
- [220 100; 120 250] [2x2] matrix. Write the significance of log function while visualizing the Fourier spectrum. Also, illustrate how Fourier transform properties are helpful in different digital image processing applications. Obtain it's inverse also.
- 3. Apply Discrete Cosine Transform for the following image data. [100 200; 150 200] [2x2] matrix. Also, illustrate how DCT is used for JPEG image Compression?

## Course Outcome 4 (CO4):

- 1. The region-growing algorithm starts with a seed pixel. Suggest a way or gray-level range to choose the seed pixel for the following two applications.
  - a. Segmenting the fractured portion of a leg in a X-Ray image
  - b. Segmenting defective welds for an image captured in industry
- 2. Illustrate whether or not closed boundaries always result from application of watershed segmentation algorithm.
- 3. Demonstrate region split and merge algorithm and apply morphological algorithms to segment the satellite image into different regions.

## Course Outcome 5 (CO5):

- 1. Write the Euler number if the shape contains 4 edges, 3 faces and 5 vertices.
- 2. Obtain the shape number for the following fig. List the limitations towards boundary representation based on chain codes.



3. Sketch the signature plots for the following geometrical figures: Rectangle, Ellipse and 5- point star. How will it be Scale normalized? **Course Outcome 6 (CO6)**:

- 1. Develop an algorithm to localize the license plate using suitable preprocessing, edge detection and morphological processing for intelligent traffic surveillance system to capture the vehicles which are not following the traffic rules.
- 2. Suggest an algorithm to find the change between two satellite images (taken in 2004 and 2014). The image captured the Madurai area. How will you find vaigai river has been encroached and how much encroached from the change detection algorithm.
- 3. The region-growing algorithm starts with a seed pixel. Suggest a way or gray level range to choose the seed pixel for the following application. Segment the brain tumour of a MRI image (cyst is indicated by an arrow). Assume the intensity values of the cyst are 220 for the first image and 90 for the second image.



## Syllabus

Theory:

**Image acquisition and Fundamentals:** Introduction to Image processing, it's need and applications – Elements of Human Visual Perception-Image acquisition- Sensors-CCD, CMOS, Imaging modalities- X-Ray, CT, MRI, Ultrasound, SAR, IR, Thermal- Imaging Components of an Image processing system. Digital Image model, Image formats, Image Sampling and Quantization –Basic relationship between pixels- Connectivity- 4, 8 and m connectivity and Distance measures- Euclidean, city-block, chessboard, Color model-RGB,CMY,HSI, Color space conversion-RGB to HSV and YCbCr. Image Enhancement: Point transformations- Gray level Transformations –Image Negative, Contrast stretching, Log transformation- Gamma correction-Histogram processing Spatial Filtering- Noise removal-Noise models – Salt and Pepper, Smoothing-Periodic – mean-median filters-Order statistics filter- Dithering: Gray level thresholding- Binary image- Sharpening-Edges- Point,

line detection, Laplacian filter, unsharp masking, high-boost filter, and Sobel and Roberts operators. **Spectral representation for enhancement and coding:** Fourier- Discrete cosine Transform – Spectrum-Frequency domain filtering –Periodic noise removal-JPEG compression. **Segmentation:** Region based segmentation – Region growing– Region splitting and merging, Watershed segmentation- Gray-scale Morphological operations: Erosion, Dilation, Opening, closing-Geometric operations: Shrinking, Zooming and Rotation by Interpolations. **Representation and Description:** Boundary representation-Chain codes–Signatures-Boundary descriptors–Shape numbers-Fourier descriptors-Regional Descriptors-Topological descriptors-Euler number. **Real world Applications:** Number plate detection, Detecting cyst/tumour in MRI images, Non-destructive testing with Thermal images, Change detection between two satellite images

## Practical:

- 1. Functional Programming: Program that generates a test pattern image
- 2. HVS and color space: (RGB to HSV, YCbCr color space)
- 3. Image enhancement: Point transformations: Image negative, log-transformation, contrast-stretching, histogram equalization
- 4. Image enhancement Spatial filtering: Apply an averaging filter of an increasing size of mask and comment (Salt and pepper noise)
- 5. Image enhancement Spatial filtering Edges- Laplacian filter, unsharp masking, high-boost filter, and Sobel and Roberts operators
- 6. Dithering: Threshold a gray scale image to get binary, Add noise to the original image and threshold, Compare and comment.
- 7. Spectral representation for enhancement and coding DFT, DCT of simple images containing an edge or a box.
- 8. Image enhancement: Filtering in the frequency domain: Perform LP of different size (spatial). Add periodic noise and remove using frequency filtering methods
- 9. Segmentation: Region growing, region splitting and merging, and watershed segmentation
- 10. Morphological operations: Erosion, Dilation, Opening, closing Selection of the structuring element, Increase the size of structuring element – Locating an object - comment
- 11. Geometric operations: Shrinking, Zooming and Rotation by Interpolations Comment on the quality of a thumbnail-size using different interpolation methods

## 12. Mini project:

- 1. Image fusion of vari-focused images
- 2. Creation of HDR images (Differently exposed images)
- 3. Experimenting Visual disabilities
- 4. Counting car colors
- 5. Color balancing Automatic way
- 6. Vehicle license plate detection.
- 7. Detecting cyst/tumour in MRI/CT /Ultra sound images.
- 8. Testing Non-destruction testing in IR/Thermal images.
- 9. Change detection between two remotely sensed satellite images taken in different periods.
- 10. Missing component detection in an automated industrial inspection application.

## Learning Resources

- 1. Oge Marques, "Practical Image and Video Processing using MATLAB", Wiley-IEEE Press, 2011, ISBN: 978-0-470-04815-3.
- Rafael.C.Gonzalez, Richard.E. Woods and Steven L. Eddins, "Digital Image Processing using Matlab", 2<sup>nd</sup> Edition, Gatesmark Publishing, 2009, ISBN 9780982085400.
- 3. Al.Bovik, "The Essential Guide to Image Processing", Academic Press, 2009.
- 4. Anil K.Jain, "Fundamentals of Digital Image Processing", Pearson Education 2003.

- 5. William K. Pratt, "Digital Image Processing", Third Edition, John Wiley & Sons, Inc., 2001, ISBNs: 0-471-37407-5.
- 6. NPTEL course Digital Image Processing: https://nptel.ac.in/courses/noc18\_ee40/
- 7. www.imageprocessingplace.com/
- 8. http://www.mathworks.com/

## 9. https://www.coursera.org/course/images

## Course Contents and Lecture Schedule

No.	Торіс	No. of	CO
		Lectures	
1	Image acquisition:		
1.1	Introduction to Image processing, it's need and applications – Elements of Human Visual Perception	2	1
1.2	Image acquisition- Sensors-CCD, CMOS, Imaging modalities: X-Ray, CT, MRI, Ultrasound	1	1
1.3	SAR	1	1
1.4	IR, Thermal		
1.5	Imaging Components of an Image processing system		
1.6	Practical: Functional Programming: Program that generates a	2	1
	test pattern image		
2	Fundamentals: Digital Image model, Image formats	1	1
2.1	Image Sampling and Quantization		
2.2	Basic relationship between pixels, Connectivity- 4, 8 and m		
	connectivity	1	1
2.3	Distance measures- Euclidean, city-block, chessboard		
	Color model-RGB,CMY,HSI,	1	1
	Color space conversion-RGB to HSV and YCbCr		
2.4	Practical: HVS and color space: (RGB to HSV, YCbCr color	2	1
	space)		
3.	Image Enhancement: Point transformations- Gray level Transformations	1	2
3.1	Image Negative, Contrast stretching, Log transformation-	1	2
	Gamma correction		
3.2	Histogram processing	1	2
3.3	Practical: Image enhancement: Point transformations: Image	2	2
	negative, log-transformation, contrast-stretching, histogram		
3.4	Spatial Filtering-Noise models – Salt and Pepper, Periodic	1	2
3.5	Mean-median filters-Order statistics filter		_
3.6	Practical: Image enhancement - Spatial filtering - Edges-	1	2
	Laplacian filter, unsharp masking, high-boost filter, and Sobel		
	and Roberts operators		
3.7	Dithering: Gray-level thresholding- Binary image	1	2
3.8	Practical: Dithering: Threshold a gray-scale image to get	2	2
	binary, Add noise to the original image and threshold,		
	Compare and comment		
3.9	Edges- Point, line detection, Laplacian filter, unsharp masking	1	2
3.10	High-boost filter, and Sobel and Roberts operators	1	2
4	Spectral representation for enhancement and coding:		
4.1	Fourier	2	3
4.2	Discrete cosine Transform	1	3
4.3	Practical: Spectral representation for enhancement and	2	3
	coding- DFT, DCT of simple images containing an edge or a		
	box.		

4.4	Spectrum-Frequency domain filtering –Periodic noi	se removal-	1	3
4.5	JPEG compression		2	3
4.6	Practical: Image enhancement: Filtering in the	frequency		3
	domain: Perform LP of different size (spatial).	\dd periodic	2	
	noise and remove using frequency filtering methods	3		
5	Segmentation: Region based segmentation		1	4
5.1	Region growing– Region splitting and merg	Jing	1	4
5.2	Watershed Segmentation		1	4
5.3	Practical: Segmentation: Region growing, region	splitting and		
	merging, and watershed segmentation			
5.4	Gray-scale Morphological operations: Erosion,	Dilation	1	4
5.5	Opening, closing, structuring element			
5.6	Geometric operations: Shrinking, Zooming and R	otation by	2	4
	Interpolations			
5.7	Practical: Morphological operations: Erosion,	Dilation,	2	4
	Opening, closing Selection of the structuring eleme	nt, Increase		
	the size of structuring element – Locating an	object		
6.	Representation and Description: Boundary repres	entation	1	5
6. 6.1	Representation and Description: Boundary repres	entation	1	5
6. 6.1 6.2	Representation and Description: Boundary repres Chain codes–Signatures Boundary descriptors–Shape numbers-Fourier de	entation escriptors	1	5 5
6. 6.1 6.2 6.3	Representation and Description: Boundary representation           Chain codes–Signatures           Boundary descriptors–Shape numbers-Fourier de Regional Descriptors-Topological descriptors-Euler	entation escriptors er number	1 1	5 5
6. 6.1 6.2 6.3 6.4	Representation and Description: Boundary representation           Chain codes–Signatures           Boundary descriptors–Shape numbers-Fourier de Regional Descriptors-Topological descriptors-Euler           Practical:         Geometric operations:	entation escriptors er number oming and	1	5 5 4
6. 6.1 6.2 6.3 6.4	Representation and Description: Boundary representationChain codes–SignaturesBoundary descriptors–Shape numbers-Fourier deRegional Descriptors-Topological descriptors-EulerPractical:Geometric operations:Shrinking, ZoRotation by InterpolationsComment on the comment	entation escriptors er number oming and uality of a	1 1 2	5 5 4
6. 6.1 6.2 6.3 6.4	Representation and Description: Boundary representation           Chain codes–Signatures           Boundary descriptors–Shape numbers-Fourier de           Regional Descriptors-Topological descriptors-Euler           Practical:         Geometric operations:           Shrinking,         Zo           Rotation by Interpolations         Comment on the content of the methods	entation escriptors er number oming and uality of a	1 1 2	5 5 4
6. 6.1 6.2 6.3 6.4 7.	Representation and Description: Boundary representation           Chain codes–Signatures           Boundary descriptors–Shape numbers-Fourier de           Regional Descriptors-Topological descriptors-Euler           Practical:         Geometric operations:           Shrinking,         Zc           Rotation by Interpolations Comment on the or           thumbnail-size using different interpolation methods           Real world Applications:         Number plate detection	entation escriptors er number oming and uality of a	1 1 2 2	5 5 4 6
6. 6.1 6.2 6.3 6.4 7.	Representation and Description: Boundary representation         Chain codes–Signatures         Boundary descriptors–Shape numbers-Fourier de         Regional Descriptors-Topological descriptors-Eule         Practical: Geometric operations: Shrinking, Zo         Rotation by Interpolations Comment on the content thumbnail-size using different interpolation methods         Real world Applications: Number plate detection	entation escriptors er number ooming and uality of a	1 1 2 2	5 5 4 6
6. 6.1 6.2 6.3 6.4 7. 7.2	Representation and Description: Boundary representation         Chain codes–Signatures         Boundary descriptors–Shape numbers-Fourier de         Regional Descriptors-Topological descriptors-Eule         Practical: Geometric operations: Shrinking, Zo         Rotation by Interpolations Comment on the content         thumbnail-size using different interpolation methods         Real world Applications: Number plate detection         Detecting cyst/tumour in MRI sound images	entation escriptors er number poming and uality of a	1 1 2 2 1	5 5 4 6 6
6. 6.1 6.2 6.3 6.4 7. 7.2 7.3	Representation and Description: Boundary representation Chain codes–Signatures         Boundary descriptors–Shape numbers-Fourier de Regional Descriptors-Topological descriptors-Euler         Practical:       Geometric       Operations:       Shrinking,       Zot         Practical:       Geometric       operations:       Shrinking,       Zot         Rotation       by       Interpolations       Comment       on       the construction         Real world Applications:       Number plate detection         Detecting cyst/tumour in MRI sound images       Non-destructive testing with Thermal images	entation escriptors er number ooming and uality of a	1 1 2 2 1 1	5 5 4 6 6 6
6. 6.1 6.2 6.3 6.4 7. 7.2 7.3 7.4	Representation and Description: Boundary representation         Chain codes–Signatures         Boundary descriptors–Shape numbers-Fourier de         Regional Descriptors-Topological descriptors-Euler         Practical: Geometric operations: Shrinking, Zo         Rotation by Interpolations Comment on the or         thumbnail-size using different interpolation methods         Real world Applications: Number plate detection         Detecting cyst/tumour in MRI sound images         Non-destructive testing with Thermal images         Change detection between two satellite images	entation escriptors er number ooming and uality of a	1 1 2 2 1 1	5 5 4 6 6 6
6. 6.1 6.2 6.3 6.4 7. 7.2 7.3 7.4	Representation and Description: Boundary representation Chain codes–Signatures         Boundary descriptors–Shape numbers-Fourier de Regional Descriptors-Topological descriptors-Euler         Practical:       Geometric       Operations:       Shrinking,       Zoc         Rotation by Interpolations Comment on the conthumbnail-size using different interpolation methods       Real world Applications:       Number plate detection         Detecting cyst/tumour in MRI sound images       Non-destructive testing with Thermal images       Change detection between two satellite images	entation escriptors er number ooming and uality of a	1 1 2 2 1 1	5 5 4 6 6 6
6. 6.1 6.2 6.3 6.4 7. 7.2 7.3 7.4	Representation and Description: Boundary representation Chain codes–Signatures         Boundary descriptors–Shape numbers-Fourier de Regional Descriptors-Topological descriptors-Eule         Practical:       Geometric       Operations:       Shrinking,       Zo         Rotation by Interpolations Comment on the conthumbnail-size using different interpolation methods       Real world Applications:       Number plate detection         Detecting cyst/tumour in MRI sound images       Non-destructive testing with Thermal images       Change detection between two satellite images         Mini project:       Total       Total	sentation escriptors er number poming and uality of a	1 1 2 2 1 1 1 48	5 5 4 6 6 6 6
6. 6.1 6.2 6.3 6.4 7. 7.2 7.3 7.4 <b>Cours</b>	Representation and Description: Boundary representation and Description: Boundary representation         Boundary descriptors-Shape numbers-Fourier de Regional Descriptors-Topological descriptors-Eule         Practical: Geometric operations: Shrinking, Zor         Rotation by Interpolations Comment on the content of thumbnail-size using different interpolation methods         Real world Applications: Number plate detection         Detecting cyst/tumour in MRI sound images         Non-destructive testing with Thermal images         Change detection between two satellite images         Mini project:         Total	sentation escriptors er number poming and uality of a s	1 1 2 2 1 1 1 48	5 5 4 6 6 6 6
6. 6.1 6.2 6.3 6.4 7. 7.2 7.3 7.4 <b>Cours</b>	Representation and Description: Boundary representation Chain codes–Signatures         Boundary descriptors–Shape numbers-Fourier de Regional Descriptors-Topological descriptors-Eule         Practical:       Geometric       Operations:       Shrinking,       Zoc         Practical:       Geometric       operations:       Shrinking,       Zoc         Rotation       by Interpolations       Comment on the content on the content of the content on the content on the content of the content on the content of the content of the content on the content of the content o	sentation escriptors er number ooming and uality of a s	1 1 2 2 1 1 1 48	5 5 4 6 6 6 6

18EC570	DATA COMMUNICATION NETWORKING	Category	L	Т	Ρ	Credit
	LABORATORY	PC	0	0	2	1

## Preamble

The goals of this course are to supplement the theory course '14EC510 Data Communication Networks' and to assist the students in obtaining a better understanding of the characteristics of data communication networks by giving hands on programming and lab activities to the students in practicing the data communication concepts and protocols. This lab course also supports in developing IoT based process control applications.

## Prerequisite

## NIL

## Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage
		in %
CO1	Analyze the throughput performance of multiple access protocols in	10
	network topologies	
CO2	Demonstrate structured cabling concepts using Straight through,	10
	Cross over and Rollover cables	
CO3	Use the routing algorithms and configure routers using Packet	10
	Tracer/e-Sim CISCO simulator	
CO4	Analyze the network performance using packet sniffer tools -	10
	NETMON / Wireshark	
CO5	Apply Socket Programming to build/configure network applications	20
CO6	Determine the network performance using network simulator package	20
	- NS2/NS3 to simulate the point-to-point networks and analyze their	
	performance	
CO7	Develop an IoT based process control applications using Arduino	20
	programming	

## CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	rning Doma	ain Level	CDIO Curricular Components
#	Proficiency Scale	Cognitive	Affective	Psychomotor	(X.Y.Z)
CO1	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO6	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2

Mapping with Programme	Outcomes and Programm	e Specific Outcomes
------------------------	-----------------------	---------------------

		-		-					-						
Cos	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO2	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO3	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO4	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L
CO5	S	М	L	-	S	-	-	L	S	S	L	-	S	-	L
CO6	S	Μ	L	-	S	-	-	L	S	S	L	-	S	-	L

## S- Strong; M-Medium; L-Low

## **Assessment Pattern: Cognitive Domain**

Cognitive Levels	Model Examination	End Semester Examination
Remember		
Understand		
Apply	70	70
Analyse		
Evaluate		
Create		

## Assessment Pattern: Psychomotor

Assessment i atterni i sychomotor								
Psychomotor Skill	Practical Component							
Perception								
Set	A Sala							
Guided Response	r la ser la la							
Mechanism	30							
Complex Overt Responses	Concern and Concer							
Adaptation								
Origination								

## List of Experiments/Activities with CO Mapping

- 1. Construct network topologies such as bus and star using trainer kit and analyze their throughput of MAC protocols for the given parameters. (CO1)
  - a. Simulate an Ethernet LAN using N-nodes (6-10)
  - b. Set packet size, duration, bit delay.
  - c. Set error rate and data rate
  - d. Compare throughput for different LAN topologies
- Implement Structured cabling concepts for TIA/EIA-358B standard to connect devices
- 3. using the following types: (CO2)
  - a. Straight through cable
  - b. Cross over cable
  - c. Roll over cable
- 4. Implement routing concepts (CO3)
  - a. to apply routing protocols such as RIP and OSPF using Packet Tracer
  - b. to configure the CISCO routers using e-Sim Simulator for the given inter-
  - c. connected subnets using IOS modes and commands
  - d. to find routing table, trace path between devices and verify the connectivity
- 5. Use Protocol Analyzer/ Sniffing Tools Wireshark/ NETMON to capturing network
- data 6. traffic (CO4)
  - a. to explore HTTP and DNS services
  - b. to explore TCP and UDP services
  - c. to explore IP services
  - d. to explore link layer services

- 7. Develop the following client-server models using Socket programming for TCP and UDP
- 8. protocols (CO5)
  - a. Time Server
  - b. Chat Server
  - c. File Server
  - d. Math Server
- 9. Determine network performance of the given network using network simulator packages –
- 10. NS2/NS3 (CO6)
  - a. Construct point-to-point/local area networks with appropriate links and nodes
  - b. Set the queue size, packet size and packet interval time.
  - c. Choose suitable link parameters such as link delay and link bandwidth for CBR / FTP traffic with UDP / TCP agents
- 11. Develop IoT based mini projects / prototype development for remote process control
- 12. applications using the following: (CO7)
  - a. Data acquisition and control using sensors and actuators
  - b. Arduino Programming for processing control
  - c. Choose appropriate wireless modules for communication
  - d. Data control using appropriate actuators / data analysis using R

## Learning Resources

- 1. NPTEL Video Lecture on "Computer Networks", weblink: https://onlinecourses.nptel.ac.in/noc19\_ee11/course
- 2. Virtual Lab of IIT Kharagpur, Weblink: http://vlabs.iitkgp.ernet.in/ant/
- 3. Lab Manual in LMS, Weblink https://murugavalli.gnomio.com/

## **Course Designers:**

- 2. Dr.M.S. K. Manikandan
- 3. Dr. E. Murugavalli

taece@tce.edu manimsk@tce.edu murugavalli@tce.edu

18EC580	ANALOG AND DIGITAL	Category	L	Т	Ρ	Credit
		PC	0	0	2	1

## Preamble

The course "18EC580: Analog and Digital Communications Laboratory" is offered in the fourth semester concurrent with the course on "Analog and Digital Communication Systems". The purpose of this course is to give hands on training to the students in understanding the theory of communications and practicing sessions used in analog and digital communication systems. This will improve the understanding capability of the communications and simulation capability of the communications.

## Prerequisite

18EC440 Signal Processing

## Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %				
CO1	Measure the directional characteristics of microphone and loud speaker	10				
CO2	Construct and test Analog modulation and demodulation circuits	15				
CO3	Construct and test circuits for pulse amplitude and time division multiplexing and de-multiplexing circuits	20				
CO4	Generate and detection of digital modulation techniques using MATLAB	20				
CO5	Improve the BER performance of modulation techniques by proper channel coding	20				
CO6	Construct and test circuits for spread spectrum modulation and demodulation	15				
CO Mapping with CDIO Curriculum Framework						

CO TCE Learning Domain Level **CDIO Curricular Components** # Proficiency Cognitive Affective Psychomotor (X.Y.Z)Scale CO1 TPS3 Value Mechanism 1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, Apply 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2 CO2 TPS3 1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, Value Apply Mechanism 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2 CO3 TPS3 Value Mechanism 1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, Apply 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2 CO4 TPS3 Apply Value Mechanism 1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2 TPS3 CO5 1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, Apply Value Mechanism 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2

Марр	Mapping with Programme Outcomes and Programme Specific Outcomes														
COs PO PO PO PO P						PO	PO	PÕ	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	М	L	-	S	-	-	-	М	Μ	-	L	S	L	L
CO2	S	М	L	-	S	-	-	-	М	М	-	L	S	L	L
CO3	S	М	L	-	S	-	-	-	Μ	Μ	-	L	S	L	L
CO4	S	М	L	-	S	-	-	-	М	Μ	-	L	S	M	L
CO5	S	М	L	-	S	-	-	-	Μ	Μ	-	L	S	M	L
CO6	S	М	L	-	S	-	-	-	М	М	-	L	S	L	L
S- Str	ong; l	N-Meo	dium;	L-Low	/										
Asse	ssme	nt Pa	ttern:	Cogr	nitive	Doma	ain								
	Co	ogniti	ve			Мос	lel Ex	amin	ation		Enc	d Sem	lester E	Examin	ation
		_evels	S												
	Re	meml	ber												
	Ur	nderst	and												
		Apply	/			70 70									
		Analys	<u>se</u>												
	E	valua	ite												
		Creat	e	_	_			m							
Asse	ssme	nt Pa	ttern:	Psyc	homo	otor									
Psyc	homo	otor S	kill			5	5A		Pra	actica	al Cor	npon	ent		
Perc	eptior	1					5								
Set						A	20	Hand I	5 SA	-					
Guid	ed Re	espon	se			ER	10	Constant of	1	7	00				
Mec	nanisi	n N				16	15	- Al			30				
Com	plex (	Jvert	Respo	onses			Sal	11.2	1						
Adap	Diation	ו					-								
Origi	nation	۱ •													
List o	of Exp	erime	ents/A	Activit	ties w	ith C	O Maj	oping							
1. (	nara	cterist	ICS OT	micro	pnon	e and	loud	speak	er						
2. F	2. AM Modulation and demodulation														
3. F	3. FM modulation and demodulation using PLL.														
4. F	4. Preemphasis and deemphasis														
0. I 6 T	5. Time Division Multiplexing and Demultiplexing														
0. I 2	<ol> <li>I ranseiver Design for BPSK modulation scheme over AWGN channel and BER analysis using MATLAB</li> </ol>														
7. 1	ranse	eiver	Desig	n for	QPS	SK m	odulat	tion s	chem	e ov	er AV	VGN	chann	el and	BER
a	nalys	is usir	ng MÃ	TLAE	3										
8. 5	Spread	d Spe	ctrum	Modu	latior	and	Demo	dulati	on						

## Learning Resources

- 1. TCE Analog and Digital Communication Lab Manual
- 2. www.ece.ucf.edu/files/labs/EEL4515\_LabManual.pdf

## **Course Designers:**

- 1. Dr.S.J.Thiruvengadam
- sjtece@tce.edu
- 2. Dr.M.N.Suresh
- mnsece@tce.edu
- 3. Dr.K.Rajeswari
- rajeswari@tce.edu
- 4. Dr.V.N.SenthilKumaran vnsenthilkumaran@tce.edu

Category	L	Т	Ρ	Credit
ES	1	-	2	2

## Preamble

Systems thinking is the integrated paradigm for systems science and system approaches to practice. It is concerned with understanding or intervening in problem situations, based on the principles and concepts of the system model. It can help to provide a common language and an intellectual foundation and make practical system concepts, principles, patterns and tools accessible to systems engineering. System thinking considers the similarities between systems from different domains in terms of a set of common systems concepts, principles, and patterns. The scope of systems thinking is a starting point for dealing with real-world situations using a set of related systems concept. The system thinking is viewed as both a set of founding ideas for the development of systems theories and practices and also as a pervasive way of thinking need by those developing and applying them. This systems approach is a way of tackling real-world problems and making use of the concepts, principle, patterns of systems thinking to enable the systems to be engineered and used.

## Prerequisite

## Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage
Number		in %
CO1	Explain the concepts of systems thinking, System engineering and Systems Life Cycle	10
CO2	Identify system elements, interactions, boundary and environment for the given system descriptions	10
CO3	Develop a functional architecture with appropriate primary function(s) and sub-functions of the identified system	15
CO4	Develop a physical architecture with appropriate sub-systems and components of the identified system	15
CO5	Prepare a system requirement specification review documents for the various stages of acquisition phase of the identified system	20
CO6	Develop a system model with logical and physical architecture using system modelling tool like SysML	30

## CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	rning Domain	Level	CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale	_		-	
CO1	TPS2	Understand	Respond	-	1.1, 2.3.1, 2.3.2
CO2	TPS3	Apply	Value	-	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3,
					2.3.4, 2.4.4, 4.3.1,
CO3	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3,
					2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4,
					3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3,
					4.4.5, 4.5.1
CO4	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3,
					2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4,
					3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3,
					4.4.5, 4.5.1
CO5	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.3.1, 2.3.2, 2.3.3,

CO	TCE	Lea	rning Domain	CDIO Curricular Components	
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale	-		-	
					2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4,
					3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3,
					4.4.5, 4.5.1
CO6	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3,
					2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4,
					3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3,
					4.4.5, 4.5.1

Mappin	Mapping with Programme Outcomes and Programme Specific Outcomes											
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	М	L	-	-	-	-	-	-	-	-	-	-
CO2	S	М	L	-	-	L	L	L	L	L	-	М
CO3	S	М	L	-	-	М	Μ	Μ	L	М	М	S
CO4	S	М	L	-	-	М	Μ	Μ	L	М	М	S
CO5	S	М	L	-	-	Μ	Μ	Μ	L	М	М	S
CO6	S	М	L	-	S	М	М	М	L	М	М	S

S- Strong; M-Medium; L-Low

# Assessment Pattern: Cognitive Domain Cognitive Levels Continuous Assessment Test -2 Remember 20 Understand 40 Apply 40 Analyse Evaluate Create

Phases	Deliverables	Marks	Course Outcomes
	Continuous Assessme	nt	
Continuous Assessment Test-1		10	CO1 and CO2
Review 1 – Functional & Physical Architecture and System Requirement Specification	Technical Report	25	CO3, CO4 and CO5
Review 2 – Systems Modeling	Technical Report	15	CO6
En	d-Semester Examination	on	
Demonstration	Virtual Prototype with simulation	60	CO1, CO2, CO3, CO4 CO5 and
Poster Presentation	Poster	40	CO6

- Reports are to be submitted at each review. The report and presentation will be evaluated based on Rubrics.
- Demonstration of Virtual Prototype with simulation and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.



## Syllabus

**1.0 Systems Fundamentals:** System - Definition, System Elements, Interactions, System Boundary, - Types of Systems: Closed-Open, Natural-Human-Made-Human-Modified, Physical-Conceptual and Precedented-Unprecedented. Systems science - Systems approaches. Systems Thinking: Concepts, principles and pattens. System of Interest - Systems of System. Systems Engineering: Product, Service, Enterprise. System Life Cycle: Pre-acquisition phase, Acquisition Phase, Utilization Phase and Retirement Phase.

**2.0 Acquisition Phase:** Conceptual Design: Business needs and requirements, Stakeholder needs and requirements, System Requirement Specification, Functional Base Line, System Requirement Review – Functional Architecture. Preliminary Design: Configuration items, Allocated Baseline, Preliminary Design Review – Physical Architecture. Detailed Design and Development: System Modeling, Product Base Line, Critical Design Review. Construction/Production: Formal Qualification Review, Acceptance Test and Evaluation.

**3.0 Systems Modeling:** System Model - Types of models – System Modeling Concepts – Modeling Standards. System Architecture: Logical Architecture Model – Physical Architecture Model. Systems Life Cycle Process Model: Vee model.

## Learning Resources

- A Guide to Guide to the Systems Engineering Body of Knowledge (SEBoK), version 2.2, INCOSE Systems Engineering Research Center and IEEE Computer Society, Released 31 October 2019 – https://www.sebokwiki.org/w/images/sebokwikifarm!w/8/8b/SEBoK\_v2.1.pdf
- 2. Systems Engineering Handbook, A Guide for Systems Life Cycle Processes and Activities, 4<sup>th</sup> Edition, INCOSE-TP-2003-002-04, 2015.
- 3. R. Ian Faulconbridge, Michael Ryan, "Systems Engineering Practice", Argos Argos Press, 2014.
- 4. Jon Holt and Simon Perry, "SysML for Systems Engineering", The Institution of Engineering and Technology, London, United Kingdom, 2008.
- 5. Sanford Friedenthal, Alan Moore and Rick Steiner, "A Practical Guide To SysML: The Systems Modeling Language, Third edition, Morgan Kaufmann, an imprint of Elsevier, 2015
- 6. Coursera course on Introduction to Systems Engineering R. Ian Faulconbridge, Michael Ryan of The University of New South Wales, Sydney.
- 7. NPTEL Course: Systems Engineering Theory and Practice IIT Kanpur Prof. Deepu Philip (Last offered in 2019) https://nptel.ac.in/courses/110/104/110104074/

Course Contents and Lecture Schedule			
Module Topic	No. o	f Hours	Course
No.	In-Class	Hands-on	Outcome
1. Systems Fundamentals: System - Definition,	1	-	CO1
System Elements, Interactions, System Boundary			
1.1 Types of Systems: Closed-Open, Natural-Human-	1	2	CO1
Made-Human-Modified, Physical-Conceptual and			
Precedented-Unprecedented.			
1.2 Systems science - Systems approaches.	1	-	CO1
1.3 Systems Thinking: Concepts, principles and	1	-	CO1
pattens.			
1.4 System of Interest - Systems of System. Systems	2	2	CO2
Engineering: Product, Service, Enterprise System			
Desc Utilization Phase and Potitomont Phase			
2 Acquisition Phase			
2.1 Conceptual Design: Business needs and	1	4	CO3
requirements. Stakeholder needs and	•	•	000
requirements, System Requirement Specification,			
Functional Base Line, System Requirement			
Review – Functional Architecture.			
2.2 Preliminary Design: Configuration items, Allocated	1	4	CO3
Baseline, Preliminary Design Review – Physical			
Architecture.			
2.3 Detailed Design and Development: System	1	4	CO4
Modeling, Product Base Line, Critical Design			
Review.	1	Λ	CO5
2.4 Construction/Froduction. Formal Qualification	I	4	005
3. Systems Modeling			
3.1 System Model - Types of models – System	1	2	CO6
Modeling Concepts – Modeling Standards.	-		
3.2 System Architecture: Logical Architecture Model –	1	4	CO6
Physical Architecture Model.			
3.3 Systems Life Cycle Process Model: Vee model.	1	2	CO6
Total	14	28	

Course Designers:1. Dr.S.J.Thiruvengadam2. Dr.S.Saravana Perumaal

sjtece@tce.edu sspmech@tce.edu

3. Dr.C.Jeyamala

jeyamala@tce.edu

Category	L	Т	Ρ	Credit
AC	2	0	0	0

## Preamble

On the successful completion of the course, the students will be able to explain the concept of Indian Traditional Knowledge along with Indian Modern Knowledge. Traditional Knowledge Systems or Indigenous Knowledge Systems are a body of knowledge, which is very ancient and deep rooted. They have their origins in the remote past. Their systematisation and canonisation gave rise to the elite (the Greater Tradition) science. The nature of Traditional Knowledge System is diverse. It covers, among other things, literary, artistic and scientific works; songs, dances, medical treatments and practices; manufacturing and industry; and agricultural technologies and techniques. There is a dramatically growing national and international interest in incorporating Traditional Knowledge Systems, including Traditional Ecological Knowledge, into truly participatory approaches to development.

## Course Outcome:

On the successful completion of the course students will be able to

CO1	Explain the concept of Traditional Knowledge and Modern knowledg of India.											ledge	Unde	stand	
CO2	Exp Kno Kno	Explain the need and importance of protecting Traditional Knowledge Knowledge sharing, and Intellectual property rights over Traditiona Knowledge.											edge, tional	Unde	rstand
CO3	Exp nee	Explain about the use of Traditional Knowledge to meet the basic needs of human being.											basic	Unde	stand
CO4	Explain the rich biodiversity materials and knowledge preserved for practicing traditional lifestyle.										ed for	Unde	stand		
CO5	Explain the use of Traditional Knowledge in Manufacturing and Industry.										and	Unde	stand		
CO6	Exp Tra	lain dition	about al Kn	t the owlec	cultu Ige	ıral e	xpres	sion	and	moder	n app	licatio	ns of	Under	stand
Марр	ing w	/ith P	rogra	amme	e Out	come	s								
Cos	P01	PO2	PO3	PO4	PO5	PO6	P07	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	М	L	-	-	-	S	М	Μ	М	Μ	-	L	Μ	-	М
CO2	М	L	-	-	-	S	М	Μ	М	Μ	-	L	Μ	-	М
CO3	М	L	-	-	-	S	М	Μ	М	Μ	-	L	Μ	-	М
CO4	Μ	L	-	-	-	S	Μ	Μ	Μ	Μ	-	L	Μ	-	М
CO5	M L S M M M - L M									Μ	-	М			
CO6	Μ	L	-	-	-	S	Μ	Μ	Μ	Μ	-	L	Μ	-	Μ

S- Strong; M-Medium; L-Low

## **Syllabus**

**Traditional and Modern Knowledge:** Two Worlds of Knowledge - Phase of Explorers, Sir Arthur Cotton and Irrigation, Smallpox Vaccination, Late Nineteenth Century, Voelcker, Howard and Agriculture, Havell and Indian Art; Indians at the Encounter - Gaekwad of Baroda and Technical Education, Science Education and Modern Industries, Hakim Ajmal Khan and Ayurveda, R. N. Chopra and Indigenous Drugs, Gauhar Jaan and Indian Classical Music; Linking Science and the Rural - Tagore's Sriniketan Experiment, Marthandam, the YMCA Model, Gandhi's Thoughts on Development, Nehru's View of Growth; Post-Independence Era - Modernization and Traditional Knowledge, Social Roots of Traditional Knowledge Activism, Global Recognition for Traditional Knowledge. **Global Mechanisms of Protection and Sharing:** For Recognition and Protection - United Nations Educational, Scientific and Cultural Organization (UNESCO), World Health Organization (WHO), International Labour Organizations; Norms of Sharing - United Nations Environment Programme (UNEP), World Intellectual Property Organization (WIPO), World Trade

Organization (WTO); IPR and Traditional Knowledge - Theoretical Background, Positive Protections of TK, Defensive Strategies, IPR Facilitation for TK. **Traditional Knowledge for Basic Needs:** Indian Midwifery Tradition—The Dai System, Surface Flow Irrigation Tanks, Housing - A Human Right, Changing Priorities—Niyamgiri. **Biodiversity and Genetic Resources:** Jeevani - The Wonder Herb of Kanis, A Holistic Approach - FRLHT, Basmati - In the New Millennium, AYUSH-Based Cosmetics. **Traditional Knowledge in Manufacturing and Industry:** Drug Discovery, A Sweetener of Bengal, The Sacred Ring of Payyanur, Channapatna Toys. **Traditional Cultural Expressions:** Banarasi Saree, Music, Built and Tangible Heritage, Modern Yoga, Sanskrit and Artificial Intelligence, Climate Change and Traditional Knowledge.

## Assessment Pattern

Bloom's category	Continuous A Tes	Assessment ts	Seminar
bloom 5 category	1	2	-
Remember	40	40	0
Understand	60	60	100
Apply	0	0	0
Analyze	0	0	0
Evaluate	0	0	0
Create	0	0	0

## Learning Resources:

1. Nirmal Sengupta "Traditional Knowledge in Modern India Preservation, Promotion, Ethical Access and Benefit Sharing Mechanisms" Springer, 2019.

- 2. Amit Jha,"Traditional Knowledge System in India", Atlantic Publishers and Distributors Pvt Ltd, 2009.
- 3. Basanta Kumar Mohanta, Vipin Kumar Singh "Traditional Knowledge System and Technology in India", Pratibha Prakashan, 2012.
- 4. Kapil Kapoor, Michel Danino "Knowledge Traditions and Practices of India", Central Board of Secondary Education, 2012.
- 5. NPTEL video lecture on "Ayurvedic Inheritance of India", Video link: https://nptel.ac.in/courses/121/106/121106003/#.
- 6. Youtube video on "Introduction to Indian Knowledge Systems", Video link: https://www.youtube.com/watch?v=LZP1StpYEPM.
- 7. Youtube video on "12 Great achievements of Indian Civilization", Video link: https://www.youtube.com/watch?v=xmogKGCmclE.

## Course Designers:

- Dr.S.J.Thiruvengadam sjtece@tce.edu
- Dr.V.R.Venkatasubramani venthiru@tce.edu

## **CURRICULUM AND SYLLABI** FOR **B.E. DEGREE (ELECTRONICS AND COMMUNICATION ENGINEERING)** PROGRAMME SIXTH SEMESTER FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2018-2019 ONWARDS THIAGARAJAR COLLEGE OF ENGINEERING (A Govt Aided Autonomous Institution Affiliated to Anna University) MADURAI - 625 015, TAMILNADU

## Vision and Mission of the Department

## Vision:

To empower the Electronics and Communication Engineering students with technological excellence, professional commitment and social responsibility.

## Mission:

- ME1. Attaining academic excellence in Electronics and Communication Engineering through dedication to duty, innovation in learning and research, state of the art laboratories and industry driven skill development.
- ME2. Establishing suitable environment for the students to develop professionalism and face life challenges with ethical integrity.
- ME3. Nurturing the students to understand the societal needs and equip them with technical expertise to provide appropriate solutions.
- ME4. Providing breeding ground to obtain entrepreneurial skills and leadership qualities for self and social growth.

## Program Educational Objectives (PEOs):

- PEO1. Graduates will be capable of developing specification and design procedures, prototyping and test methodologies for modern electronics and communication systems and gadgets that perform analog and digital processing functions.
- PEO2. Graduates will be able to work and adapt to changes in allied areas of Electronics and Communication Engineering through personal success and life long learning.
- PEO3. Graduates will be able to identify technological requirements for the society and provide cost effective solutions.
  - These objectives will be evidenced by professional visibility (publications, presentations, inventions, patents and awards), entrepreneurial activities, international activities (participation in international conferences, collaborative research and employment abroad)

## Program Outcomes: Engineering Graduates will be able to:

- 1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- 2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- 3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- 4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- 5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- 6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- 8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- 9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- 10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- 11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- 12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## Program Specific Outcomes:

Engineering Graduates will be able to

- PSO1. Design circuits and systems for complex engineering problems in Electronics and Communication and allied areas.
- PSO2. Apply research methodologies to provide solutions for contemporary problems in the areas including RF, Signal Processing, Image Processing, VLSI, Optical Communication, Networks and Embedded Systems for given specifications.
- PSO3. Actively contribute as a member or leader in diverse teams, and communicate effectively on complex engineering activities and involve in life-long learning, by applying reasoning and ethical principles.

## PEO- Mission Mapping:

	ME1	ME2	ME3	ME4
PEO1	S	М	М	L
PEO2	L	S	М	М
PEO3	М	L	S	М

## **PEO-PO-PSO Mapping:**

	P 0 1	P 0 2	P 0 3	P 0 4	P 0 5	P O 6	P O 7	P O 8	P O 9	P O 10	P 0 11	P O 12	PS O 1	PS O 2	PS O 3
PEO 1															
PEO 2															
PEO 3															

## **PO-GA Mapping:**

	GA	GA	GA	GA	GA	GA	GA	GA	GA	GA1	GA1	GA1
	1	2	3	4	5	6	7	8	9	0	1	2
PO1						ST	2 D					
PO2					R		1 d					
PO3							PI					
PO4					N	Condition of the second	S Y	5				
PO5						E.	de la	1				
PO6					1							
PO7												
PO8					/		1					
PO9					1			S.				
PO1												
0												
PO1												
1												
PO1												
2												

## TCE PROFICIENCY SCALE (CDIO Curriculum Framework)

TCE Proficiency Scale (TPS)	Proficiency	Cognitive	Affective	Psychomotor
TPS1	To have been exposed to	Remember	Receive	Perception, Set
TPS2	To be able to interpret and imitate	Understand	Respond	Guided Response
TPS3	To be skilled in the practice or implement	Apply	Value	Mechanism
TPS4	To be able to participate in and contribute	Analyse	Organise	Complex Overt Responses
TPS5	To be able to judge and adapt	Evaluate	Organise	Adaptation
TPS6	To be able to lead and innovate	Create	Characterize	Origination

S.No	Category	Cre	dits
		Regular	Lateral
А	Foundation Courses	53 — 58	23-28
	Humanities and Social Science (HSS)	9 -11	6-8
	Basic Science (BS)	21	6
	Engineering Science (ES)	23 – 26	11-14
В	Professional Core Courses	55	45
С	Elective Courses	24 – 48	24-48
	Programme Specific Elective	12-24	12-24
	Programme Elective for Expanded Scope	6 – 12	6-12
	General Elective	3-6	3-6
	Foundation Elective	3-6	3-6
D	Project work, seminar, internship in industry or at	15	15
	Higher Learning institutions		
E	Mandatory Courses – Environment Science,	Non-Credit	Non-Credit
	Induction Programme, Indian Constitution,	(Not included	(Not included
	Essence of Indian Tradition knowledge,	for CGPA)	for CGPA)
	consumer Affairs ( as per UGC guideline)		
	Minimum Credits to be earned for the award of	160	120
	the Degree	(from A to D)	(from A to D)
		and the	and the
	A SA SA	successful	successful
	r l l	completion of	completion of
	Contraction of the second	Mandatory	Mandatory
		Courses	Courses

## **Credit Distribution**

- General electives are courses offered by different departments that do not have any prerequisites and could be of interest to students of any branch
- All students have to undertake co-curricular and extra-curricular activities that include activities related to NCC, NSS, Sports, Professional Societies, participation in identified activities which promote the growth of Departments and the College.

## THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015 (A Govt. Aided Autonomous Institution affiliated to Anna University)

## CATEGORIZATION OF COURSES (CHOICE BASED CREDIT SYSTEM)

A. I		ON COURSES: Total Cre	edits t	o be	earne	ed: {	53-58	
	a. Hum	anities and Social Science (09-11)						
S.No.	Course	Name of the Course	Nu	ımbe	er of		Credit	
	Code		Ηου	irs / \	Neek			
			L	Т	P			
THEOF	٦Y							
1.	18EG140	English	2	-	-		2	
2.	18EC610	Accounting and Finance	3	-	-		3	
3.	18EC490	Project Management	3	-	-		3	
THEO	RY CUM PR	ACTICAL						
1.	18EG460	Professional Communication	-	1	2		2	
PRAC	TICAL							
1.	18EG170	English Laboratory	-	-	2		1	
	b. Basio	c Science (21)						
S.No.	Course	Name of the Course	Nur	nber	of Ho	urs	Credit	
	Code			/ W	/eek			
					т	D	-	
		A Canada A SA		.	I	Г		
			<u> </u>		1		1	
1.	TOWATTU	Engineering Calculus	3	·	1	-	4	
2.	18PHB20	Physics	3		-	-	3	
3.	18CHB30	Chemistry	3		-	-	3	
4.	18MA210	Matrices and Ordinary Differential	2	.	1	-	3	
		Equations						
5.	18EC310	Complex Analysis and Linear Algebra	2	<u> </u>	1		3	
6.	18EC410	Optimization and Numerical Methods	2		1		3	
PRAC	TICAL	1					-	
1.	18PH180	Physics Laboratory	-		-	2	1	
2.	18CH190	Chemistry Laboratory	-		-	2	1	
	c. Engi	neering Science (23-26)						
S.No.	Course	Name of the Course	N	lumb	er of		Credit	
	Code		Ho	urs /	Weeł	<b>(</b>		
			L	Т	P			
THEO	<u> YY</u>	1						
1.	18ES150	Engineering Exploration	3	-	-		3	
2.	18EC240	Semiconductor Physics	3	-	-		3	
3.	18EC630	Data Structures and Algorithms	2	-	-		2	
4.	18XXPE0	Engineering Sciences Elective	3	-	-		3	
THEOR	<u>RY CUM PR</u>	ACTICAL						
1.	18ME160	Engineering Graphics	3	-	2		4	
2.	18EC360	Programming for Problem Solving	2 - 2				3	
3.	18ES390	Design Thinking	1	-	2		2	
4.	18ES590 System Thinking 1 -							
PRAC	TICAL							
1.	18EC280	Electronics Workshop	-	-	2		1	
2.	18ES290	Lateral Thinking	-	-	2		1	

Degree: B.E. Programme: ECE

Batch: 2018-19 onwards

18EC670

Data

Laboratory

Structures

and

Algorithms

3.

\_

-

2

1

## **Engineering Sciences Elective**

S.No.	Course	Name of the Course	Ν	Number of		Credit				
	Code		Hc	ours /	Week					
			L	Т	Р					
THEOF	THEORY									
1.	18ECEA0	MEMS Technology	3	-	-	3				
2.	18ECEB0	Machine Learning for All	3	-	-	3				
3.	18ECEC0	IOT Sensors and Device	3	-	-	3				
4.	18ECED0	Blockchain Technology	3	-	-	3				
5.	18ECEE0	5G Wireless Networks	3	-	-	3				
THEOF	THEORY CUM PRACTICAL									
	-	-	-	-	-	-				

## **B. PROFESSIONAL CORE COURSES**

## Credits to be earned: 55

SI. No.	Course Code	Name of the Course	Number of Hours /		er of s /	Credit
		TOT	١	Nee	k	
			L	T	Р	
THEOR	Y		-			
1.	18EC220	Network Theory	2	1	-	3
2.	18EC230	Electronic Devices	3	-	-	3
3.	18EC320	RF Passive Devices and Circuits	2	1	-	3
4.	18EC330	Electronic Circuits	3	-	-	3
5.	18EC340	Signals and Systems	2	1	-	3
6.	18EC350	Microprocessors and Microcontrollers	2	1	-	3
7.	18EC420	RF Active Circuits	2	1	-	3
8.	18EC430	CMOS VLSI Systems	3	-	-	3
9.	18EC440	Signal Processing	2	1	-	3
10.	18EC510	Data Communication Networks	2	1	-	3
11.	18EC530	Analog and Digital Communication	2	1	-	3
		Systems				
12.	18EC620	Control Systems	2	1	-	3
13.	18EC710	Consumer Electronics	1	-	-	1
THEOR	Y CUM PRAC	TICAL				
14.	18EC260	Digital System Design	2	-	2	3
15.	18EC520	Antenna and Wave Propagation	2	-	2	3
16.	18EC560	Digital Image Processing	2	-	2	3
17.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTI	CAL					
18.	18EC270	Circuits and Devices Laboratory	-	-	2	1
19.	18EC370	Microprocessor and Microcontroller	-	-	2	1
		Laboratory				
20.	18EC380	Electronic Circuits Laboratory	-	-	2	1
21.	18EC470	RF Circuits Laboratory	-	-	2	1
22.	18EC480	Signal Processing Laboratory	-	-	2	1
23.	18EC570	Data Communication Networking	-	-	2	1
		Laboratory				
24.	18EC580	Analog and Digital Communications	-	-	2	1

C. EL	. ELECTIVE COURSES: Credit			ear	med:	24-48
a. Pr	ogramme Specifi	c Elective Credits t	o be	earr	ned:12	2-24
SI. No.	Course Code	Name of the Course	Number Hours / Week		er of s / k P	Credit
THEOR	Ý		_			
1.	18ECPA0	Computer Vision and Applications	3	-	-	3
2.	18ECPB0	Data Compression	3	-	-	3
3.	18ECPD0	Wireless Communication Systems	2	1	-	3
4.	18ECPF0	FPGA Based Digital System Design	3	-	-	3
5.	18ECPH0	Electronic Measurement and	3	-	-	3
6.	18ECPJ0	Network Security	3	-	-	3
7.	18ECPK0	Optical Communication	3	-	-	3
8.	18ECPM0	Planar Antennas for Wireless Applications	2	-	2	3
9.	18ECPN0	Electromagnetic Interference and Compatibility	3	-	-	3
10.	18ECPQ0	Statistical Signal Processing	2	1	-	3
11.	18ECPT0	Deep Learning For Speech Processing	2	1	-	3
12.	18ECPU0	VLSI Device Modeling	3	-	-	3
13.	18ECPY0	ASIC Design	3	-	-	3
14.	18ECPZ0	oT System and Applications	3	-	-	3
15.	18ECRA0	Real Time Embedded Systems	3	-	-	3
THEOR	Y CUM PRACTIC	AL		1	1	1
16.	18ECPC0	DSP Architecture and Programming	2	-	2	3
17.	18ECPE0	Biomedical Signal Processing	2	-	2	3
18.	18ECPG0	Analog System Design	2	-	2	3

b. Program	b. Programme Elective for Expanded Scope Credits t						6-12
SI. No.	Course Code	Name of the Course		Nu H L	mbe ours Vee T	er of s / k P	Credit

THEORY						
1.	18ECPL0	Medical Imaging and Processing	3	-	-	3
2.	18ECPP0	RF MEMS Design and Technology	3	-	-	3
3.	18ECPR0	LDPC and Polar Codes	2	1	-	3
4.	18ECPS0	Physical Channel Processing in 5G NR	2	1	-	3
5.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3
6.	18ECPW0	CAD for VLSI	3	-	-	3
7.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3
8.	18ECRC0	Multimedia Compression Techniques	3	1	-	4
9.	18ECRD0	Signal Processing in 5G NR	3	1	-	4
10.	18ECRE0	Algorithms for VLSI Design Automation	3	1	-	4
11.	18ECRF0	Low Power VLSI Design	3	1	-	4
12.	18EC1A0	Field Tests for a 5G Future	1	-	-	1
13.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1
14.	18EC1C0	Synchronization for 5G NR	1	-	-	1

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

15.	18EC1D0	Speech Signal Processing	1	-	-	1			
16.	18EC1E0	VLSI Implementation of	1	-	-	1			
		Communication Transceivers							
17.	18EC1F0	Embedded System Design	1	-	-	1			
THEORY CUM PRACTICAL									
	-	-	-	-	-	-			

c. General Elective

## Credits to be earned: 03-06

SI. No.	Course Code	Name of the Course	Number of Hours / Week		Credit	
			L	Т	Ρ	
THEORY						
1.	18ECGA0	Consumer Electronics	3	-	-	3
2.	18ECGB0	Multimedia Systems	3	-	-	3
3.	18ECGD0	Telecom Systems	3	-	-	3
4.	18ECGE0	Applied Image Processing	3	-	-	3

## d. Electives from foundation courses- HSS, BS, ES

## D. Project

## Credits to be earned: 15

Credits to be earned: 03-06

S.No.	Course Code	Name of the Course	Nu Hou	Number of Hours / Week		Credit
		and the second sec	L	Т	Р	
1.	18ES690	Engineering Design Project	2	-	4	3
2.	18ES790	Capstone Design Project	-	-	6	3
3.	18EC810	Project	-	-	18	9
		a second				

E. M	E. Mandatory Courses (Not included for CGPA)										
S.No.	Course	Name of the Course	Νι	ımbe	r of	Credit					
	Code		Hou	irs / V	Veek						
			L	Т	P						
THEOR	THEORY										
1.	18CHAA0	Environmental Sciences	-	-	2	0					
2.	18CHAB0	Constitution of India	-	-	2	0					
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0					
THEOR	Y CUM PRA	CTICAL									
-	-	-	-	-	-	-					
PRACT	PRACTICAL										
-	-	-	-	-	-	-					

Minimum credits to be earned for the award of the degree = 160

Batch: 2021-22 onwards

## THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015 (A Govt. Aided Autonomous Institution affiliated to Anna University)

## CATEGORIZATION OF COURSES (CHOICE BASED CREDIT SYSTEM)

Programme: ECE

F. F	F. FOUNDATION COURSES: Total Credits to be earned: 53-58									
	d. Huma	anities and Social Science (09-11)								
S.No.	Course	Name of the Course	Νι	umbe	r of		Credit			
	Code		Hou	ırs / \	Veek					
			L	Т	P					
THEOF	RY									
1.	18EG140	English	2	-	-		2			
2.	18EC610	Accounting and Finance	3	-	-		3			
3.	18EC490	Project Management	3	-	-		3			
THEOF	RY CUM PR	ACTICAL								
1.	18EG460	Professional Communication	-	1	2		2			
PRAC	TICAL									
1.	18EG170	English Laboratory	-	-	2		1			
	e. Basio	c Science (21)								
S.No.	Course	Name of the Course	Nur	nber	of Ho	urs	Credit			
	Code			/ W	eek					
				<u>і т</u>		D	_			
	<b>&gt;</b> V	A Canada A SA		•	•	1				
	18MA110	Engineering Calculus	3		1	_	4			
1.					-					
2.	18PHB20	Physics	3		-	-	3			
3.	18CHB30	Chemistry	3		-	-	3			
4.	18MA210	Matrices and Ordinary Differential	2	.	1	-	3			
5	18EC310	Complex Analysis and Linear Algebra	2	,	1		3			
6	18EC410	Ontimization and Numerical Methods	2	·	1		3			
PRAC				·	•					
1	18PH180	Physics Laboratory			-	2	1			
1.	18CH190	Chemistry Laboratory	-		-	2	1			
<u> </u>	f Engi	peering Science (23-26)				-	<u> </u>			
S No	Course	Name of the Course	N	lumb	er of		Credit			
0.110.	Code		Ho	urs /	Week		oroun			
				T	P	<u> </u>				
THEOF	ΥΥ					_				
1.	18ES150	Engineering Exploration	3	-	-		3			
2.	21EC240	Electronic Materials	3	_	-		3			
3.	18EC630	Data Structures and Algorithms	2	_	-		2			
4.	18XXPE0	Engineering Sciences Elective	3	_	-		3			
THEOF		ACTICAL		1	1					
1.	18ME160	Engineering Graphics	3	_	2		4			
2.	18EC360	Programming for Problem Solving	2	-	2		3			
3.	18ES390	Design Thinking	1	-	2		2			
4.	18ES590	System Thinking	1	-	1		2			
PRACT	TICAL			1						
1.	18EC280	Electronics Workshop	-	-	2		1			
2	18ES290	Lateral Thinking	-	-	2		1			

18EC670

Data

Laboratory

Structures

and

Algorithms

3.

Degree: B.E.

Approved in 61th Academic Council Meeting 03.07.2021

-

-

2

1

## **Engineering Sciences Elective**

S.No.	Course	Name of the Course	۸. I	Number of		Credit				
	Code		HC	urs /	Week					
			L	Т	Р					
THEOF	THEORY									
1.	18ECEA0	MEMS Technology	3	-	-	3				
2.	18ECEB0	Machine Learning for All	3	-	-	3				
3.	18ECEC0	IOT Sensors and Device	3	-	-	3				
4.	18ECED0	Blockchain Technology	3	-	-	3				
5.	18ECEE0	5G Wireless Networks	3	-	-	3				
THEOF	THEORY CUM PRACTICAL									
	-	-	-	-	-	-				

## G. PROFESSIONAL CORE COURSES

## Credits to be earned: 55

SI. No.	Course	Name of the Course	Number of			Credit
	Code	AT DA	H	lours	s /	
		1 STRIN	۱ ۱	Nee	k	
			L	T	Р	
THEOR'	Ý					
25.	18EC220	Network Theory	2	1	-	3
26.	18EC231	Electronic Devices	3	-	-	3
27.	18EC320	RF Passive Devices and Circuits	2	1	-	3
28.	18EC330	Electronic Circuits	3	-	-	3
29.	18EC340	Signals and Systems	2	1	-	3
30.	18EC350	Microprocessors and Microcontrollers	2	1	-	3
31.	18EC420	RF Active Circuits	2	1	-	3
32.	18EC430	CMOS VLSI Systems	3	-	-	3
33.	18EC440	Signal Processing	2	1	-	3
34.	18EC510	Data Communication Networks	2	1	-	3
35.	18EC530	Analog and Digital Communication	2	1	-	3
		Systems				
36.	18EC620	Control Systems	2	1	-	3
37.	18EC710	Consumer Electronics	1	-	-	1
THEOR	Y CUM PRAC	TICAL				
38.	18EC260	Digital System Design	2	-	2	3
39.	18EC520	Antenna and Wave Propagation	2	-	2	3
40.	18EC560	Digital Image Processing	2	-	2	3
41.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTI	CAL					
42.	18EC270	Circuits and Devices Laboratory	-	-	2	1
43.	18EC370	Microprocessor and Microcontroller	-	-	2	1
		Laboratory				
44.	18EC380	Electronic Circuits Laboratory	-	-	2	1
45.	18EC470	RF Circuits Laboratory	-	-	2	1
46.	18EC480	Signal Processing Laboratory	-	-	2	1
47.	18EC570	Data Communication Networking	-	-	2	1
		Laboratory				
48.	18EC580	Analog and Digital Communications	-	-	2	1
		Laboratory				

H. EL	H. ELECTIVE COURSES: Cro		to be earned: 24-48			
a. Pr	ogramme Specif	c Elective Credits t	o be	earned:12-24		
SI. No.	Course Code	Name of the Course	Nu H	mbe lour: Nee	er of s / k	Credit
	-		L	T	Р	
THEORY	Y	-				-
19.	18ECPA0	Computer Vision and Applications	3	-	-	3
20.	18ECPB0	Data Compression	3	-	-	3
21.	18ECPD0	Wireless Communication Systems	2	1	-	3
22.	18ECPF0	FPGA Based Digital System Design	3	-	-	3
23.	18ECPH0	Electronic Measurement and Instruments	3	-	-	3
24.	18ECPJ0	Network Security	3	-	-	3
25.	18ECPK0	Optical Communication	3	-	-	3
26.	18ECPM0	Planar Antennas for Wireless Applications	2	-	2	3
27.	18ECPN0	Electromagnetic Interference and Compatibility	3	-	-	3
28.	18ECPQ0	Statistical Signal Processing	2	1	-	3
29.	18ECPT0	Deep Learning for Speech Processing	2	1	-	3
30.	18ECPU0	VLSI Device Modeling	3	-	-	3
31.	18ECPY0	ASIC Design	3	-	-	3
32.	18ECPZ0	IoT System and Applications	3	-	-	3
33.	18ECRA0	Real Time Embedded Systems	3	-	-	3
THEORY	Y CUM PRACTIC	AL				
34.	18ECPC0	DSP Architecture and Programming	2	-	2	3
35.	18ECPE0	Biomedical Signal Processing	2	-	2	3
36.	18ECPG0	Analog System Design	2	-	2	3

## b. Programme Elective for Expanded Scope Credits to be earned: 06-12

SI. No.	Course Code	Name of the Course		umber of Hours /		Credit
	-		N	Nee	k	
			L	Т	Р	
THEORY	/					
18.	18ECPL0	Medical Imaging and Processing	3	-	-	3
19.	18ECPP0	RF MEMS Design and Technology	3	-	-	3
20.	18ECPR0	LDPC and Polar Codes	2	1	-	3
21.	18ECPS0	Physical Channel Processing in 5G	2	1	-	3
		NR				
22.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3
23.	18ECPW0	CAD for VLSI	3	-	-	3
24.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3
25.	18ECRC0	Multimedia Compression Techniques	3	1	-	4
26.	18ECRD0	Signal Processing in 5G NR	3	1	-	4
27.	18ECRE0	Algorithms for VLSI Design	3	1	-	4
		Automation				
28.	18ECRF0	Low Power VLSI Design	3	1	-	4
29.	18EC1A0	Field Tests for a 5G Future	1	-	-	1

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

30.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1	
31.	18EC1C0	Synchronization for 5G NR	1	-	-	1	
32.	18EC1D0	Speech Signal Processing	1	-	-	1	
33.	18EC1E0	VLSI Implementation of	1	-	-	1	
		Communication Transceivers					
34.	18EC1F0	Embedded System Design	1	-	-	1	
THEORY	THEORY CUM PRACTICAL						
	-	-	-	-	-	-	

d. General Elective Credits to			o be	earn	ed: 0	3-06	
SI. No.	Course	Name of the Course	Number of			Credit	
	Code		H	Hours /			
				Nee			
			L	Т	Р		
THEORY							
5.	18ECGA0	Consumer Electronics	3	-	-	3	
6.	18ECGB0	Multimedia Systems	3	-	-	3	
7.	18ECGD0	Telecom Systems	3	-	-	3	
8.	18ECGE0	Applied Image Processing	3	-	-	3	

d. Electives from foundation courses- HSS, BS, ES Credits to be earned: 03-06

## I. Project

## Credits to be earned: 15

S.No.	Course	Name of the Course	Number of			Credit
	Code	Sardin a	Hou	Hours / Week		
			L	Т	Р	
1.	18ES690	Engineering Design Project	2	-	4	3
2.	18ES790	Capstone Design Project	-	-	6	3
3.	18EC810	Project	-	-	18	9

J. N	landatory Co	urses (Not included for CGPA)					
S.No.	Course	Name of the Course	Nu	umbe	r of	Credit	
	Code		Hou	ırs / V			
			L	Т	P		
THEOR	Y						
1.	18CHAA0	Environmental Sciences	-	-	2	0	
2.	18CHAB0	Constitution of India	-	-	2	0	
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0	
THEOR	Y CUM PRAG	CTICAL					
-	-	-	-	-	-	-	
PRACT	PRACTICAL						
-	-	-	-	-	-	-	

Minimum credits to be earned for the award of the degree = 160

c C ts		22	8	22	22	22
Audit Courses (Mandato ry Non- credit}	12	1	18CHAA0 Environm ental Sciences (0)		18CHAB0 Constituti on of India (0)	Essence of Indian Knowledg e (0)
Special Courses	11	1	18ES290 Lateral Thinking (1)	18ES390 Design Thinking (TCP) (2)	18EC490 Project Managem ent (3)	18ES590 System Thinking (2)
	10	18CH19 0 Chemist ry Lab. (1)			•	
Practical	9	18PH180 Physics Lab. (1)	18EC280 Workshop (1)	18EC380 Electronic Circuits Lab (1)	18EC480 Signal Processin g Lab (1)	18EC580 Analog and Digital Commn. Lab (1)
	8	18EG170 English Lab. (1)	18EC270 Circuits and Devices Lab (1)	18EC370 Microproc essor and Microcont roller Lab (1)	18EC470 RF Circuits Lab (1)	18EC570 Data Commn. Networkin g Lab `(1)
Theory cum Practical	7	18ME160 Engg Graphics (4)	18EC260 Digital System Design (3)	18EC360 Programmin g for Problem Solving (3)	18EG460 Professional Communicat ion (2)	18EC560 Digital Image Processing (3)
	9	L.			•	1
	5	18ES150 Engg Explorati on (3)	No.	18EC350 Micropro cessors and Microcont rollers (3)	18YYFX0 Foundati on Elective I (3)	18YYGX 0 Gen. Elective .I (3)
	4	18EG180 English (2)	18EC240** Semicondu ctor Physics (3)	18EC340 Signals and Systems (3)	18EC440 Signal Processing (3)	18ECPX0 Prog. Elective -I (3)
Theory	3	18CHB 30 Chemistry (3)	18EC230** Electronic Devices (3)	18EC330 Electronic Circuits (3)	18EC430 CMOS VLSI Systems (3)	18EC530 Analog and Digital Communicat ions (3)
	2	18PHB20 Physics (3)	18EC220 Network Theory (3)	18EC320 RF Passive Devices and Circuits (3)	18EC420 RF Active Circuits (3)	18EC520 Antenna and Wave Propagatio n (TCP) (3)
	1	18MA110 Engineering Calculus (4)	18MA210 Matrices and Ordinary Differential Equations (3)	18EC310 Complex Analysis and Linear Algebra (3)	18EC410 Optimization and Numerical Methods (3)	18EC510 Data Communicat ion Networks (3)
Se est er	5	_	=	≡	≥	>

SCHEDULING OF COURSES FOR 2018-19 onwards (B.E. ECE Programme)\*

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

B.E. (Electronics and Communication Engineering)

Cr edi ts		23	16	15
Audit Courses (Mandato ry Non- credit}	12	•	1	1
Special Courses	11	18ES690 Engineeri ng Design Project (3)	18ES790 Capstone Design Project (3)	1
	10		1	18EC81 0 Project (9)
Practical	6	1	1	1
	8	18EC670 Data Structures and Algorithm s Lab (1)		1
Theory cum Practical	7	18EC660 Digital Communicat ion System Design (2)		-
	9	Engg Scienc es (3)		-
	5	18ECPX 0 Prog. Elective/ 18YYFX0 Foundati on Elective II (3)	18ECPX 0 Prog. Elec. VI/ 18YYFX0 General Elective (3)	-
	4	18ECPX0 Prog. (3) (3)	18ECPX0 Prog. Elec.V (3)	1
Theory	3	18EC630 Data Structures and Algorithms (2)	18ECPX0 Prog. Elec IV (3)	
	2	18EC620 Control Systems (3)	18ECPX0 Prog. Elec.III (3)	18XXPX0 Prog. Elec. VIII (3)
	1	18EC610 Accounting and Finance (3)	18EC710 Consumer Electronics (1)	18XXPX0 Prog. Elec. VII (3)
Se est er	5	⋝	T	IIN

Total Credits for Curricular Activities: 160 \*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & \*This schedule shows an optimal way of completing the B.E. Degree programme successfully in 4 Years 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

Passed in BoS Meeting 22.06.2021

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

## THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI - 625 015

## B.E Degree (Electronics and Communication Engineering) Program

## COURSES OF STUDY

(For the students admitted from the Academic year 2018-19 onwards)

## **FIRST SEMESTER**

Course code	Name of the Course	Category	Nu of I V	Number of Hours / Week		Credits		
			L	Τ	Ρ			
THEORY								
18MA110	Engineering Calculus	BS	3	1	-	4		
18PHB20	Physics	BS	3	I	-	3		
18CHB30	Chemistry	BS	3	I	-	3		
18EG140	English	HSS	2	I	-	2		
18ES150	Engineering Exploration	ES	3	I	-	3		
THEORY CL	IM PRACTICAL							
18ME160	Engineering Graphics	ES	3	I	2	4		
PRACTICAL								
18EG170	English Laboratory	HSS	-	-	2	1		
18PH180	Physics Laboratory	BS	-	I	2	1		
18CH190	Chemistry Laboratory	BS	-	-	2	1		
	Total 17							

## SECOND SEMESTER

Course code	Name of the Course	Category	Nu F	Number of Hours / Week		Credits
			L	Т		
THEORY						
18MA210	Matrices and Ordinary Differential	BS	2	1	-	3
	Equations					
18EC220	Network Theory	PC	2	1	-	3
18EC230**	Electronic Devices	PC	3	-	-	3
18EC240**	Semiconductor Physics	ES	3	-	-	3
THEORY CL	JM PRACTICAL					
18EC260	Digital System Design	PC	2	-	2	3
PRACTICAL	-					
18EC270	Circuits and Devices Laboratory	PC	-	-	2	1
18EC280	Electronics Workshop	ES	-	-	2	1
18ES290	Lateral Thinking	ES	-	-	2	1
Non-credit co	ourse (Mandatory) – Audit Course					
18CHAA0	Environment Sciences	ES	1	-	1	-
	Total		13	2	9	18

\*\*For students joined from 2021-22 onwards,

18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

## THIRD SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits	
			L	Т	Ρ		
THEORY							
18EC310	Complex Analysis and Linear Algebra	BS	2	1	-	3	
18EC320	RF Passive Devices and Circuits	PC	2	1	-	3	
18EC330	Electronic Circuits	PC	3	-	-	3	
18EC340	Signals and Systems	PC	2	1	-	3	
18EC350	Microprocessors and Microcontrollers	PC	2	1	-	3	
THEORY C							
18EC360	Programming for Problem Solving	ES	2	-	2	3	
18ES390	Design Thinking	ES	1	-	2	2	
PRACTICA	<u>L</u>						
18EC370	Microprocessor and Microcontroller Laboratory	PC	-	-	2	1	
18EC380	Electronic Circuits Laboratory	PC	-	-	2	1	
	Total	14	4	8	22		
FOURTH SE	EMESTER						
			Number of				
Course	Name of the Course	Category	Nu	Imbei	r of	Credits	
Course code	Name of the Course	Category	Nu Hou	imbei irs / V	r of Veek	Credits	
Course code	Name of the Course	Category	Nu Hou L	imbei irs / V T	r of Veek P	Credits	
Course code THEORY	Name of the Course	Category	Nu Hou L	Imbei Irs / V T	r of Veek P	Credits	
Course code THEORY 18EC410	Name of the Course Optimization and Numerical Methods	Category BS	Nu Hou L	Imbei Irs / V T	r of Veek P -	Credits 3	
Course code THEORY 18EC410 18EC420	Name of the Course Optimization and Numerical Methods RF Active Circuits	Category BS PC	Nu Hou L 2 2	Imbei Irs / V T 1 1	r of Veek P -	Credits 3 3	
Course code THEORY 18EC410 18EC420 18EC430	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems	Category BS PC PC	Nu Hou L 2 3	Imbei Irs / V T 1 1 -	r of Veek P - -	Credits 3 3 3	
Course code THEORY 18EC410 18EC420 18EC430 18EC440	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing	Category BS PC PC PC	Nu Hou 2 2 3 2	Imbei Irs / V T 1 - 1	r of Veek P - - -	Credits 3 3 3 3 3	
Course code THEORY 18EC410 18EC420 18EC420 18EC440 18YYFX0	Name of the Course Optimization and Numerical Methods RF Active Circuits CMOS VLSI Systems Signal Processing Foundation Elective I	Category BS PC PC PC BS	Nu Hou 2 2 3 2 3	Imbei Irs / V T 1 1 - 1	r of Veek P - - - -	Credits 3 3 3 3 3 3 3 3 3	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490	Name of the CourseOptimization and Numerical MethodsRF Active CircuitsCMOS VLSI SystemsSignal ProcessingFoundation Elective IProject Management	Category BS PC PC PC BS HSS	Nu Hou 2 2 3 2 3 3 3 3	Imbei Irs / V T 1 - 1 - -	r of Veek P - - - - - -	Credits 3 3 3 3 3 3 3 3 3	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490 THEORY C	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL	Category BS PC PC PC BS HSS	Nu Hou L 2 2 3 2 3 3 3	Imbei Irs / V T 1 1 - 1 -	r of Veek P - - - - - - - - -	Credits 3 3 3 3 3 3 3 3 3	
Course code THEORY 18EC410 18EC420 18EC430 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460	Name of the CourseOptimization and Numerical MethodsRF Active CircuitsCMOS VLSI SystemsSignal ProcessingFoundation Elective IProject ManagementCUM PRACTICALProfessional Communication	Category BS PC PC BS HSS HSS	Nu Hou L 2 3 2 3 3 3 -	Imbei Irs / V T 1 1 - 1 - -	r of Veek P - - - - - - - 2	Credits 3 3 3 3 3 3 2	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460 PRACTICA	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication	Category BS PC PC PC BS HSS HSS	Nu Hou 2 2 3 2 3 3 -	Imbei Irs / V T 1 - 1 - - 1	r of Veek P - - - - - - 2	Credits 3 3 3 3 3 2 2	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         L         RF Circuits Laboratory	Category BS PC PC PC BS HSS HSS	Nu Hou 2 2 3 2 3 3 -	Imbei Irs / V T 1 1 - 1 - 1 - -	r of Veek P - - - - - 2	Credits 3 3 3 3 3 2 1	
Course code THEORY 18EC410 18EC420 18EC430 18EC430 18EC440 18YYFX0 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC470	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory	Category BS PC PC PC BS HSS HSS PC PC	Nu Hou L 2 3 2 3 3 - -	Imbei Irs / V T 1 1 - 1 - 1 - - - -	r of Veek P - - - - - - 2 2 2	Credits 3 3 3 3 3 2 1 1 1	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC480 AUDIT CO	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory         URSE - NON-CREDIT MANDATORY COM	Category BS PC PC PC BS HSS HSS PC PC JRSE	Nu Hou L 2 3 2 3 3 3 - -	Imbei Irs / V T 1 1 - 1 - 1 - 1 - -	r of Veek P - - - - - - 2 2 2	Credits 3 3 3 3 3 2 1 1 1	
Course code THEORY 18EC410 18EC420 18EC420 18EC430 18EC430 18EC490 THEORY C 18EG460 PRACTICA 18EC470 18EC480 AUDIT CO 18CHAB0	Name of the Course         Optimization and Numerical Methods         RF Active Circuits         CMOS VLSI Systems         Signal Processing         Foundation Elective I         Project Management         CUM PRACTICAL         Professional Communication         NL         RF Circuits Laboratory         Signal Processing Laboratory         URSE - NON-CREDIT MANDATORY CON         Constitution of India	Category BS PC PC PC BS HSS HSS PC PC JRSE HSS	Nu Hou 2 2 3 2 3 3 - - - -	Imbei Irs / V T 1 1 - 1 - 1 - - - - -	r of Veek P - - - - - 2 2 2 2	Credits 3 3 3 3 3 2 1 1 0	

## **FIFTH SEMESTER**

Course code	Name of the Course	Category	Number of Hours / Week		Credits	
			L	Т	Ρ	
THEORY						
18EC510	Data Communication Networks	PC	2	1	-	3
18EC530	Analog and Digital Communication	PC	2	1	-	3
	Programme Elective -I	DE	3			3
	Conoral Elective		2	-	-	3
THEORY		GE	5	-	-	5
18EC520	Antenna and Wave Propagation	PC	2	_	2	3
1950560	Digital Imaga Processing		2	-	2	3
10EC300		PC		-	2	3
18ES590	System Thinking	ES	1 - 1*			2
PRACTICA	NL					

18EC570	Data Communication Networking	PC	-	-	2	1				
1850580	Applog and Digital Communications	PC			2	1				
TOEC300		FC	-	-	2	I				
	URSE - NON-CREDIT MANDATORY CC				2	0				
INCHACU		192	-	-	2	0				
Total				2	11	22				
*One hour per week is allotted for off the classroom work										
SIXTH SEMESTER										
Course	Name of the Course	Category	Number of		Credits					
code			Hours / Week							
			L	T	Ρ					
THEORY										
18EC610	Accounting and Finance	HSS	3	-	-	3				
18EC620	Control Systems	PC	2	1	-	3				
18EC630	Data Structures and Algorithms	ES	2	-	-	2				
18ECPX0	Programme Elective-II	PE	3	-	-	3				
18YYZX0	Programme / Foundation Elective - I	PE/FE	3	-	-	3				
18ESEX0	Engineering Sciences Elective	ES	3	-	-	3				
THEORY CUM PRACTICAL										
18EC660	Digital Communication Transceiver	PC	1	-	2	2				
PRACTICAL										
18EC670	Data Structures and Algorithms	ES	-	-	2	1				
	Laboratory									
PROJECT										
18ES690	Engineering Design Project	Project	1	-	4	3				
Total				1	8	23				

## SEVENTH SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week		Credits					
			L	Т	P					
THEORY										
18EC710	Consumer Electronics	PC	1	-	-	1				
18ECPX0	Programme Elective -III	PE	3	-	-	3				
18ECPX0	Programme Elective -IV	PE	3	-	-	3				
18ECPX0	Programme Elective -V	PE	3	-	-	3				
18YYZX0	Programme-VI / General Elective - II	PE/GE	3	-	-	3				
THEORY CUM PRACTICAL										
-	-	-	-	-	-	-				
PRACTICAL										
-	-	-	-	-	-	-				
PROJECT										
18ES790	Capstone Design Project	Project	-	-	6	3				
	Total		13	-	6	16				
# **EIGHTH SEMESTER**

Course code	Name of the Course	Category	Nu Hou	mber rs / V	Credits				
			L	Т					
THEORY									
18ECPX0	Programme Elective -VII	PE	3	-	-	3			
18ECPX0	Programme Elective -VIII	PE	3	-	-	3			
THEORY C	THEORY CUM PRACTICAL								
-	-	-	-	-	-	-			
PRACTICA	\L								
-	-	-	-	-	-	-			
PROJECT									
18EC810	Project	Project	-	-	18	9			
	Total 6 - 18 15								

- BS : Basic Science
- HSS : Humanities and Social Science
- ES : Engineering Science
- PC : Programme Core
- PE : Programme Elective
- GE : General Elective
- FE : Foundation Elective
- L : Lecture
- T : Tutorial
- P : Practical

# Note:

- 1 Hour Lecture/week is equivalent to 1 Credit
- 1 Hour Tutorial/week is equivalent to 1 Credit
- 2 Hours Practical/week is equivalent to 1 Credit

# THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E Degree (Electronics and Communication Engineering) Program SCHEME OF EXAMINATIONS

(For the students admitted from the Academic Year 2018-19 onwards) **SECOND SEMESTER** 

Course	Name of the	Duration	Ν	Minimum	Marks		
code	Course	Torminal	Continuouo	Terminel	Max	Torminal	Tatal
			Continuous		Max.		Total
		Exam	Assessment	Exam**	Marks	Exam	
		In Hrs.					
THEORY	1						
18MA210	Matrices and	3	50	50	100	25	50
	Ordinary						
	Differential						
	Equations						
18EC220	Network	3	50	50	100	25	50
	Theory	_				_	
18EC230***	Electronic	3	50	50	100	25	50
	Devices						
18EC240***	Semiconductor	3	50	50	100	25	50
	Physics						
THEORY CU	M PRACTICAL	•				•	
18EC260	Digital System	3	50	50	100	25	50
	Design						
PRACTICAL	• • • •	•	•	•	•	•	
18EC270	Circuits and	3	50	50	100	25	50
	Devices						
	Laboratory						
18EC280	Electronics	3	50	50	100	25	50
	Workshop						
18ES290	Lateral	_	50	50	100	25	50
	Thinking						
AUDIT COUI	RSE - NON-CRED	IT MANDA	TORY COURS	E	1	1	1
18CHAA0	Environmental	-	50	50	100	25	50
	Sciences						

\*\*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

# THIRD SEMESTER

Course	Name of the	Duration	Marks			Minimum	Marks
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY							
18EC310	Complex Analysis and Linear Algebra	3	50	50	100	25	50
18EC320	RF Passive Devices and Circuits	3	50	50	100	25	50
18EC330	Electronic Circuits	3	50	50	100	25	50
18EC340	Signals and Systems	3	50	50	100	25	50

18EC350	Microprocessors	3		50		50	100	25	50
	and Microcontrollers								
THEORY									
18EC360	Programming for	3		50		50	100	25	50
	Problem Solving								
18ES390	Design Thinking	-	-			50	100	25	50
PRACTICA	AL							1	1
18EC370	Microprocessor	3		50		50	100	25	50
	and Microcontrollor								
18EC380	Electronic	3		50		50	100	25	50
1020000	Circuits	J J		00			100	20	
	Laboratory								
FOURTH SI	EMESTER	·							
Course	Name of the	Duration of	of		I	Marks		Minimum	Marks
code	Course	End		0 "				for Pass	
		Semester		Continuous	*	End	Max.	End	Iotal
		Exam\		Assessmer	IT.	Semeste	er Marks	Semester	
THEORY									
18EC410	Optimization	3		50		50	100	25	50
1020110	and Numerical	U		00			100	20	00
	Methods								
18EC420	RF Active	3		50		50	100	25	50
	Circuits								
18EC430	CMOS VLSI	3		50		50	100	25	50
4050440	Systems	0		50		50	100	05	50
18EC440	Signal	3		50		50	100	25	50
18YYEX0	Foundation	3		50		50	100	25	50
	Flective I	0		50		00	100	20	50
18EC490	Project	3		50		50	100	25	50
	Management								
THEORY O	CUM PRACTICAL							•	
18EG460	Professional	-		50		50	100	25	50
	Communication								
PRACTICA		•		50		50	400	05	50
18EC4/0		3		50		50	100	25	50
1950490	Laboratory	2		50		50	100	25	50
10EC400	Processing	3		50		50	100	25	50
	Laboratory								
AUDIT CO	URSE - NON-CRE	DIT MANDA	TO	RY COURS	E	1		1	I
18CHAB0	Constitution of	-		50		50	100	25	50
	India								

# **FIFTH SEMESTER**

						1	
Course code	Name of the Course	Duration of End	ſ	Varks		for Pass	Marks
		Semester Exam\ in Hrs.	Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY						•	•
18EC510	Data Communication Networks	3	50	50	100	25	50
18EC530	Analog and Digital Communication Systems	3	50	50	100	25	50
18ECPX0	Programme Elective -I	3	50	50	100	25	50
18YYGX0	General Elective	3	50	50	100	25	50
THEORY C		L. L		L	1	•	-
18EC520	Antennas and Wave Propagation	3	50	50	100	25	50
18EC560	Digital Image Processing	3	50	50	100	25	50
18ES590	System Thinking	-	50	50	100	25	50
PRACTICA	L					•	•
18EC570	Data Communication Networking Laboratory	3	50	50	100	25	50
18EC580	Analog and Digital Communications Laboratory	3	50	50	100	25	50
AUDIT COU	JRSE - NON-CREDI	T MANDATO	DRY COURSE			•	
18CHAC0	Essence of Indian Knowledge	-	50	50	100	25	50
SIXTH SEME	ESTER	1	•				
Course code	Name of the Course	Duration of End		Marks		Minimum for Pass	Marks
		Semester Exam\ in Hrs.	Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY	1			1			
18EC610	Accounting and Finance	3	50	50	100	25	50
18EC620	Control Systems	3	50	50	100	25	50
18EC630	Data Structures and Algorithms	3	50	50	100	25	50
18ECPX0	Programme Elective -II	3	50 50		100	25	50
18YYZX0	Programme / Foundation Elective - I	3	50	50	100	25	50

18ESEX0	Engineering	3	50	50	100	25	50
THEORY C							
18EC660	Digital	3	50	50	100	25	50
1020000	Communication	U	00	00		20	
	System Design						
PRACTICA	L				I		1
18EC670	Data Structures	3	50	50	100	25	50
	and Algorithms	_				_	
	Laboratory						
Project		•				•	
18ES690	Engineering	-	50	50	100	25	50
	Design Project						
SEVENTH S	EMESTER						
Course	Name of the	Duration	1	Marks		Minimum	Marks
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY		-					
18EC710	Consumer	3	50	50	100	25	50
(0505)(0	Electronics			=	100		
18ECPX0	Programme	3	50	50	100	25	50
			50	50	100	05	50
18ECPX0	Programme	3	50	50	100	25	50
	Dregromme	2	50	50	100	25	50
TOECFAU		3	50	50	100	25	50
187770		3	50	50	100	25	50
1011270		5	50	50		25	50
Project							I
18ES790	Capstone Design	_	50	50	100	25	50
1020100	Project			00	100	20	00
EIGTH SEME	ESTER				I		
Course	Name of the	Duration		Marks		Minimum	Marks
code	Course	of End				for Pass	
		Semester	Continuous	End	Max.	End	Total
		Exam\	Assessment*	Semester	Marks	Semester	
		in Hrs.		Exam**		Exam	
THEORY					•	•	
18ECPX0	Programme	PE	3	-	-	3	-
	Elective -VII						
18ECPX0	Programme	PE	3	-	-	3	50
	Elective -VIII						
Project							
18FC810	Project	-	50	50	100	25	50

\*Continuous Assessment evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

\*\*End Semester Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of End semester examination marks.

\*\*\*For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

18EC610	ACCOUNTING AND FINANCE	Category	L	Т	Ρ	Credit
		HSS	З	0	0	3

#### Preamble

Engineering profession involves lots of decision making. The decisions may range from operation to non-operation. For taking decisions of these kinds, an engineer needs among other data about the organization routine operations and non-routine operations. Accounting is a science which provides all the data by recording, classifying, summarizing and interpreting the various transactions taking place in an organization and thereby helps an engineer in taking vital decisions in an effective manner. Finance is an allied but a separate field relying on accounting and enables engineers in taking useful financial and cost related decisions by providing well defined concepts, tools and techniques

# Prerequisite

Nil

# Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Prepare financial statements of accounting and analyze them with common size statements and comparative statements.	20
CO2	Prepare cost sheet, depreciation and its applications in business.	15
CO3	Compute various types of budgets in an organization	15
CO4	Practice break even analysis and activity based costing systems for business applications.	15
CO5	Compute working capital requirements and long term investment decisions.	20
CO6	Apply the appropriate sources of finance and mobilize the right quantum of finance and use them in most profitable investment avenues	15

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	rning Doma	ain Level	CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale				
CO1	TPS3	Apply	Value	Mechanism	1.1, 2.3.4, 2.4.3, 3.2.3, 4.2.1,
					4.2.2.
CO2	TPS3	Apply	Value	Mechanism	1.1, 2.3.4, 2.4.6, 3.2.3, 3.2.4,
					4.2.2
CO3	TPS3	Apply	Value	Mechanism	1.1, 2.3.4, 2.4.6, 3.2.3, 3.2.4,
					4.2.2
CO4	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.3.4, 2.4.6, 2.4.7,
					3.2.3, 3.2.4, 4.2.2
CO5	TPS3	Apply	Value	Mechanism	1.1, 2.3.4, 2.4.6, 2.4.7,
					3.2.3,3.2.4, 4.2.2
CO6	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.3.4, 2.3.3, 2.4.6,
					2.4.7, 3.2.3, 3.2.4, 4.2.1, 4.2.2

	wapp	mapping with Programme Outcomes and Programme Specific Outcomes													
	Cos	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO	PO	PO	PSO1	PSO2
	-										10	11	12		
	CO1	S	М	L	-	-	М	S	Μ	S	s	S	S	-	-
	CO2	S	М	L	-	-	-	М	Μ	S	s	S	M	-	-
	CO3	S	М	L	-	-	-	-	S	S	s	S	S	-	-
	CO4	S	М	L	-	М	М	L	S	S	s	S	M	-	-
	CO5	S	М	L	-	S	М	М	S	S	S	Μ	M	-	-
	CO6	S	М	L	-	-	М	М	S	S	М	М	S	-	-
ľ															

# Mapping with Programme Outcomes and Programme Specific Outcomes

S- Strong; M-Medium; L-Low

#### **Assessment Pattern: Cognitive Domain**

Cognitive	Continuous Assessmen Tests			As	it	End	
Levels	1	2	3	1	2	3	Semester Examinatio n
Remember	20	20	20	-	-	-	20
Understand	30	30	30	-	-	-	20
Apply	50	50	50	100	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

## **Assessment Pattern: Psychomotor**

Psychomotor Skill	Miniproject/Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	Assignment
Complex Overt Responses	
Adaptation	
Origination	

# Sample Questions for Course Outcome Assessment

- Course Outcome 1(CO1):
- 1. Define accounting.
- 2. Explain in detail about accounting concepts and conventions.
- 3. Prepare Trading Account, Profit and Loss Account and Balance Sheet from the following

S.NO	PARTICULARS	Debit balances (in Rs)	Credit balances(in Rs)			
1	Capital		300000			
2	Bank	15000				
3	Plant and machinery	40000				
4	Land and building	60000				
5	Debtors	20000				
6	Creditors		40000			
7	Cash	70000				
8	Purchases and sales	35000	50000			
9	Purchase returns and	7000	4000			
	sales returns					
10	Bills receivable	3000				

11	Bills payable		5000
12	Wages	40000	
13	Salaries	30000	
14	Discount		4000
15	Stock on Jan 2017	10000	
16	Furniture	7000	
17	Carriage inwards	5000	
18	Carriage outwards	6000	
19	Advertising	10000	
20	Travelling expense	3000	
21	Loans		60000
22	Vans	100000	
23	Telephone	2000	
	Total	463000	463000

4. From the following particulars, prepare comparative balance sheet of Malar Ltd as on 31<sup>st</sup> March 2017 and 31<sup>st</sup> March 2018.

Particulars	31 <sup>st</sup> March 2017	31 <sup>st</sup> March 2018
I EQUITY AND LIABILITIES		
1. Shareholders' fund		
a) Share capital		
b) Reserves and surplus	2,00,000	2,50,000
2. Non-current liabilities	50,000	50,000
Long-term borrowings		
3. Current liabilities	30,000	60,000
Trade payables		
	20,000	60,000
Total	3,00,000	4,20,000
II ASSETS		
1. Non-current assets		
a) Fixed assets	1,00,000	1,50,000
b) Non - current investments	50,000	75,000
2. Current assets		
a)Inventories	75,000	1,50,000
b) Cash and cash equivalents	75,000	45,000
Total	3,00,000	4,20,000

# Course Outcome 2(CO2):

- 1. Define cost sheet. Comment the uses of it.
- 2. Classify the cost according to function.
- 3. Prepare cost sheet in the book of Vimi from the following particulars.

Opening stock:	<ul> <li>Raw material</li> </ul>	=	Rs 5,000
	Finished goods	=	Rs 4,000
Closing stock:	Raw material	=	Rs 4,000
	Finished goods	=	Rs 5,000
Raw materia	al purchased	=	Rs 50,000
Wages paid	to labours	=	Rs 20,000
Chargeable	expenses	=	Rs 2,000
Rent and Ta	ixes	=	Rs 7,400
Power		=	Rs 3,000
Experimenta	al expenses	=	Rs 600
Sale of wast	age of material	=	Rs 200
Office mana	gement salary	=	Rs 4,000
Office printir	ng & stationery	=	Rs 200

Salaries to salesman	=	Rs 2,000
Commission to travelling agents	=	Rs 1,000
Sales	=	Rs 1, 00,000

# Course Outcome 3(CO3):

- 1. Define budget and budgeting.
- 2. Classify the budget based on function.
- 3. Explain the advantages and applications of budgetary control.
- 4. Define depreciation.
- 5. From the forecast of income and expenditure prepare a cash budget for the months from April to June 2019.

Month	Sales Rs	Purchases Rs	Wages Rs	Office expenses Rs	Selling expenses Rs
Feb	70,000	45,000	4,500	2,700	1,800
Mar	72,000	43,000	4,700	3,000	2,000
Apr	75,000	44,000	4,900	2,900	2,200
May	71,000	40,000	5,000	3,000	2,100
Jun	70,000	42,000	5,000	2,800	1,900

- Plant worth Rs25, 000 purchased in June. 40% payable immediately and the remaining in two equal instalments in subsequent months.
- o Advance tax payable in April Rs 4500
- Period of credit allowed
  - By suppliers 2 months
  - To customer 1 month
- Dividend payable Rs 7000 in June
- Delay in payment of wages and office expenses 1 month and selling expenses 1 month. Expected cash balance on 1<sup>st</sup> April Rs 30,000
- Machinery expected to sell on May is Rs 20,000

# Course Outcome 4 (CO4):

- 1. What is meant by breakeven point?
- 2. List the business applications of breakeven analysis.
- 3. From the following information calculate the Breakeven point in terms of units and breakeven point in terms of sales. Sales....Rs.10, 000, Variable costs Rs.6, 000, fixed costs Rs.2000: profit Rs.2, 000; No. Of units produced 1,000 units.
- 4. Calculate the breakeven point and margin of safety from the following information Fixed cost ...Rs.10, 000, sales in Rs.25, 000, selling price per unit Rs.30; variable Cost per unit Rs.10

# Course Outcome 5(CO5):

- 1. What is meant by working capital?
- 2. Classify capital budgeting decisions.
- 3. From the following information extracted from the books of a manufacturing company, compute the operating cycle in days and the amount of working capital required:

Period Covered	= 365 days
Average period of credit allowed by suppliers	= 16 days
Average Total of Debtors Outstanding	= 480
Raw Material Consumption	= 4,400
Total Production Cost	= 10,000
Total Cost of Sales	= 10,500
Sales for the year	= 16,000
Value of Average Stock maintained:	
Raw Material	= 320
Work-in-progress	= 350

#### Finished Goods

= 260

4. From the following data of a project, Calculate IRR and suggest whether the project is to be undertaken or not if the cut off rate is 9%.

Cash Out fl	ow (Rs.)	1,50,000
	Year 1	41,000
Cach Inflow/(Bc.)	Year 2	50,000
Cash Innow(RS.)	Year 3	50,000
	Year 4	42,000

## Course Outcome 6(CO6):

- 1. List the sources of finance.
- 2. What is meant by dividend?
- 3. Suggest suitable sources of finance to start a business with a capital of 60 crores.

#### **Concept Map**



#### Syllabus

**Accounting** –Introduction, definition, accounting principles-functions of accounting – Preparation of Financial statements and their analysis with the common size and comparative statements.

**Cost Accounting** - Meaning and importance -Elements of cost- classification of cost- Cost centre, Preparation of cost sheet and its applications. Depreciation – meaning and causes of depreciation, Methods to find out the depreciation

**Budget and Budgetary control**- Introduction-Meaning -objectives of budgetary control – Budget-Types of budgets and their preparation.

**Marginal costing-** Introduction, Break even analysis –Managerial of breakeven analysis. Activity based Costing

**Capital budgeting-** Meaning and features, capital budgeting decisions, Methods of evaluating capital budgeting decisions by traditional and modern methods, Working capital management - concept, classification, estimation of working capital requirements.

**Finance**: Functions, Objectives of financial management and Source of finance and financial institutions, Venture capital.

#### Learning Resources

- M.C.Shukla,T.S.Grewal, "AdvancedAccounts-Volume-I,2010 Reprint, S. Chand & company Ltd.,2010.
- Prasanna Chandra, "Financial Management-Theory and practice" seventh Reprint, Tata McGraw-Hill publishing company Limited, 2010.
- P.S.Boopathi Manickam "Financial and Management Accounting" PSG publications 2009.
- Don R. Hansen and Maryanne M. Mowen "Cost Management: Accounting and Control, Fifth Edition" Thomson, 2006.
- Michael C . Ehrhardt and Eugene F. Brigham, "Financial Management: Theory and Practice -thirteenth edition" South-Western cengage learning, 2011
- Pandey, "Financial Management", Vikas Publishing House Pvt. Ltd., 2007

- Paramasivan.C, Subramanian.T, "Financial management" New Age international Publishers, 2014.
- https://nptel.ac.in/courses/110101003/
- https://swayam.gov.in/nd1\_noc19\_mg38/preview
- Website: https://www.youtube.com/watch?v=P9JIBbZas3w

#### **Course Contents and Lecture Schedule**

Module	Торіс	No. of	COs
1	Accounting	Lectures	
11	Introduction Definition Eurocians of accounting	1	
1.1	Accounting principles	1	
13	Prenaration of Financial statements	3	CO1
1.0	Common size statement analysis	1	
1.4	Comparative statement analysis	1	
2	Cost Accounting	1	
21	Meaning importance and Elements of cost	1	CO2
2.1	classification of cost and meaning of Cost centre	1	002
2.2	Preparation of Cost sheet and its applications	3	
2.0	Depreciation – meaning and causes of depreciation	1	
2.5	Methods to find out the depreciation	2	
3	Budget and Budgetary control	-	CO3
31	Introduction- Meaning -objectives of budgetary control –	1	
3.2	Budget- Types of budgets and their preparation	4	
4	Marginal costing	-	
4.1	Introduction, Break even analysis	2	CO4
4.2	Managerial uses of breakeven analysis.	1	
4.3	Activity Based Costing	2	
5	Capital budgeting		
5.1	Meaning and features, capital budgeting decisions	1	
5.2	Methods of evaluating capital budgeting decisions by	4	
	traditional and modern methods		CO5
5.3	Working capital management – concept, classification,	1	
5.4	Estimation of working capital requirements.	1	
6	Finance		
6.1	Functions and Objectives of Financial management	1	CO6
6.2	Source of finance and financial institutions	3	
6.3	Venture capital.	1	
	Total	37 hrs	

# **Course Designers:**

• Mr. B.Brucelee

• Dr. R.Sivasankaran

bbmech@tce.edu rssmech@tce.edu

18EC620	CONTROL SYSTEMS	Category	L	Т	Ρ	Credit
		PC	2	1	0	3

#### Preamble

Control Systems plays vital role in the advance of engineering and science. Automatic control has become an important and integral part of modern manufacturing and industrial processes. Advances in the theory and practice of automatic control provide the means for attaining optimal performance of dynamic systems improving productivity.

#### Prerequisite

18EC340 Signals and Systems, Laplace Transforms

#### Course Outcomes

On the successful completion of the course students will be able to

CO#		Course Outcome Statement Weightage in %										
CO1	Develop a	mathematio	cal model	for a given sy	ystem in Laplace	10						
	domain and	time domai	n.		-							
CO2	Compute transfer function of multiple subsystems modelled as 15											
	block diagra	m/ signal flo	ow graph/ s	state space repr	resentation							
CO3	Compute ar	nd describe	the output	response and	steady state error	20						
	of first, seco	nd and high	ner order sy	stems for stand	dard input signals							
CO4	Determine	the stability	of a sys	tem using Rou	uth Hurwitz/ Root	20						
	locus/ Nyqu	ist criterion	F									
CO5	Find the c	losed loop	frequency	<mark>/ response</mark> an	d time response	20						
	parameter g	iven the op	en loop free	quency respons	e.							
CO6	Design PIE	) controlle	r with fre	quency respor	ise method and	15						
	computation	al optimizat	tion approa	ich								
CO M	lapping with	<b>CDIO Curr</b>	iculum Fra	amework								
CO	TCE	Lea	rning Doma	ain Level	CDIO Curricula	r Components						
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y	′.Z)						
	Scale		10-10									
CO1	TPS3	Apply	Value	Guided	1.2, 2.1.1, 2.1.2, 2	2.1.4, 2.1.5, 2.4.1,						
				Response	2.4.2, 2.4.5, 3.2.3	, 3.2.5,						
CO2	TPS3	Apply	Value	Guided	1.2, 2.1.1, 2.1.2, 2	2.1.4, 2.1.5, 2.4.1,						
				Response	2.4.2, 2.4.5, 3.2.3	, 3.2.5,						
CO3	TPS3	Apply	Value	Guided	1.2, 2.1.1, 2.1.2, 2	2.1.4, 2.1.5, 2.4.1,						
				Response	2.4.2, 2.4.5, 3.2.3	, 3.2.5,						
CO4	TPS4	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2	2.1.3, 2.1.4, 2.1.5,						
					2.4.1, 2.4.2, 2.4.5	, 3.2.3, 3.2.5,						
CO5	TPS4	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2	2.1.3, 2.1.4, 2.1.5,						
					2.4.1, 2.4.2, 2.4.5	, 3.2.3, 3.2.5,						
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2	2.1.3, 2.1.4, 2.1.5,						
L					2.4.1, 2.4.2, 2.4.5	, 3.2.3, 3.2.5,						
Марр	ing with Pro	gramme Ou	utcomes a	nd Programme	Specific Outcome	es						
- COs		PO   PO   F	20   PO   F	PO   PO   PO		SO   PSO   PSO						

Mappi	mapping with rogramme outcomes and rogramme opecine outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	М	L	-	L	-	-	М	М	М	-	L	М	-	М
CO2	S	М	L	-	L	-	-	М	М	М	-	L	М	-	М
CO3	S	М	L	-	L	-	-	М	М	М	-	L	М	-	М
CO4	S	М	L	-	L	-	-	М	М	М	-	L	М	-	М
CO5	S	М	L	-	L	-	-	М	М	М	-	L	М	-	М
CO6	S	М	L	-	L	-	-	М	М	М	-	L	М	-	М

S- Strong; M-Medium; L-Low

Assessment i attern. oogintive bornan											
Cognitive	Contir	nuous As	sessment		Assignme	End Semester					
Levels		Tests					Examination				
	1	2	3	1	2	3					
Remember	0	0	0	0	0	0	0				
Understand	20	20	20	0	30	30	20				
Apply	80	80	80	100	40	40	80				
Analyse	0	0	0	0	0	0	0				
Evaluate	0	0	0	0	0	0	0				
Create	0	0	0	0	0	0	0				
<b>Assessment P</b>	attern: P	sychomo	otor								
Psychomotor	Skill		Assignme	ent-1	Assignm	ent-2	Assignment-3				
Perception			-		-		-				
Set			-		-		-				
Guided Respo	nse		-		-		-				
Mechanism			-		30		30				
Complex Over	t Respon	ses	-		-		-				
Adaptation			-		-		-				
Origination				-			-				

# Assessment Pattern: Cognitive Domain

Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

1. Find the transfer function G(s) = C(s)/R(s) corresponding to the differential equation

$$\frac{d^{3}c}{dt^{3}} + 3\frac{d^{2}c}{dt^{2}} + 7\frac{dc}{dt} + 5c = \frac{d^{2}r}{dt^{2}} + 4\frac{dr}{dt} + 3r$$

2. Find the transfer function relating the capacitor voltage  $V_C(s)$  to the input voltage V(s) in Figure.1.



3. Find the state space representation of the transfer function shown in Figure.2.

$$\xrightarrow{R(s)} \underbrace{\frac{s^2 + 7s + 2}{s^3 + 9s^2 + 26s + 24}}_{(a)} C(s)$$

#### Course Outcome 2 (CO2):

2. Consider the unit step response of a unity feedback control system whose open loop transfer function is  $G(s) = \frac{1}{s(s+1)}$ . Determine the rise time, peak time, maximum

overshoot and settling time.

3. Compare the rise time, peak time and maximum overshoot of the following systems.

a. 
$$\frac{C(s)}{R(s)} = \frac{36}{s^2 + 2s + 36}$$
 b.  $\frac{C(s)}{R(s)} = \frac{16}{s^2 + 6s + 16}$ 

4. If the step response of a network is  $1 - e^{-\alpha t}$ , what is the impulse response? **Course Outcome 3 (CO3):** 

# 1. Simplify the block diagram shown in Figure 3, then obtain the closed loop transfer

function C(s)/R(s).



2. Consider the signal flow graph shown in Figure 1. The gain  $X_5/X_1$  is



3. Find the closed loop transfer function T(s) = C(s)/R(s) for the system shown in Figure.5. using block diagram reduction



#### Course Outcome 4 (CO4):

1. How many poles are in the right half plane, in the left plane and on the  $j\omega$  axis for the open loop system of Figure.6.

$$\frac{R(s)}{s^4 + 4s^3 + 8s^2 + 20s + 15} \xrightarrow{C(s)}$$

Figure.6.

2. In the system of Figure.7, let  $G(s) = \frac{K(s+2)}{s(s-1)(s+3)}$ . Find the range of K for closed loop

stability.



- 3. For the system shown in Figure.8. make an accurate plot of the root locus and find the following:
  - a. The breakaway and break-in points
  - b. The range of K to keep the system stable
  - c. The value of K that yields a stable system with critically damped second order poles.



#### Course Outcome 5 (CO5):

- 1. Draw the Bode diagram of the transfer function  $G(s) = \frac{100(s+1)}{s(s+5)}$ .
- 2. Draw the Polar plot of the transfer function  $G(s) = \frac{5}{s(s+1)(s+2)}$
- 3. Design a lag compensator by using frequency response method for the system with open loop transfer function  $G(s) = \frac{1}{s(s+1)(0.5s+1)}$ .

#### Course Outcome 6 (CO6):

1. Consider the electronic circuit involving two operational amplifiers shown in Figure 9. This is a modified PID controller in that the transfer function involves an integrator and a first-order lag term. Obtain the transfer function of this PID controller.



Figure.9

2. In practice, it is impossible to realize the true differentiator. Hence, we always have to approximate the true differentiator  $T_d s$  by something like  $\frac{T_d s}{1 + \gamma T_d s}$  One way to realize

such an approximate differentiator is to utilize an integrator in the feedback path. Show that the closed-loop transfer function of the system shown in Figure.10 is given by the preceding expression. (In the commercially available differentiator, the value of  $\gamma$  may be set as 0.1.)



Figure.10

3. Consider the system shown in Figure 11. This is a PID control of a second-order plant G(s). Assume that disturbances D(s) enter the system as shown in the diagram. It is assumed that the reference input R(s) is normally held constant, and the response characteristics to disturbances area very important consideration in this system.



#### **Concept Map**



#### **Syllabus**

Modeling of Control Systems: Open loop LTI systems, Closed loop LTI systems, Modelling in Laplace Domain, Laplace transform review, transfer function, electrical network transfer function, Electric circuits analogs, Modelling in time domain, general state-space representation, converting a transfer function to state space, converting from state space to a transfer function

Reduction of multiple subsystems: Block diagrams, Analysis and design of feedback systems, signal flow graphs, Mason's rule, signal flow graph of state equation.

**Time response:** Poles, zeros and system response, First order systems, second order Systems, General second order systems, underdamped second order systems, Higher order systems, System response with additional poles, system response with zeros, Effects of non linearities upon time response

Stability: Routh Hurwitz criterion, Root locus techniques, Nyquist stability

Frequency response techniques: Bode plot, Nyquist diagram, Gain margin, phase margin, transient response via gain adjustment. Lag compensation, Lead compensation, Lag-Lead compensation

**PID Controllers:** Design of PID controller using frequency response approach and computational optimization approach

#### Learning Resources

- 1. Norman Nise, " Control System Engineering" John Wiley & Sons, 6th Edition, 2011
- 2. Katsuhiko Ogata, "Modern Control Engineering", 4<sup>th</sup> Edition, Prentice Hall, 2002
- 3. Richard C.Dorf and Robert H.Bishop, "Modern Control Systems" Twelfth Edition, Prentice Hall. 2011.
- 4. https://nptel.ac.in/courses/108101037/
- 5. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-30-feedback-controlsystems-fall-2010/

Cours										
No.	Торіс	No.	of	COs						
		Lecture	es							
1	Modeling of Control Systems									
1.1	Open loop LTI systems, Closed loop LTI systems	1		CO1						
1.2	Modelling in Laplace Domain, Laplace transform review	1		CO1						
1.3	Transfer function	1		CO1						
1.4	Electrical network transfer function	1		CO1						

1.5	Electric circuits analogs	1	CO1
1.6	Modelling in time domain, general state-space representation	1	CO2
1.7	Converting a transfer function to state space	1	CO2
1.8	Converting from state space to a transfer function	1	CO2
2	Reduction of multiple subsystems		
2.1	Block diagrams	1	CO2
2.2	Analysis and design of feedback systems	1	CO2
2.3	signal flow graphs	1	CO2
2.4	Mason's rule	1	CO2
2.5	signal flow graph of state equation	1	CO2
3	Time response		
3.1	Poles, zeros and system response	1	CO3
3.2	First order systems, second order Systems	1	CO3
3.3	General second order systems, underdamped second order systems	1	CO3
3.4	Higher order systems	1	CO3
3.5	System response with additional poles	1	CO3
3.6	system response with zeros	1	CO3
3.7	Effects of non linearities upon time response	1	CO3
4	Stability		
4.1	Routh Hurwitz criterion	1	CO4
4.2	Root locus techniques	2	CO4
4.3	Nyquist stability	2	CO4
5	Frequency response techniques		
5.1	Bode plot	2	CO5
5.2	Nyquist diagram	1	CO5
5.3	Gain margin, phase margin	1	CO5
5.4	Transient response via gain adjustment	1	CO5
5.5	Lag compensation	1	CO5
5.6	Lead compensation	1	CO5
5.7	Lag-Lead compensation	1	CO5
6	PID Controllers		
6.1	Design of PID controller using frequency response	2	CO6
6.2	approach and computational optimization approach	1	CO6
	Total	36	
Cours	se Designers:		

1. Dr.S.J.Thiruvengadam

2. Dr.P.G.S.Velmurugan

sjtece@tce.edu pgsvels@tce.edu

18EC630	DATA STRUCTURES AND	Category	L	Т	Ρ	Credit
1020000	ALGORITHMS	ES	2	0	0	2

#### Preamble

The study of data structures is important for efficient way of organising big data and implement cost effective algorithms to process the data in solving any real-world application. This course aims at introducing the abstract concepts for data organization and manipulation using data structures such as stacks, queues, linked lists, binary and multi-way trees, heaps, hash tables and graphs. It also discusses about implementation and time complexity of algorithms including various sorting algorithm, graph algorithms and dynamic programming paradigm.

#### Prerequisite

18EC360 Programming for Problem Solving

#### **Course Outcomes**

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Implement linear data structures such as stack, queue, linked	25
	lists	
CO2	Implement non-linear data structures such as binary trees,	30
	multi-way trees and priority queues.	
CO3	Analyze the time complexity of various sorting and hashing	15
	algorithms.	
CO4	Apply dynamic programming and graph algorithms in solving	15
	real time problem.	
CO5	Choose appropriate data structure and algorithms to solve a	15
	problem efficiently.	

#### CO Mapping with CDIO Curriculum Framework

CO		TCE			Le	earning	g Dom	nain Le	evel				CDIO (	Curricul	ar
#	Pr	oficier	icy [	Cogn	itive	Affe	ective	P	sycho	moto	or		Comp	onents	
		Scale	-	•					•				(X.	Y.Z)	
CO1		TPS3		Ар	ply	Valu	е	Me	chanis	sm		1.1,	2.1.1, 2	2.1.2, 2.	4.3,
				-	-							4.5.3	3		
CO2		TPS3		Ap	ply	Valu	е	Me	chanis	sm		1.1,	2.1.1, 2	2.1.2, 2.	4.3,
												4.5.3	3		
CO3		TPS3		Ap	ply	Valu	е	Me	chanis	sm		1.1,	2.1.1, 2	2.1.2, 2.	4.3,
												4.5.3			
CO4		TPS4		Ana	lyze	Orga	anize	Co	mplex	Ove	rt	1.1, 2.1.1, 2.1.2, 2.1.3,			1.3,
					•			Re	spons	es		2.3.1, 2.4.3, 4.5.3			
CO5		TPS4		Ana	lyze	Orga	anize	Co	Complex Overt			1.1,	2.1.1, 2	2.1.2, 2.	1.3,
					•	-		Re	spons	es		2.3.1	1, 2.4.3	, 3.1.1,	3.1.2,
									-			3.2.4	4, 4.5.1	, 4.5.3	
Марр	ing w	ith Pr	ogra	mme (	Dutco	mes a	nd Pr	ograr	nme S	Spec	ific (	Outco	omes		
COs	PO1	PO2	PO3	PO4	PO5	PO6	P07	PO8	PO9	PO	PO	PO	PSO1	PSO2	PSO3
001	-									10	11	12			
001	S	M	L	-	M	-	-	-	-	-	-	L	M	-	-
CO2	S	М	L	-	М	-	-	-	-	-	-	L	M	-	-
CO3	S	Μ	L	-	M	-	-	-	-	-	-	L M -			-
CO4	S	S	M	L	M	-	-	-	-	-	-	L	S	-	-

\_

S

\_

S

\_

S S- Strong; M-Medium; L-Low

Μ

L

Μ \_

CO5 S

S

\_

Assessment Fattern. Cognitive Domain											
Cognitive	Contir	nuous As	ssessment		Assignme	nt	End Semester				
Levels		Test	S		C	Examination					
	1	2	3	1	2	3					
Remember	0	0	0	0	0	0	0				
Understand	20	20	20	0	0	0	20				
Apply	60	60	60	100	60	60	50				
Analyse	20	20	20	0	40	40	30				
Evaluate	0	0	0	0	0	0	0				
Create	0	0	0	0	0	0	0				
Assessment P	attern: P	sychom	otor								
Psychomotor Skill			Assignme	ent-1	Assignm	ent-2	Assignment-3				

Create	U	0		0	0		0	0		0	
Assessment Pattern: Psychomotor											
Psychomotor Skill			Assignment-1				Assignm	Assignment			
Perception				-			-			-	
Set				-			-			-	
Guided Respo	nse			-			-			-	
Mechanism				-			-			-	
Complex Over	t Respor	ises		-			-			-	
Adaptation				-			-			-	
Origination				-			-			-	

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

1. Given a linked list, split it into two lists where each list containing alternating elements from the original list. The elements in the new lists may be in any order. For example, if the original list is {a, b, a, b, a}, then one sublist should be {a, a, a} and the other should be {b, b}.

2. Write a program to implement operations of queue using linked list

#### Course Outcome 2 (CO2):

1. Given a Binary Search Tree and a positive number K, find K'th smallest and K'th largest element in BST. For example, consider below binary search tree. If k = 2, the K'th smallest element is 10 and K'th largest element is 20.



2. Write the algorithm for inserting the keys into a B- tree and insert the keys 12, 9, 6, 3, 15, 56, 36, 34, 28, 45, 74, 71, 60, 55, 1, 5, 7, 4, 24, 27, 50, 52 into a B-tree of order 5. Draw the resultant B-tree after deleting the keys 23, 74, 45, 6, 9 from the constructed tree.

#### Course Outcome 3 (CO3):

1. Write the procedure to find minimum spanning tree of a graph shown below using Kruskal's algorithm. Obtain the minimum cost using Kruskal's algorithm. (5)



2. Obtain the topological sorting of the process flow of a manufacturing company shown below.



#### Course Outcome 4 (CO4):

- 1. Analyze the time complexity of insertion sort if (i) all keys are equal (ii) keys already sorted (iii) keys in descending order
- 2. Given input keys {55, 45, 66, 77, 95, 98, 79} and a hash function h(x) = x (mod 10), analyze the performance of hashing done by open hashing and closed hashing techniques.

#### Course Outcome 5 (CO5):

- 1. Given an arithmetic expression, develop an algorithm to check for matching parenthesis and choose an appropriate data structure to implement the algorithm efficiently.
- 2. Analyze the efficiency of using singly linked list and doubly linked list for checking whether a given text is palindrome or not.

#### Concept Map



#### Syllabus

**Overview:** Role of data structures and algorithms in data organization, Abstract Data Types, Asymptotic measures, Types of algorithms: Divide and Conquer, greedy, back tracking, dynamic programming, parallel algorithms

**Linear Data Structures:** Implementation of Stacks, Queues, Linked Lists and applications. **Nonlinear Data Structures:** Implementation of Binary Search tree, AVL tree, Splay Tree, B-

tree and Priority Queues: Binary Heaps, Binomial heap, applications.

Hashing: Hash tables, Hash functions, Collision Resolution: Open Addressing, Closed Hashing

**Sorting Algorithms:** Implementation and time complexity analysis of Shell Sort, Quick Sort, Heap sort, Merge Sort, Bitonic sort (parallel algorithm)

**Graph Algorithms:** Graph Terminologies, Topological Sorting, Shortest Path Algorithms, Minimum Spanning Tree algorithms, Case study on Data science/ Big Data problems modelled as Graph

**Dynamic Programming:** Elements of dynamic programming, knapsack problem, Longest Common subsequence

#### Learning Resources

- Mark Allen Weiss, "Data Structures and Algorithm Analysis in C ", 2<sup>nd</sup>edition, Pearson Education, 2002.
- Lipschutz and G.A.V. Pai, "Data Structures with C", Tata McGraw-Hill, 2010.
- Michael T., Goodrich, "Data Structures and Algorithms in C++", 2<sup>nd</sup> edition, John Wiley, 2016.
- Sartaj Sahni, "Data Structures, Algorithms and applications in C++", 2<sup>nd</sup> edition, Silicon Press, 2017.
- Adam Drozdek," Data Structures and Algorithms in C++", 4<sup>th</sup> edition, Cengage Learning, 2013.
- Michael T., Goodrich, "Data Structures and Algorithms in Python", 2<sup>nd</sup> edition, John Wiley, 2016.
- Mark Allen Weiss, "Data Structures and Algorithm Analysis in java ", 6<sup>th</sup> edition, Pearson Education, 2014.
- Nell Dale, "C++ Data structures", 6<sup>th</sup> edition, Jones and Bartlett Publishers, 2016.
- Cormen, Thomas, Charles Leiserson, et al. *Introduction to Algorithms*. 3<sup>rd</sup> edition, MIT Press, 2009.
- Coursera course on "Big Data Graph Analytics", https://www.coursera.org/learn/big-datagraph-analytics/home/welcome
- NPTEL course on "Programming, Data Structures And Algorithms Using C", https://nptel.ac.in/noc/courses/noc18/SEM1/noc18-cs25/
- NPTEL course on "Data Structure and Algorithms using Java" https://onlinecourses.nptel.ac.in/noc20\_cs85/

Cours	Course Contents and Lecture Schedule									
No.	Торіс	No. of	Cos							
		Hours								
1	Overview									
1.1	Role of data structures and algorithms in data organization, Data	2	CO1							
	Abstraction and Abstract Data Types, Asymptotic measures,									
	Types of algorithms: Divide and Conquer, greedy, back tracking,									
	dynamic programming, parallel algorithms									
2	Linear Data structures									
2.1	Basic operations and applications of Stacks, Queues	3	CO1							
2.2	Linked Lists: Single Linked List – Doubly Linked List – Circular	2	CO1							
	Linked									
3	Non-linear Data structures									
3.1	Basic operations and applications of Binary Search Tree, AVL	2	CO2							
	tree									
3.2	Splay Tree, B-tree	2	CO2							
3.3	Priority Queues: Binary Heaps, Binomial heap	2	CO2							
	Assignment 1: B+ tree, Trie Tree, Red-Black Tree									
4	Hashing									
4.1	Hash tables, Hash functions.	1	CO3							
4.2	Collision Resolution: Open Addressing, Closed Hashing	1	CO3							
5	Sorting Algorithms									
5.1	Shell sort, Quick Sort, Heap Sort	2	CO3							

# Passed in BoS Meeting 04.07.2020

5.2	Merge Sort, Bitonic sort (Parallel Algorithm)	1	CO3
	Assignment 2: Parallel Algorithms		
6	Graph Algorithms		
6.1	Topological Sorting	1	CO4
6.2	Minimum Spanning Tree Algorithms	1	CO4
6.3	Shortest Path Algorithms	1	CO4
6.4	Case study on Data science/ Big Data problems modelled as	1	CO4
	Graph		
7	Dynamic Programming		
7.1	Elements of dynamic programming, knapsack problem	1	CO4
7.2	Longest Common subsequence	1	CO4
	Assignment 3: Real Time Applications of data structures and		
	algorithms in different fields		
	*CO5 covered in complete syllabus	24	
Cours	se Designers:		

• Dr. S. Ponmalar

spmece@tce.edu manimsk@tce.edu

Dr.M.S.K. ManikandanDr. E. Murugavalli

murugavalli@tce.edu

18EC660	DIGITAL COMMUNICATION SYSTEM	Category	L	Т	Ρ	Credit
	DESIGN	PC	1	0	2	2

# Preamble

The course is offered as theory cum practical course. The objective of this course is to design, simulate and implement a complete digital communication system. The theory part gives the state of the art in digital synchronization for a communication system. The practical part of the course provides hands on training for the students to simulate and implement a complete digital communication system for the transmission of text/image over real time channels.

## Prerequisite

18EC580 Analog and Digital Communications Laboratory

#### Course Outcomes

On the successful completion of the course, students will be able to

CO#			Weightage							
CO1	Describe the	- functionalitie	es of sub	blocks of diait	al communication	10 <sup>IN</sup> %				
001	system			blocke of digit		10				
CO2	Design and	simulate the i	mapper, pu	lse shaper and	matched filter for	15				
	a digital com	munication tra	ansceiver							
CO3	Determine the tapped delay line model for the wire line channel.									
CO4	Simulate th communicati	ie timing, c on system	arrier reco	overy algorith	m for a digital	15				
CO5	Design and communicati	simulate ec	qualizer an	d the detecto	or for the digital	20				
CO6	Implement the complete the digital communication transceiver in 20 Universal Software Radio Peripheral (USRP)									
C07	Transmit and receive the given text and image through the digital 20 communication transceiver.									
CO Mapping with CDIO Curriculum Framework										
CO	TCE	Learr	ning Domair	n Level	CDIO Curricular C	Components				
#	Proficiency Scale	Cognitive	Affective	Psychomotor	(X.Y.Z	)				
CO1	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.1.2, 2	.1.3, 2.4.3				
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2 2.4.4, 3.1.1, 3.1.2,	.1.3, 2.4.3, 3.2.5, 3.2.6				
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2	.1.3, 2.4.3,				
					2.4.4, 3.1.1, 3.1.2,	3.2.5, 3.2.6				
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2	.1.3, 2.4.3,				
					2.4.4, 3.1.1, 3.1.2,	3.2.5, 3.2.6				
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2	.1.3, 2.4.3,				
					2.4.4, 3.1.1, 3.1.2,	3.2.5, 3.2.6				
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2	.1.3, 2.4.3,				
					2.4.4, 3.1.1, 3.1.2,	3.2.5, 3.2.6,				
0.07			<u> </u>		4.5.3, 4.5.5					
C07	1954	Analyze	Organise	Complex	1.2, 2.1.1, 2.1.2, 2	.1.3, 2.1.4,				
				Overt	2.1.5, 2.4.3, 2.4.4,	2.4.6, 3.1.1,				
				Responses	3.1.2, 3.2.5, 3.2.6,	4.5.3, 4.5.5				

# Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO	PO	PO	PSO1	PSO2	PSO3
										10	11	12			
CO1	S	М	L	-	-	-	-	-	S	-	-	-	М	-	Μ
CO2	S	М	L	-	S	-	-	М	S	-	-	-	М	-	Μ
CO3	S	М	L	-	S	-	-	Μ	S	-	-	-	М	I	Μ
CO4	S	М	L	-	S	-	-	Μ	S	-	-	-	М	I	Μ
CO5	S	М	L	-	S	-	-	Μ	S	-	-	-	М	I	Μ
CO6	S	М	L	-	S	-	-	М	S	S	-	-	М	-	S
CO7	S	S	М	L	S	-	-	Μ	S	S	-	-	Μ	-	S

S- Strong; M-Medium; L-Low

# **Assessment Pattern: Cognitive Domain**

Cognitive	Contin	uous Assess	End Semester	
Levels	1	2	3	Examination
Remember	0	0	0	
Understand	20	20	20	
Apply	80	60	60	Lab Examination
Analyse	0	20	20	
Evaluate	0	0	0	
Create	0	0	0	

# **Assessment Pattern: Psychomotor**

Psychomotor Skill	Practical
Perception	-
Set	-
Guided Response	50
Mechanism	50
Complex Overt Responses	-
Adaptation	-
Origination	-

# Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

1. Show that I(X:Y) = H(X) + H(Y) - H(XY).

- 2. Draw the block diagram of digital communication system and explain the individual sub blocks.
- 3. Consider the four waveforms shown in Figure.1. Determine the dimensionality of the waveform and set of basis functions.



# Course Outcome 2 (CO2):

- 1. Calculate the bandwidth required to transmit data at the rate of 5000bps with the following specification.
  - a. 16 QAM constellations filtered with RC pulses of roll off factor=0.5.
  - b. 16 QAM constellations filtered with Nyquist pulses
- 2. For a data rate of 9600 bps data transmission with 4 PAM modulation over a channel

with transfer function given by,  $C(f) = \frac{1}{1 + \left(\frac{f}{2400}\right)^2}$ . Obtain the transmit filter and

receive filter frequency response assuming channel compensation at transmitter.

3. For data rate of 4800bps data transmission with 2 PAM modulation over a channel with transfer function given by,

$$\left|C(f)\right| = \frac{1}{\sqrt{1 + \left(\frac{f}{W}\right)^2}} \quad \left|f\right| \le W$$

Where W =4800.Obtain the transmit filter and receive filter frequency response assuming compensation at both transmitter and receiver.

# Course Outcome 3 (CO3):

- 1. Suppose that h(t) = g(t) 0.5g(t T), is the received pulse, with the transmitted pulse g(t) as unit energy pulse and T as the symbol time. Obtain the equivalent white noise filter model.
- 2. Given an input sequence  $I_n = \{1, 1, -1\}$  and the impulse response of the equivalent channel  $x(n) = \{1, 0.5\}$ . Determine the noise free output of the channel.
- 3. The impulse response of a channel is given by  $h = \{1, 0.5.0.25\}$ . Determine the sample autocorrelation.

# Course Outcome 4 (CO4):

1. In the transmission and reception of signals to and from moving vehicles, the transmitted signal frequency is shifted in direct proportion to the speed of the vehicle. The so called Doppler frequency shift imparted to a signal that is received in a vehicle travelling at a

velocity v relative to a fixed transmitter is given by the formula  $f_0 = \pm \frac{v}{\lambda}$ , where  $\lambda$  is he

wavelength and the sign depends on the direction (moving toward or moving away) that the vehicle is travelling relative to the transmitter. Suppose that a vehicle is travelling at a speed of 100 km/h relative to a base station in a mobile cellular communication system. The signal is a narrowband signal transmitted at a carrier frequency 1 GHz.

- a. Determine the Doppler frequency shift.
- b. What should be the bandwidth of a Doppler frequency tracking loop if the loop is designed to track Doppler frequency shifts for vehicles travelling at speeds up to 100 km/h?
- 2. Repeat the problem (2) if the signal bandwidth is 2 MHz centred at 1 GHz
- 3. Consider a 600 baud signal with 100 % excess bandwidth. Design a pre-filter for square law timing recovery. Will the pre-filter improve performance?

# Course Outcome 5 (CO5):

- 1. Derive the transfer function of zero forcing equalizer. Consider  $X(z) = (1.16 + 0.4z^{-1} + 0.4z)$ ,
  - a. Determine the transfer function and impulse response of the zero forcing equalizer.
  - b. Determine the transfer function of equivalent equalizer with whitening filter.

- 2. Binary PAM is used to transmit information over an un-equalized channel. The noise free un-equalised samples are given as,  $v_{un}(k) = \{0.2, 0.3, 0.2\}$ ; Obtain the coefficient of three tap equalizer which gives an output of  $v_{eq}(k) = \{0, 1, 0\}$ ; Also find the  $v_{eq}(k)$  for  $k = \pm 2, \pm 3$
- 3. Suppose that a three tap MMSE equalizer is used to equalize a channel as shown below. Assume that the white noise density is 0.1.Determine the equalizer coefficients. Also determine the minimum error.



# **Syllabus**

**Theory:** Digital Communication Transceiver functional block diagram, Review of modulation, pulse shaping and matched filtering, Modelling of wire line channel, Phase Locked Loops, Frequency Synchronization, Timing synchronization, Equalization and detection, USRP functional block diagram, realization of transceiver on USRP with wire line channel

# Practical

1.	Design and simulation of Pulse Shape filters	CO2
2.	Design and simulation of Matched filters	CO2
3.	Design and simulation of digital Phase Locked Loops	CO2
4.	Design and simulation of timing recovery algorithms	CO4
5.	Design and simulation of carrier recovery algorithms	CO4
6.	Design and simulation of equalizer	CO5
7.	Design and simulation of a end to end PSK transceiver	CO6
8.	Design and simulation of a end to end QPSK/QAM transceiver	CO6
9.	Realization of Transceiver in USRP platform	CO7
10.	Text and image transmission using digital modulation techniques in	n USRP
	platform	CO7

# Learning Resources

• John R. Barry, Edward A. Lee and David G. Messerschmitt, "Digital Communication", Springer Science & Business Media, 2004.

- John. G. Proakis, Masoud Salehi, "Digital Communication", McGraw-Hill Education; 5th edition, 2007.
- Heinrich Meyr Marc Moeneclaey Stefan A. Fechtel, "Digital Communication Receivers Synchronization, Channel Estimation, and Signal Processing", JOHN WILEY & SONS, INC, 1998.
- Umberto Mengali & Aldo N.D.Andrea, "Synchronization techniques for receivers", Plenum Press, 1997.
- Prof. Suvra Sekhar Das, IIT Kharagpur, Modern Digital Communication Techniques, NPTEL Video Lectures, https://nptel.ac.in/courses/117/105/117105144/

**Course Contents and Lecture Schedule** 

No.	Торіс	No. of	COs
		Hours	
1	Digital Communication System Design		
1.1	Digital Communication Transceiver functional block diagram	1	CO1
1.2	Review of modulation	1	CO1
1.3	pulse shaping and matched filtering	2	CO2
1.4	Phase Locked Loops	1	CO2
1.5	Modelling of wire line channel	1	CO3
1.6	Frequency Synchronization	1	CO4
1.7	Timing synchronization	1	CO4
1.8	Equalization and detection	2	CO5
1.9	USRP functional block diagram	1	CO6
1.10	realization of transceiver on USRP with wire line channel	1	CO7
	Total	12	

# **Course Designers:**

- Dr.S.J.Thiruvengadam sjtece@tce.edu
- Dr.M.N.Suresh mnsece@tce.edu
- Dr.P.G.S.Velmurugan pgsvels@tce.edu

18EC670

## DATA STRUCTURES AND ALGORITHMS LABORATORY

Category	L	Т	Ρ	Credit
ES	0	0	2	1

# Preamble

The course is designed to supplement the theory course '18EC630 Data structures and Algorithms' by giving a practical exposure to design and analyse linear and non-linear data structures to the students. The course also provides students to identify and apply the suitable data structure and algorithms for the given real-world problem.

# Prerequisite

18EC360 Programming for Problem Solving

# Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage
		in %
CO1	Implement linear data structures such as stack, queue and linked link	30
	in solving real world application	
CO2	Implement insertion, removal, search and traversal operations in non- linear data structures such as binary search tree and AVL tree	10
CO3	Implement insertion find minimum and remove operations in binary	10
	heap data structure.	10
CO4	Implement Hash table with different collision resolution techniques.	10
CO5	Analyse the time complexity of sorting algorithms.	10
CO6	Implement graph algorithms such as topological sorting, minimum	10
	spanning tree and shortest path routing algorithm.	
CO7	Design and implement dynamic programming concepts for solving real	10
	world problems.	
CO8	Choose appropriate data structure and algorithms in implementing a	10
	given case study application.	

# CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	arning Doma	ain Level	CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale	_			
CO1	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO2	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO3	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO4	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO5	TPS4	Analyze	Organise	Complex	1.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1,
		-	_	Overt	2.4.3, 4.5.3
				Responses	
CO6	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO7	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO8	TPS4	Analyze	Organise	Complex	1.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1,
				Overt	2.4.3, 3.1.1, 3.1.2, 3.2.4,
				Responses:	4.5.1, 4.5.3

# Mapping with Programme Outcomes and Programme Specific Outcomes

			- 3												
Cos	P01	PO2	PO3	PO4	PO5	PO6	P07	PO8	PO9	PO	PO	PO	PSO1	PSO2	PSO3
										10	11	12			
CO1	S	Μ	L	-	S	-	-	-	-	-	-	-	М	-	-
CO2	S	Μ	L	-	S	-	-	-	-	-	-	-	M	-	-
CO3	S	Μ	L	-	S	-	-	-	-	-	-	-	M	-	-
CO4	S	Μ	L	-	S	-	-	-	-	-	-	-	M	-	-
CO5	S	S	Μ	L	S	-	-	-	-	-	-	-	S	L	-
CO6	S	Μ	L	-	S	-	-	-	-	-	-	-	M	-	-
CO7	S	Μ	L	-	S	-	-	-	-	-	-	-	M	-	-
CO8	S	S	Μ	L	S	-	-	-	S	S	-	S	S	L	S

#### S- Strong; M-Medium; L-Low

#### Assessment Pattern: Cognitive Domain

Cognitive	Model Examination/	End Semester Examination							
Leveis	WIIII FIOJECI								
Remember	-	-							
Understand	-	-							
Apply	70	70							
Analyse	30	30							
Evaluate	-								
Create	-								

# **Assessment Pattern: Psychomotor**

Psychomotor Skill	Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

# List of Experiments/Activities with CO Mapping

- a. Implement basic operations on Stack ADT using arrays CO1
   b. Implement Infix to Postfix conversion using Stack ADT
- 2. a. Implement operations on Queue ADT using arrays- CO1b. Implement Round Robin Scheduling using QueueADT
- a. Implement insertion, deletion and searching operations in linked list CO1
   b. Implement Polynomial addition and Josephus problem using Linked Lists
- 4. Implement insertion, deletion and searching operations in Binary Search Tree CO2
- 5. Implement insertion, deletion and searching operations in AVLTree CO2
- 6. Implement insertion, Find Min and delete operation in Binary Heaps- CO3
- 7. Implement Hash table with different collision resolution Techniques CO4
- 8. Analyze time complexity of insertion, merge and quick sort algorithms CO5
- 9. Implement the following graph algorithms CO6
  - a. Topological sorting using depth first search,
  - b. Minimum Spanning Tree Algorithm using Kruskal's algorithm,
  - c. Shortest path algorithm using Dijkstra's Algorithm
- 10. Implement dynamic programming concept in solving a given problem CO7
- 11. **Mini Project -** Given a case study problem identify suitable data structure and algorithm for solving it.- CO8

# Learning Resources

- Mark Allen Weiss, "Data Structures and Algorithm Analysis in C ", 2<sup>nd</sup>edition, Pearson Education, 2002.
- Sartaj Sahni, "Data Structures, Algorithms and applications in C++", 2<sup>nd</sup> edition, Silicon Press, 2017.
- Michael T., Goodrich, "Data Structures and Algorithms in C++", 2<sup>nd</sup> edition, John Wiley, 2016.
- Adam Drozdek," Data Structures and Algorithms in C++", 4<sup>th</sup> edition, Cengage Learning, 2013.
- Michael T., Goodrich, "Data Structures and Algorithms in Python", 2<sup>nd</sup> edition, John Wiley, 2016.
- Mark Allen Weiss, "Data Structures and Algorithm Analysis in java ", 6<sup>th</sup> edition, Pearson Education, 2014.
- Bjarne Stroustrup, "The C++ Programming Language", Fourth Edition, Pearson Education, 2013
- NPTEL course on "Programming, Data Structures And Algorithms Using C", https://nptel.ac.in/noc/courses/noc18/SEM1/noc18-cs25/
- NPTEL course on "Data Structure and Algorithms using Java" https://onlinecourses.nptel.ac.in/noc20\_cs85/

# **Course Designers:**

- Dr.S. Ponmalar spmece@tce.edu
- Dr.M.S.K. Manikandan manimsk@tce.edu
- Dr. E. Murugavalli murugavalli@tce.edu

18ES690	ENGINEERING DESIGN PROJECT	Category	L	Т	Ρ	Credit
		Project	1	0	4	3

# Preamble

An engineer must understand the economic, social, political, sustainability and environmental contexts in which the need arises. Engineering solutions are always created in response to some societal/industrial need. Understanding the societal/industrial need is central to success in engineering design. Therefore, the engineering students have been assigned on the problem identification phase of engineering design. Now, they have an opportunity to reflect and realise the knowledge that have been gained through the courses such as 18ES150 Engineering Exploration, 18ES290 Lateral Thinking, 18ES390 Design Thinking, 18XX490 Project Management and 18ES590 System Thinking. This course will enable the students to integrate CDIO Skill-based courses and their domain-specific courses. More specifically, by employing the broad knowledge they gain from experiences in foundation elective, general elective and audit courses, students are better equipped to provide engineering solution societal and/or industrial needs.

# Prerequisite

Nil

#### Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Execute different phases of engineering design project including	20
	functional composition and design specification in a team.	
CO2	Evaluate the alternate engineering design approaches as per the	20
	performance criteria with design verification and validation.	
CO3	Evaluate a design with the use of test verification matrix / Design	15
	Failure Mode Effect Analysis (DFMEA)/ Usability testing	
CO4	Explain the significance of Intellectual Property rights and the	15
	procedure for searching and filing a patent.	
CO5	Exhibit team work with appropriate conflict management strategies.	10
CO6	Prepare appropriate design documents and deliver effective technical presentations	10
CO4 CO5 CO6	<ul> <li>Failure Mode Effect Analysis (DFMEA)/ Usability testing</li> <li>Explain the significance of Intellectual Property rights and the procedure for searching and filing a patent.</li> <li>Exhibit team work with appropriate conflict management strategies.</li> <li>Prepare appropriate design documents and deliver effective technical presentations</li> </ul>	15 10 10

# CO Mapping with CDIO Curriculum Framework

CO	TCE	Learning Domain Level			CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale	-			
CO1	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 3.1.2, 3.2.3,
					3.2.6, 4.1.2
CO2	TPS5	Evaluate	Organise	Adaptation	1.1, 1.2, 2.1.2, 2.5.1, 2.5.2,
					3.1.2, 3.2.3, 3.2.6, 4.1.2
CO3	TPS5	Evaluate	Organise	Adaptation	1.1, 1.2, 2.1.3, 3.1.2, 3.2.3,
					3.2.6, 4.1.2, 4.3.1
CO4	TPS2	Understand	Respond	Guided	1.1, 1.2, 2.1.4, 3.1.2, 3.2.3,
				Response	3.2.6, 4.1.2, 4.4.1
CO5	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.5, 3.1.2, 3.2.3,
					3.2.6, 4.1.2, 4.4.1
CO6	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.4, 3.1.2, 3.2.3,
					3.2.6, 4.1.2, 4.4.1

# Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P011	PO12
CO1	S	Μ	L	-	-	Μ	Μ	Μ	S	S	S	S
CO2	S	S	S	М	-	Μ	Μ	Μ	S	S	S	S
CO3	S	S	S	М	S	Μ	Μ	S	S	S	S	S
CO4	М	L	-	-	-	Μ	Μ	-	-	-	-	S
CO5	S	Μ	L	-	-	Μ	Μ	S	S	S	М	S
CO6	S	М	L	-	-	-	-	S	S	S	-	S

S- Strong; M-Medium; L-Low

#### Assessment Pattern:

Phases	Deliverables	Marks	Course Outcomes
Continuo	us Assessment		•
Review 1 – Engineering Design Project	Technical	10	CO1, C06
Selection, functional decomposition and	Report		
Specification			
Review 2 – Evaluation of Design Approaches	Technical	20	CO2, CO5, CO6
	Report		
Review 3 – Design Verification and validation	Technical	20	CO3, CO4, CO6
	Report		
End-Semest	er Examination		
Demonstration	Prototype	60	CO1, CO2, CO3,
Design Portfolio Presentation	Portfolio	40	CO4 CO5, CO6
-	Document		

• Reports are to be submitted at each review. The report and presentation will be evaluated based on customized Rubrics for periodic reviews.

• Demonstration and Design Portfolio presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

# Syllabus

**Project Selection** – Search Phase, Preliminary Design Review (PDR) and Critical Design Review (CDR), Project Specification, Proposal Report, Proposal Presentation

**Engineering Design Process** - The NASA Design Approach, Design Verification and Validation ,Design Verification Plan – DFMEA, test verification matrix, Usability testing, DRIDS-V Design Approach and Plan

**Intellectual Property Rights** – Trademarks, Copyrights and Patents, Types of patents, Searching patents, Filing Patents

**Team formation and Communication** – Types of teams, Team Conflict Management – common causes, cultural styles and conflict, Project Team Evaluation, Conducting Meetings and Making Presentations

# Learning Resources

- Harvey F. Hoffman, "The Engineering Capstone Course: Fundamentals for Students and Engineers", Springer, 2014
- <u>https://sharepoint.ecn.purdue.edu/epics/teams/Public%20Documents/EPICS\_Design\_Process.pdf?\_ga=2.252800138.2089889711.1612784342-1089955741.1612784342</u>

# **Course Contents and Lecture Schedule**

Module No	Торіс	No. of Lectures	Course Outcome
1	Project Selection		
	Search Phase, Preliminary Design Review (PDR) and	2	CO1,
	Critical Design Review (CDR), Project Specification,		CO6

	Proposal Report, Proposal Presentation		
2	Engineering Design Process		
2.1	The NASA Design Approach	1	CO2
2.2	Design Verification and Validation	1	CO2
2.3	Design Verification Plan – DFMEA, test verification	2	CO3
	matrix, Usability testing,		
2.4	DRIDS-V Design Approach and Plan	1	CO3
3	Intellectual Property Rights		
3.1	Trademarks, Copyrights and Patents,	1	CO4
3.2	Types of patents, Searching patents,.	1	CO4
3.3	Filing Patents	1	CO4
4	Team formation and Communication		
4.1	Types of teams, Team Conflict Management – common	1	CO5
	causes, cultural styles and conflict,		
4.2	Project Team Evaluation, Conducting Meetings and	1	CO5,
	Making Presentations		CO6
	Total	12	

Course Designers:Dr.S.J. ThiruvengadamDr. S.Saravana Perumaal

• Dr.C.Jeyamala

sjtece@tce.edu sspmech@tce.edu jeyamala@tce.edu



18ECEA0	MEMS TECHNOLOGY	Category	L	Т	Р	Credit
		ES	3	0	0	3

# Preamble

MEMS has been identified as one of the most promising technologies for the 21st Century and has the potential to revolutionize both industrial and consumer products by combining silicon-based microelectronics with micromachining technology. This course starts with the glimpses of MEMS covering the introduction and origin of MEMS, driving force for MEMS development, commercial applications, fabrication process and packaging techniques. The latter half of the course will be devoted to provide a thumb rule in designing, modelling of micro sensors and micro actuators. They are also exposed to the MEMS CAD tools available in the Design centre. Special weight is given to design circuits and do simulation with Comsol, Intellisuite and Coventorware. By taking this course, students can make good preparations for their research in relevant areas.

# Prerequisite

#### Nil

# **Course Outcomes**

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage
Inumber	1 alpha 1	111 70
CO1	Summarize the Concept of miniaturization, need for MEMS in various applications, Micro fabrication techniques	20
CO2	Apply knowledge of micro fabrication techniques to design Micro sensors	20
CO3	Apply knowledge of micro fabrication techniques to design Micro actuators	10
CO4	Apply micro fabrication techniques to design a micro accelerometers	10
CO5	Apply the concepts of micro machining to design devices for diversifying areas	20
CO6	Acquire skills in computer aided design tools for modelling and simulating MEMS device	20
<b>AA H</b>		

# CO Mapping with CDIO Curriculum Framework

CO	TC	E		Learning Domain Level							CDIO	Curric	ular C	ompon	ents
#	Pro	oficien	су [	Cogni	tive	Aff	ective	Ps	ychor	notor	(X.Y.Z)				
	Sca	ale		_					-						
CO1	T	PS2		Under	stand	Re	spond		- 1.3, 2.4.6						
CO2	T	PS3		Apply		Va	lue		-		1.3, 2	.1.1, 2	.1.2, 2	.1.3, 2.	5.1
CO3	T	PS3		Apply		Va	lue		-		1.3, 2	.4.6			
CO4	TPS3			Apply		Va	lue		-		1.3, 2	.1.1, 2	.1.2, 2	.5.1	
CO5	T	PS3		Apply		Va	lue		-		1.3, 2.4.6				
CO6	Т	PS3		Apply		Va	Value		-		1.3, 2.1.1, 2.1.2, 2.5.1				
Марр	ing w	ith P	rogr	amme	Outc	omes	s and	Prog	ramn	ne Spe	cific C	Dutcor	nes		
Cos	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	Μ	L	-	-	-	-	-	-	-	-	-	-	L	L	L
CO2	S	М	L	-	L	-	-	L	-	L	-	L	L	-	-
CO3	S	М	L	-	L	-	-	L	-	L	-	L	L	-	-
CO4	S	М	L	-	L	-	-	L	-	L	-	L	L	-	-
CO5	S	М	L	-	L	-	-	L	-	L	-	L	L	-	-
CO6	S	Μ	L	-	L	-	-	L	-	L	-	L	L	-	-

S- Strong; M-Medium; L-Low

Assessment Fattern. Cognitive Domain											
Cognitive	Conti	nuous Asses Tests	ssment	As	End						
Levels	1	2	3	1	2	3	Semester Examination				
Remember	0	0	0	0	0	0	0				
Understand	50	40	20	50	0	0	20				
Apply	50	60	80	50	100	100	80				
Analyse	0	0	0	0	0	0	0				
Evaluate	0	0	0	0	0	0	0				
Create	0	0	0	0	0	0	0				

# Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	and the second	-	-
Adaptation	Carlos a	-	-
Origination		-	-

# Sample Questions for Course Outcome Assessment

# Course Outcome 1(CO1):

- 1. Tabulate the direct analogy of electrical and mechanical domains.
- 2. Classify MEMS packages. Based on the need for packaging of MEMS devices classify and differentiate various packaging methodologies.

# Course Outcome 2(CO2):

- 1. With neat diagram explain the functioning of micro pressure sensor.
- 2. Explain the working principle of a thermal flow sensor.

# Course Outcome 3 (CO3):

- 1. Explain in detail the ink jet printer head and its fabrication process flow in detail.
- 2. Explain the working principle of micro pumps.

# Course Outcome 4 (CO4):

- 1. Derive a formula for estimating the natural frequency of a micro accelerometer with negligible damping effect.
- 2. Determine the equivalent spring constant K and natural frequency Wm of a cantilever beam element in a micro accelerometer .The beam is made of silicon with a Young's modulus of 190 MPa, length of the beam is 100um, width is 10um and mass is 10 mg.

# Course Outcome 5 (CO5):

- 1. Discuss the integration of micro optics with MEMS
- 2. Explain the sensing mechanism used in biomedical micro systems

# Course Outcome 6(CO6):

- 1. Discuss the steps involved in developing a micro machined cantilever using any MEMS CAD tool (e.g. Coventorware software)
- 2. Given the following description of a micro machined accelerometer, draw the step-bystep process flow with cross-section diagrams. For your convenience, the cross-section of the final device is also given below.

In order to micro fabricate a micro machined accelerometer, combinations of bulk and surface micromachining techniques are used. The process has seven masks and involves double-sided processing utilizing silicon dioxide as a sacrificial layer. The device structure is defined by anisotropic etching at the end of the process.

The process begins with a shallow p++ boron diffusion, defining the proof-mass and supporting rim, on a <100> silicon wafer that is polished on both the sides. Then, 60 um deep trenches are DRIE etched in the silicon and are used later to form the vertical
electrodes. The trenches are then refilled completely with a combination of LPCVD silicon dioxide (sacrificial layer), silicon nitride, and doped polysilicon. The polysilicon trench refilling is used to form vertical sense/drive electrodes and high aspect ratio springs to support the proof mass. After polysilicon deposition, annealing is followed to alleviate any compressive stress in the polysilicon.

Next, the polysilicon and nitride films are etched using RIE and another LPCVD silicon dioxide (capping oxide) is deposited. The oxide is patterned to form contact openings to the bulk silicon for the subsequent etch in the EDP. Then, contact metal is electroplated. To minimize the etch-time in the EDP and help undercut the electrodes by the etchant, some of the single-crystal silicon is etched by DRIE. After the DRIE, EDP etch is followed not only to release the proof mass and the supporting rim but also to etch the unnecessary silicon around the sense/drive electrodes. This step is important to achieve high-sensitivity. Finally, the sacrificial oxide layer is removed by etching in HF.





#### Syllabus

Historical Background: Introduction, emergence, MEMS application, scaling issues, Silicon Pressure sensors, Micromachining, Micro fabrication. Micro Fabrication Techniques: MEMS Materials, Material Properties, Bulk and surface micromachining, Wet and dry etching Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating). Conventional IC fabrication processes. Physical Micro Sensors: Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples, Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical, Biosensors and underwater flow sensors. Micro Actuators: Electromagnetic and Thermal micro actuation, Micro actuator examples, micro valves, micro pumps, micro motors, Ink-Jet printer heads, Micro-mirror TV Projector. Micro Accelerometer: Capacitive and piezoresistive, Electronic interfaces. Application Areas: 3-D electromagnetic actuators and sensors, RF/Electronics devices, Optical/Photonic devices, Medical devices e.g. DNAchip, micro-arrays. Computer Aided Design of MEMS: Introduction to Commercial packages, Introduction and usage of Intellisuite, Coventorware and Comsol, Design and simulation of MEMS Sensors, actuators and accelerometers using CAD tools. Learning Resources

• Stephen D. Senturia, "Micro system Design" by, Kluwer Academic Publishers, 2001.

- Tai Ran Hsu, MEMS & Micro system Design and Manufacture, Tata McGraw Hill, New Delhi 2002
- Marc Madou, Fundamentals of Micro fabrication, CRC Press, 2ndEdition, 2002.
- Julian W. Gardner and Vijay K. Varadan, Micro sensors, MEMS, and Smart Devices, John Wiley & Sons Ltd, 1stEdition, reprinted 2007
- Fundamentals of Micro fabrication by, CRC Press, 1997.Gregory Kovacs, Micro machined Transducers Sourcebook WCB McGraw-Hill, Boston, 1998.
- M.-H. Bao, Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes by Elsevier, New York, 2000.
- http://nptel.ac.in/courses/'MEMS and Micro Systems.

#### Course Contents and Lecture Schedule

Module	Торіс	No. of	CO
No.		Hours	
1.	Historical Background		
1.1	Introduction, emergence, MEMS application	1	CO1
1.2	Scaling issues, Micromachining, Micro fabrication, Conventional	1	CO1
1.2	IC fabrication processes.	I	
1.3	Silicon Pressure sensors	1	CO1
2	Micro fabrication Techniques:		
2.1	MEMS Materials, Material Properties	1	CO1
2.2	Bulk and surface micromachining, Wet and dry etching	1	CO1
2.3	Thin-film depositions (LPCVD, Sputtering, Evaporation),	1	CO1
2.4	LIGA, Electroplating	1	CO1
3	Physical Micro sensors		
2.1	Classification of physical sensors, Integrated, Intelligent, or Smart	1	CO2
5.1	sensors,		
3.2	Sensor Principles and Examples, Thermal sensors	2	CO2
3.3	Electrical Sensors, Mechanical Sensors,	1	CO2
3.4	Chemical, Biosensors	1	CO2
3.5	Underwater flow sensors	2	CO2
4	Micro actuators		
4.1	Electromagnetic and Thermal micro actuation, Micro actuator	1	CO3
	examples		
4.2	Micro valves, micro pumps, micro motors,3D printing	6	CO3
4.3	Ink-Jet printer heads, Micro-mirror TV Projector	2	CO3
5	Micro accelerometer :,		
5.1	Capacitive and piezoresistive	1	CO4
5.2	Electronic interfaces	1	CO4
6	Application Areas:		
6.1	3-D electromagnetic actuators and sensors,	1	CO5
6.2	RF/Electronics devices,	1	CO5
6.2	Optical/Photonic devices, Medical devices e.g. DNA-chip, micro-	1	CO5
0.5	arrays	I	
7	Computer aided design of MEMS:		
7.1	Introduction to Commercial packages, Introduction and usage of	2	CO6
	Intellisuite, Coventorware and Comsol.		
7.2	Design and simulation of MEMS Sensors using CAD tools	3	CO6
7.3	Design and simulation of MEMS actuators using CAD tools	3	CO6
7.4	Design and simulation of MEMS accelerometers using CAD tools	3	CO6
	Total hrs	36	

#### **Course Designers:**

• Dr.S.Kanthamani

skmece@tce.edu

Dr.K.Vasudevan kvasudevan@tce.edu

18ECEB0	FUNDAMENTALS OF MACHINE	Category	L	Т	Ρ	Credit
	LEARNING	ES	2	1	0	3

#### Preamble

The objective of this course is to provide the mathematical background necessary for developing Machine Learning Algorithms. In this course, mathematical topics namely linear algebra, analytical geometry, multivariate calculus and probability theory are covered. This course also covers dimensionality reduction, classification, density estimation and regression methods which are the building blocks of machine learning.

#### Prerequisite

#### NIL

#### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Calculate the prediction value of particular test data point using probability theory	15
CO2	Determine suitable matrix decomposition method for an intuitive interpretation of the data and more efficient learning	15
CO3	Determine the parameter that maximize the performance measure in machine learning using multivariate calculus	15
CO4	Determine the suitable linear regression function in a diverse range of research areas in machine learning.	15
CO5	Represent the data in compact form with Principal Component Analysis	15
CO6	Represent the characteristics of data compactly using probability distributions	15
CO7	Classify the data using Support Vector Machine	10

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	L	earning Dom	ain Level	CDIO Curricular
#	Proficien	Cognitive	Affective	Psychomotor	Components
	cy Scale	-		-	(X.Y.Z)
CO1	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1,
		-			2.4.2, 3.1.1, 3.1.2
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.2, 3.1.1, 3.1.2
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.2, 3.1.1, 3.1.2
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.2, 3.1.1, 3.1.2
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.2, 3.1.1, 3.1.2
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.2, 3.1.1, 3.1.2
CO7	TPS2	Understand	Respond	Guided Response	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.3

#### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	P01	PO2	PO3	P04	P05	P06	P07	PO8	PO9	10 PO	PO 11	PO 12	PS01	PSO2	PSO3
CO1	S	М	L	-	-	-	-	-	М	-	-	-	М		L
CO2	S	М	L	-	-	-	-	-	М	-	-	-	М	-	L
CO3	S	М	L	-	-	-	-	-	М	-	-	-	М	I	L
CO4	S	М	L	-	Μ	-	-	-	S	-	-	-	М	-	Μ
CO5	S	М	L	-	М	-	-	-	S	-	-	-	М	-	M

CO6	S	М	L	-	М	-	-	-	S	-	-	-	М	-	М
C07	Μ	L	-	-	Μ	-	-	-	S	ï	-	-	Μ	-	Μ

S- Strong; M-Medium; L-Low

Assessm	ent P	attern:	Cognitive	Domain	

Cognitive Levels	Contir	Continuous Assessment Tests			Assignme	nt	End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	100	50	50	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	m the	-	-
Mechanism	( allo	50	50
Complex Overt Responses		-	-
Adaptation		-	-
Origination	AL LOND	A -	-

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. Consider a statistical experiment where we model a funfair game consisting of drawing two coins from a bag (with replacement). There are coins from USA (denoted as \$) and UK (denoted as £) in the bag, and since we draw two coins from the bag, there are four outcomes in total. Let us assume that the composition of the bag of coins is such that a draw returns at random a \$ with probability 0:3. Find the the probability mass function
- 2. Consider two random variables X and Y, where X has five possible states and Y has three possible states, as shown in Figure.1. We denote by  $n_{ij}$  the number of events with state

 $X = x_i$  and  $Y = y_i$  and denote by N the total number of events. The value c is the sum of

the individual frequencies for the ith column, that is,  $c_i = \sum_{j=1}^{3} n_{ij}$ . Similarly, the value  $r_j$  is the

row sum, that is,  $r_j = \sum_{i=1}^{3} n_{ij}$ . Using these definitions, compactly express the distribution of X and X

and Y .



Figure.1

3. Consider a random variable X with zero mean and also  $E[x^3] = 0$ . Let  $y = x^2$  (hence, Y is dependent on X). Compute the covariance between X and Y.

#### Course Outcome 2 (CO2):

1. Compute the determinant of  $A = \begin{bmatrix} 1 & 2 & 3 \\ 3 & 1 & 2 \\ 0 & 0 & 1 \end{bmatrix}$  using the Laplace expansion along the first

row.

- 2. Compute the Eigen values, Eigen vectors and Eigen spaces of the  $2 \times 2$  matrix  $A = \begin{bmatrix} 4 & 2 \\ 1 & 3 \end{bmatrix}$ .
- **3.** Determine the orthogonal basis function for the matrix  $A = \begin{bmatrix} 3 & 2 & 2 \\ 2 & 3 & 2 \\ 2 & 2 & 3 \end{bmatrix}$

#### Course Outcome 3 (CO3):

1. Consider the function in Figure.2 given by  $f(x) = \sin(x) + \cos(x) \in C^{\infty}$ . Find the Taylor series expansion of f at  $x_0 = 0$ .



- 2. Find the gradient for the function  $f(x_1, x_2) = x_1^2 x_2 + x_1 x_2^3 \in \Box$ .
- 3. Prove the negative entropy of  $f(x) = x \log_2 x$  is convex for x > 0.

#### Course Outcome 4 (CO4):

- 1. Find the feature matrix for a second-order polynomial and N training points  $x_n \in \square$ ,  $n = 1, \dots N$ .
- 2. Let  $b \in \square^m \{\mathbf{0}_m\}$  and  $y \in \square^m$ . Prove that  $\|\mathbf{b}r \mathbf{y}\|$  is minimal when  $r = \frac{(\mathbf{y} \cdot \mathbf{b})}{\|\mathbf{b}\|^2}$ .
- 3. Let  $B = (\mathbf{b}^1, \cdots, \mathbf{b}^n) \in \square^{m \times n}$  be a matrix having orthogonal columns (in other words,  $i \neq j$  implies  $(b^i, b^j) = 0$ ) such that m > n. Prove that
  - i. Matrix **B** has full rank, that is  $rank(\mathbf{B}) = n$ .
  - ii. If **r** is the solution of the optimization problem that consists in minimizing the function  $f(r) = \|\mathbf{Br} \mathbf{y}\|^2$ , then  $r_j = \frac{(\mathbf{y} \cdot \mathbf{b}^j)}{\|\mathbf{b}^j\|^2}, 1 \le j \le n$ . In other words, the

components of the solution of linear regression do no influence each other.

#### Course Outcome 5 (CO5):

1. Let us analyze the following 3-variate dataset with 10 observations. Each observation consists of 3 measurements on a wafer: thickness, horizontal displacement, and vertical

 $displacement. \mathbf{x} = \begin{bmatrix} 7 & 4 & 3 \\ 4 & 1 & 8 \\ 6 & 3 & 5 \\ 8 & 6 & 1 \\ 8 & 5 & 7 \\ 7 & 2 & 9 \\ 5 & 3 & 3 \\ 9 & 5 & 8 \\ 7 & 4 & 5 \\ 8 & 2 & 2 \end{bmatrix}.$  Compute the principal factors. 2. Consider a small 3 x 2 matrix,  $\begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$ , centers the data in the matrix, calculates the

covariance matrix of the centered data, and then the eigen decomposition of the covariance matrix. The eigen vectors and eigen values are taken as the principal components and singular values and used to project the original data.

- 3. Write a program in python to calculate the Principal Component Analysis on a dataset using the PCA () class in the scikit-learn library.
- Course Outcome 6 (CO6):
- 1. Compute the responsibilities  $r_{n,k}$  for the given Figure.3.



2. Prove the update of the mean parameters  $\mu_k, k = 1, \dots K$  of the Gaussian Mixture Model

given by  $\mu_k = \frac{\sum_{n=1}^{N} r_{nk} x_n}{\sum_{n=1}^{N} r_{nk}}$ , where  $r_{nk}$  is the responsibilities.

3. Prove the update of the covariance parameters  $\sum_{k}, k = 1, \dots K$  of the Gaussian Mixture Model given by  $\sum_{k}^{new} = \frac{1}{N_k} \sum_{n=1}^{N} r_{nk} (\mathbf{x}_n - \mu_k) (\mathbf{x}_n - \mu_k)^T$ .

#### Course Outcomes 7 (CO7):

- 1. What is the distance between two parallel Hyperplanes  $\{x \in \Re^n | a^T x = b_1\}$  and  $\{x \in \Re^n | a^T x = b_2\}$ ?
- 2. Consider the data set D in  $\square^2$  shown in Figure.4, where C is a circle centred in (6,4) having radius 3. Define a transformation  $\phi:\square^2 \rightarrow \square^2$  such that  $\phi(D)$  is linearly separable.



3. Prove that if K is not linearly separable, then K is summable. Concept Map



#### Syllabus

Probability and Distribution – Continuous and probability space, Discrete and continuous probability, Sum rule, product rule and Bayes Theorem Matrix Decomposition-Determinant and trace, Eigen values and Eigen vectors, Cholesky decomposition, Eigen decomposition, Singular value decomposition Multivariate Calculus- Vector Calculus, Continuous optimization Regression – Parameter estimation, Bayesian linear regression, Maximum Likelihood as Orthogonal Projection Dimensionality Reduction with Principal Component Analysis (PCA) Maximum Variance perspective, Projection perspective, Eigenvector computation and low-rank approximations, PCA in high dimensions Density Estimation with Gaussian Mixture Models Gaussian mixture, Parameter learning via Maximum likelihood, EM algorithm Classification with Support Vector Machines Separating Hyperplanes, Primal support vector machine, dual support vector machine Learning Resources

- Marc Peter Deisenroth, A. Aldo Faisal and Cheng Soon Ong , " Mathematics for Machine Learning", Cambridge University Press, 2019
- Jason Brownlee, "Basics of Linear Algebra for Machine Learning", ebook, 2018
- Alpaydin, Ethem. "Introduction to Machine Learning", MIT Press, 2010.

• Dan Simovice, "Mathematical Analysis for Machine Learning and Data Mining", World Scientific, 2018.

•	Mehryar Mohri, Afshin R	lostamizadeh ar	nd Ameet	Talwalkar,	"Foundations	of	Machine
	Learning" MIT Press, 201	8.					

Cour	se Contents and Lecture Schedule							
No.	Торіс	No. of	COs					
		Hours						
1	Probability and Distribution							
1.1	Continuous and probability space	1	CO1					
1.2	Discrete and continuous probability	1	CO1					
1.3	Sum rule, product rule and Bayes Theorem	1	CO1					
1.4	Tutorial	1	CO1					
2	Matrix Decomposition							
2.1	Determinant and trace	1	CO2					
2.2	Eigen values and Eigen vectors	1	CO2					
2.3	Cholesky decomposition	1	CO2					
2.4	Eigen decomposition	1	CO2					
2.5	Singular value decomposition	1	CO2					
2.6	Tutorial	1	CO2					
3	Multivariate Calculus-,							
3.1	Vector Calculus	2	CO3					
3.2	Continuous optimization	2	CO3					
3.3	Tutorial	1	CO3					
4	4 Regression,							
4.1	Parameter estimation	1	CO4					
4.2	Bayesian linear regression	1	CO4					
4.3	Maximum Likelihood as Orthogonal Projection	2	CO4					
4.4	Tutorial	1	CO4					
5	Dimensionality Reduction with Principal Component Analysis (	PCA)						
5.1	Maximum Variance perspective	1	CO5					
5.2	Projection perspective	1	CO5					
5.3	Eigenvector computation and low-rank approximations	2	CO5					
5.4	PCA in high dimensions	1	CO5					
5.6	Tutorial	1	CO5					
6.	Density Estimation with Gaussian Mixture Models	1						
6.1	Gaussian mixture	1	CO6					
6.2	Parameter learning via Maximum likelihood	2	CO6					
6.3	EM algorithm	1	CO6					
6.4	Tutorial	1	CO6					
7	Classification with Support Vector Machines							
7.1	Separating Hyperplanes	1	CO7					
7.2	Primal support vector machine	2	CO7					
7.3	dual support vector machine	1	CO7					
7.4	Tutorial	1	CO7					
	Total	36						

#### **Course Designers:**

- Dr.S.J.Thiruvengadam sjtece@tce.edu
- Dr.K.Rajeswari
- rajeswari@tce.edu
- Dr.P.G.S.Velmurugan pgsvels@tce.edu

1	۶F	CI	FC	:0

#### **IOT SENSORS AND DEVICE**

Category	L	I	Р	Credit
ES	3	0	0	3

#### Preamble

This course aims to provide students to course learn about the 'things' that get connected in the Internet of Things to sense and interact with the real world environment, and to explore and interact with the IoT bridge between the cyberand physical worlds.

#### Prerequisite

NIL

#### **Course Outcomes**

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage
Number		in %
CO1	Describe the IoT and Embedded hardware and software.	10
CO2	Demonstrate the ability to incorporate sensors and actuators into a	20
	circuit.	
CO3	Consturuct the IoT Intermediary devices and internet capable link.	10
CO4	Design and sketchprograms using IoT Virtual tool.	20
CO5	Apply the open and closed loop system transfer functions forIoT	20
	based system	
CO6	Design and Test the IoT based system using use case and test case.	20

#### **CO Mapping with CDIO Curriculum Framework**

	TCE	Learr	ning Domain	CDIO Curricular Components	
CO#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale		A SPACE		
CO1	TPS2	Understand	Respond		1.3, 2.1.5, 2.2.2, 2.3.1,
CO2	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO3	TPS2	Understand	Respond		1.3, 2.1.5, 2.2.2, 2.3.1,
CO4	TPS3	Apply	Value		1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO5	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO6	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3

# Mapping with Programme Outcomes and Programme Specific OutcomesCosP01P02P03P04P05P06P07P08P09P010P011P012PS01PS02PS03

CO1	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	Μ	L	-	L	-	-	-	L	-	-	L	М	-	-
CO3	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO4	S	Μ	L	-	L	-	-	-	L	-	-	L	М	-	-
CO5	S	Μ	L	-	L	-	-	-	L	-	-	L	М	-	-
CO6	S	Μ	L	-	L	-	-	-	L	-	-	L	Μ	-	-

#### S- Strong; M-Medium; L-Low

#### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continu	ious Asse Tests	essment	ļ	Assignment	End Semester Examination	
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	40	40	40	0	0	0	20
Apply	60	60	60	100	100	100	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### AssessmentPattern: Psychomotor

Psychomotor Skill	Miniproject/Assignment/Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

#### Sample Questions for Course Outcome Assessment

#### Course Outcome1 (CO1):

- 1. Explain the range of IoT and Embedded System.
- 2. Describe the IoT hardware and software component.
- 3. Explain the role of an operating system in an IoT device.

#### Course Outcome2 (CO2):

- 1. Design a circuit that lights an LED when it is sufficiently dark in a room. Demonstrate the circuit by covering the photo-resistor to darkness.
- 2. Design a grade separation a highway junction and a pedestrian road junction with a redundant audio alarm and a time and requests the green light by pressing the button the train can be detected by a special optical sensor.
- 3. Design a mobile robot, which can shoot objects in a basket at different angles in proper selection of sensor and motors and IoT Board.

#### Course Outcome 3 (CO3):

- 1. List the Microcontroller based on a set of requirements,
- 2. Explain the architecture of Microcontroller to Microcontroller communication.
- 3. Explain the communication between Microcontrollers to Computer/Cloud.

#### Course Outcome 4 (CO4):

- 1. Design a circuit and write a program that causes the built-in LED connected to pin 13 on the Arduino to blink, alternating between fast blinks and slow blinks.
- 2. Design a circuit and write a program that allows the user to control the LED connected to pin 13 of the Arduino. If the user sends the character '1' through the serial monitor then the LED should turn on. If the user sends the character '0' through the serial monitor then the LED should turn off.
- 3. Design a circuit that contains two push buttons, an LED, and any other basic components, the LED should turn on when either the first button or the second button is pressed.

#### Course Outcome 5 (CO5):

- 1. Design of an Unmanned Aircraft Vehicle (UAV) apply the both Yaw and Roll, pitch control and find step response, nyquist diagram, and magnitude and phase plot using open loop and closed loop system.
- 2. Design of an IoT based Temperature monitoring system the different ways IoT systems are controlled using open loop and closed loop system.

#### Course Outcome 6(CO6):

- 1. Design of an IoT based agricultural storage monitoring system with block diagram of following draft
  - Specification requirement document in user perspective and designer Perspective.
  - System design and option evaluation, option choice document.
  - Testing of Components and Integration testing document.
- 2. Design of an IoT based Implementation of Traffic Intersection Interface system with block diagram of following draft
  - Specification requirement document in user perspective and designer Perspective.
  - System design and option evaluation, option choice document.
  - Testing of Components and Integration testing document.
- 3. Design of an IoT based Temperature monitoring system with block diagram of following draft
  - Specification requirement document in user perspective and designer Perspective.

- System design and option evaluation, option choice document.
- Testing of Components and Integration testing document.



#### Syllabus

loT and Embedded system: Concept of the Internet of Things, Structure of embedded systems and interactions with the physical world, IoT hardware and software component, Role of an operating system in an IoT device, Networking enables devices and small local networks of IoT devices. IoT Sensors: Differentiate between different sensor types and application areas for a selected range of sensors and actuators, Incorporation sensors and actuators into a circuit. IoT Intermediary devices and internet capable link: Microcontroller based on a set of requirements, Communication protocols, Microcontroller to Microcontroller communication, Microcontroller to Computer/Cloud communication, Fog, Edge, and Cloud processing, Cellular networks, **IoT Virtual Programming:** Blink an LED with digital output, Blink multiple LED, Fading LED with Analog outputs, RGB LED Colour Mixing, Digital Input / Analog output, Push button, Potentiometer using serial monitor, PIR Motion Sensor, Photo resistor, Temperature sensor, Ultrasonic Distance Sensor. Processes and systems: Concept of both open loop and closed loop systems, Inputs, outputs, control and feedback for a system, Different ways that systems are controlled. IoT based system **Design:** Specification requirement document in user perspective and designer Perspective, System design and option evaluation, option choice document, Testing of Components and Integration testing, virtual circuit software tool to solve IoT problems.

#### Learning Resources

- Adrian McEwen, Hakim Cassimally "Designing the Internet of Things", Wiley Publishing,2015
- Arshdeep Bahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach", 2015 Web link : https://www.universitiespress.com/details?id=9788173719547
- Sudip Misra, IIT- Kharagpur, swayam course on "Introduction to Internet of Things" https://swayam.gov.in/nd1\_noc20\_cs66/preview
- Ian Harris, Professor, University of California, Irvine, Coursera, Course on "Introduction to the Internet of Things and Embedded Systems"
- Iain Murray, Cesar Ortega-Sanchez, Sivas' Khaksar, Curtin University, Perth, Edx course on "IOT2x – IoT Devices and Sensors"
- Online-Virtual circuit software tool web link: https://www.tinkercad.com/learn/projectgallery;collectionId=OMOZACHJ9IR8LRE
- Kallol Bosu Roy Choudhuri "Learn Arduino Prototyping in 10 days Your crash course to build innovative devices" Packt Publishing, 2017.

Course	Contents and Lecture Schedule		
Module	Торіс	No. of	Course
No.		Hours	Outcome
1	IoT and Embedded system		
1.1	Concept of the Internet of Things.	1	CO1
1.2	Structure of embedded systems.	1	CO1
1.3	IoT Interactions with the physical world.	1	CO1
1.4	IoT hardware and software component.	1	CO1
1.5	Role of an operating system in an IoT device.	1	CO1
1.6	Networking enables devices.	1	CO1
1.7	Small local networks of IoT devices.	1	CO1
2	IoT Sensors		
2.1	Differentiate between different sensor types	3	CO2
2.2	Application areas for a selected range of sensors and actuators	3	CO2
2.3	Incorporate sensors and actuators into a circuit	3	CO2
3.	IoT Intermediary devices and internet capable link		
3.1	Microcontroller based on a set of requirements.	1	CO3
3.2	Communication protocols.	1	CO3
3.3	Microcontroller to Microcontroller communication.	1	CO3
3.4	Microcontroller to Computer/Cloud communication.	1	CO3
3.5	Fog, Edge, and Cloud processing.	2	CO3
4	IoT Virtual Programming		
4.1	Blink an LED with digital output, Blink multiple LED.	1	CO4
4.2	Fading LED with Analog outputs, RGB, LED Colour Mixing.	1	CO4
4.3	Digital Input / Analog output, Push button, Potentiometer using serial monitor.	1	CO4
4.4	PIR Motion Sensor and Photo resistor, Temperature sensor, Ultrasonic Distance Sensor	2	CO4
5	Processes and systems		
5.1	Concept of open loop and closed loop systems, Inputs, outputs, control and feedback for a system.	2	CO5
5.2	Different ways that systems are controlled	1	CO5
6	IoT system Design		
6.1	Specification requirement in user and designer perspective,	2	CO6
6.2	System design and option evaluation, option choice and	2	CO6
	Testing of Components and Integration testing.		
6.3	Virtual circuit software tool to solve IoT problems.	2	CO6
	Total No. of Hours	36	
Course	Decignero		

Mr.M.Senthilnathan msnece@tce.edu

Category	L	Т	Р	Credit
ES	3	0	0	3

#### Preamble

Blockchain is an emerging technology platform for developing decentralized applications and data storage. This course includes the fundamental design and architectural primitives of Blockchain, the system and the security aspects, along with consensus mechanisms, crypto currencies, smart contracts, and problems of blockchain. The applications of Blockchain have now spread from crypto-currencies to various other domains, including business process management, smart contracts, IoT, trustworthy e-governance and so on. **Prerequisite** 

NIL

#### Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage
Number		in %
CO1	Determine the role of Hash functions, digital signature and	15
	distribution systems as blockchain primitives	
CO2	Describe the operations of crypto-currencies, Bitcoin and Ethereum	10
CO3	Apply the distributed consensus mechanisms of proof of work and	15
	proof of stake	
CO4	Use the scripting language to write smart contracts and blockchain	20
	platforms to develop hyperledgers	
CO5	Analyze the privacy, security and scalability problems of blockchain	20
CO6	Build the Blockchain use cases in finance, industry, IoT and e-	20
	dovernance.	

#### CO Mapping with CDIO Curriculum Framework

CO	٦	TCE			Lea	rning	Doma	in Lev	/el			С	DIO Cu	ırricular		
#	Prof	ficier	ncy 🛛	Cogr	nitive	Af	Affective Psychomotor					Components				
	S	Scale	-	-								(X.Y.Z)				
CO1	T	PS3		Ар	ply	Val	Value - ć				1.3	1.3, 2.1.1, 2.1.5				
CO2	T	PS2		Unde	Jnderstand Respond				-		1.3	3, 2.2	2.2			
CO3	T	PS3		Apply Value					-		1.3	1.3, 2.1.1, 2.1.5				
CO4	T	PS3		Ар	Val	ue		-			1.3, 2.1.1, 2.3.1, 3.2.4					
CO5	T	PS4		Ana	lyze	Org	ganise		-			1.3, 2.1.1, 2.1.5, 2.2.2,				
					-						2.3	3.1, 3	8.2,6			
CO6	Т	PS3		Ар	ply	Val	ue		-		1.3	3, 2.1	.5, 2.2.	2, 3.2.6	3	
Mappi	ng wi	th Pi	rogra	imme (	Outco	mes a	and Pr	ogra	mme \$	Spec	ific C	Outco	omes			
Cos	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	
004	~															

	1									10	11	12			
CO1	S	М	L	-	-	-	-	-	-	-	-	L	Μ	-	-
CO2	М	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	М	L	-	-	-	-	-	-	-	-	L	Μ	-	-
CO4	S	М	L	-	S	-	-	-	-	L	I	L	Μ	-	L
CO5	S	S	М	L	-	-	-	-	-	L	-	Μ	S	-	L
CO6	S	Μ	L	-	L	-	-	-	-	Μ	-	L	Μ	-	М

S- Strong; M-Medium; L-Low

Cognitive Levels	Continuous Assessment Tests				Assignme	nt	End Semester Examination
	1	2	3	1	2	3	]
Remember	15	0	0	0	0	0	0
Understand	25	40	30	0	0	0	30
Apply	60	60	50	100	100	70	50
Analyse	0	0	20	0	0	30	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0
<b>Assessment P</b>	Assessment Pattern: Psychomotor						

#### **Psychomotor Skill** Assignment-1 Assignment-2 Assignment-3 Perception ---Set ---Guided Response ---Mechanism ---Complex Overt Responses \_ Adaptation \_ \_ Origination --\_

## Sample Questions for Course Outcome Assessment

#### Course Outcome 1 (CO1):

- 1. Describe the requirements and characteristics of hash function.
- 2. User A wants to digitally sign his/her document to user B by using the global parameters, prime number p = 71 and its primitive root, alpha = 2. The signed document needs to be verified by user B. Assume that user A's private key, XA is 7, the random value k is 3 and its message is 10. Verify user A's digital signature in user B using appropriate public key method.
- 3. Consider an Elliptic Curve signature scheme. We have a global elliptic curve, prime p, and "generator" G. Alice picks a private signing key XA and forms the public verifying key YA = XAG. To sign a message M: Alice picks a value k. Alice sends Bob M, k and the signature S = MkXAG. Bob verifies that M = S + kYA.

a. Show that this scheme works. That is, show that the verification process produces equality if the signature is valid.

b. Show that the scheme is unacceptable by describing a simple technique for forging a user's signature on an arbitrary message.

#### Course Outcome 2 (CO2):

- 1. Explain design principles of Bitcoin and Ethereum.
- 2. Compare Blockchain, Crypto-currency and Token.
- 3. How to find a transaction in Blockchain and compare the types on blockchains.

#### Course Outcome 3 (CO3):

- 1. Design and deploy a distributed application.
- 2. Distinguish between proof-of-work and proof-of-stake consensus and write their security implications.
- 3. Explain the process of mining and how do miners make money?

#### Course Outcome 4 (CO4):

- 1. Write smart contracts for various transactions and explain why this is revolutionary and different from legal documents?
- 2. Develop a simple application using Solidity.
- 3. Develop projects using Hyperledger fabric platform, Plug-and-play platform

#### Course Outcome 5 (CO5):

- 1. How is scalability problem resolved?
- 2. Examine the security issues, failed currencies & blockchains and protection from attackers.

3. Evaluate security, privacy, and efficiency of a given blockchain system.

#### Course Outcome 6 (CO6):

- 1. How will you create your own blockchain and explain the necessary steps needed.
- 2. Design a use case for blockchain in a business case or area of interest. What problem is this trying to solve? What is the value proposition of solving this problem? How will a blockchain be applied to this use case? Which component pieces will be utilized?
- 3. Design Blockchain use cases for the following:
  - i. Digital Rights ownership and accessibility, education
  - ii. Industry healthcare, identity, finance
  - iii. Paradigm shift/future/big picture
  - iv. Elections and Voting: Auto execution of contracts, escrow, etc.

#### Concept Map



#### Syllabus

Cryptographic primitives in Blockchain: Secure, Collision-resistant hash functions, digital signature, public key cryptosystems - encryption schemes and elliptic curve cryptography, verifiable random functions, zero-knowledge proof systems **Distributed System concepts**: Need for Distributed Record Keeping, Modeling faults and adversaries, Consensus algorithms - scalability problems and distributed consensus Blockchain 1.0: Advantages over conventional distributed database, Blockchain Network, private and public, Mining Mechanism, Bitcoin blockchain, the challenges, operations and solutions, contemporary proof-of-work based consensus mechanisms, Proof of stake, alternatives to Bitcoin consensus, crypto-currency, Bitcoin scripting language and their use Blockchain 2.0: Ethereum and smart contracts and Turing complete blockchain scripting - Solidity, issues of correctness and verifiability. Ethereum platform and its smart contract mechanism Blockchain 3.0: Hyperledger fabric platform, Plug-and-play platform and mechanisms for consensus and smart contract evaluation engines **Beyond Crypto-currency**: Privacy, Security issues in Blockchain: Pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains – Sybil attacks, selfish mining and Sharding based consensus algorithms Blockchain Use Cases: Finance, Industry - supply chain management, e-governance, Land Registration, Internet of Things, Medical Record Management System, and Domain Name Service

#### Learning Resources

- Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder, "Bitcoin and Cryptocurrency Technologies: a comprehensive introduction", Princeton University Press, 2016.
- S.Shukla, M.Dhawan, S.Sharma, S.Venkatesan, "Blockchain Technology: Cryptocurrency and Applications", Oxford University Press, 2019.

- Josh Thompson, "Blockchain: The Blockchain for beginners guide to Blockchain technology and Blockchain programming", Create Space Independent Publishing Platform, 2017.
- Andreas M. Antonopoulos, "Mastering Bitcoin: Unlocking Digital Cryptocurrencies", O'Reilly Media, 2014.
- Gavin Wood, "ETHEREUM: A Secure Decentralized Transaction Ledger", Yellow paper, 2014.
- Nicola Atzei, Massimo Bartoletti, and Tiziana Cimoli, "A survey of attacks on Ethereum smart contracts" IACR Cryptology ePrint Arch., 2016.
- NPTEL Course on Blockchain architecture design and use cases:
- https://nptel.ac.in/courses/106/105/106105184/
- NPTEL Course on Introduction to Blockchain technology and applications: https://nptel.ac.in/courses/106/104/106104220/#
- Virtual Lab: http://vlabs.iitb.ac.in/vlabs-dev/labs/blockchain/

Cour	se contents and Lecture Schedule		
No.	Торіс	No. of	COs
		Hours	
1	Primitives in Blockchain		
1.1	Secure, Collision-resistant hash functions, Properties	1	CO1
1.2	Hash Algorithms	1	CO1
1.3	Digital Signature, public key cryptosystems - encryption schemes	2	CO1
1.4	Elliptic Curve Cryptography	1	CO1
1.5	verifiable random functions, zero-knowledge proof systems	1	CO1
1.6	Distributed System concepts - Need for Distributed Record	2	CO1
	Keeping,		
1.7	Modeling faults and adversaries,	1	CO1
1.8	Consensus algorithms - scalability problems and distributed	1	CO1
	consensus		
2	Blockchain 1.0		
2.1	Blockchain Networks - private and public	1	CO2
2.2	Mining Mechanism, Bitcoin blockchain, the challenges, operations	2	CO2
	and solutions		
2.3	contemporary proof-of-work based consensus mechanisms, Proof	2	CO3
	of stake		
2.4	alternatives to Bitcoin consensus, crypto-currency	1	CO2
2.5	Bitcoin scripting language and their use	1	CO2
3	Blockchain 2.0		
3.1	Ethereum and smart contracts	1	CO3
3.2	Turing complete blockchain scripting – Solidity	2	CO3
3.3	Issues of correctness and verifiability	1	CO3
3.5	Ethereum platform and its smart contract mechanism	1	CO3
4	Blockchain 3.0		
4.1	Hyperledger fabric platform	2	CO4
4.2	Plug-and-play platform	1	CO4
4.3	mechanisms for consensus and smart contract evaluation engines	1	CO4
5	Beyond Crypto-currency	II	
5.1	Privacy, Security issues in Blockchain, Pseudo-anonymity vs.	1	CO5
	anonymity		
5.2	Zcash and Zk-SNARKS for anonymity preservation	1	CO5
5.3	Attacks on Blockchains – Sybil attacks, selfish mining	1	CO5
5.4	Sharding based consensus algorithms	2	CO5

6.	Blockchain Use Cases		
6.1	Finance, Industry – supply chain management	2	CO6
6.2	e-governance, Land Registration	1	CO6
6.3	IoT, Medical Record Management System, and Domain Name	2	CO6
	Service		
	Total Hours	36	

#### **Course Designers:**

- Dr. E. Murugavalli murugavalli@tce.edu
- Dr. M.S.K. Manikandan manimsk@tce.edu
- Dr. S. Ponmalar spmece@tce.edu



18ECEE0	5G WIRELESS NETWORKS	Category	L	T	Ρ	Credit	
		ES	3	0	0	3	

#### Preamble

The objective of this course is to introduce the students with a comprehensive understanding of current and 5G wireless Networks that includes 5G Fundamentals with its architecture, small cells, 5G Internets with Internet of Things and Software Defined Network. This course also includes cloud network and Security challenges in 5G network

### Prerequisite

NIL

CO5

CO6

#### **Course Outcomes**

On the successful completion of the course students will be able to

CO#	Course Outcome Statement					
CO1	Discuss the o	concepts of cur	rent mobile	networks and 50	G networks	10
CO2	Demonstrate	the ten pillars	of 5G			10
CO3	Use the role and Resource	play of Interne e Provisioning	et of Things in 5G Tech	s and Software I nology	Defined Network	30
CO4	Determine characteristic	capacity limits s of small cells	s and Da in 5G Netv	ta Demands vorks.	to identify the	20
CO5	5 Describe the concepts behind Mobile clouds and Mobile cloud enablers					15
CO6	Examine the Security Issues and Challenges in 5G Systems					15
CO M	apping with C	CDIO Curriculu	um Framew	/ork		
CO	TCE	Lean	ning Domaii	n Level	CDIO Cur	ricular
#	Proficiency	Cognitive	Affective	Psychomotor	Compon	ents
	Scale (X.Y.)					<u>Z)</u>
CO1	TPS2 Understand Respond - 1.3, 2.1.1, 2.1.5					
CO2	TPS3 Apply Value - 1.3, 2.1.1, 2.2.2,					2.1.5, 3.2.6
CO3	TPS3 Apply Value - 1.3, 2.1.1, 2.2.2					2.1.5, 3.2.6
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.2.2,	2.1.5, 3.2.6

## Mapping with Programme Outcomes and Programme Specific Outcomes

Respond

Organise

COS		. •-													
CO1	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	Μ	L	-	-	-	-	-	-	L	-	-	Μ	-	-
CO3	S	Μ	L	-	-	-	-	-	-	L	-	-	Μ	-	-
CO4	S	Μ	L	-	-	-	-	-	-	-	-	-	Μ	-	-
CO5	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO6	S	S	Μ	L	-	-	-	-	-	L	-	-	S	-	-

-

-

S- Strong; M-Medium; L-Low

TPS2

TPS4

#### **Assessment Pattern: Cognitive Domain**

Understand

Analyze

Cognitive	As	Continuo sessment	us Tests		Assignme	ent	End Semester
Levels	1	2	3	1	2	3	Examinatio n
Remember	30	20	0	0	0	0	0
Understand	40	40	50	0	0	0	40
Apply	30	40	30	100	100	70	40
Analyse	0	0	20	0	0	30	20
Evaluate	0	0	10	0	0	0	10
Create	0	0	0	0	0	0	0

1.3, 2.2.2, 2.3.1

1.3, 2.1.1, 2.1.5, 3.2.6

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

#### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

- 1. Determine the challenges posed by these 5G wireless systems?
- 2. Discuss the specifications of different generation of wireless Systems.
- 3. Explain how cellular systems evaluate towards 5G communication systems?

#### Course Outcome 2(CO2):

- 1. Explain the ten pillars of 5G wireless Networks
- 2. Discuss the evolution of Existing RATs.
- 3. How Self organizing networks work in 5G Networks?

#### Course Outcome 3(CO3):

- 1. Using IoT, how 5G network is enabled?
- 2. Discuss the operation of SDN with example
- 3. How Network function virtualization works in 5G Networks?

#### Course Outcome 4 (CO4):

- 1. Compare different small cells types
- 2. Based on deployments, how cells are works in 5G networks?
- 3. Why Wi-Fi and Femto cells as candidates for 5G technology?

#### Course Outcome 5 (CO5):

- 1. How cooperation modes work in mobile user domain?
- 2. Examine wireless technologies from short range to wide area.
- 3. Explain with example, how mobile cloud participants share their resources in 5G Networks?

#### Course Outcome 6(CO6):

- 1. Discuss the security challenges in 5G Networks
- 2. How Mobile Botnets are functioning in 5G Networks?
- 3. How Femto cells attacks are overcome in 5G Networks?

#### Concept Map



#### Syllabus

**Drivers for 5G:** Historical Trend of Wireless Communications, Evolution of LTE Technology to Beyond 4G 5G Roadmap, 10 Pillars of 5G- Evolution of Existing RATs, Hyperdense Small Organising Network, Machine Type Communication, Developing Cell Deployment, Self Millimetre Wave RATs, Redesigning Backhaul Links, Energy Efficiency, Allocation of New Spectrum for 5G, Spectrum Sharing, 5G Architecture. The 5G Internet: Internet of Things -Networking Reconfiguration and Virtualisation Support -Software Context Awareness Defined Networking ,Network Function Virtualisation , Mobility-An Evolutionary Approach from the Current Internet, A Clean Slate Approach Quality of Service Control-Network Resource Provisioning, Aggregate Resource Provisioning, Emerging Approach for Resource Over• Provisioning -Control Information Repository, Service Admission Control Policies ,Network Resource Provisioning ,Control Enforcement Functions Network Configurations , Network Operations Small Cells for 5G Mobile Networks: Small Cells- Wi-Fi and Femto cells as Candidate Small Cell Technologies, Wi-Fi and Femto Performance - Indoors Vs. Outdoors, Capacity Limits and Achievable Gains with Densification- Gains with Multi Antenna Techniques, Gains with Small Cells, Mobile Data Demands-Approach and Methodology, Demand vs Capacity, Small Cell Challenges Mobile Clouds: Technology and Services for Future Communication Platforms: The Mobile Cloud-User Resources, Software Resources, Hardware Resources, Networking Resources, Mobile Cloud Enablers-The Mobile User Domain, Wireless Technologies Software and Middleware, Network Coding. Security for 5G Communications: Overview of a Potential 5G Communications System Architecture, Security Issues and Challenges in 5G Communications Systems-User Equipment, Access Networks, Mobile Operator's Core Network , External IP Networks

#### Learning Resources

- Jonathan Rodriguez, Fundamentals of 5G Mobile Networks, Wiley, 2015
- Stefan Rommer, Peter Hedman, Magnus Olsson, Lars Frid, Shabnam Sultana, Catherine Mulligan, 5G Core Networks, Elsevier, 2020.
- Savo Glisic, Advanced Wireless Networks, Technology and Business Models, Wiley 2012
- Fei Hu, "Opportunities in 5G Networks", CRC press 2016.
- Hrishikesh Venkatarman and Ramona Trestian, "5G Radio Access Networks: Centralized RAN, Cloud-RAN, and Virtualization of Small Cells", CRC press 2017.
- Yang Yang, Jing Xu, Guang Shi, Cheng-Xiang Wang, "5G Wireless Systems Simulation and Evaluation Techniques", Springer International Publishing AG 2018.
- Sassan Ahmadil, "LTE-Advanced: A Practical Systems Approach To Understanding 3gpp LTE Releases 10 And 11 Radio Access Technologies", Academic Press 2013.
  Course Contents and Lecture Schedule

000130 0			
Module	Торіс	No. of	Course
No.		Hours	Outcome
1.	Drivers for 5G		
1.1	Historical Trend of Wireless Communications,	1	CO1
	Evolution of LTE Technology to Beyond 4G		
1.2	Roadmap, 10 Pillars of 5G- Evolution of Existing	1	CO1
	RATs, Hyperdense Small Cell Deployment, Self		
	Organising Network		
1.3	Machine Type Communication, Developing Millimetre	1	CO1
	Wave RATs		
1.4	Redesigning Backhaul Links, Energy Efficiency,	1	CO1
	Allocation of New Spectrum for 5G		
1.5	Spectrum Sharing, 5G Architecture	2	CO1
2.	The 5G Internet		
2.1	Internet of Things - Context Awareness Networking	2	CO2
	Reconfiguration and Virtualisation Support		

2.2	Software Defined Networking ,Network Function Virtualisation, Mobility-An Evolutionary Approach from the Current Internet	3	CO2
2.3	A Clean Slate Approach Quality of Service Control- Network Resource Provisioning	1	CO3
2.4	Aggregate Resource Provisioning, Emerging Approach for Resource Over• Provisioning	2	CO3
2.5	Control Information Repository, Service Admission Control Policies ,Network Resource Provisioning	1	CO3
2.6	Control Enforcement Functions ,Network Configurations , Network Operations	1	CO3
3.	Small Cells for 5G Mobile Networks		
3.1	Small Cells- Wi-Fi and Femtocells as Candidate Small Cell Technologies,	1	CO4
3.2	Wi-Fi and Femto Performance – Indoors vs Outdoors,	1	CO4
3.3	Capacity Limits and Achievable Gains with Densification- Gains with Multi Antenna Techniques,	1	CO4
3.4	Gains with Small Cells, Mobile Data Demands - Approach and Methodology, Demand vs Capacity, Small Cell Challenges	1	CO4
4.	Mobile Clouds: Technology and Services for Com	munication F	Platforms
4.1	The Mobile Cloud-User Resources, Software Resources, Hardware Resources	1	CO5
4.2	Networking Resources, Mobile Cloud Enablers-	1	CO5
4.3	The Mobile User Domain, Wireless Technologies	1	CO5
4.4	Software and Middleware, Network Coding	1	CO5
5	Security for 5G Communications		
5.1	Overview of a Potential 5G Communications System Architecture	1	CO6
5.2	Security Issues and Challenges in 5G Communications Systems	2	CO6
5.3	User Equipment, Access Networks, Mobile Operator's Core Network	2	CO6
5.4	External IP Networks	1	CO6
	Total Hours	36	

### **Course Designers:**

- Dr. M.S.K. Manikandan manimsk@tce.edu
- Dr. E. Murugavalli

murugavalli@tce.edu

Dr.S. Ponmalar spmece@tce.edu

Passed in BoS Meeting 04.07.2020

18FC710	CONSUMER ELECTRONICS	Category	L	Т	Ρ	Credit
1020710		PC	1	0	0	1

#### Preamble

Consumer Electronics includes a broad set of electronic devices that provide one or more functionalities in a home or for a particular individual. It is referred to electronic devices that are installed or used specifically inside a home/house. However, they also now incorporate mobile and computing devices, which can easily be carried by an individual outside the home, such as a cell phone or a tablet PC. The objective is to acquaint the students with the fundamental principles of operation of these devices.

Prerequisite NIL

#### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Understand the elctronic control of domestic appliances	30
CO2	Explore various audio-video systems.	50
CO3	Explore the architecture of commnunication gadgets ensuring safety	20
	and standards	

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Learn	ing Domair	CDIO Curricular				
#	Proficiency	Cognitive Affective		Psychomotor	Components			
	Scale			-	(X.Y.Z)			
CO1	TPS2	Understand	Respond	-	1.3, 2.4.6			
CO2	TPS2	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2,			
CO3	TPS2	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2,4.5.3			
Mapping with Programme Outcomes and Programme Specific Outcome								

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	М	L	-	-	-	-	-	-	-	-	-	М	-	-
CO3	S	Μ	L	-	-	-	-	-	-	-	-	-	М	-	-

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain** 

Cognitive Levels	Continuous Assessment Test – 3*	End Semester Examination*
Remember	0	0
Understand	80	80
Apply	20	20

\*Continuous Assessment Test – 3 and End Semester Examination shall be for 50 marks with 90 minutes duration.

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject/Assignment/Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

Passed in BoS Meeting 22.06.2021

Approved in 61th Academic Council Meeting 03.07.2021

#### Sample Questions for Course Outcome Assessment

#### Course Outcome 1 (CO1):

- 1. Draw the Block diagram of Washing Machine. State and Justify type of Washing machine having more advantages.
- 2. List any two wiring and safety instructions for use of microwave oven.
- 3. How the temperature is controlled in Refrigerator
- 4. Explain the working of microwave oven and give its four electrical specifications.

#### Course Outcome 2 (CO2):

- 1. Differentiate between Moving coil Microphone and Velocity Microphone.
- 2. An audio amplifier produces 20 watt output across and 8 ohm resistance When a 5 millivolts signal is applied to its input across a 1 mega ohm resistor. Determine the decibel gain.
- 3. Differentiate LED and LCCD Standards.
- 4. Draw the hardware architecture of Digital Set top Box and explain its operation.
- 5. List the significance of LCD display and explain its operation

#### Course Outcome 3 (CO3):

- 1. Give CCIR-B standards for colour signal transmission and reception.
- 2. We feel electric shock at times, when we touch TV and Computer monitors. Give the reason.
- 3. Summarize the effect of EMI on secured communications.
- 4. Consider the past historical facts. Criticize on the impact of radio communication
- 5. Identify the three criteria to be satisfied by any system to become electromagnetically compatible.

#### **Concept Map**



#### **Syllabus**

Domestic Appliances: Electronic controls in Micro-wave oven, Refrigerator, Washing Machine, Inverter, Remote control, Audio, Video Systems; Mics and Speakers Home Theatre System -DVD player, Amplifiers. LCD -LED OLED TVs, PLASMA, LCD, DLP projectors, set top box. Communication Devices: Principle of operation of Phones, Cellular Phones, Smart Phone, Internet systems: Media converter, Modem. Standards and safety: Bureau of Indian Standards (BIS), International Standards Organisation (ISO), Concept of Reliability, TV and Mobile Phone Standards, Specific Absorption Rate, EMC, EMI compatibility

#### Learning Resources

- Bali S.P., "Consumer Electronics", Pearson Education, 2017.
- B. R. Gupta, Vandana Singhal, "Consumer Electronics", S. K. Kataria & Sons, 2006
- The Digital Consumer Technology Handbook A Comprehensive Guide to Devices, Standards, Future Directions, and Programmable Logic Solutions by Amit Dhir, Xilinx Inc., Elsevier 2004.

Course C	ontents and Lecture Schedule		
Module	Торіс	No. of	Course
No.		Hours	Outcom
			е
1	Domestic Appliances		
1.1	Electronic controls in, Refrigerator, Washing Machine	1	CO1
1.2	Remote control, Micro-wave oven	1	CO1
1.3	Inverter, Induction stove	1	CO1
2	Audio –Video Systems		
2.1	Microphones, Carbon, condenser	1	CO2
2.2	Loud Speaker: Direct radiating, horn loaded woofer	1	CO2
2.3	Home theatre systems: Stereo Amplifier, DVD player,	2	CO2
	DTH, Set top Box		
2.4	TV systems: HDTV, LCD, LED, Organic LED, Plasma TV	2	CO2
2.5	LCD, DLP projectors	1	
3.	Communication Devices		
3.1	Architecture of Cellular Phones	1	CO3
3.2	Internet systems- Media converter, Modem	1	CO3
3.3			CO3
4	Standards and safety		
4.1	Bureau of Indian Standards (BIS), International Standards	2	CO3
	Organisation (ISO), Concept of Reliability		
4.2	T.V. and Mobile Phone Standards	1	CO3
4.3	SAR, EMC-EMI compatibility	1	CO3
	Total No. of Hours	16	

### **Course Designers:**

• Dr S.Md.Mansoor Roomi

smmroomi@tce.edu

CAPSTONE DESIGN PROJECT (COMMON TO B.E./B.TECH PROGRAMMES)

Category	L	Т	Ρ	Credit
Project	0	0	6	3

#### Preamble

Capstone Design Project is a culminating course where students work in teams to design, build, and test prototypes with real world applications. The Capstone Design course provides students an opportunity to work with real-world, open-ended, interdisciplinary challenges proposed by industrial and research project sponsors. They learn and apply the engineering design process: defining functional requirements, conceptualization, analysis, identifying risks and countermeasures, selection, and physical prototyping. Student teams design and build working, physical prototypes to validate their solutions. The course reemphasizes teamwork, project management, research and development.

#### Prerequisite

NIL

#### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement
CO1	Apply prior knowledge, independent research, published information, patents, and original ideas in addressing complex engineering problems and generating
	solutions.
CO2	Make design decisions based on product design requirements, product lifecycle considerations, resource availability, and associated risks
CO3	Develop design solutions in addressing performance requirements while satisfying relevant societal/industrial and professional constraints.
CO4	Demonstrate effective use of contemporary tools for engineering analysis, fabrication, testing, and design communication.
CO5	Plan, monitor, and manage project schedule, resources, and work assignments to ensure timely and within-budget completion.
CO6	Test and defend performance of a design product with respect to at least one primary design requirement.
C07	Perform professionally—exhibiting integrity, accepting responsibility, taking initiative and providing leadership percessary to ensure project success
CO8	Use formal and informal communications with team advisor and clients to
	document and facilitate progress

\* Weightage needs to be assigned based on the customized domain-specific rubrics CO Mapping with CDIO Curriculum Framework

CO#	TCE Proficiencv	Le	earning Dom	nain Level	CDIO Curricular Components (X.Y.Z)
	Scale	Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 1.2,1.3, 2.1, 2.2, 2.4, 3.1, 3.2, 4.1, 4.2, 4.3, 4.4, 4.5
CO2	TPS5	Evaluate	Organise	Adaptation	4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5, 4.1.6, 4.2.1, 4.2.2, 4.2.3, 4.2.4
CO3	TPS3	Apply	Value	Mechanism	4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.4.5
CO4	TPS4	Analyse	Organise	Complex Overt Response	4.5.1, 4.5.2, 4.5.3, 4.5.4, 4.5.5
CO5	TPS4	Analyse	Organise	Complex Overt Response	4.3.1, 4.3.2, 4.3.3, 4.3.4
CO6	TPS4	Analyse	Organise	Complex Overt Response	4.5.1, 4.5.2, 4.5.3, 4.5.4, 4.5.5
CO7	TPS3	Apply	Value	Mechanism	2.5.1, 2.5.2

CO8	TPS3	Apply	Value	Mechanism	3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6
-----	------	-------	-------	-----------	---

#### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L	-	-	M	M	S	S	M	M	S
CO2	S	S	М	L	S	М	М	M	S	М	М	S
CO3	S	М	L	-	-	М	М	M	S	М	М	S
CO4	S	S	М	L	М	М	М	M	S	М	М	S
CO5	S	S	М	L	М	М	М	M	S	М	S	S
CO6	S	S	М	L	М	М	М	M	S	М	М	S
C07	S	М	L	-	-	М	М	S	S	S	М	S
CO8	S	М	L	-	-	М	М	S	S	S	М	S

S- Strong; M-Medium; L-Low

#### **Assessment Pattern: Cognitive Domain**

Phases	Deliverables	Marks	Course Outcomes						
Continuous Assessment									
Comprehensive Test on disciplinary knowledge*	MCQ format	20	CO1						
Review 1 – Capstone Project Selection, functional decomposition and Technical Specification	Technical Report & Presentation	25	CO1, CO2, CO7, CO8						
Review 2 – Evaluation of Design Approaches, Project planning and modern tool usage	Technical Report & Presentation	30	CO3, CO4, CO5, CO7, CO8						
Review 3 – Evaluation of Testing and Validation, Documentation	Technical Report & Presentation	25	CO5, CO6, CO7, CO8						
End-Sei	mester Examinatio	n							
Demonstration of the product	Presentation & Viva -voce	60	CO1, CO2, CO3, CO4 CO5, CO6, CO7, CO8						
Poster Presentation	Poster	40							
• Reports are to be submitted at each review. The report and presentation will be evaluated									

• Reports are to be submitted at each review. The report and presentation will be evaluated based on customized domain-specific rubrics for periodic reviews.

• Demonstration and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

\* The content for comprehensive test on disciplinary knowledge shall be decided by the committee at department level.

#### **Course Designers:**

- Dr.S.J. Thiruvengadam
- Dr.S.Saravana Perumaal
- Dr. C.Jeyamala

<u>sjtece@tce.edu</u> <u>sspmech@tce.edu</u> jeyamala@tce.edu

18ECPA0	COMPUTER VISION AND	Category	L	Т	Ρ	Credit
	APPLICATIONS	PE	3	0	0	3

#### Preamble

This course focuses on how computer treats vision as a process to understand human visual world. It deals with the construction of explicit meaningful descriptions of physical objects or other observable phenomena from images and how they are visualized by a computer and its applications. It focuses theoretical and algorithmic basis by which useful information about the world can be automatically extracted and visualized from a single image or a set of images. Since images are two-dimensional projections of the three-dimensional world, knowledge about the objects in the scene and projection as well as photometric geometries are required for low-level vision process. In mid-level, it describes that how the feature points such as interest points, corner points are detected, matched and the alignment of matched feature points. Subsequently, it deals various clustering and segmentation algorithms to obtain meaningful segments using similarity and discontinuity properties for further analysis. The higher-level vision encompasses object recognition and categorization which includes various classifiers. Finally, it explores applications such as face detection and recognition for visual authentication, Optical Character Recognition (OCR) for automatic number plate recognition, Image stitching, medical image segmentation and augmented reality. Prerequisite

#### Prerequisite

18EC560 Digital Image Processing 🌱 🌾 🦄

#### Course Outcomes

On the successful completion of the course, students will be able to

СО	Course Outcome Statement	Weightage %
CO1	Illustrate image formation using projective and photometric geometry with the relationship between world coordinates and image coordinates.	10
CO2	Measure the similarity between two images by applying rotation, scale invariant and oriented gradient feature detectors with Euclidean distance matching and least squares alignment method.	20
CO3	Obtain meaningful segments using similarity based K Means clustering segmentation algorithm and discontinuity based active contour segmentation algorithm.	15
CO4	Recognize the detected objects by applying supervised algorithms like K-nearest neighbour and SVM.	15
CO5	Recognize the detected objects by applying PCA, an unsupervised algorithm and deep learning algorithms such as Convolutional Neural Networks (CNN), and Region-based CNN.	20
CO6	Develop computer vision applications such as face detection and recognition, visual authentication, Optical Character Recognition (OCR) for automatic number plate recognition, Image stitching, medical image segmentation and Augmented Reality.	20

CO Mapping with CDIO Curriculum Framework										
CO	TCE	Learning Dom	Learning Domain Level							
#	Proficiency	Cognitive	Affective	Psychomotor	Components					
	Scale				(X.Y.Z)					
CO1	TPS2	Understand	Respond	Guided Response	1.3, 2.4.6					
CO2	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4,					
					3.3.1, 4.1.2, 4.5.3					
CO3	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4,					
					3.3.1, 4.1.2, 4.5.3					
CO4	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4					
CO5	TPS2	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4					

Approved in 59<sup>TH</sup> Academic Council Meeting 07.12.2019

C06	TDC2	Apply	Value	Machaniam	12 211 221
000	1833	Арріу	value	Mechanism	1.3, 2.1.1, 2.3.1,
					2.4.3, 2.4.4, 2.4.6,
					2.5.1, 3.1, 3.2.3,
					3.2.4, 3.2.6, 3.3.1,
					4.1.1, 4.1.2, 4.5.3

#### Mapping with Programme Outcomes

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	М	L	-	-	-	-	-	-	L	-	-	М	L	L	L
CO2	S	М	L	-	Μ	-	-	-	М	-	-	М	М	Μ	М
CO3	S	М	L	-	Μ	-	-	-	М	-	-	Μ	М	Μ	М
CO4	S	М	L	-	L	-	-	-	Μ	L	-	М	М	L	L
CO5	S	М	L	-	Μ	-	-	-	Μ	-	-	Μ	L	L	М
CO6	S	М	L	-	Μ	Μ	I	Μ	Μ	Μ	I	М	L	L	М

#### S- Strong; M-Medium; L-Low

#### **Assessment Pattern: Cognitive Domain**

		- J					
Cognitive Levels	As	Continu sessme	uous nt Tests	Assignment			End Semester Examination
	1	2	3	A1	2	3	
Remember	10	10	0	IX)			0
Understand	10	10	10				10
Apply	80	80	90	50	50	50	90
Analyse	0	0	0		M		0
Evaluate	0	0	0	- Al	2/		0
Create	0	0	0	A			0

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment-I	Assignment-II	Assignment-III		
Perception	1 Martin		-		
Set		-	-		
Guided Response	-	-	-		
Mechanism	50	50	50		
Complex Overt Responses	-	-	-		
Adaptation	-	-	-		
Origination	-	-	-		

## Sample Questions for Course Outcome Assessment

#### Course Outcome 1 (CO1):

- 1. Consider a vector (7,5,3) which is rotated around the Z axis by 45<sup>0,</sup> and then rotated around the Y axis by 45<sup>0</sup> and finally translated by (6, -5,9). Find the new coordinates of the vector. All rotations are counter clockwise.
- 2. An ideal pinhole camera has focal length 5mm. Each pixel is  $0.02 \text{ mm} \cdot 0.02 \text{ mm}$  and the image principal point is at pixel (500, 500). Pixel coordinates start at (0, 0) in the upper-left corner of the image. Obtain the  $3 \cdot 3$  camera calibration matrix, K, for this camera configuration.

Hint: The first two vertices of the cube, the ones with world coordinates (X,Y,Z) = (0,0,0) and (1,0,0), project to pixel locations (x,y) = (252, 240) and (301,255), rounded to the nearest pixel.

3. Obtain the transformation matrix for an object translation of 50 pixels in X, Y, Z direction, an object rotation of  $60^{0}$  around the Z axis in clockwise direction.

#### Course Outcome 2 (CO2):

1. Use SIFT features and propose solution for matching and alignment Describe how this algorithm could be used to detect the orientation of the plane in the scene from the scene points. Illustrate the term 'scale-space' and describe how SIFT achieves scale and rotation invariance.

- 2. Develop an algorithm using Harris corner detection and describe one feature alignment technique for the two matched points captured in our TCE Dome.
- 3. Illustrate various matching strategies and error rates. Compare the results by fixing the false positive rates.

#### Course Outcome 3 (CO3):

 Assume the following dataset is given: (3,3), (4,4), (6,6), (7,7), (8,8), (9,9), (0,6), (6,0). K-Means is used with k=3 to cluster the dataset. Moreover, Euclidean distance is used as the distance function to compute distances between centroids and objects in the dataset. K-Means' initial clusters C1, C2, and C3 are as follows:

C1: {(4,4), (6,6), (9,9)}

C2: {(0,6), (6,0)}

C3:  $\{(3,3), (7,7), (8,8)\}$ 

If K-means is run fo two iterations; what are the new clusters and what are their centroids? Illustrate how K-Means form the cluster with this example.

- 2. Develop an algorithm to group the scattered nodules in a mammogram image using K-means clustering algorithm.
- 3. Illustrate active contour model algorithm to segment tumour in MRI.

#### Course Outcome 4 (CO4):

- 1. Develop an algorithm to recognize the detected object is car or a human being when this frame is captured by a single static camera. Write the complexities for such classification for the given scenario.
- 2. Illustrate K nearest neighbor classifier to categorize the objects in the given image.
- 3. Develop an algorithm to recognize objects based on shape in a clutterd environment, for example an office table comprises of penstand, stapler, cup and water bottle etc.

#### Course Outcome 5 (CO5):

- 1. Illustrate the architecture of CNN and write the significance of different layers.
- 2. Demonstrate the training and testing process by convolutional neural networks to recognize the face in the given image.
- 3. Distinguish traditional vs deep learning algorithms.

#### Course Outcome 6 (CO6):

- 1. Develop an algorithm to localize the license plate and recognize the vehicle number for intelligent traffic surveillance system to capture the vehicles which are not following the traffic rules.
- 2. Develop a face recognition system using PCA subspace approach for authentication system to enter into the restricted zone.
- 3. How Augmented reality is helpful in cricket sports for example to display the batsman's performance, ball height and Ibw review.

#### **Concept Map**



#### Syllabus

Computer Vision: Low Level Vision: Introduction to computer vision and its applications. Image formation: Geometric image formation, projection, Pinholes, Lenses, perspective, orthographic projections, 2D Transformations, 3D Transformations, camera intrinsic and extrinsic parameters. Photometric image formation, Lighting, reflectance and shading, optics. Middle Level Vision: Feature detection, matching and alignment: Feature detectors and descriptors, Interest points, Harris corner detection, Scale Invariant Feature Transform (SIFT), Histogram of Oriented Gradients (HOG), Feature matching algorithms, Euclidean distance metric, Error rates, Feature alignment algorithms, 2D alignment using least squares. Clustering and Segmentation: K-Means Clustering, Active Contour Model based segmentation, Stereo correspondence, Epipolar geometry, Stereo matching. High Level Vision: Classifiers-Machine Learning: Supervised, K-nearest neiahbour. SVM. Unsupervised, PCA, Deep Learning: Neural networks, Convolutional Neural Networks (CNN), Region-based CNN (R-CNN). Applications: Face detection using R-CNN and recognition using PCA and RCNN for visual authentication, Optical Character Recognition (OCR) for automatic number plate recognition, Image stitching, Medical Image Segmentation and augmented reality.

#### Learning Resources

- R Szeliski, "Computer vision: algorithms and applications", Springer Science & Business Media, 2010.
- David A. Forsyth, Jean Ponce, "Computer Vision A Modern Approach", Prentice Hall, 2003, ISBN: 0130851981.
- Richard Hartley and Andrew Zisserman, "Multiple View Geometry in Computer Vision", Second Edition, Cambridge University Press, March 2004.
- Al Bovik, "Handbook of Image & Video Processing", Academic Press, 2000, ISBN: 0121197905.
- Prince, S.J.D, "Computer Vision: Models, Learning, and Inference", Cambridge University Press, 2012.
- Ragav VenRagav Venkatesan and Baoxin Li, "Convolutional Neural Networks in
  - Visual Computing A Concise Guide", CRC Press, Taylor and Francis Group, LCCN
  - 2017029154 ISBN 9781498770392 (hardback : alk. paper), 2017.
- http://www.ius.cs.cmu.edu/demos/facedemo.html
- https://nptel.ac.in/courses/106105216/Course on Computer Vision by Jayanta Mukhopadhyay.
- https://www.coursera.org/courses?query=computer%20vision.

No.	Торіс	No. of	CO
		Lectures	
1.	Introduction to the Course and course outcomes Computer	1	1
	Vision and Applications		
2.	Low Level Vision – Introduction -Pinholes	1	1
3.	Image formation-Geometric image formation-projection	1	1
4.	Lenses-perspective-orthographic	1	1
5.	Camera intrinsic and extrinsic parameters	1	1
6.	2D Transformations	1	1
7.	3D Transformations	1	1
8.	Photometric image formation	1	1
9.	Lighting-reflectance and shading	1	1
10.	Optics	1	1
11.	Middle Level Vision- Feature detection, matching and	1	2
	alignment		
12.	Feature detectors and descriptors-Interest points-Harris corner	1	2

#### Course Contents and Lecture Schedule

	detection		
13.	Scale Invariant Feature Transform (SIFT)	1	2
14.	Histogram of Oriented Gradients (HOG)	1	2
15.	Feature matching algorithms	1	2
16.	Euclidean distance metric-Error rates	1	2
17.	Feature alignment algorithms	1	2
18.	2D alignment using least squares	1	2
19.	Clustering and Segmentation- K-Means Clustering	1	3
20.	Active Contour Model	1	3
21.	Stereo correspondence, Epipolar geometry, Stereo matching.	2	3
22.	Assignment 1: Feature Extraction and Segmentation		
23.	High Level Vision-Classifiers-Machine Learning: Supervised	1	4
24.	K-nearest neighbour	1	4
25.	SVM	2	4
26.	Unsupervised- PCA	1	5
27.	Deep Learning		
28.	Neural networks	1	5
29.	Convolutional Neural Networks (CNN)	1	5
30.	Region-based CNN	1	5
31.	Assignment II: PCA/ RCNN classifiers		
32.	Applications: Face detection using RCNN	1	6
33.	Face recognition using PCA for visual authentication	1	6
34.	Face recognition using RCNN for visual authentication		
35.	Optical Character Recognition (OCR) for automatic number	1	6
	plate recognition		
36.	Image stitching	1	6
37.	Medical Image Segmentation	1	6
38.	Augmented reality	1	6
39.	Assignment III: Mini Project on CV Applications		
	Total	36	
Cour	so Designers:		

#### Dr.B.Yogameena •

Dr.S.Md.Mansoor Roomi •

ymece@tce.edu smmroomi@tce.edu

18ECPB0	DATA COMPRESSION	Category	L	Т	Ρ	Credit
		PE	З	0	0	3

#### Preamble

Data compression is a key part of almost every aspect of computer and communications technology. Irrespective of large storage systems, the concern of space optimization and the algorithmic aspects of the efficiency appear large. Developing techniques to achieve better transmission rates is paramount importance today. Data compression is grounded in information theory, and there are many fundamental algorithms that one must deal with daily in information transmission and storage tasks. This course provides an overview of classical and modern techniques and algorithms of various types of data compression. It covers statistical and dictionary methods, lossless and lossy compression algorithms in graphics, video and Big data compression.

#### Prerequisite

18EC520 Analog and Digital Communication Systems

#### **Course Outcomes**

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage***
Number		in %
CO1	Outline the basics of Data Compression and its performance	10
	measure	
CO2	Analyse various lossless Compression Algorithms to data	25
CO3	Analyse various lossy Compression Algorithms to data	20
CO4	Demonstrate different Image Compression Standards	15
CO5	Illustrate the principles of basic video and Big data	15
	compression techniques	
CO6	Demonstrate the principles of various Video coding standards	15

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	rning Doma	in Level	CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale				
CO1	TPS2	Underst	Respond	Guided	1.1.1,2.1.1, 2.1.2
		and		Response	
CO2	TPS4	Analyse	Organise	Mechanism	2.1.2, 2.1.2,2.1.3,2.1.4,2.1.5
					2.4.1,3.1.1, 3.2.3, 3.2.4,3.2.5
					4.5.3, 4.6.1, 4.6.2
CO3	TPS4	Analyse	Organise	Mechanism	2.1.2, 2.1.2,2.1.3,2.1.4,2.1.5
					2.4.1,3.1.1, 3.2.3, 3.2.4,3.2.5
					4.5.3, 4.6.1, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	2.1.2, 2.1.2,2.1.3,2.1.4,2.1.5
					2.4.6,3.1.1,3.2.3,
					3.2.4,3.2.6,3.2.7, 4.5.3
CO5	TPS3	Apply	Value	-	2.1.2, 2.1.2,2.1.3,2.1.4,2.1.5
					2.4.6,3.1.1,3.2.3,
					3.2.4,3.2.6,3.2.7, 4.5.3
CO6	TPS3	Apply	Value	-	2.1.2, 2.1.2,2.1.3,2.1.4,2.1.5
					2.4.6,3.1.1,3.2.3,
					3.2.4,3.2.6,3.2.7, 4.5.3

Mapping with Programme	Outcomes and Pro	paramme Specific	Outcomes

COs	PO	PÒ	PO	PO	PSO	PSO	PSO								
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Μ	L	-	-	-	L	-	-	-	L	-	-	L	-	-
CO2	S	S	Μ	L	Μ	L	L	-	L	М	-	-	S	-	L
CO3	S	S	Μ	L	Μ	L	L	-	L	М	-	-	S	-	L
CO4	S	Μ	L	L	L	М	L	М	L	М	L	L	S	L	М
CO5	S	Μ	L	L	L	М	L	L	L	М	L	L	S	L	Μ
CO6	S	М	L	L	L	М	L	М	L	М	L	L	S	L	Μ

S- Strong; M-Medium; L-Low

#### **Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continuous Assessment Tests				Assignme	End Semester Examination	
	1	2	3	1	2	3	
Remember	20	-	-	0	0	0	0
Understand	20	20	30	0	0	0	20
Apply	40	60	70	100	60	60	60
Analyse	20	20	0	0	0	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	Look Land		-
Set	SerGiu De	-	-
Guided Response	-	-	-
Mechanism		40	40
Complex Overt Responses	The second s	-	-
Adaptation		-	-
Origination	-	-	-

# Sample Questions for Course Outcome Assessment Course Outcome1 (CO1):

- 1. State entropy
- 2. Discuss redundancies
- 3. What is the term "compression Ratio" in compression?

#### Course Outcome2 (CO2):

- 1. Consider a source alphabet with probabilities A={a1, a2, a3, a4, a5} with P(a1)= P(a3)=P(a4)=0.2, P(a2)=0.3 and P(a5)=0.1. Will the Human and minimum variance Huffman code have the same average length?
- 2. Encode the word 'DANCE' using Adaptive Huffman procedure which is produced from a source consists of 26 upper case English alphabet.
- 3. In a transmission of an English book the following tongue twister 'Freezy breeze made these three trees freeze', **is** sent. Encode it by LZ77.The first 21 characters without space are kept it in the search buffer and the remaining 16 are in look ahead buffer.

#### Course Outcome3 (CO3):

- 1. Explain Rate control in multimedia transmission by quantizer step size adaptation.
- 2. Explain LBG Algorithm for vector quantization.
- 3. For an image the seven-level decomposition shown below:
  - 21 6 15 12

- -6363
- 3 -3 0 -3
- 3 0 0 0

Find the bit stream generated by EZW coder.

#### Course Outcome 4 (CO4):

- 1. Is the JPEG2000 bit stream SNR scalable? If so, explain how it is achieved using the EBCOT algorithm.
- 2. Could we use wavelet-based compression in ordinary JPEG? How?
- 3. You are given a computer cartoon picture and a photograph. If you have a choice of using either JPEG compression or GIF, which compression would you apply for these two images? Justify your answer.

#### Course Outcome 5 (CO5):

- 1. Discuss in detail about the motion vector search methods.
- 2. Demonstrate I-Frame and P- Frame coding of H.261 with neat block diagram.
- 3. Discuss how the advanced prediction mode in H.263 achieves better compression ?

#### Course Outcome 6(CO6):

- 1. Demonstrate the method of estimating motion vectors with searching procedures in MPEG 1 video coding.
- 2. Explain Spatial interleaving of block-wise picture coding with neat diagram
- 3. Demonstrate Object oriented hierarchical description used in MPEG 4 video coding.

#### Concept Map



#### **Syllabus**

**Introduction to Compression Techniques** - Lossless- Lossy Compression Schemes - Measures of Performance - Modeling and coding.

**Lossless Compression and Algorithms:** Basics of Information Theory-Run length coding-Variable-Length coding(VLC)-Shannon-Fano Algorithm-Huffman coding-Variations of Huffman coding- Adaptive Huffman coding-Dictionary-Based coding-Arithmetic Coding- Lossless Image Compression-Differential Coding of Images-Lossless JPEG

**Lossy Compression Algorithms:** Distortion measures-The Rate-Distortion Theory-Quantization-Uniform Scalar Quantization-Nonuniform Scalar Quantization-Vector Quantization-Transform Coding-Discrete Cosine Transform(DCT)-Karhunenloeve Transform-Wavelet Based Coding-Continuous Wavelet Transform-Discrete Wavelet Transform-Wavelet

Passed in BoS Meeting 16.11.2019

Packets-Embedded Zero tree of Wavelet Coding (EZW) -Set Partitioning in Hierarchical Trees(SPIHT)

**Image Compression Standards:** The JPEG Standard - JPEG 2000 -Comparison of JPEG and JPEG 2000 Performance- JPEG-LS standard-The JBIG Standard-The JBIG 2 Standard

**Basic Video Compression and Big Data Compression Techniques:** Fundamental Concepts of Video- Introduction to Video Compression-Video Compression Based on Motion Compensation-Search for Motion Vectors-H.261- H.263 .Compression of Big Data – Query IO-Recompression

**Videos Coding:**MPEG-1-MPEG-2-MPEG-4-Object-Based Visual Coding in MPEG-4-Synthetic Object Coding in MPEG-4-MPEG-4 Object types,Profiles and Levels-H.264

#### Learning Resources

- Li, Ze-Nian, Mark S. Drew, and Jiangchuan Liu, "Fundamentals of multimedia" Upper Saddle River (NJ):: Pearson Prentice Hall, 2004.
- Khalid Sayood, "Introduction to Data Compression" Fourth Edition, Morgan Kauffmann Publishers, Inc, Newnes, 2012.
- David Salomon, "A Guide to Data Compression Methods" Fourth Edition Springer Science & Business Media, 2013.
- http://queryio.com/hadoop-big-data-docs/hadoop-big-data-admin-guide/

Module	Topic	No. of	Course
No.	AS AGAIN	Hours	Outcome
1	Introduction to Compression Techniques	2	CO1
1.1	Lossless Compression Algorithms	1	CO2
1.1.1	Basics of Information Theory		
1.2	Run-length Coding		
1.3	Variable Length Coding (VLC)		
1.3.1	Shannon-Fano Algorithm	1	
1.4	Huffman coding		
1.4.1	Variations of Huffman Coding	1	
1.4.2	Adaptive Huffman Coding	2	
1.5	Dictionary-Based Coding	2	
1.6	Arithmetic Coding	1	
1.7	Lossless Image Compression		
1.7.1	Differential Coding of Images	1	
1.7.2	Lossless JPEG	1	
2	Lossy Compression Algorithms		CO3
2.1	Distortion measures	1	
2.2	The Rate-Distortion Theory	1	
2.3	Quantization		
2.3.1	Uniform Scalar Quantization	1	
2.3.2	Non-uniform Scalar Quantization	1	
2.3.3	Vector Quantization	1	
2.4	Transform Coding		
2.4.1	Discrete Cosine Transform(DCT)	1	
2.4.2	Karhunenloeve Transform	1	
2.5	Wavelet Based Coding		
2.5.1	Continuous Wavelet Transform	1	
2.5.2	Discrete Wavelet Transform		
2.6	Wavelet Packets	1	
2.7	Embedded Zero tree of Wavelet Coding (EZW)	1	

### **Course Contents and Lecture Schedule**

2.8	Set Partitioning in Hierarchical Trees(SPIHT)	1	
3	Image Compression Standards		CO4
3.1	The JPEG Standard	2	
3.1.1	JPEG 2000		
3.1.2	Comparison of JPEG and JPEG 2000 Performance		
3.1.3	The JPEG-LS standard		
3.2	Bilevel Image Compression Standards	2	
3.2.1	The JBIG Standard		
3.2.2	The JBIG 2 Standard		
4	Basic Video Compression Techniques		CO5
4.1	Introduction to Video Compression	1	
4.1.1	Video Compression Based on Motion Compensation		
4.1.2	Search for Motion Vectors		
4.2	H.261	1	
4.2.1	Intra-Frame (I-Frame) Coding		
4.2.2	Inter-Frame (P-Frame) Predictive Coding		
4.2.3	Quantization in H.261		
4.2.4	H.261 Encoder and Decoder		
4.3	H.263	1	
4.3.1	Motion Compensation in H.263		
4.4	Big Data Compression	1	CO5
4.4.1	Query IO		
4.4.2	Re-Compression		
5	Video Coding		CO6
5.1	MPEG-1	1	
5.1.1	Motion Compensation in MPEG-1		
5.2	MPEG-2	1	
5.2.1	Supporting Interlaced Video		
5.2.2	MPEG-2 scalabilities		
5.2.3	Other Major Differences from MPEG-1		
5.3	MPEG-4	2	
5.3.1	Object-Based Visual Coding in MPEG-4		
5.3.2	Synthetic Object Coding in MPEG -4		
5.3.3	MPEG-4 Object Types, Profiles and Levels		
5.4	H.264	1	
	Total Hours	36	

#### **Course Designers:**

- Dr.S.Mohamed Mansoor Roomi smmroomi@tce.edu
- Dr.B.Sathya Bama sbece@tce.edu
| 18ECPC0 | DSP ARCHITECTURE AND | Category | L | Т | Ρ | Credit |
|---------|----------------------|----------|---|---|---|--------|
|         | PROGRAMMING          | PE       | 2 | 0 | 2 | 3      |

## Preamble

This course describes the architecture and instruction set of fixed point DSP processor to design and implement digital filters for real world applications such as audio coding, audio effects and speech processing.

## Prerequisite

18EC440 Signal processing

## **Course Outcomes**

On the successful completion of the course, students will be able to

CO	Course Outcome Statement	Weightage***
Number		in %
CO1	Explain the architecture and instruction set of fixed point DSP	10
	processor	
CO2	Represent signal samples in fixed point format to perform	10
	arithmetic operations based on this format	
CO3	Write and simulate programs in assembly language and C	10
	language.	
CO4	Develop ALP and C coding to implement FIR/IIR filter and their	25
	frequency domain analysis 👂 🎢 📩 🥂 🎽	
CO5	Develop ALP and C code for audio signal processing	25
	applications	
CO6	Apply code optimization and power management for efficient	20
	embedded system in fixed point processor	

\*\*\* Weightage depends on Bloom's Level, number of contact hours CO Mapping with CDIO Curriculum Framework

СО	TCE	Learning Domain Level			CDIO	Cu	rricular
#	Proficiency	Cognitive	Affective	<b>Psychomotor</b>	Compo	onents	
	Scale				(X.Y.Z)		
CO1	TPS2	Understand	Respond	-	1.1.3		
CO2	TPS2	Apply	Value	Mechanism	2.1.1,	2.1.2,	2.1.3,
					2.1.5,	2.4.1,	2.4.2
CO3	TPS3	Apply	Value	Mechanism	2.1.1,	2.1.2,	2.1.3,
					2.1.5, 2	.4.1, 2.4.2	2
CO4	TPS4	Apply	Value	Mechanism	2.1.1,	2.1.2,	2.1.3,
					2.1.4,	2.1.5,	2.4.1,
					2.4.2,	2.4.3,	2.4.4,
					2.4.6,	3.1.1,	3.1.2,
					3.2.1,	3.2.2,	3.2.6,
					4.4.1,	4.4.2,	4.4.3
CO5	TPS4	Apply	Value	Mechanism	2.1.1,	2.1.2,	2.1.3,
					2.1.4,	2.1.5,	2.4.1,
					2.4.2,	2.4.3,	2.4.4,
					2.4.6,	3.1.1,	3.1.2,
					3.2.1,	3.2.2,	3.2.6,
					4.4.1,	4.4.2,	4.4.3
CO6	TPS3	Apply	Value	Mechanism	2.1.1,	2.1.2,	2.1.3,
					2.1.4,	2.1.5,	2.4.1,
					2.4.2,	2.4.3,	2.4.4,
					2.4.6,	3.1.1,	3.1.2,
					3.2.1,	3.2.2,	3.2.6,
					4.4.1,	4.4.2,	4.4.3

Марр	Mapping with Programme Outcomes															
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	
CO1	Μ	L		-	-	-	-	L	L	L	-	L	L	-	L	
CO2	S	М	L	-	S	-	-	L	L	L	-	L	L	L	L	
CO3	S	М	L	-	S	-	-	L	L	L	-	L	М	L	L	
CO4	S	Μ	L	-	S	-	-	M	Μ	М	L	L	M	M	М	
CO5	S	М	L	-	S	-	-	Μ	Μ	М	L	L	M	M	М	
CO6	S	Μ	L	-	S	-	-	Μ	Μ	Μ	L	L	М	Μ	М	
S- Str	ong; l	M-Me	dium;	L-Lo	N											
Asses	ssme	nt Pa	ttern	: Cog	nitive	Dom	nain					1				
Blo	om's	Cate	aorv		Co	ntinuo	ous A	ssess	ment	Tests	ests End Semester				er	
	Bloom's Galegory				1		2			3		Examination				
	Remember		r		20			0		0						
	Unde	Understand 20 2		20		20		-								
	Ap	ply			60			80		80						
	Ana	alyse			0			0		0		_	Lab Ex	ab Examination		
	Eva	luate			0			0		0						
	Cre	eate			0		100	0		0						
Asses	ssme	nt Pa	ttern	: Psy	chom	otor							<u> </u>			
Psyc	homo	otor S	5KIII				23	mit (	29				Praction	cal		
Perc	eptior	1				-	2		57				-			
Set						A	120	Sand	15 3							
Guid	ed Re	espon	se			10	N.		A.		50					
Mech	nanisr	n				4	22	20	-84	1	50					
Com	plex (	Dvert	Resp	onses	5			SU 1	/							
Adap	otatior	۱					-	_	-							
Origi	natior	<u>ן</u>						-	-		_	_	-			

## Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. Mention the computational units available in Blackfin processor.
- 2. Lists the flags and their positions in ASTAT register.
- 3. Let *R*4 = 0xA5A5C3AA, R3.L=0x0D09, Find the result in R7 after executing the instruction R7=extract (R4, R3.L) (x);

## Course Outcome 2 (CO2):

- 1. Represent -0.01171875 in 1.15 format.
- 2. Find the largest positive value represented by 4.12 format.
- 3. Write the difference between truncation and rounding. What are the types of rounding? Give examples for types of rounding.

## Course Outcome 3 (CO3):

- 1. Write an assembly language program in DSP processor to find 5!
- 2. Write an Assembly language program in DSP processor to arrange the number in ascending order for the given array.
  - *Input* = {0x2828, 0x4444, 0x1234, 0x2F02, 0x7777, 0x4FFE}
- 3. Write an Assembly language program in DSP processor to arrange the number in descending order for the given array.

 $Input = \{0x2828, 0x4444, 0x1234, 0x2F02, 0x7777, 0x4FFE\}$ 

## Course Outcome 4 (CO4):

 A dc signal generator fluctuate between 1Volt to 10 Volt in an observation interval of T seconds is given by {1,5,8,2,4,9,3}. Choose appropriate FIR filter to smooth the variation in the output voltage and implement in DSP processor simulator.

Passed in BoS Meeting 16.11.2019

- 2. Compute the gain  $|H(\omega_0)|$  of moving average filters with length L=5, L=10, and L=20 at frequency  $\omega_0 = 0.1\pi$ .
- 3. Develop C code to implement moving average filter in DSP processor to remove a 1,000 Hz tone that muffles the speech signal.

## Course Outcome 5 (CO5):

- 1. A noisy speech signal, noisy wav is recorded offline. This signal contains band limited noise that can be removed with the graphic equalizer. Analyze the band limited noise in order to design a suitable graphic equalizer to remove the band limited noise with the EZ-KIT.
- 2. Develop C code in DSP processor to implementing FIR graphic equalizer.
- 3. Develop C code in DSP processor to implementing IIR graphic equalizer.

## Course Outcome 6 (CO6):

- 1. Determine the cycle count and processing MIPS in implementing a 256- tap FIR filter (with 16-bit arithmetic) using sample and block processing modes. The FIR filter is sampled at 48 kHz.
- 2. The cycle count for performing FIR filter in linear assembly code without branch prediction is [28 × Nc +22] × Nb + 66 cycles, where Nc is the number of coefficients in the FIR filter and Nb is the number of samples per block. The 66 cycles are overhead for setting up the FIR filter. Compute the cycle count/input sample and processing time/input sample in implementing a 32-tap FIR filter with different data samples per block. The Blackfin processor is operating at 270 MHz.
- 3. Implement a symmetric FIR filter in C with intrinsic functions on the Blackfin processor. Build the project by enabling the optimization in the Visual DSP++ compiler. Benchmark on the cycle count, data, and code size of the symmetric FIR filter and compare the results with the direct-form FIR filter. Does the symmetric FIR filter always result in a better performance as compared to the direct-form FIR filter? If not, why?



# Syllabus

## Theory:

**Core Architecture:** Introduction to Signal Processing Algorithms, Architecture of fixed point DSP processor, Data Arithmetic Unit, Address Arithmetic Unit, Control Unit, Memory map, Peripherals: General purpose Timers, General purpose flags, UART, serial peripheral interface, serial ports, parallel peripheral interface.

Passed in BoS Meeting 16.11.2019

**Instruction Set:** Load/Store, move, Arithmetic and Logical operations, Bit operations, Shift/Rotate operations, Program flow control **Number Format:** Fixed point format, fixed point extended format, fixed point data types, dynamic range, precision and quantization error, Comparison between fixed point and floating point data types. **Assembly Language Programming:** Programs for working on Load-Store – Move – Buffers - Loops, Programs for working on Arithmetic and Logical instructions, Programs for working on Program flow – CC management – Bit operations. **Implementation in EZ-KIT:** Convolution, FIR filter, IIR filter, Spectral analysis of FIR and IIR filter. **Applications:** Audio coder, Audio effects, **Code Optimization and Power Management:** C optimization techniques, Assembly coding for efficient programming, Cycle count and Code size, Power consumption and management. **Practical:** 

- 1. Assembly Language Programming in fixed point DSP processor
  - a) Working on Load-Store-Move-Buffers-Loops
  - b) Working on Arithmetic and Logical Instructions
  - c) Working on Program Flow CC management Bit operations
- 2. Implementation of moving average filter in EZ-KIT platform.
- 3. Frequency analysis in EZ-KIT platform.
- 4. Implementation of FIR/IIR based graphic equalizer in EZ-KIT.
- 5. Implementation of A-law and  $\mu$ -law companding algorithm in EZ-KIT.
- 6. Sample rate conversion in EZ-KIT

## Learning Resources

- ADSP Blackfin Processor Hardware Reference, Revision 3.6, 2013.
- Blackfin Processor Programming Reference, Revision 2.2, 2013.
- Woon-Seng Gan, Sen.M.Kuo, Embedded Signal Processing with Micro Signal Architecture, John Wiley Sons, 2007
- Richard Newbold, "Practical applications in Digital Signal Processing, Pearson Prentice Hall, 2012.

## **Course Contents and Lecture Schedule**

Module No.	Торіс	No.of Lectures	CO
1	Core Architecture		
1.1	Introduction to Signal Processing algorithms	1	CO1
1.2	Micro signal architecture Blackfin processor	1	CO1
1.3	Data Arithmetic Unit, Address Arithmetic Unit	1	CO1
1.4	Control Unit, memory map	1	CO1
1.5	Peripherals: General purpose Timers, General purpose flags,	1	CO1
1.6	UART, serial peripheral interface,	1	CO1
1.7	serial ports, parallel peripheral interface	1	CO1
2	Instruction Set		
2.1	Arithmetic and Logical operations	1	CO1
2.2	Bit operations	1	CO1
2.3	Shift/Rotate operations, Program flow control	1	CO1
3	Number Format:		
3.1	Fixed point format, fixed point extended format	1	CO2
3.2	fixed point data types, dynamic range, precision and quantization error	1	CO2
3.3	Comparison between fixed point and floating point data	1	CO2
	types		
4	Assembly Language Programming		
4.1	Programs for working on Load-Store – Move – Buffers -	1	CO3
4.2	Programs for working on Arithmetic and Logical	1	CO3

	instructions		
4.3	Programs for working on Program flow – CC management	1	CO3
	- Bit operations		
5	Implementation in EZ-KIT		
5.1	Convolution	1	CO4
5.2	FIR filter, IIR filter	1	CO4
5.3	Spectral analysis of FIR and IIR filter.	1	CO4
6	Applications		
6.1	Audio coder	1	CO5
6.2	Audio effects	1	CO5
7	Code Optimization and Power Management		
7.1	C optimization techniques	1	CO6
7.2	Assembly coding for efficient programming, cycle count	1	CO6
	and code size.		
7.3	Power consumption and management	1	CO6
	Theory	24	
	Practical	24	
	Total	48	
Course			

### Course Designers:

Dr.S.J.Thiruvengadam

• Dr.P.G.S.Velmurugan

sjtece@tce.edu pgsvels@tce.edu

18ECPD0	WIRELESS COMMUNICATION SYSTEMS	Category	L	Т	Ρ	Credit
		PE	2	1	0	3

## Preamble

The objective of the course on "Wireless Communication systems" is to present the techniques in the physical layer aspects of wireless communication systems and determine the performance of wireless systems in terms of capacity and probability of error.

## Prerequisite

18EC520 Analog and Digital Communication Systems

## **Course Outcomes**

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Describe the fundamentals of cellular concepts in Wireless	15
	communication systems.	
CO2	Characterize the wireless channel in terms of small scale and	15
	large-scale fading parameters.	
CO3	Determine the BER and outage performance of wireless systems in	15
	fading environments.	
CO4	Calculate the Capacity of SIMO, MISO and MIMO Wireless	15
	channels.	
CO5	Determine the BER performance of SIMO, MISO and MIMO	20
	Wireless communication systems in fading environments.	
CO6	Determine the capacity region of the given interference channels.	20

## CO Mapping with CDIO Curriculum Framework

CO	TCE	Learning Domain Level			CDIO Curricular Components
#	Proficien	Cognitive	Affective	Psychomotor	(X.Y.Z)
	cy Scale	-			
CO1	TPS2	Understand	Respond	-	1.2.3, 2.4.6, 3.2.3
CO2	TPS3	Apply	Value		1.2.1, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO3	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6,
					2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6,
					2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6,
					2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO6	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6,
					2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2

## Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	М	L	-	-	-	-	-	-	-	-	-	-	L	I	L
CO2	S	М	L	-	-	-	-	-	-	-	-	-	М	-	L
CO3	S	М	L	-	-	-	-	-	-	-	-	-	М	L	L
CO4	S	М	L	-	S	-	-	-	S	S	-	-	М	L	L
CO5	S	М	L	-	S	-	-	-	S	S	-	-	М	L	L
CO6	М	М	L	-	-	-	-	-	-	-	-	-	L	I	L

S- Strong; M-Medium; L-Low

Cognitive Levels	Contir	nuous Ass Tests	End Semester Examination				
	1	2	3	1	2	3	
Remember	20	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	60	80	80	100	100	100	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	30
Complex Overt Responses	-	-	-
Adaptation	- monton	-	-
Origination	Father	-	-

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. If a total of 33MHz of bandwidth is allocated to a particular FDD Cellular telephone system which uses two 25KHz simplex channels to provide full duplex voice and control channels, compute the number of channels available per cell for four cell reuse system.
- 2. Show that the frequency reuse factor for a cellular system is given by k/s, where k is the average number of channels per cell, and s is the total number of channels available to the cellular service provider.
- 3. Find the far field distance for an antenna with maximum dimension of 1m and operating frequency of 900MHz.

## Course Outcome 2 (CO2):

- 1. Classify the following as slow or fast and frequency selective or frequency flat. Justify your answers. Assume that the system occupies the full bandwidth listed.
  - (a) A cellular system with carrier frequency of 2GHz, bandwidth of 1.25MHz, that provides service to high-speed trains. The RMS delay spread is 2us.
  - (b) A vehicle-to-vehicle communication system with carrier frequency of 800MHz and bandwidth of 100kHz. The RMS delay spread is 20ns.
  - (c) A 5G communication system with carrier frequency of 3.7GHz and bandwidth of 200MHz.
  - (d) A 60GHz wireless personal area network with a bandwidth of 2GHz and an RMS delay spread of 40ns. The main application is high-speed multimedia deliverv.
  - (e) Police-band radio. Vehicles move at upwards of 100mph and communicate with a base station. The bandwidth is 50kHz at 900MHz carrier.
- 2. Consider the LOS/NLOS path-loss model with  $P_{los}(d) = e^{-d/200}$ , free space for the LOS path loss, log distance without shadowing for the NLOS with  $\beta$  = 4, reference distance of 1m,  $G_t = G_r = 0$ dB, and  $\lambda = 0.1$ m. Plot the path loss in decibels for distances from 1 to 400m.
- 3. Compute the maximum Doppler shift for the following sets of parameters: (a) 40MHz of bandwidth, carrier of 2.4GHz, and supporting 3km/h speeds (b) 2GHz of bandwidth, carrier of 64GHz, and supporting 3km/h speeds

## Course Outcome 3 (CO3):

- 1. The received signal model in wireless communication system is given by y = hx + n, where magnitude of *h* is Rayleigh distributed, *x* is a unit energy BPSK symbol and *n* is complex Gaussian noise with variance  $\sigma_n^2$ . Derive the probability of occurrence for deep fade event.
- 2. Consider a voice system with acceptable BER when the received signal power is at or above half its average value. If the BER is below is acceptable level for more than 120ms, users will turn off their phone. Find the range of Doppler values in a Rayleigh fading channel such that the average time duration when users have unacceptable voice quality is less than t = 60ms.
- 3. Determine the capacity of slow fading channel and prove that the outage probability  $2^{R}$  1

is 
$$P_{out}(R) = \frac{2^{R} - 1}{SNR}$$
 where R is the data rate.

## Course Outcome 4 (CO4):

1. Consider a SIMO System with flat fading described by

$$y[n] = hs[n] + v[n]$$

Suppose that v[n] is zero mean and covariance  $R_v$ , determine the receive beamforming vector w that maximizes the signal to noise ratio. Assume that  $R_v$  is invertible.

- 2. Consider the Alamouti code with two transmit and two receive antennas with an optimum combiner. Write the equations for the received signal on each antenna. Stack them together and perform the spatial matched filter. Then, show how the observations on each antenna can be combined to get better performance. Determine the diversity order.
- 3. Derive the maximum likelihood decoder for a spatial multiplexing system with  $N_t = 2$  and where different constellations  $C_1$  and  $C_2$  are used.

## Course Outcome 5 (CO5):

- 1. Consider the groundbreaking space-time code devised by Alamouti, used in a MIMO system with  $N_t = 2$  and Nr receive antennas. Derive the pairwise error probability for the Alamouti code and show that the diversity order is 2Nr.
- 2. Three well-known diversity combining methods are maximum ratio combining (MRC), selection combining (SC), and switch-and-stay combining (SSC). Compare and contrast these techniques. In a flat-fading channel, what is the impact of each method on the symbol error rate; that is, how is the probability of symbol error different from the symbol error rate for a SISO channel?
- 3. Look up cyclic delay diversity as used in IEEE 802.11n and explain how it works.

## Course Outcome 6 (CO6):

- 1. What is the capacity region of the Gaussian Interference channel with weak interference?
- 2. Is the Han-Kobayashi Inner bound tight in general?
- 3. What is the capacity region of the 3 user pair injective deterministic interference channels?



## Syllabus

Wireless Fundamentals: Cellular concept, Path loss and shadowing: Radio Wave Propagation, Transmit and Receive Signal Models, Free-Space Path Loss Wireless Propagation: Statistical Multipath models, Time varying channel Impulse response, Calculating Impulse response from Power Delay Profile, Large scale channel models, Friis free space model, Log distance path loss model, LoS and NLoS path loss models, Small scale fading selectivity: Frequency selective fading, Time selective fading, Signal models for channel selectivity, Small scale channel models: Flat fading channel models, Frequency selective channel models, Link Budget analysis Performance analysis with fading channel models: Capacity Analysis: Capacity of Flat fading Channels, Capacity of frequency selective fading Channels BER Analysis: SISO Flat fading channels, Multiantenna Communications: Single Input and Multiple output(SIMO), Multiple input and Single output (MISO), Multiple Input and Multiple Output (MIMO), Receiver diversity for Flat fading SIMO Systems: Antenna selection, Maximum Ratio Combining, Transmit diversity for MISO Systems: Transmit Beamforming, Alamouti code, Space Time Coding, MIMO Transceiver techniques, Spatial Multiplexing Interference channels: Discrete Memoryless Interference channel, Simple coding scheme, strong Interference, Gaussian Interference channel, Han-Kobayashi Inner bound, Capacity region, Gaussian vector channels Case studies: RF over Optics, 5G wireless systems.

## Learning Resources

- Robert W. Heath Jr. "Introduction to Wireless Digital Communication: A Signal processing perspective", 1<sup>st</sup> Edition, Prentice Hall,2017.
- Aditya.K.Jegannatham, "Principles of Modern Wireless Communication Systems", Tata McGraw Hill, 2016.
- E.Gamal,Y-H.Kim, Network Information Theory, First Edition, Cambridge University Press, Cambridge,UK,2011.
- Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005
- David Tse and Pramod Viswanath, "Fundamentals of Wireless Communications", Cambridge University Press, 2006.
- A.Paulraj, R. Nabar and D Gore, "Introduction to Space-Time Wireless Communications", Cambridge University Press, 2003.
- Hueber, G., and Niknejad, A. (Eds.). (2019), Millimeter-Wave Circuits for 5G and Radar (The Cambridge RF and Microwave Engineering Series), Cambridge: Cambridge University Press.
- Ranjan Bose, Wireless Communication, NPTEL Video lectures: https://nptel.ac.in/courses/117102062/#

Cour	se Contents and Lecture Schedule		
No.	Торіс	No. of	COs
		Hours	
1	Wireless Fundamentals		
1.1	Cellular concept, Path loss and shadowing	1	CO1
1.2	Radio Wave Propagation, Transmit and Receive Signal Models	1	CO1
1.3	Free-Space Path Loss	1	CO1
2	Wireless Propagation		
2.1	Statistical Multipath models, Time varying channel Impulse	1	CO2
	response		
2.2	Calculating Impulse response from Power Delay Profile	1	CO2
2.3	Large scale channel models, Friis free space model	1	CO2
2.4	Log distance path loss model, LoS and NLoS path loss models	1	CO2
2.5	Small scale fading selectivity, Frequency selective fading	1	CO2
2.6	Time selective fading, Signal models for channel selectivity	1	CO2
2.7	Small scale channel models, Flat fading channel models	1	CO2
2.8	Frequency selective channel models,	1	CO2
3	Performance analysis with fading channel models	•	
3.1	Capacity of Flat fading Channels	2	CO3
3.2	Capacity of frequency selective fading Channels	1	CO3
3.3	BER Analysis		
4.1	SISO Flat fading channels 🥂 🔧	1	CO3
4	Multi antenna Communications		
4.1	Multi antenna communication, Single Input and Multiple output(SIMO)	2	CO4
4.2	Multiple input and Single output (MISO), Multiple Input and Multiple	2	CO4
4.0	Output (MIMO)		005
4.3	selection	2	005
4.4	Maximum Ratio Combining, Transmit diversity for MISO Systems	2	CO5
4.6	Reciprocity based beamforming, Alamouti code	2	CO5
4.7	Spatial Multiplexing	2	CO5
4.8	MIMO Transceiver techniques	2	CO5
5	Interference channels		
5.1	Discrete Memoryless Interference channel, Simple coding scheme	1	CO6
5.2	strong Interference, Gaussian Interference channel	1	CO6
5.3	Han-Kobayashi Inner bound, Capacity region	1	CO6
5.4	Gaussian vector channels	1	CO6
6	Case studies		
6.1	RF over Optics, 5G wireless systems		
Cour	se Designers:	·	

# Dr.S.J.Thiruvengadam Dr.G.Ananthi •

•

sjtece@tce.edu gananthi@tce.edu

7 [

BIOMEDICAL SIGNAL PROCESSING	Catego
	PE

Category	L	Т	Ρ	Credit
PE	2	0	2	3

## Preamble

The first objective of this course is to present signal processing techniques/algorithms to process biomedical signals for removal of artifacts and event detection in both time domain and frequency domain. The second objective is to simulate the signal processing algorithms using MATLAB for detecting events in the available biomedical data files which helps in diagnosis.

## Prerequisite

18EC440 Signal Processing

### Course Outcomes

On the successful completion of the course, students will be able to

CO#	Course Outcome Statement	Weightage***						
		in %						
CO1	Explain the nature of biomedical signals and their artifacts.	10						
CO2	Remove artifacts in biomedical signals with time domain and frequency domain filters and implement the filters using simulation tool.	20						
CO3	Identify the discrete signal epochs in a biomedical signal and correlate them with events in the related physiological process and develop programs for the same.	20						
CO4	Perform spectral analysis of biomedical signals and systems with suitable signal processing methods and implement the methods.	20						
CO5	Diagnose the abnormality in biomedical signals using Aurdino	20						
CO6	Describe the basic building blocks of healthcare IoT	10						
*** \//ai	*** Weightens depende on Disem's Level number of contact hours							

\*\*\* Weightage depends on Bloom's Level, number of contact hours

CO#	TCE	Learning Dor	nain Level		CDIO Curricular
	Proficiency	Cognitive	Cognitive Affective		Components
	Scale	_		_	(X.Y.Z)
CO1	TPS2	Understand	Respond	-	1.1.4, 2.1.1, 2.2.3, 2.3.1
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.2.3, 2.4.2,
					3.1.1, 3.1.5, 3.2.3, 3.2.5,
					4.4.1, 4.4.4, 4.5.1, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.2.1, 2.2.3,
					2.3.1, 2.4.2, 3.1.1, 3.1.5,
					3.2.3, 4.4.1, 4.4.4, 4.5.1,
					4.6.2
CO4	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.5, 2.2.1, 2.2.3,
					2.3.1, 2.4.2, 3.1.1, 3.1.5,
					3.2.3, 4.4.4, 4.5.1, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	2.4.2, 3.1.1, 3.1.5, 3.2.3,
					3.2.5, 4.4.4, 4.5.1, 4.6.2
CO6	TPS2	Understand	Respond	-	2.4.2, 3.1.1, 3.1.5, 3.2.3,
					4.4.4, 4.5.1, 4.6.2

Mapping with Programme Outcomes															
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Μ	L		-	-	-	-	-	-	-	-	L	L	-	L
CO2	S	Μ	L	-	S	-	-	L	М	L	-	L	S	М	L
CO3	S	Μ	L	-	S	-	-	L	М	L	-	L	S	M	L
CO4	S	Μ	L	-	S	-	-	L	Μ	L	-	L	S	M	L
CO5	S	Μ	L	-	S	-	-	L	Μ	L	-	L	S	M	L
CO6	Μ	L	-	1	-	-	-	-	1	-	-	L	L	-	L
S- Str	ong; l	M-Me	dium;	L-Lo	N										
Asse	ssme	nt Pa	ttern:	Cog	nitive	Dom	ain								
Blo	om's	Cate	aorv		Co	ntinuc	ous As	ssess	ment	Tests			End Se	emeste	r
	501113	Oale	gory		1			2		3		Examination			
	Rem	embe	r		20			0		0		0			
	Unde	rstan	d		20			20		20	20 20				
	Ap	ply			60			80		80	80 80				
	Ana	alyse			0			0		0	0 0				
	Eva	luate			0			0		0	0 0				
	Cro	eate			0		750	0		0	0 0				
Asse	ssme	nt Pa	ttern:	Psyc	chom	otor				-					
Psyc	homo	otor S	Skill			1	297	mit (	P D			F	Practica	al	
Perc	eptior	1				-		間	E	-					
Set								A							
Guided Response								7			-				
Mec	Mechanism								1			100			
Complex Overt Responses											-				
Adap	otatior	1					-	_					-		
Origi	natior	<u>ו</u>				1.0							-		

### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. Draw a typical ECG waveform over one cardiac cycle indicating the important component waves their typical durations and the typical intervals between them.
- 2. Draw the waveform corresponding to two cycles of a typical ECG and indicate the following waves and periods: a)the P,QRS, and T waves b) the RR interval c) atrial contraction d) atrial relaxation
- 3. Explain why the P and T waves are low-frequency signals whereas the QRS complex is a high-frequency signal.

## Course Outcome 2 (CO2):

- 1. Explain how you would apply synchronized averaging to remove noise in a) ECG signals b) event-related potentials c) heart sound (PCG) signals d) EMG signals?
- Draw a typical ECG waveform over one cardiac cycle indicating the important component waves. How is the waveform affected by passage through

   a) alowpass filter with a cutoff frequency of 40Hz?
  - b) ahighpass filter with a cutoff frequency of 5Hz?
- 3. A biomedical signal sampled at 500Hz was found to have a significant amount of 60Hz interference. a)Design a notch filter with two zeros to remove the interference. b)What is the effect of the filter if a signal sampled at 100Hz is applied at the input?

## Course Outcome 3 (CO3):

- 1. Explain Pan-Tompkins algorithm for QRS detection.
- 2. Prove that autocorrelation  $\phi_{xx}(\tau)$  of any function is maximum at  $\tau = 0$ .
- 3. Propose an algorithm to detect the P wave in the ECG signal.

## Course Outcome 4 (CO4):

- 1. Two real signals  $x_1(n)$  and  $x_2(n)$  are combined to form a complex signal defined as  $y(n) = x_1(n) + jx_2(n)$ . Derive a procedure to extract the DFTs  $X_1(k)$  and  $X_2(k)$  of  $x_1(n)$  and  $x_2(n)$  from the DFT Y(k) of y(n).
- 2. Two signals with sample values: {3,1,-1} and {4,4,2,1} are given. Implement the convolution of these two signals using FFT.
- 3. A signal x(t) is transmitted through a channel. The received signal y(t) is obtained as  $y(t) = \alpha x(t - t_0) + \eta(t)$  where  $\alpha$  is a scale factor,  $t_0$  is the time delay and  $\eta(t)$  is noise. Derive expressions for the Power Spectral Density (PSD) of y(t) in terms of PSDs of x and  $\eta$ .

## Course Outcome 5 (CO5):

- 1. Develop an algorithm using time domain technique to remove base-line drift in the ECG signal.
- 2. Using Arduino kit, filter the noisy ECG signal using Butterworth highpass filters with orders 2-8 and cutoff frequencies 0.5-5 Hz.
- 3. Detect the presence of the alpha rhythm in the given EEG signal using Arduino kit.

## Course Outcome 6 (CO6):

- 1. List the most important physiological data for the development of a ubiquitous IoT healthcare system that can ensure more accurate diagnosis, real-time evidence based treatment, lower hospital visits, and optimal utilization of resources.
- 2. List the protocols employed in the IoT cloud in order to provide visual and timely data to users.
- 3. Explain the basic building blocks of healthcare IoT.

## Concept Map



# Theory:

**Introduction to Biomedical Signals:** Nature of Biomedical Signals, Examples of Biomedical Signals-Action Potential, Electromygraphy (EMG), Electrocardiography (ECG), Electroencephalography (EEG), Event Related Potentials (ERPs), Electrogastrogtam (EGG), Phonocardiogram (PCG), Carotid Pulse (CP), Vibromyogram (VMG) and Vibroarthrogram (VAG), Objectives of Biomedical Signal Analysis **Filtering for Removal of Artifacts:** Time Domain Filters –Synchronized averaging, Moving-average filters, Derivative based operators to remove low-frequency artifacts, Frequency-domain Filters –Removal of high-frequency noise using Butterworth low pass filters, Removal of low-frequency noise using Butterworth low pass filters, Removal of low-frequency noise using Butterworth high pass filters, Removal of periodic artifacts using Notch and Comb filters, Optimal filtering, Removal of artifacts using Arduino **Event Detection:** Derivative based methods for QRS detection, The Pan-Tompkins algorithm for QRS detection, Detection of the dicrotic notch, Detection of EEG rhythms, EEG spike-and-wave detection, Detection of the P wave, Homomorphic filtering, Event detection using Arduino **Frequency domain characterization of biomedical signals:** Estimation of power spectral density function: The periodogram,

Averaged periodogram, Use of windows: Spectral resolution and leakage. **Basic building blocks of healthcare IoT** 

# Practical:

# Filtering for Removal of Artifacts:

- 1. Removal of power line artifacts in biosignals.
- 2. Removal of noise using IIR filters.
- 3. Removal of random noise using synchronized averaging.
- 4. Removal of baseline drift using derivative based Filter.

## **Event Detection:**

- 5. QRS Complex Detection using Pan Tompkin Algorithm.
- 6. Detection of alpha rhythm using cross-correlation coefficients.
- 7. Detection of s1 and s2 onset in PCG signal.

## **Spectral Analysis of Biomedical Signals:**

8. Analysis of power spectral density of EEG and VAG signals for diagnosis.

## Learning Resources

- R.M.Rangayan, "Biomedical Signal Analysis: A Case Study Approach" John Wiley & Sons. Inc, 2005.
- Willis J.Tompkins, "Biomedical Signal Processing", EEE, PHI,2004.
- D.C.Reddy, "Biomedical Signal Processing: Principles and Techniques", Tata McGraw Hill Publishing Co. Ltd, 2005.
- NPTEL course on Biomedical Signal Processing: https://onlinecoursesarchive.nptel.ac.in/noc19\_ee23/.
- Balas, V.E., Solanki, V.K., Kumar, R., Ahad, M.A.R, "A Handbook of Internet of Things in Biomedical and Cyber Physical System", Intelligent Systems Reference Library, Springer, 2020.

Module	Торіс	No. of	CO
No.		Lectures	
1	Introduction to Biomedical Signals:		
1.1	Nature of Biomedical Signals	1	CO1
1.2	Examples of Biomedical Signals-Action Potential, EMG,	2	CO1
	ECG, EEG, ERPs, EGG, PCG, CP, Speech Signals, VMG and VAG		
1.3	Objectives of Biomedical Signal Analysis	1	CO1
2	Filtering for Removal of Artifacts:		
2.1	Time Domain Filters –Synchronized averaging	1	CO2
2.2	Moving-average filters	1	CO2
2.3	Derivative based operators to remove low-frequency	1	CO2
	artifacts		
2.4	Frequency-domain Filters – Removal of high-frequency	2	CO2
	noise using Butterworth lowpass filters		
2.5	Removal of low-frequency noise using Butterworth high pass filters	1	CO2
2.6	Removal of periodic artifacts using Notch and Comb filters	1	CO2
2.7	Optimal filtering	2	CO2
2.8	Practical – Filtering for Removal of Artifacts using MATLAB	4	CO2
2.9	Practical – Filtering for Removal of Artifacts using Arduino	4	CO5
3	Event Detection:		
3.1	Derivative based methods for QRS detection	1	CO3
3.2	The Pan-Tompkins algorithm for QRS detection	3	CO3
3.3	Detection of the dicrotic notch	1	CO3
3.4	Detection of EEG rhythms	1	CO3

## **Course Contents and Lecture Schedule**

3.5	EEG spike-and-wave detection	1	CO3
3.6	Detection of the P wave	1	CO3
3.7	Homomorphic filtering	1	CO3
3.8	Practical: Event Detection using MATLAB	4	CO3
3.9	Practical: Event Detection using Arduino	4	CO5
4	Frequency domain characterization of biomedical		
	signals:		
4.1	Estimation of power spectral density function: The	1	CO4
	periodogram		
4.2	Averaged periodogram	2	CO4
4.3	Use of windows: Spectral resolution and leakage	1	CO4
4.4	Practical: Spectral analysis of Biomedical signals using	4	CO4
	MATLAB		
5	Basic building blocks of healthcare IoT	2	CO6
	Total	48	

# **Course Designers:**

- Dr.S.J.Thiruvengadam
- Dr.K.Rajeswari

sjtece@tce.edu rajeswari@tce.edu



18ECPF0	FPGA BASED DIGITAL SYSTEM DESIGN	Category	L	Т	Ρ	Credit
		PE	3	0	0	3

## Preamble

FPGA based Digital System Design aims at analyse the different architecture and organisation of Field Programmable Gate Arrays. Initially the different elements like Programmable logic cell, interconnect and Input/Output cells of the FPGA are explored and analysed. The subject focuses on the procedure for the design of sequential digital circuits and their mapping with the fixed platform of FPGA. It also analyses the timing issues related with the digital circuits of major concern and the alternate to overcome the timing issues in FPGA. Finally the learner is exposed with some reference case studies for FPGA implementation of both combinational and sequential digital circuits.

## Prerequisite

18EC270 Digital System Design

## Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage
	A DA	in %
CO1	Describe the FPGA design flow, architecture, programming technologies.	15
CO2	Analyse the configurable logic elements of Xilinx and altera FPGAs	10
CO3	Map the combinational and sequential circuits in the preferred FPGA hardware platform.	20
CO4	Analyse the Input / Output cells of FPGA for interfacing with external peripherals.	20
CO5	Understand the interconnect architectures of different vendors of FPGA	10
CO6	Analyse the timing parameters of combinational and sequential digital circuits.	15
CO7	Demonstrate the functioning of a digital system in a FPGA hardware platform	10

## CO Mapping with CDIO Curriculum Framework

CO	TCE	Learr	ning Domair	n Level	CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale	-			
CO1	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.4.2, 2.5.1,
					3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3,
					4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3,
					4.5.5, 4.6.2
CO4	TPS4	Analyse	Organise	Complex	2.1.1, 2.1.2, 2.1.3, 2.5.1
				Overt	
				Response	
CO5	TPS2	Understand	Respond	Guided	2.5.4, 3.2.6
				Response	
CO6	TPS5	Evaluate	Organise	Adaptation	2.1.1, 2.1.2, 2.1.3, 2.5.1
CO7	TPS5	Evaluate	Organise	Adaptation	2.1.1, 2.1.2, 2.1.3, 2.5.1

## Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	Μ	L	-	L	-	-	L	L	L	-	L	М	-	L
CO2	S	М	L	-	L	-	-	L	L	L	-	L	М	-	L
CO3	S	М	L	-	L	-	-	L	L	L	-	L	М	-	L
CO4	S	S	Μ	L	L	-	-	L	L	L	-	L	S	-	L
CO5	Μ	L	-	-	-	-	-	-	L	L	-	L	S	-	L
CO6	S	S	M	Μ	L	-	-	-	-	-	-	-	S	-	-
CO7	S	S	Μ	Μ	L	-	-	-	-	-	-	-	S	-	-

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

Cognitive	As	Continuo sessment	ous Tests		Assignme	End	
Levels	1	2	3	1	2	3	Semester Examinatio n
Remember	20	0	0	-	-	-	10
Understand	20	20	20	-	-	-	10
Apply	60	40	30 🦯	100	50		50
Analyse	0	40	30 🧹 🏑	0	50	40	20
Evaluate	0	0	10	0	0	20	10
Create	0	0	0	0	0	0	0

## **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment 3
Perception	
Set	
Guided Response	
Mechanism	40
Complex Overt Responses	
Adaptation	
Origination	

# Sample Questions for Course Outcome Assessment\*\*

## Course Outcome 1(CO1):

- 1. Compare the coarse grained architecture and fine grained architecture of FPGA.
- 2. Draw and illustrate the process of storing information in an SRAM and DRAM cell.
- 3. Explain the method of programming and erasing the EPROM and EEPROM memory cell.

## Course Outcome 2(CO2):

- 1. Draw the architecture of logic cells used in Altera MAX.
- 2. Draw the different elements present inside the Configurable Logic Block of Xilinx XC4000 series FPGA.
- 3. Compare the internal architecture, I/O and routing resources of CPLD and FPGA devices.

## Course Outcome 3(CO3):

- 1. Implement the Mod-8 counter circuit using an FPGA whose logic block consist of 3 input and show the interconnection between the blocks to derive the complete circuit from primary input to output.
- 2. Implement the logic function F(a,b,c) = a.b'.c'+a'.b'.c+a'.b.c+a'.b'.c' using three input CPLD and draw the circuit.

3. Report the memory content of Look Up Table of Xilinx XC4000 series FPGA for implementing an MOD-4 counter.

## Course Outcome 4 (CO4):

- 1. Draw the I/O cell structure of Xilinx FPGA and show the state of the programmable transistors to configure the cell.
- 2. Compare the I/O cells of Xilinx and Altera FPGA and conduct an investigation to find the scenario of limitation for implementation.
- 3. Illustrate an algorithm to interface the PS2 keyboard with the FPGA device present in an Development board.

## Course Outcome 5 (CO5):

- 1. Draw the switch matrix used for changing the interconnect routing inside an FPGA.
- 2. With the help of neat diagram, show the interconnect architecture of Altera CPLD.
- 3. Describe the mapping process of interconnect for an specific application in FPGA and CPLD.

## Course Outcome 6(CO6):

- 1. Consider a flip flop with a setup time of 3 ns and a hold time of 1ns. If the clock input rises at time t, is it ok for the data input to change at time t-2? What about t-4? What about t+1/2? What about t+2? Explain why it is not acceptable for the data input to change at certain times.
- 2. Consider a circuit in which there is a path from an input *x* to a flip flop that has a maximum possible delay of 7 ns, and there is also a path from *x* to another flip flop with a minimum delay of 3 ns. If the setup and hold times are 2 ns and 1 ns respectively and the clock input rises at time *t*, is it ok for *x* to change at time *t*–5? What about *t*–1? What about *t*? What about *t*–10?
- 3. Consider a flip flop with a setup time of 5 ns and a hold time of 3 ns. The clock input rises at time 20 ns. What it the latest time that the D input can change prior to the clock edge to ensure proper timing?

## Course Outcome 7(CO7):

- 1. Consider the design of a sequential circuit that could control a vending machine. Suppose that a coin-operated vending machine dispenses candy under the following conditions:
  - The machine accepts nickels and dimes.
  - It takes 15 cents for a piece of candy to be released from the machine.

If 20 cents is deposited, the machine will not return the change, but it will credit the buyer with 5 cents and wait for the buyer to make a second purchase. All electronic signals in the vending machine are synchronized to the positive edge of a clock.

2. The specification for the counter is

The counting sequence is 0, 1, 2, ..., 6, 7, 0, 1, ...

There exists an input signal w. The value of this signal is considered during each clock cycle. If w = 0, the present count remains the same; if w = 1, the count is incremented. The counter can be designed as a synchronous sequential circuit.

Concept Map



## Syllabus

**Digital Design process:** Standard ICs, ASIC and FPGA design flow, Programmable Logic Devices, FPGA architectures, Programming technologies: SRAM, DRAM, EPROM, EEPROM FLASH and Anti-fuses.

**Programmable Logic cells**: Xilinx and Altera logic blocks, Logic synthesis for combinational circuits, sequential circuits - Synchronous and Asynchronous Sequential Circuit -Finite State Machine design, Design examples: SOP and POS implementation, Flip flops and registers.

**Programmable I/O cells**: AC, DC inputs and outputs, Clock inputs and power inputs Xilinx I/O cells and Altera I/O cells. Interfaces: LED, LCD, Keyboard, DC motor and Stepper motor. **Programmable interconnects:** Switch matrix, Actel ACT, Xilinx LCA, EPLD, Altera Max and FLEX interconnect architectures.

**Timing Analysis:** Static Timing Analysis (STA) - Propagation delay, Critical path, Clock skew, Clock jitter, setup time and Hold time - violations, metastability, synchronisers, races and hazards.

Case studies: Vending machines, Counters, Arbiter, Arithmetic circuits.

## Learning Resources

- M. Morris Mano and Michael D. Ciletti, "Digital Design: with an Introduction to the Verilog HDL", 5<sup>th</sup> Edition, Prentice Hall 2012.
- Jan M. Rabey, Anantha Chandrakasan and Borivoje Nikolic "Digital integrated circuits: A Design Perspective (2<sup>nd</sup> Edition) ", Pearson 2009
- M.J.S.Smith, "Application Specific Integrated Circuits", Pearson, 2003.
- Stephen D. Brown, and Zvonko Vranesic, "Fundamentals of Digital Logic with Verilog Design, 2nd Edition," McGraw Hill, June, 2007.
- Samir Palnitkar, "Verilog HDL: A guide to digital design and synthesis" Pearson Education India, 2010.

Module	Торіс	No. of	Course
No.		Hours	Outcome
1.	Digital Design process		
1.1	Implementation Technologies		
1.1.1	Standard ICs, ASIC, Programmable Logic Devices	1	CO1
1.2	FPGA Design flow and architectures	1	CO1
1.5	Programming technologies:		
1.5.1	SRAM, DRAM	1	CO1
1.5.2	EPROM, EEPROM	1	CO1
1.5.3	FLASH and Anti-fuses.	1	CO1
2.	Programmable Logic cells:		
2.1	Xilinx and Altera logic blocks	2	CO2
2.1.1	Logic synthesis - combinational circuits,	2	CO2
2.1.1.1	Sequential circuits - Synchronous and Asynchronous	3	CO3
2.1.1.2	Finite State Machines	2	CO3
2.2	Design examples: SOP and POS implementation, Flip	2	CO3
	flops and registers.		
3.	Programmable I/O cells:		
3.1	AC & DC inputs	1	CO4
3.2	AC & DC outputs.	1	CO4
3.3	Clock inputs and power inputs	1	CO4
3.4	Xilinx I/O cells and Altera I/O cells	1	CO4
3.5	Peripheral Interfaces	1	CO4
3.5.1	LED, LCD	1	CO4
3.5.2	Keyboard	1	CO4
3.5.3	DC motor, Stepper motor	1	CO4
4.	Programmable interconnects:		

Passed in BoS Meeting 16.11.2019

Approved in 59<sup>TH</sup> Academic Council Meeting 07.12.2019

4.1	Switch matrix,	1	CO5
4.2	Actel ACT interconnect	1	CO5
4.3	Xilinx LCA, EPLD interconnect	1	CO5
4.4	Altera Max and FLEX interconnect	1	CO5
5.	Timing Analysis		
5.1	Static Timing Analysis (STA)	1	CO6
5.2	Propagation delay, Critical path	1	CO6
5.3	Clock skew, Clock jitter	1	CO6
5.4	setup time and Hold time - violations,	1	CO6
5.5	metastability, synchronisers, races and hazards.	1	CO6
6	Case studies: Vending machines, Counters, Arbiter,	3	C07
	Arithmetic circuits		
	Total Hours	36	

## **Course Designers:**

- Dr. V. Vinoth Thyagarjan
- Dr. D. Gracia Nirmala Rani
- Dr.S. Rajaram
- Dr. N.B. Balamurugan
- Dr. V. R. Venkatasubramani

vvkece@tce.edu gracia@tce.edu rajaram\_siva@tce.edu nbbalamurugan@tce.edu

venthiru@tce.edu

18ECPG0	ANALOG SYSTEM DESIGN	Category	L	Т	Ρ	Credit
		PE	2	0	2	3

## Preamble

This course deals with the design and applications of JFET and MOSFET differential and operational amplifier circuits. Use of analog multipliers to build analog systems is emphasized. Much attention is given to PLL, VCO, linear and non-linear applications of op-amp and active filter synthesis, including switched capacitor configurations. It also deals with DC-DC converters and Low dropout regulators.

## Prerequisite

18EC330 : Electronic Circuits

#### **Course Outcomes**

On the successful completion of the course, students will be able to							
CO#	Course Outcome Statement	Weightage in %					
CO1	Demonstrate the characteristics of JFET and MOSFET	10					
	Differential amplifier and operational amplifier						
CO2	Use analog multipliers to build analog systems	10					
CO3	Demonstrate the operation of PLL, Automatic gain control, DC-	30					
	DC converter, Low drop-out regulator and Switched capacitor						
	filter IC MF10.						
CO4	Experiment Instrumentation Amplifier and regenerative	15					
	feedback systems						
CO5	Experiment function generator, Voltage Controlled Oscillator	20					
	and PLL						
CO6	Experiment Automatic Gain Control and Low Dropout Regulator	15					

CO Mapping with CDIO Curriculum Framework

CO	TCE	Learning Dom	nain Level	-	CDIO Curricular
#	Proficiency	Cognitive	Affective	<b>Psychomotor</b>	Components
	Scale	· · · · · · · · · · · · · · · · · · ·			(X.Y.Z)
CO1	TPS3	Apply	Value	-	1.2.3, 2.4.6, 3.2.3
CO2	TPS3	Apply	Value	-	1.2.3,2.1.1, 2.3.4, 2.4.6,
					2.5.1, 3.1.1, 3.2.3, 4.5.1,
					4.6.1
CO3	TPS3	Apply	Value	-	1.2.3, 2.1.1, 2.3.4, 2.5.1,
		-			3.1.1, 3.2.3, 4.5.1, 4.6.1
CO4	TPS3	Apply	Value	Mechanism	1.2.3, 2.1.1, 2.3.4, 2.5.1,
					3.1.1, 3.2.3, 4.5.1, 4.6.1
CO5	TPS3	Apply	Value	Mechanism	1.2.3, 2.4.6, 3.2.3,
CO6	TPS3	Apply	Value	Mechanism	1.2.3, 2.1.1, 2.3.4, 2.5.1,
		-			311 151 161

### Mapping with Programme Outcomes

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	Μ	L	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	Μ	L	-	-	-	-	-	-	-	-	-	М	-	-
CO3	S	Μ	L	-	-	-	-	-	-	-	-	-	М	-	-
CO4	S	Μ	L	-	S	-	-	-	Μ	Μ	-	-	М	L	-
CO5	S	Μ	L	-	S	-	-	-	Μ	Μ	-	-	М	L	-
CO6	S	Μ	L	-	S	-	-	-	Μ	Μ	-	-	Μ	L	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain								
Bloom's Catagony	Continuo	ous Assessme	ent Tests	End Semester				
Bioonis Calegory	1	2	3	Examination				
Remember	0	0	0	0				
Understand	40	20	20	20				
Apply	60	80	80	80				
Analyse	0	0	0	0				
Evaluate	0	0	0	0				
Create	0	0	0	0 0				
Assessment Pattern: P	sychomotor							
Psychomotor Skill				Practical				
Perception				-				
Set				-				
Guided Response				-				
Mechanism				100				
Complex Overt Response		-						
Ad		-						
aptation								
Origination			-					

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. Write note about TL082 wide bandwidth dual JFET input operational amplifier with necessarv diagram.
- 2. A square wave peak-to-peak amplitude of 50mV has to be amplified to a peak-to-peak amplitude of 3V, with rise time of 4 µs or less. Can TL082 be used?
- 3. A op-amp whose slew rate is 0.5V/µs is used as an inverting amplifier with a gain of 50. The voltage gain Vs frequency curve is flat up to 20 kHz. What maximum peak to peak input signal can be applied without distorting the output?

## Course Outcome 2 (CO2):

- 1. Assess the need of pre-distortion circuits in Gilbert analog multiplier.
- 2. How is the configuration of Gilbert multiplier done with pre-distortion circuits.

## Course Outcome 3 (CO3):

- 1. A PLL has a free running frequency of 300 KHz and the bandwidth of the low pass filter is 50KHz. Check whether the loop acquires lock for an input signal of 320KHz.
- 2. Design a second order Butterworth low-pass filter having upper cut-off frequency of 2.1961 kHz.
- 3. Design an OP-AMP based first order active low pass filter.

## Course Outcome 4 (CO4):

1. Design an instrumentation amplifier circuit to provide a gain that can be varied over the range of 5 to 500, utilizing a  $47K\Omega$  variable resistance. Draw the designed circuit.

## Course Outcome 5 (CO5):

- 1. Design a function generator to generate both square and triangular waveforms for a frequency of 50KHz. Draw the designed circuit diagram, generated square and triangular waveforms specifying the peak amplitude and time period. Assume that the operational amplifier saturates at  $\pm 10V$ .
- 2. Design a voltage controlled oscillator to generate triangular waveform. Assume that the operational amplifier saturates at  $\pm 10V$ .

## Course Outcome 6 (CO6):

- 1. Plot the graphs of output characteristics, transfer characteristics and ripple rejection for a typical low dropout regulator.
- 2. Elaborate the steps for determining the lock range of AGC.

### **Concept Map**



# Syllabus

## Theory:

**Characteristics of Op Amp**: JFET and MOSFET Differential amplifier with active loads, DC and AC performance characteristics, JFET Operational Amplifiers –TL082 Op Amp Data sheet **Analog Multiplier**: Analog Multiplier using Source Coupled Transistor Pair - Gilbert Multiplier cell – Variable transconductance technique, ICs - MPY634, function generator, Voltage controlled oscillator **Special Function Circuits**: Universal Active filters, Principles of PLL, PLL using analog multiplier **Application of PLL**: FM detection, FSK modulation and demodulation and Frequency synthesizing and clock synchronization, Automatic gain control, DC-DC converter, Low drop-out regulator, Switched capacitor filter IC MF10. **Practical**:

- 1. Design and implement Instrumentation Amplifier.
- 2. Design and implement regenerative feedback systems Schmitt trigger, Astable and Monostable multivibrators.
- 3. Design and implementation of Universal Active filters.
- 4. Design and implementation of function generator and Voltage Controlled Oscillator.
- 5. Design and implementation of Phase locked loop.
- 6. Design and implementation of Automatic Gain Control (AGC).
- 7. Design and implementation of a Low Dropout Regulator.

## Learning Resources

- Adel S. Sedra, Kenneth C. Smith, "Microelectronic Circuits: Theory and Applications", Oxford University Press, 2014.
- K.R.K.Rao, C.P. Ravikumar, "Analog Systems Lab Manual", 2<sup>nd</sup> edition, Wiley, 2012.
- David A. Bell, "Operational Amplifiers and Linear ICs", 3<sup>rd</sup> edition, OUP, 2013.
- Sergio Franco, "Design with operational amplifier and analog integrated circuits", McGraw Hill, 1997
- Robert F. Coughlin, Frederick F. Driscoll, "Operational-Amplifiers and Linear Integrated Circuits", 6th Edition, Prentice Hall, 2001.
- David A Bell, "Laboratory Manual for Operational Amplifiers & Linear ICs", 2nd edition, D.A. Bell, 2001.
- Analog System Design using ASLK Kit by K.R.K. Rao, Video Lecture Link: https://www.youtube.com/watch?v=S\_v70oFKmnw

Module	Торіс	No.of	CO				
No.		Lectures					
1	Characteristics of Op Amp						
1.1	JFET and MOSFET Differential amplifier with active loads	2	CO1				
1.2	DC and AC performance characteristics	1	CO1				
1.3	JFET Operational Amplifiers	1	CO1				
1.4	TL082 Op Amp Data sheet	1					
1.5	Practical	2	CO4				
2	Analog Multiplier						
2.1	Analog Multiplier using Source Coupled Transistor Pair	2	CO2				
2.2	Gilbert Multiplier cell	1	CO2				
2.3	Variable transconductance technique	1	CO2				
2.4	ICs - MPY634, function generator	2	CO2				
2.5	Voltage controlled oscillator	1	CO2				
2.6	Practical	8	CO5				
3	Special Function Circuits						
3.1	Universal Active filters	2	CO3				
3.2	Principles of PLL	2	CO3				
3.3	PLL using analog multiplier	1	CO3				
3.4	Practical	6	CO5				
4	Application of PLL						
4.1	FM detection	1	CO3				
4.2	FSK modulation and demodulation	1	CO3				
4.3	Frequency synthesizing and clock synchronization	1	CO3				
4.4	Automatic gain control ,DC-DC converter	2	CO3				
4.5	Low drop-out regulator, Switched capacitor filter IC MF10	2					
4.5	Practical	8	CO6				
	Total	48					

## **Course Designers:**

#### Dr. N.B. Balamurugan •

- Dr. V. R. Venkatasubramani •
- Dr. S. Rajaram •
- Dr. V. Vinoth Thyagarjan
- Dr. D. Gracia Nirmala Rani •

nbbalamurugan@tce.edu venthiru@tce.edu rajaram\_siva@tce.edu vvkece@tce.edu gracia@tce.edu

18ECPH0 ELECTRO	ELECTRONIC MEASUREMENT AND	Category	L	Т	Ρ	Credit
	INSTRUMENTS	PE	3	0	0	3

## Course Outcomes

On the su	uccessful completion of the course, students will be able to	
CO#	Course Outcome Statement	Weightage in %
CO1	Identify errors in different types of electrical measurements.	10
CO2	Determine resistance, capacitance and inductance using AC	30
	bridges.	
CO3	Use Digital Measurement Concepts.	30
CO4	Analyze the characteristics of components used in Analog and	15
	Digital data acquisition systems.	
CO5	Classify and employ the sensor for various applications.	15

## CO Mapping with CDIO Curriculum Framework

CO	TCE	Learr	ning Domair	n Level	CDIO Curricular Components							
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)							
	Scale			-								
CO1	TPS3	Apply	Value	-	1.2.2, 2.1.1, 2.1.2, 2.4.2,							
		-	17	03	2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2							
CO2	TPS3	Apply	Value		1.2.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1,							
			8711		3.2.3, 4.5.5, 4.6.2							
CO3	TPS3	Apply	Value		1.2.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1,							
		-	AT AG	EN PA	3.2.3, 4.5.5, 4.6.2							
CO4	TPS4	Analyse	Organise		1.2.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1							
CO5	TPS2	Understand	Respond		1.2.2, 2.5.4, 3.2.6							

## Mapping with Programme Outcomes

COs	PO	PO	PO	PO	PSO	PSO	PSO								
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	Μ	L	-	-		-	-	2-1	<u>`</u> -	-	-	М	-	-
CO2	S	Μ	L	-	-	-	-	-	-	-	-	-	М	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	М	-	-
CO4	S	S	Μ	L	-	-	-	-	-	-	-	-	S	-	-
CO5	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-

S- Strong; M-Medium; L-Low

## **Assessment Pattern: Cognitive Domain**

Cognitive	As	Continuo sessment	us Tests	Å	Assignme	nt	End
Levels	1	2	3	1	2	3	Semester Examination
Remember	10	0	10	0	0	0	0
Understand	10	20	20	0	0	0	20
Apply	80	40	30	100	50	0	50
Analyse	0	40	40	0	50	50	30
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

## Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment 3
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

## **Course Level Assessment Questions**

## Course Outcome 1 (CO1):

- 1. Mention the standards of measurement and errors.
- 2. Explain in detail about PMMC.
- 3. Calculate random error, systematic error, gross error for the given MI readings.

## Course Outcome 2 (CO2)

- 1. What is the value of series resistance to be used to extent '0'to 200V range of  $20,000\Omega$ /volt voltmeter to 0 to 2000 volt?
- 2. Discuss about AC -Bridge to measure capacitance.
- 3. A 250V M.I. voltmeter has coil resistance of  $500\Omega$ , coil inductance of 1.04 H and series resistance of  $2k\Omega$ . The meter reads correctively at 250V D.C. What will be the value of capacitance to be used for shunting the series resistance to make the meter read correctly at 50HZ? What is the reading of voltmeter on A.C. without capacitance?

## Course Outcome 3 (CO3)

- 1. What is Hysteresis effect?
- 2. Prove that for electrodynamometer type wattmeter true power = {cos  $\Phi$  / [cos  $\Phi$  cos ( $\Phi - \beta$ ]} x actual wattmeter reading Where cos  $\Phi$ power factor of the circuit  $\beta$  = tan-1 ( $\omega$ L/R) where L and R are the inductance and resistance of the pressure coil of the circuit. Enumerate about the various testing methods on single phase energy meter.
- 3. Describe the measurement of frequency, phase angle and time delay using oscilloscope with suitable diagrams and mathematical expressions.

## Course Outcome 4 (CO4)

- 1. List out the basic components in a function generator.
- 2. Illustrate the working of Basic Schmitt trigger used in Function generator.
- 3. Describe the Working of PLL and its use in Frequency synthesizer

## Course Outcome 5 (CO5)

- 1. Analyze the effects of voltmeter calibrated with a potentiometer.
- 2. Design a smart sensor and mention its applications.
- 3. Illustrate about Data Acquisition System

## Concept Map



Passed in BoS Meeting 16.11.2019

Approved in 59<sup>TH</sup> Academic Council Meeting 07.12.2019

## Syllabus

Measurement Units, Measurement System Design, Review of Instrument Types: Active, Passive, Analog and Digital Instruments. Static Characteristics: Accuracy, Precision. Repeatability, Tolerance, range/Span, Linearity, Sensitivity, threshold, resolution, hysteresis, dead Space. Dynamic Characteristics: Zero-Order. First-Order. Second-Order Instrument. Measurement Error and source of error: Statistical analysis of error and Calibration. Analog Meters: Moving Coil, Moving Iron, Clamp-on Meters, Analog Multimeter, High-Frequency Signals analog Meters. Digital Meters: Voltage-to-Time Conversion Digital Voltmeter, Potentiometric Digital Voltmeter, Dual-Slope Integration Digital Voltmeter, Voltage-to-Frequency Conversion Digital Voltmeter, Digital Multimeter. Bridges: Resistance, inductance and capacitor measurement, DC bridges. Current, frequency, phase, power and energy measurements. Sensor and actuator: classification & selection of transducersinductive & capacitive transducers- piezoelectric and Hall-effect transducers- encoder, thermisters, thermocouples, potentiometer, photo-diodes & photo-transistors, strain gauges, signal conditioning and telemetry, basic concepts of smart sensors and application. Signal generators and oscilloscope. Function generators- pulse and square wave generators-Frequency Synthesizer. Oscilloscopes: Analog, Digital CRO and DSO. PC based virtual instrument: RS232 and 4-20mA current loop, Field bus, safety and reliability.

## Learning Resources

- Measurement and Instrumentation Theory and Application, Reza Langari Alan S. Morris Elsevier 2017.
- A.K.Sawhney, "A Course in Electrical and Electronic Measurements and Instrumentation (Nineteenth Revised Edition 2011 Reprint 2014), Dhanpatrai & co.
- Golding, E.W., "Electrical Measurement and Measuring Instruments", 3rd Edition, Sirlssac Pitman and Sons, 1960.

Module	Торіс	No. of	Course
No.		Lectures	outcome
1	Measurement Units, Measurement system types:		
1.1	Units, Active, and Passive	1	CO1
1.2	Analog and Digital Instruments	1	CO1
2	Static and Dynamic Characteristics:		
2.1	Accuracy, Precision, Repeatability, Tolerance, range /	2	CO1
	Span, Linearity, Sensitivity, threshold, resolution,		
	hysteresis, dead Space.		
2.2	Zero-Order, First-Order, Second-Order Instrument.	2	CO1
2.3	source of error: Statistical analysis of error	2	CO2
2.4	Calibration	1	CO2
3	Analog and digital Meters:		
3.1	Analog meters: Moving Coil, Moving Iron,	2	CO2
3.2	Clamp-on Meters, Analog Multimeter	1	CO2
3.3	High-Frequency Signals analog Meters.	1	CO2
3.4	Digital Meters: Voltage-to-Time Conversion Digital	1	CO2
	Voltmeter,		
3.5	Potentiometric Digital Voltmeter,	1	CO2
3.6	Dual-Slope Integration Digital Voltmeter,	1	CO3
3.7	Voltage-to-Frequency Conversion	2	CO3
3.8	Digital Voltmeter, Digital Multimeter	1	CO3
4	Bridges:		CO3
4.1	Resistance, inductance and capacitor measurement	1	CO3
4.2	Current, frequency, phase, power and energy	2	CO3
	measurement		
5	Sensor and actuator:		

**Course Contents and Lecture Schedule** 

5.1	Transducers- inductive & capacitive transducers	1	
5.2	piezoelectric and Hall-effect transducers- encoder,	1	CO4
5.3	Thermisters, thermocouples, potentiometer,	1	CO4
5.4	photo-diodes & photo-transistors, strain gauges,	1	
5.5	signal conditioning and telemetry, basic concepts of	2	CO4
	smart sensors and application		
6	Signal generators and oscilloscope:		CO4
6.1	Function generators- pulse and square wave generator	2	CO4
6.2	Analog, Digital CRO and DSO.	2	CO5
7	PC based virtual instrument		
7.1	Building blocks of PC based instruments	1	CO5
7.2	RS232 and 4-20mA current loop,	2	CO5
7.3	Field bus, safety and reliability	1	CO5
	Total	36	

# **Course Designer:**

- Dr.S.Md Mansoor Roomi
- Dr.K.Hariharan

.

• Dr.V.R.Venkatasubramani

smmroomi@tce.edu khh@tce.edu venthiru@tce.edu



18ECPJ0	NETWORK AND DATA SECURITY	Category	L	Т	Ρ	Credit	
		PE	S	0	0	3	

## Preamble

The objectives of this course are to provide in-depth understanding of the underlying concepts of different classical and modern cryptographic techniques along with their network security applications like IP security, WEB security and System security **Prerequisite** 

NIL

## Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage***
Number		in %
CO1	Identify the threats and security attacks in the networks and	7
	corresponding services and mechanisms	
CO2	Use conventional encryption technique, classical encryption	18
	technique and modern encryption technique	
CO3	Use Asymmetric encryption algorithm and Diffie-Hellman	20
	algorithm, Elliptic Curve Cryptography	
CO4	Determine key management and distribution technique in IP	20
	Security.	
CO5	Compare principles and practices of cryptography and	15
	network security technologies in financial sectors	
CO6	Relate various system security attacks along with their	20
	countermeasures.	

## CO Mapping with CDIO Curriculum Framework

CO	TCE	Learn	ing Domain	Level	CDIO Curricular Components				
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)				
	Scale	-							
CO1	TPS2	Understand	Respond	-	2.1.1, 2.1.2, 2.4.2, 2.4.6,				
			-		2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2				
CO2	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.5.1, 3.1.1,				
					3.2.3, 4.5.5, 4.6.2				
CO3	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.5.1, 3.1.1,				
		-			3.2.3, 4.5.5, 4.6.2				
CO4	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.1.3, 2.5.1				
CO5	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.1.3, 2.5.1				
CO6	TPS4	Analyse	Organise	-	2.1.1, 2.1.2, 2.5.1				

Марр	Mapping with Programme Outcomes and Programme Specific Outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Μ	L	-	-	-	-	-	-	-	-	-	-	L		
CO2	S	Μ	L	-	-	-	-	-	-	-	-	-	L		
CO3	S	Μ	L	-	L	-	-	M	М	М	-	-	М	L	L
CO4	S	Μ	L	-	L	-	-	Μ	М	Μ	-	L	М	L	L
CO5	S	Μ	L	-	-	-	-	Μ	М	Μ	-	-	М	L	
CO6	S	S	М	L	Μ	-	-	М	М	М	-	-	М		

S- Strong; M-Medium; L-Low

Cognitive Levels	Contir	uous Ass Tests	sessment		Assignme	End Semester Examination	
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	60	40	20	0	0	0	20
Apply	40	40	60	100	0	100	60
Analyse	0	20	20	0	100	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

## Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	100	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination		-	-

# Sample Questions for Course Outcome Assessment

## Course Outcome 1(CO1):

- 1. Discuss about the web security threats and the methods used to overcome the threats
- 2. What is digital immune system
- 3. Compare Active and Passive attacks

## Course Outcome 2 (CO2):

- 1. Encrypt the term "EXAM" using playfair cipher
- 2. Encrypt and decrypt the term "Final Exam" using the Hill cipher with the key  $\begin{bmatrix} 0 & 3 & 0 \end{bmatrix}$

$$k = \begin{bmatrix} 0 & 0 & 21 \\ 15 & 0 & 0 \end{bmatrix}$$
 such that kk<sup>-1</sup>=I.

3. The plaintext 'letus meetnow' and the corresponding 'HBCDFNOPIKLB'are given. The algorithm used is Hill cipher, but the key size is unknown. Identify the key matrix.

## Course Outcome 3 (CO3)

- **1.** For  $E_{11}(1,6)$ , consider the point G=(2,7). Compute the multiples of 2G through 13G.
- 2. List four general categories of schemes for the distribution of public keys
- 3. Consider a Diffie Hellmen scheme with a common prime g=11 and a primitive root alpha=2.
  - a. show that 2 is the primitive root of 11.
  - b. If user A has public key  $Y_A=9$ , what is a A's private key  $X_A$  If user B has
  - public key  $Y_B$ =3, what is the shared secret key K

## Course Outcome 4 (CO4):

- 1. Elaborate Key management operation in IPsec
- 2. Differentiate transport and tunnel mode of IP Security by its operation and header format for both IPv4 and IPv6.
- 3. Discuss in detail about the ISAKMP with its header format, payload and exchange type

## Course Outcome 5 (CO5):

1. Explain about payment processing in SET

- 2. Discuss in detail about SSL handshake protocol along with its message type and corresponding associated parameters
- 3. What is the purpose of Dual signature?

## Course Outcome 6 (CO6):

- 1. Explain Statistical anomaly detection and rule based detection techniques
- 2. Discuss in detail about different types of malicious programs.
- 3. Discuss about firewall design principles and its characteristics

## Concept Map



## Syllabus

**Conventional Encryption:** Introduction – Conventional Encryption model – Data Encryption Standard – block cipher – Encryption algorithms – confidentiality – Key distribution. **Public Key Encryption and Hashing**: Principles of Public key cryptosystems – Number Theory – Fermat's theorem and Euler's theorem, Discrete Logarithms RSA algorithm – Diffie-Hellman Key Exchange, Elliptic curve cryptography – Message authentication and Hash function – Hash MAC algorithms – Digital signatures. **IP Security**: IP security overview – IP security Architecture, authentication Header – Security payload – security association – key management. **WEB Security:** Web security requirement – secure sockets layer – transport layer security –secure electronic transaction – dual signature. **System Security:** Intruders – Intrusion detection-password management -Viruses – Viruses and related threats-Worms – Firewall design – Trusted systems – Antivirus techniques – digital immune systems. Case study – cloud security and embedded system security.

## Learning Resources

- William Stallings. "Cryptography and Network Security", 4th Edition, Prentice Hall of India, New Delhi, 2012.
- C. Kaufmann, R. Perlman and M. Speciner, "Network Security: Private Communication in a Public World", Prentice Hall PTR, 2002.
- W.R. Cheswick, S.M. Bellovin and A.D. Rubin, "Firewalls and Internet Security", Addison- Wesley, 2003.
- NPTEL course on Cryptography and network security: https://nptel.ac.in/courses/106105031/

Course Contents	and Lecture Schedule		
Module No.	Торіс	No. of	Course
		Hours	Outcome
1	Conventional Encryption		
1.1	Introduction – Conventional Encryption model	2	CO1
1.2	Confidentiality, data integrity, authentication,	2	CO1
1.2	Passive and active attacks	2	
1.3	Data Encryption Standard – block cipiter	2	
1.4		<u> </u>	<u> </u>
1.0	Rey distribution		002
2	Public Key Encryption and Hasning:	4	000
2.1	Principles of Public key cryptosystems	1	003
2.2	Number Theory – Fermat's theorem and Euler's theorem	2	CO3
2.3	Discrete Logarithms	2	CO3
2.4	RSA algorithm	2	CO3
2.5	Diffie-Hellman Key Exchange	2	CO3
2.6	Elliptic curve cryptography	2	CO3
2.7	Message authentication and Hash function	2	CO3
2.8	Hash MAC algorithms, Digital signatures.	2	CO3
3	IP Security		
3.1	IP security overview	1	CO4
3.2	IP security Architecture	1	CO4
3.3	Authentication Header Security Payload	1	CO4
3.4	Security association -key management.	1	CO4
4	Web Security		•
4.1	Web security requirement	1	CO5
4.1	Secure sockets layer – transport layer security	2	CO5
4.3	Secure electronic transaction – dual signature	2	CO5
5	System Security		
5.1	Intruders – Intrusion detection-	1	CO6
5.2	Password management	1	CO6
5.3	Viruses – Viruses and Related threats-Worms	1	CO6
5.4	Firewall design – Trusted systems	1	CO6
5.5	Antivirus techniques – digital immune Systems.	1	CO6
5.6	Case study – cloud security and embedded system security	1	CO6
	Total Number of Hours	39	

# Course Designers:

Dr MSK Manikandan ٠

- Dr E Murugavalli ٠
- Dr S. Ponmalar •

manimsk@tce.edu murugavalli@tce.edu spmece@tc e.edu

18ECPK0	OPTICAL COMMUNICATION NETWORKS	Category	L	Т	Ρ	Credit	
		PE	3	0	0	3	

## Preamble

The objective of this course is to provide a comprehensive understanding of optical communication systems and networks. This course provides coverage of basic optical technology including physical aspects of light propagation, fiber optic components and its characteristics and modulation/demodulation techniques and link design. It also covers enabling technologies for optical network including SONET/SDH, WDM network and future optical systems and Networks.

Prerequisite NIL

## Course Outcomes

On the successful completion of the course students will be able to

COs	Course Outcome Statement	Weightage
		in %
CO1	Determine the transmission characteristics of optical fiber and their	25
	measurement procedures.	
CO2	Demonstrate the characteristics of optical sources and modulation	15
	techniques.	
CO3	Demonstrate the characteristics of optical detectors and demodulation	15
	techniques	
CO4	Demonstrate the characteristics of SONET, WDM network and network	15
	components. (Couplers, isolators, multiplexers, switches, filters, etc.)	
CO5	Solve network survivability and wavelength routing and assignment	10
	problem in optical networks.	
CO6	Design and analyze the performance of optical communication links.	20

### CO Mapping with CDIO Curriculum Framework

CO	TCE	Learr	ning Domain	Level	CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale	-		-	
CO1	TPS3	Apply	Value	-	1.1, 1.2, 2.1.1, 2.1.3, 2.3.1
CO2	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3, 2.3.1,
		-			3.2.4
CO3	TPS2	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3, 2.3.1,
		-			3.2.4
CO4	TPS3	Apply	Value	-	1.1, 1.2, 2.1.1, 2.1.3, 2.3.1,
CO5	TPS3	Apply	Value	-	1.1, 1.2, 2.1.1, 2.1.3, 2.3.1,
		-			2.4.4
CO6	TPS3	Analyze	Organise	Complex	1.1, 1.2, 2.1.1, 2.1.2, 2.1.3,
		-	-	Overt	2.3.1, 2.5.1, 4.1.1, 4.1.3
				Responses	

Марр	Mapping with Programme Outcomes and Programme Specific Outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	М	L	-	L	-	-	Μ	М	М	-	-	М	L	-
CO2	S	М	L	-	L	-	-	M	Μ	М	-	-	М	L	-
CO3	S	Μ	L	-	L	-	-	Μ	Μ	М	-	-	М	L	-
CO4	S	М	L	-	L	-	-	M	Μ	М	-	-	М	L	-
CO5	S	Μ	L	-	L	-	-	M	Μ	М	-	-	М	L	-
CO6	S	S	Μ	L	Μ	-	-	Μ	Μ	Μ	-	-	М	L	-

S- Strong; M-Medium; L-Low

Assessment Fattern. Cognitive Domain									
Cognitive		Continuous			ssignme	End			
Levels	A	Assessment Tests					Semester		
	1	2	3	1	2	3	Examination		
Remember	0	0	0	-	-	-	0		
Understand	40	40	30	-	-	-	30		
Apply	60	60	50	100	100	100	50		
Analyse	0	0	20	-	-	-	20		
Evaluate	0	0	0	-	-	-	0		
Create	0	0	0	-	-	-			

## As a second Defference Os welther De

## Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	100
Complex Overt Responses	-
Adaptation	A DA
Origination	

## Sample Questions for Course Outcome Assessment\*\*

## Course Outcome 1 (CO1):

- 1. Differentiate intermodal and intramodal dispersion.
- 2. How does dispersion limit the performance of a fibre optic system?
- 3. An optical fiber has the following data: n1 = 1.5, n2 = 1.45. Calculate: (a) Critical angle.(b) Numerical aperture (c) Acceptance angle.

## Course Outcome 2 (CO2):

- 1. Explain the working principle of laser diode.
- 2. A 1550-nm LED has an internal quantum efficiency n<sub>int</sub> of 99% and external quantum efficiency  $\eta_{ext}$  of 20%. Calculate the output power  $P_{out}$  of the LED when it is driven by a current / of 80 mA.
- 3. A laser source of length 4cm with refractive index of 1.78. The peak emission wavelength from the device is 0.55um. Determine the number of longitudinal modes and their frequency separations.

## Course Outcome 3 (CO3):

- 1. Explain the working principle of avalanche photo diode.
- 2. When 4×10<sup>11</sup> photons each with a wavelength of 850 nm are incident on a photodiode, on average 2×10<sup>11</sup> electrons are collected at the terminals of the device. Determine the quantum efficiency and the responsivity of the photodiode at the above wavelength.
- 3. A photodiode has a quantum efficiency of 65% when photons of energy 1.5  $\times 10^{-19}$  J are incident upon it. (i) What is the operating wavelength of the photodiode? (ii) Calculate the incident optical power required to obtain a photo current of 2.5µA?

## Course Outcome 4 (CO4):

- 1. Write down the features of SONET.
- 2. A product sheet of a 2×2 biconical tapered coupler with 40:60 splitting ratio shows a insertion loss of 2.5 dB for 60 percent port and 4 dB for 40 percent port
  - a. If the input power  $P_0 = 150 \ \mu W$ , find the power at output port 1 and output port 2.
  - b. From the calculated output power  $P_1$  and  $P_2$ , show that the splitting ratio is 40:60.
  - Find the excess loss of the coupler. C.
- 3. Assume that wavelengths  $\lambda_1$  = 1530nm  $\lambda_2$  = 1534nm  $\lambda_3$ = 1538nm and  $\lambda_4$ =1542nm are transmitted through an optical add drop multiplexer. Construct a fiber bragg grating based add drop multiplexer to drop wavelength  $\lambda_1$ ,  $\lambda_2$ ,  $\lambda_3$  respectively at each stage and add

Passed in BoS Meeting 16.11.2019

wavelength  $\lambda_5$  (1550nm) at the last stage by properly designing the grating period. (  $n_{eff} = 1.48$  ). Draw the OADM architecture.

## Course Outcome 5 (CO5):

1. Consider the network topology shown below. Each undirected link represents two fibers, one for the transmission in each direction. There are 4 end nodes and 2 hub nodes.



Consider the following s-d pairs each of which has 1 wavelength unit of traffic: 1-3, 1-4, 2-3, 2-4, 3-1, 3-2, 4-1, 4-2, 4-3. Specify the wavelength assignment (WA) that uses the minimum number of wavelengths.

2. Consider the network shown below. Assign wavelengths using first fit and random fit algorithm for the following lightpath requests: (i) C-F (ii) A-E (iii) H-E (iv) B-H (v) A-C (vi) G-B (vii) A-B.



3. Consider a ring topology with 5 nodes. Find the ways by which the network can be protected against link failure.

## Course Outcome 6 (CO6):

- 1. For an optical fiber link of 15km and B. W. of 100Mbps, receiver sensitivity is -50dBm, fiber loss is 2dB/km and power launch is 0dBm into the fiber by transmitter, detector coupling loss is 1dB and splicing loss of 0.4 dB/splice for 10 splices. Determine the feasibility of system.
- 2. A 100Mbit/s signal is to be sent through a 100m length of fiber with eight connector pairs to a receiver with sensitivity of -30dBm. The fiber loss is 4dB/km, and the average connector loss is 1.0dB. if the system margin is 5dB,what is the minimum power that the light source must launch into fiber?
- 3. Consider an optical transmission system operating at a wavelength of 1550 nm over an unrepeatered distance of 75km at the rate of 800 Mb/s. The transmitter available has a minimum coupled output power of 2mw, while the receiver has a worst case received power of 125µW. Two types of fibre with different specifications are available as shown in the table below. Two connectors are to be used in the system with a loss of 0.5 dB each, while the splice loss for both fibre types is 0.2 dB maximum. Assume a system margin of 3dB. Prepare a power budget for each system and decide which fibre type should be used and why.

Fibre type	Attenuation	Maximum distance between splices
A	0.5 dB/km	1500 metres
В	0.3 dB/km	1200 metres



## Syllabus

**Introduction:** Motivation and evolution of fiber optic system, role of fiber optics in telecom, fiber backhaul network, Elements of optical fiber transmission link, bandwidth and spectral efficiency; Fiber Optic Links: power budget and rise time budget. Optical Fibers: Types: single mode fiber, multi-mode fiber, graded index fiber, photonic crystal fiber; Optical fiber modes and configurations, transmission characteristics of optical fiber: Attenuation, Dispersion; Test and Measurements: Basic test equipment, Optical power measurement, Attenuation and dispersion measurement, Optical time domain reflectometer, Eye diagram tests. Optical Transmitters: Light Emitting Diode: structure, LED characteristics: output power, quantum efficiency, modulation bandwidth; Laser: laser diode mode, threshold condition, rate equation, Laser characteristics: quantum efficiency, resonant frequency; Modulation/multiplexing: Direct modulation, sub carrier modulation/multiplexing, QPSK, QAM, OTDM, Optical OFDM. Optical Receivers: pin photo detector, characteristics; Avalanche photodiode, characteristics, Noise in Photo detector; demodulation: Direct detection, coherent detection. Optical Networks: Overview of Fiber Backhaul Network, SONET/SDH: multiplexing, physical layer, infra structure, Network survivability; WDM Networks, WDM Components : Coupler, Isolator, Multiplexers, switches, cross connects, Optical amplifiers: Wavelength Assignment and Routing problem: Future Optical Networks. Fiber Optic Link Design: Analog, digital and WDM link design

## Sample Assignment:

Hands on with Light Runner Equipment:

- 1. Characterisation of optical sources, detectors, and numerical aperture measurement.
- 2. Characterisation of wavelength division multiplexer and de-multiplexer.
- 3. Voice and data transmission over optical fiber system.
- 4. Power budget and rise time budget of optical fiber link

Hands on with OptSim software

- 1. BER and eye pattern analysis of point to point optical communication link.
- 2. BER and eye pattern analysis of WDM link.
- 3. Simulation of free space optics system

## Learning Resources

- Gerd Kaiser, "Optical fiber communications", McGraw Hill Int., 5<sup>th</sup> edition, 2017.
- Rajiv Ramaswami, Kumar Sivarajan, Galen Sasaki, "Optical Networks: a practical perspective", Morgan Kaufmann Publishers, 3<sup>nd</sup> edition, 2009.
- G.P. Agrawal, "Fiber-Optic Communication Systems", Wiley, 4<sup>th</sup> edition, 2010
- John Senior, "Optical fiber communications-principles and practices", Prentice Hall of India, 3<sup>rd</sup> edition, 2013.
- J.Gower, "Optical communication systems", Prentice Hall of India, 2<sup>nd</sup> edition, 2001.
- Joseph C. Palais, "Fiber Optic Communication", Pearson Education, 5<sup>th</sup> edition, 2011.

Passed in BoS Meeting 16.11.2019

Approved in 59<sup>TH</sup> Academic Council Meeting 07.12.2019
- Biswanath Mukherjee, "Optical WDM Network", Springer, 1<sup>st</sup> edition, 2006. •
- NPTEL course on "Introduction to Photonics" by Dr. Balaji Srinivasan Link: https://nptel.ac.in/courses/108106135/

Modul e No	Topics	No. of Hours	COs
1	Overview of Optical Fiber Communication		
1.1	Motivation and evolution of fiber optic system, Elements of optical fiber transmission link, optics in telecom	2	CO1
1.2	bandwidth and spectral efficiency, power budget and rise time budget in fiber optic link	1	CO1
2	Optical Fibers		
2.1	Fiber Types: Step index, Graded index, Single mode, multimode, photonic crystal fiber	1	CO1
2. 2	Optical fiber modes and configurations	1	CO1
2. 3	Transmission characteristics of optical fiber: Attenuation, Dispersion	2	CO1
2.4	Basic test equipment, Optical power measurement, Attenuation measurement	2	CO1
2.5	Optical time domain reflectometer, Eye diagram tests	1	CO1
3	Optical Transmitters		
3.1	Light Emitting Diode: structure, Characteristics: Quantum efficiency, output power, modulation bandwidth	2	CO2
3.2	Laser: Structure, laser diode mode and threshold condition, rate equation, quantum efficiency and resonant frequency	2	CO2
3.3	Direct modulation, sub carrier modulation/multiplexing, QPSK, QAM, OTDM, Optical OFDM	2	CO2
4	Optical Receivers		
4.1	p-i-n photo detector - Avalanche photodiode	1	CO3
4.2	Noise in Photo detectors	2	CO3
4.3	Demodulation: Direct Detection, Coherent Detection	2	CO3
5	Optical Networks		
5.1	<b>SONET/SDH:</b> multiplexing, physical layer, infrastructure, Network Survivability	2	CO4, CO5
5.2	WDM Networks - WDM Network Components: Coupler, Isolator, Multiplexers, Filters, Switches, Cross connects, Optical Amplifiers	3	CO4
5.3	Wavelength Assignment and Routing problem	3	CO5
6	Fiber Optic Link Design		
6.1	Digital Systems: Power Budget, Rise time Budget	2	CO6
6.2	Analog systems: Carrier to Noise ratio	2	CO6
6.3	WDM link design	2	CO6
	Total	36	

## 0

**Course Designers:** 

Dr S. Ponmalar •

Dr MSK Manikandan

Dr E. Murugavalli ٠

spmece@tce.edu manimsk@tce.edu murugavalli@tce.edu

1	8	F	C	P	L	n

MEDICAL IMAGING AND PROCESSING

Category	L	1	Р	Credit
PEES	3	0	0	3

### Preamble

The course is offered to provide the basic concepts of various medical imaging modalities and the use of analysis tools for medical image reconstruction. It involves three different levels. In the lower level, the course introduces the terminology of medical imaging and explains how X-ray, CT, MRI and ultrasound images are reconstructed. In the middle level, it addresses how to select the specific segmentation and classification methods for extracting meaningful information from the medical imaging modalities. In higher level, it addresses how to visualize and analyze the 3D images and some of the case studies.

## Prerequisite

18EC560 Digital Image Processing

#### **Course Outcomes**

On the successful completion of the course, students will be able to

CO	Course Outcome Statement	Weightage
Number		in %
CO1.	Describe the various medical imaging modalities.	15
CO2.	Determine the resultant images with various reconstruction	20
	techniques	
CO3.	Solve problems on various medical images by segmentation	20
	techniques and morphological operations	
CO4.	Examine the classifier for the given medical images	15
CO5.	Examine the given 3-D images with visualization	15
CO6.	Distinguish case studies with segmentation and classification	15
	techniques	

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lear	rning Domain	Level	CDIO Curricular
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale	-		-	(X.Y.Z)
CO1	TPS2	Understand	Respond	-	1.3, 2.3.1
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.4,
		-			2.1.5, 3.2.3
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.5, 3.2.4
CO4	TPS4	Analyze	Organise	Complex Overt	1.3, 2.1.1, 3.2.3
				Responses	
CO5	TPS4	Analyze	Organise	-	1.3, 2.2.1
CO6	TPS4	Analyze	Organise	-	1.3, 2.3.2

S- Strong; M-Medium; L-Low

#### **Mapping with Programme Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PS O3
CO1	Μ	L	-		-		-	-	-	-	-	-	L	-	-
CO2	S	Μ	L		S		-	-	-	L	-	-	Μ	-	L
CO3	S	Μ	L		М		-	-	-	L	-	-	Μ	-	L
CO4	S	S	M	L	М		-	-	-	L	-	-	Μ	-	L
CO5	S	S	M	L	-		-	-	-	-	-	-	М	-	-
CO6	S	S	Μ	L	-		-	-	-	-	-	-	М	-	-

Assessment Pattern - Cognitive									
Cognitive Levels	Continuous Assessment Tests				Assignme	End Semester Examination			
	1	2	3	1	2	3			
Remember	20	20	0	0	0	0	0		
Understand	20	40	20	0	0	0	20		
Apply	40	40	40	100	50	50	40		
Analyze	0	0	40	0	0	0	40		
Evaluate	0	0	0	0	0	0	0		
Create	0	0	0	0	0	0	0		

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	25	25
Complex Overt Responses	-	25	25
Adaptation	- monton	-	-
Origination	( all a	-	-

#### Sample Questions for Course Outcome Assessment COURSE OUTCOME 1 (CO1):

- 1. How breast cancer is detected using Mammographic images?
- 2. What is the principle of X-ray Computer tomography?
- 3. How T1-weighted spin echo is generated in MRI?
- 4. Explain how M-mode images are useful in the display of moving structures

## COURSE OUTCOME 2 (CO2):

- 1. What is central slice theorem? Explain
- 2. Demonstrate the role of Sinogram in medical imaging reconstruction
- 3. Consider the following image:

4	5	6	9
13	14	7	7
15	16	8	4
15	16	8	3

Apply iterative reconstruction method and obtain the resultant image.

#### COURSE OUTCOME 3 (CO3):

- 1. What is the use of Morphological Operation in medical image processing?
- 2. Illustrate how active contour model is useful in image segmentation
- 3. Demonstrate the performance of watershed segmentation algorithm in detail.

## COURSE OUTCOME 4 (CO4):

- 1. Mention the use of Bayesian Decision Making
- 2. Calculate the weights and specify the structure of a neural network capable of performing exactly the same function as a Baye's classifier for two pattern classes in n-dimensional space.
- 3. Demonstrate the basic concept of SVM Classifier

## COURSE OUTCOME 5 (CO5):

- 1. List out the various 3-D imaging operations
- 2. Compare and contrast the scene based visualization with object based visualization
- 3. Interpret the necessity of manipulation and analysis in 3D visualization

#### COURSE OUTCOME 6 (CO6):

1. List out the various pre processing techniques which are suitable for the enhancement of dental X-Ray images

- 2. Experiment how image processing techniques will be Useful for identification of Dental caries
- 3. Contrast how automated system is better than manual diagnosis of Dental Deformities by Cephalometry X-ray images



## Syllabus

X-Ray Imaging- X-rays in Diagnostic imaging-Mammography-Computed tomography systems- Grating based imaging Magnetic Resonance Imaging Basic principles of nuclear magnetic resonance-Image creation-slice selection Ultrasound Imaging- The wave equation- Impedance, power and reflection - Diagnostic imaging modes- Doppler principle. Medical Image Reconstruction: Mathematical preliminaries for two dimensional image reconstructions-Radon transform - Sinogram - Two dimensional projection reconstruction-Iterative reconstruction techniques Medical Image Segmentation: Histogram based image segmentation – Watershed Method – K Means clustering – Active Contour Model Morphological Image Processing - Thinning- Thickening -Boundary detection. Classification:-Support vector machine-Bayesian classifier-Neural network 3D Visualization - Preprocessing in Visualization - Scene based visualization- Object based visualization – Manipulation. Case Studies for segmentation and Classification: Dental caries detection - Diagnosis of Dental Deformities

#### Learning Resources

- Atam.P.Dhawan, "Medical Image Analysis", John Wiley and Sons ,2011
- Rafael.C.Gonzalez and Richard.E. Woods, "Digital Image Processing", 4th Edition, Pearson publication,2017
- William.R.Hendee and Russell Ritenour.E. Woods, "Medical Imaging Physics", A John Wiley & sons , Inc. publications, 2002
- P.Hariharan, "Basics of Interferometry" Academic Press, 2012
- Geoff Dougherty, "Digital Image Processing for Medical Applications", Cambridge, 2009.
- G. R. Sinha, Bhagwati Charan Patel, "Medical Image Processing (Concepts and Applications)" PHI Learning private Limited, 2014.
- Issac Bankman and I.N.Bankman, "Handbook of Medical Imaging: Processing and Analysis", Academic press,2009
- Zang-Hee Cho, Joie P. Jones, Manbir Singh, "Foundations of Medical Imaging", A John Wiley & sons, Inc. publications, 2017
- Jacob Beutel and M.Sonka, "Handbook of Medical Imaging", volume 2. "Medical Image Processing and Analysis", SPIE press 2000.

Cours	Course Contents and Lecture Schedule					
No	Topic	No. of	COs			
110.	10010	Lectures				
1.	X-ray imaging					
1.1	X-rays in Diagnostic imaging	1	CO1			
1.2	Mammography	1	CO1			
1.3	computed tomography	1	CO1			
1.4	Grating based imaging	1	CO1			
2.0	MR imaging					
2.1	Basic principles	1	CO1			
2.2	Image creation	2	CO1			
2.3	slice selection	1	CO1			
3.0	Ultra sound imaging					
3.1	The wave equation	1	CO1			
3.2	Impedance, power and reflection	1	CO1			
3.3	Diagnostic imaging modes	2	CO1			
3.4	Doppler principle	1	CO1			
4.0	Medical Image Reconstruction					
4.1	Mathematical preliminaries for two dimensional	1	<u> </u>			
	image reconstructions	I	002			
4.2	Radon transform	1	CO2			
4.3	Sinogram	1	CO2			
4.4	Two dimensional projection reconstruction	1	CO2			
4.5	Iterative reconstruction techniques	2	CO2			
5.0	Medical Image Segmentation					
5.1	Histogram based image segmentation	1	CO3			
5.2	Watershed Method	1	CO3			
5.3	K- Means clustering	1	CO3			
5.4	Active Contour Model	1	CO3			
6.0	Morphological Image Processing					
6.1	Thinning, Thickening	1	CO3			
6.2	Boundary detection	1	CO3			
7.0	Classification					
7.1	Bayesian classifier	1	CO4			
7.2	Neural network	1	CO4			
7.3	Support vector machine	1	CO4			
8.0	3-D Visualization					
8.1	Preprocessing	1	CO5			
8.2	Scene based visualization,	1	CO5			
8.3	Object based visualization, Manipulation	2	CO5			
9.0	Case Studies for segmentation and	4				
	Classification:	1				
9.1	Dental caries detection	1	CO6			
9.2	Diagnosis of Dental Deformities	2	CO6			
	Total Number of Hours	36				
<b>^</b>	- Desimonar		-			

urse Designers:

Dr.A.Banumathi au\_banu@tce.edu

18FCPM0 PLANAR ANTENNAS FOR WIRELESS				
APPLICATIONS	2	1	0	3

## Preamble

Planar antennas have a range of applications in both the military and commercial sectors, and are often mounted on the exterior of aircraft and spacecraft as well as incorporated into mobile radio communication devices. Furthermore, the development of new services and radio technologies demand for low cost, light weight, compact, efficient antennas for portable wireless devices. One of the main competencies that a present day antenna engineer has to posses is the capability to design basic antennas and evolve novel designs suitable for portable wireless devices that have good bandwidth, gain and radiation characteristics. This subject is essential to understand the need for designing broadband and miniaturized antennas for wireless applications such as Radio frequency identification, RADAR, 5G and Body centric communication. This course presents various types of antenna geometry suitable for the above mentioned wireless applications, the issues in respect of their design and development.

#### Prerequisite

18EC520 Antennas and Wave Propagation

#### Course Outcomes

On the s	On the successful completion of the course, students will be able to					
CO #	Course Outcome Statement	Weightage				
	AND SOLAN	in %				
CO1.	Explain different wireless applications and requirements of an	10				
	antenna in terms its parameters					
CO2.	Identify, design antennas for RFID applications and BAN	15				
CO3.	Simulate the radiation pattern of RFID and flexible antennas	20				
	using EM CAD simulators					
CO4.	Identify, design antennas for Radar and Communication Systems	15				
CO5.	Simulate the characteristics of phased array and MIMO	20				
CO6.	Develop prototype of a designed antenna and Measure its	20				
	parameters					

## CO Mapping with CDIO Curriculum Framework

-				-	
CO	TCE	Learning Don	nain Level		CDIO Curricular
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale				(X.Y.Z)
CO1	TPS2	Understand	Respond	Guided Response	1.3, 2.1.1
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.5, 3.1,
		-			4.4.1, 4.5.1 – 4.5.4
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.5.1,
					3.1.1, 3.2.3, 4.5.5
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.5, 3.1,
		-			4.4.1, 4.5.1- 4.5.4
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.5.1,
		-			3.1.1, 3.2.3, 4.5.5
CO6	TPS5	Evaluate	Organize	Adaptation	1.3, 2.1.1, 2.1.5, 3.1,
			_		4.4.1, 4.5.1- 4.5.4

## Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	М	L	-	-	-	-	-	-	-	-	-	-	L	-	L
CO2	S	М	L	L	М	-	-	L	L	L	-	L	Μ	-	L
CO3	S	М	L	L	М	-	-	L	L	L	-	L	Μ	-	L
CO4	S	М	L	L	М	-	-	L	L	L	-	L	Μ	-	L
CO5	S	М	L	L	М	-	-	L	L	L	-	L	Μ	-	L
CO6	S	S	S	М	М	-	-	L	М	L	-	L	S	М	L

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

Cognitive Levels	Contir	nuous Ass Tests	sessment		Assignme	End Semester Examination		
	1	2	3	1	2	3	-	
Remember	0	0	0	0	0	0	0	
Understand	30	30	30	0	0	0	30	
Apply	70	70	70	50	50	0	70	
Analyse	0	0	0	0	0	0	0	
Evaluate	0	0	0	0	0	50	0	
Create	0	0	0	0	0	0	0	

## Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3	
Perception	- MY ACOM	PA	-	
Set	-	C-S/A	-	
Guided Response	50		-	
Mechanism		50	50	
Complex Overt Responses		-	-	
Adaptation	-	-	-	
Origination			-	

#### Sample Questions for Course Outcome Assessment Course Outcome (CO1)

- 1. What are the features of 5G wireless systems?
- 2. Explain the standards of RFID applications.
- 3. List some of the antennas used in RADAR.
- 4. What are the effects of environment on RFID Tag antenna?

## **Course Outcome (CO2)**

- 1. Design a suitable antenna used in RFID Tag for animal tracking?
- 2. Design a conformal, flexible E shaped antenna for wearable antenna application.
- Suggest a suitable planar antenna system for the given specifications: Center Frequency-5GHz, Dielectric constant-3.38, Thickness - 1.52mm, VSWR-2:1 Bandwidth > 500MHz

# Course Outcome (CO3)

1. Propose simulation steps to facilitate the design of patch antenna on a multilayer substrate having effective dielectric constant of 5.5.

2. Evaluate the performance of compact antennas for wearable devices in health care.

3. Prepare a model chart for developing antenna for wearable devices considering different RF constraints.

## Course Outcome (CO4)

- 1. Design a wide band antenna system operating in RADAR system?
- 2. Design a MIMO array for 5G mobile communication in sub 6GHz band?
- 3. Derive the specification and design antenna for wide band Radar operation

## Course Outcome (CO5)

1. Simulate an antenna operating in the RADAR

- 2. Design and simulate the 2\*2 array operating in the 3.3 to 3.5GHz band
- 3. Prepare a model chart for developing phased array used in Radar system

## Course Outcome (CO6)

- 1. Prototype the given antenna simulated using EM simulator and validate the performance
- 2. Develop the prototype of RFID tag antenna used in library book management.
- 3. Evaluate the performance of MIMO array integrated with base band system.

#### Concept Map



## Syllabus

**Overview:** Requirements and Typical Challenges antenna design for different wireless communication. RFID, BAN, RADAR and 5G.**Printed Antennas for RFID system:** Frequency, Regulations and Standardization, RFID antennas, Reader antennas, Tag architecture, Types of Tag antenna, Read range calculation, Design of reader and tag antenna. **Antennas for Wireless Body Area Network:** standards, on body, off body communication, antenna design challenges, Wearable Antennas, flexible antennas. **Phased Array for Radar and Communication Systems:** Transceiver, System requirements, Array characterization, Array design, Electronic Scanning techniques. **Array and BFN for 5G mobile communication system:** 5G technology,– Mobile communication, challenges, Massive MIMO, phased array and beam forming, antenna design, form factor and broadband performance, Antenna design. **Case Study:** Design, development of antennas for RFID, BAN, Radar and 5G Applications.

#### Learning Resources:

- "Handbook of RF and Wireless Technologies", Edited by Farid Dowla, Science Direct, 2004
- Anil Pandey, "Microstrip and Printed Antennas: Application-Based Designs" Artech House, 2019.
- Daniel M. Dobkin, "The RF in RFID UHF RFID in Practice", Elsevier, 2013.
- Peter von Butovitsch, Henrik Asplund, "Advanced Antenna Systems for 5G Network Deployments" Published by Elsevier 2020.
- ZhiHao Jiang,, Douglas H. Werner, "Electromagnetics of Body Area Networks" : John Wiley Publishers 2016.
- ZhiNing Chen, "Antennas for Portable devices" Wiley Publishers, 2007.
- R.Waterhouse" Printed antennas for wireless communications" John Wiley Publishers, 2007.
- Grishkumar and K.P. Ray, "Broadband Microstrip Antennas" Artech House, 2003.
- John D.Kraus, Ronald J. Marhefka "Antennas for all Applications" Fourth Edition, Tata McGraw-Hill, 2006.

## **Course Contents and Lecture Schedule**

Module	Торіс	No. of	Course
No.		Hours	Outcome
1.	Introduction: Course CO,PO, PSO, Introduction to	1	CO1
	course with concept map		
1.1	Overview of different wireless communication. RFID,	1	CO1
	BAN, RADAR and 5G. Requirements and Typical		
	Challenges antenna design		
2.	RFID Frequency, Regulations and Standardization	1	CO2
2.1	Reader antennas- Specifications, types	1	CO2
2.2	RFID Tag Antennas: Tag architecture- Tag, clip type,	1	CO2
2.3	Read range calculation, Design of reader and tag antenna.	1	CO2
3.	Tutorial: RFID reader and tag antenna design and	3	CO3
	simulation		
3.1	Antennas for Wireless Body Area Network	1	CO3
3.2	Standards, on body, off body communication, antenna	1	CO3
	design challenges		
3.3	Wearable Antennas, flexible antennas.	1	CO3
4	Tutorial: design, simulation of compact flexible antenna	3	CO4
4.1	Phased Array for Radar and Communication Systems:	1	CO4
4.2	Transceiver, System requirements,	1	CO4
4.3	Array characterization, Array design,	1	CO4
5	Electronic Scanning techniques.	1	CO5
5.1	Tutorial: Radar antenna design, simulation	3	CO5
5.2	Array and BFN for 5G mobile communication system	1	CO5
5.3	5G technology,- Mobile communication, challenges,	2	CO5
	Massive MIMO,		
6	phased array and beam forming	1	CO6
6.1	form factor and broadband performance, ,	1	CO6
6.2	Tutorial : Design, simulation of 5G array Antenna	3	CO6
6.3	Assignment 3: Mini project- Design, development of	4	CO6
	antennas for RFID, BAN, Radar and 5G Applications,		
	wearable and UWB antenna		

# Course Designers:

- Dr.B.Manimegalai naveenmegaa@tce.edu
- Dr.S.Kanthamani skmece@tce.edu
- Dr.K.Vasudevan kvasudevan@tce.edu

ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY

Category	L	Т	Ρ	Credit
PE	3	0	0	3

## Preamble

The objective of this course is to provide insight in to the different sources of EMI, basic EMC requirements for the electronic devices, EMI filters to mitigate the noise, and the measurement techniques for EMI/EMC.

## Prerequisite

18EC320- RF Passive Devices and Circuits

#### Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage***
Number		in %
CO1	Comprehend the EMI regulations and EMC requirements for	10
	the commercial wireless applications	
CO2	Determine the major sources of interference by applying the	10
	concepts of non-ideal passives and conducted interference	
CO3	Design an EMI filter to suppress the common-mode noise	20
	for wireless applications	
CO4	Determine the possible shielding and grounding mechanism	20
	for the given device in an EM environment	
CO5	Analyse the near-end and far-end crosstalk noise in a high	20
	density printed circuit boards	
CO6	Illustrate the impact of EMI/EMC effects through	20
	measurements	

\*\*\* Weightage depends on Bloom's Level, number of contact hours, CO Mapping with CDIO Curriculum Framework

CO	TCE	Le	earning Doma	CDIO Curricular	
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale	-			(X.Y.Z)
CO1	TPS2	Understand	Respond	-	1.3, 2.4.6, 3.2.3
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.3.4, 2.4.6,
					2.5.1, 3.1.1, 3.2.3
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.3.4, 2.5.1,
					3.1.1, 3.2.3
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.3.4, 2.4.6,
		-			2.5.1, 3.1.1, 3.2.3
CO5	TPS4	Analyse	Organise	-	1.3, 2.1.1, 2.3.4, 2.5.1,
					3.1.1, 3.2.3
CO6	TPS3	Apply	Value	-	1.3, 2.1.1, 2.3.4, 2.4.6,
					2.5.1,3.1.1, 3.2.3

Mapp	oing w	vith P	rogra	mme	Outc	omes	and	Prog	ramm	ne Spe	cific C	Outcor	nes	
Caa	PO1	PO2	PO	PO	PO	PO	PO	PO	PO	PO1	PO1	PO1	PSO	

Cos	P01	P02	P0		P0				PO q		PO1   1	PO1	PS0 1	2	PSO 3
CO1	М	L	-	-	-	-	-	-	-	-	-	-	M	-	L
CO2	S	Μ	L	-	-	-	-	-	-	-	-	L	М	-	Γ
CO3	S	Μ	L	L	L	-	-	-	L	L	-	L	М	L	L
CO4	S	Μ	L	L	L	-	-	-	L	L	-	L	М	L	L
CO5	S	S	Μ	L	L	-	-	-	L	L	-	L	S	L	Γ
CO6	S	Μ	L	L	-	-	-	-	L	L	-	L	Μ	L	Γ

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain												
Cognitive	Continu	uous Asse Tests	ssment	J	End Semester							
Levels	1	2	3	1	2	3	Examination					
Understand	30	20	20	20	-	-	20					
Apply	70	80	60	80	100	80	60					
Analyse	0	0	20	0	0	20	20					
Evaluate	0	0	0	0	0	0	0					
Create	0	0	0	0	0	0	0					

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. Compare the MIL-STD-461E RE102 radiated emission limits for U.S. Air Force ground applications at 30 MHz and 1 GHz to the FCC Class A radiated emission limits. Is this a valid comparison?
- 2. The voltage induced at the terminals of an antenna  $V_{ant}$  is 5V for every V/m of incident field E<sub>ant</sub>. What level in dBµV at the base of the antenna would correspond to the FCC Class B limit at 100MHz? Determine the reading of the spectrum analyzer if it is connected to the antenna with 200 ft of RG58U coaxial cable that has 4.5 dB/100 ft of loss at 100MHz.
- 3. The radiated emissions from a product are measured at 50 MHz at 15 m away and are found to be 21 mV/m. Does the product comply with the FCC Class B limit? [No] By how much does the product pass or fail?

# Course Outcome 2 (CO2):

- 1. An inductor is to be placed in series with a 50-V load to block a 100 MHz noise current. Determine a value for the inductance that will reduce the 100-MHz noise signal across the load by 20 dB.
- 2. Determine the frequency where the internal inductance of a #32 AWG solid wire begins to decrease due to skin effect. Determine the internal inductance of this wire at 100 MHz.
- 3. Determine the effective dielectric constant and characteristic impedance of a coplanar stripline constructed of a glass epoxy board of thickness 47 mils supporting two 1-oz Cu lands 100 mils in width and separated (edge to edge) by 100 mils.

# Course Outcome 3 (CO3):

- 1. Suppose that a common-mode choke has self-inductances of 28 mH and a coupling coefficient of 0.98. Determine the leakage inductance presented to differential-mode currents. Repeat this for a coupling coefficient of 0.95.
- 2. Suppose that a green-wire inductor has an inductance of 1 mH and a parasitic capacitance of 10 pF. Determine the resonant frequency of this inductance and its impedance at 30 MHz.
- 3. The Class B guasi-peak conducted emission limits at 150 kHz, 500 kHz, and 30 MHz are 66 dB $\mu$ V, 56 dB $\mu$ V, and 60 dB $\mu$ V. Determine these in amperes and dB $\mu$ A.

## Course Outcome 4 (CO4):

- 1. A circular rod of diameter 3cm is inserted vertically into the ground up to a depth of 3 m. The resistivity of earth soil is 104  $\Omega$ -cm. If the resistances between the electrode and the adjacent soil and the contact resistance between the electrode and the soil are neglected, calculate the percentage of total resistance to earth of the electrode established within 3m of the rod inside the soil.
- 2. A 100-MHz plane wave is incident on a plane isolated double shield made of copper having same thickness with air between the two shields. Calculate the difference between the reflection losses and absorption losses for double and single shields.
- 3. Calculate the difference in total shielding effectiveness provided by two layers of aluminum sheets of thickness 1mm each separated by a 2mm air gap and a single aluminum sheet of thickness 2mm at a frequency of 10MHz.

## Course Outcome 5 (CO5):

- 1. A printed circuit board (PCB) has inner planes surrounding the embedded lands. This resembles a coupled stripline illustrated in Fig. 9.3a. If the board length is 9 in., determine the propagation delay of voltage and current waves from one end to the other.
- 2. Use the SLEM method to calculate the effective even- and odd-mode impedances and propagation velocities for the coupled striplines whose capacitance and inductance matrices are shown below. Estimate the impacts of crosstalk on the propagation delay for a 0.5-m coupled length.

$$L = \begin{bmatrix} 3.480 \times 10^{-7} & 1.951 \times 10^{-8} \\ 1.951 \times 10^{-8} & 3.480 \times 10^{-7} \end{bmatrix}$$
 H/m  
$$C = \begin{bmatrix} 1.271 \times 10^{-10} & -7.213 \times 10^{-12} \\ -7.213 \times 10^{-12} & 1.271 \times 10^{-10} \end{bmatrix}$$
 F/m

3. Sketch the far-end crosstalk pulse for a two-line case with no termination at the near end, and matched termination at the far end.

## Course Outcome 6 (CO6):

- 1. Assume that 1-m radiated emission pre-compliance testing is being performed in a location where the closest metallic object is 5 m away from both the product and the antenna. How many decibels below the desired signal will the reflected signal be?
- 2. What will be the output voltage from an F-33-1 common-mode current clamp when it is placed around a cable with 100 mA of common-mode current?
- 3. At what voltage level (in dBmV) should the limit line be placed on a spectrum analyzer when using an F-61 common-mode current clamp on a 1/3-m long cable in order to pass FCC Class A radiated emission?



#### Syllabus

**Introduction:** Sources of EMI - International EMI regulations - EMC requirements - EMC standards – Need for standards – Civilian EMC standards – Military standards. **Non-ideal behaviour of components** – Wires - Printed Circuit Board - Effect of Component Leads – Resistors – Inductors - Capacitors. **Conducted Emissions and Susceptibility** - Measurement of Conducted Emissions – LISN - Common and Differential Mode Currents - Power Supply Filters - Power Supplies - Linear Power Supplies - SMPS - Power Supply and Filter Placement - Conducted Susceptibility. **Shielding** - Shielding Effectiveness - Far-Field Sources - reflection loss - absorption loss - Multiple- Reflection Loss – Near Field Sources - Electric Sources - Magnetic Sources – Magnetic field shielding - Effect of Apertures.

**Grounding** - Safety Ground - Signal Ground - Ground Bounce and Partial Inductance -Single-Point Grounding - Multipoint Grounding - Hybrid Grounding - Ground Loops -Subsystem Decoupling. **Crosstalk** - Mutual Inductance and Capacitance – Coupled line analysis - Near end and Far end cross talk - estimation of crosstalk – time and frequency domain analysis for different load terminations - crosstalk minimization. **EMC Tests and Measurements** – Risk Analysis in EMC Tests and Measurements - Emission Measurements - Immunity/Susceptibility Tests - Harmonic Measurements - Surge and Flicker Tests - Electrostatic Discharge Tests - Electrical Fast Transients - Measurements of Spurious - Error Analysis and Uncertainty.

#### Learning Resources

- Clayton R. Paul, Introduction to Electromagnetic Compatibility, Second Edition, John Wiley & Sons, 2006.
- Henry W. Ott, Electromagnetic Compatibility Engineering, John Wiley & Sons, 2009.
- Ralph Morrison, Grounding and Shielding: Circuits and Interference, Sixth Edition, John Wiley & Sons, 2016.
- Clayton R. Paul, Transmission Lines in Digital Systems for EMC Practitioners, John Wiley & Sons, 2012.
- Stephen H. Hall, Howard L. Heck, Advanced Signal Integrity for High-Speed Digital Designs, Wiley-IEEE Press, 2009.
- Mark I. Montrose, EMC and the Printed Circuit Board: Design, Theory, and Layout Made Simple, Wiley-IEEE Press, 2004.
- NPTEL Course: https://nptelmooc2013.appspot.com/noc19\_ee17/preview

Module	Topic	No. of	Course
No.	GU	Hours	Outcome
1.	Introduction - Sources of EMI - International EMI regulations	2	CO1
1.1	EMC requirements - EMC standards – Need for standards – Civilian EMC standards – Military standards	2	CO1
1.2	Non-ideal behaviour of components – Wires - Printed Circuit Board	2	CO2
1.3	Effect of Component Leads – Resistors – Inductors - Capacitors	2	CO2
2	<b>Conducted Emissions and Susceptibility</b> - Measurement of Conducted Emissions – LISN - Common and Differential Mode Currents	2	CO3
2.1	Power Supply Filters - Power Supplies - Linear Power Supplies	2	CO3
2.2	SMPS - Power Supply and Filter Placement - Conducted Susceptibility	2	CO3
3	<b>Shielding</b> - Shielding Effectiveness - Far-Field Sources - reflection loss - absorption loss - Multiple- Reflection Loss	2	CO4
3.1	Near Field Sources - Electric Sources - Magnetic Sources – Magnetic field shielding - Effect of Apertures	2	CO4
3.2	<b>Grounding</b> - Safety Ground - Signal Ground - Ground Bounce and Partial Inductance	2	CO4
3.3	Single-Point Grounding - Multipoint Grounding - Hybrid Grounding - Ground Loops - Subsystem Decoupling	2	CO4

#### **Course Contents and Lecture Schedule**

4	<b>Crosstalk</b> - Mutual Inductance and Capacitance – Coupled line analysis	2	CO5
4.1	Near end & Far end cross talk - estimation of crosstalk	2	CO5
4.2	Time and frequency domain analysis for different load terminations - crosstalk minimization.	2	CO5
5	<b>EMC Tests and Measurements</b> – Risk Analysis in EMC Tests and Measurements	2	CO6
5.1	Emission Measurements - Immunity/Susceptibility Tests - Harmonic Measurements -	2	CO6
5.2	Surge and Flicker Tests - Electrostatic Discharge Tests - Electrical Fast Transients	2	CO6
5.3	Measurements of Spurious - Error Analysis and Uncertainty.	2	CO6
<u> </u>			

# **Course Designers:**

•

•

- Dr.K.Vasudevan kvasudevan@tce.edu
- Dr.B.Manimegalai naveenmega@tce.edu
- Dr.S.Kanthamani skmece@tce.edu



18ECPP0	CPP0 REMEMS DESIGN AND TECHNOLOGY	Category	L	Т	Ρ	Credit
	ECPPU RF MEMS DESIGN AND TECHNOLOGY		3	0	0	3

# Preamble

MEMS has been identified as one of the most promising technologies for the 21st Century and has the potential to revolutionize both industrial and consumer products by combining silicon-based microelectronics with micromachining technology. The performance of current RF (Radio Frequency) systems can be enhanced by replacing critical components by their MEMS counterparts (Micro Electro Mechanical systems). This course starts with the glimpses of MEMS covering the introduction and origin of MEMS, driving force for MEMS development, commercial applications, fabrication process and packaging techniques. The latter half of the course will be devoted to provide a thumb rule in designing, modelling various RF MEMS components such as switches, capacitors, phase shifters, micromachined Transmission lines and antennas. They are also exposed to the MEMS CAD tools available in the Design center. Special weight is given to design circuits and do simulation with Comsol, Intellisuite and Coventorware. By taking this course, students can make good preparations for their research in relevant areas.

#### Prerequisite

18EC320- RF Passive Devices and Circuits

#### **Course Outcomes**

#### On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage
Number	AL CONTRACTOR	in %
CO1	Summarize the Concept of miniaturization, actuation	10
	mechanisms, packaging and micro fabrication techniques	
CO2	Design RF MEMS Switch circuits for phase shifter applications	20
CO3	Design RF MEMS capacitors and inductors.	15
CO4	Design RF MEMS phase shifters for phased array antennas	20
CO5	Apply micromachining techniques to antennas	15
CO6	Acquire skills in computer aided design tools for modelling	20
	and simulating RF MEMS devices	

## CO Mapping with CDIO Curriculum Framework

CO		TCE		Learning Domain Level					CDIO Curricular Components			nents			
#	Pro	oficien	icy [	Cogr	nitive	Aff	ective	Ps	ychor	notor	(X.Y.Z)				
		Scale		_					-						
CO1	Т	PS2		Under	stand	Re	spond		-		1.3, 2	.4.6			
CO2	T	PS3		Apply		Val	lue		-		1.3, 2	.1.1, 2	.1.2, 2	1.3, 2.	5.1
CO3	Т	PS3		Apply		Va	lue		-		1.3, 2	.4.6			
CO4	Т	PS3		Apply		Va	lue		-		1.3, 2	.1.1, 2	.1.2, 2	.5.1	
CO5	Т	PS3		Apply		Va	lue		-		1.3, 2.4.6				
CO6	Т	PS3		Apply		Va	lue		-		1.3, 2.1.1, 2.1.2, 2.5.1		.5.1		
Маррі	ing w	vith P	rogr	amme	Outc	omes	s and	Prog	ramm	ne Spe	cific C	Outcor	nes		
Cos	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	М	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	М	L	-	L	-	-	L	-	L	-	L	М	-	-
CO3	S	М	L	-	L	-	-	L	-	L	-	L	M	-	-
CO4	S	М	L	-	L	-	-	L	-	-	-	L	М	-	-
CO5	S	М	L	-	L	-	-	L	-	-	-	L	M	-	-
CO6	S	М	L	-	L	-	-	L	-	-	-	L	М	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain									
Cognitive	Cor	ntinuous Ass Tests	essment	A	ssignmen	End			
Levels	1	2	3	1	2	3	Semester Examinatio n		
Remember	0	0	0	0	0	0	0		
Understand	50	20	20	50	0	0	20		
Apply	50	80	80	50	100	100	80		
Analyse	0	0	0	0	0	0	0		
Evaluate	0	0	0	0	0	0	0		
Create	0	0	0	0	0	0	0		

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	- The	-	-
Adaptation		-	-
Origination		-	-

## Sample Questions for Course Outcome Assessment

## Course Outcome 1(CO1):

- 1. Tabulate the direct analogy of electrical and mechanical domains.
- 2. Classify MEMS packages. Based on the need for packaging of MEMS devices classify and differentiate various packaging methodologies.

#### Course Outcome 2(CO2):

- 1. 1 Design a RF MEMS shunt switch with an equivalent circuit approach operating at a frequency of 40 GHz.
- 2. i) Applying the concepts of direct analogy between electrical and mechanical domains Convert the mechanical model of a RF MEMS shunt switch to electrical model.

ii) Derive the expression for pull down voltage of a switch.

#### Course Outcome 3 (CO3):

- 1. List the ways of designing RF MEMS capacitors and explain the draw backs present in two plate system. How three plate system provides better capacitance ratio.
- 2. How a planar inductor can be modelled and designed? Explain the various design issues for enhancing the performance of the MEMS inductors.

# Course Outcome 4 (CO4):

- 1. Determine the Bragg frequency and the phase shift per unit length of a DMTL phase shifter at a frequency of 10 GHZ.
- 2. Design a DMTL phase shifter using LC model with the following design specifications.

f = 30 GHz, Length of the membrane (L) = 300  $\mu m$ , wxW = 40 \* 100  $\mu m^2$ , g=4  $\mu m$ ,

t = 
$$2 \mu m$$
,  $Z_0 = 100$  ohms,  $Z_{h} = 60$  ohms,  $Z_{ld} = 42$  ohms,  $t_d = 1500 A^0$ .

## Course Outcome 5 (CO5):

- 1. How radiation occurs from micro strip antennas. Comment on the various choices of micromachining techniques for realizing micro strip antennas.
- 2. What do you mean by reconfigurability? How micromachining technique could be applied to build a Vee antenna for beam steering and beam shaping?

## Course Outcome 6(CO6):

- 1. Compare and contrast the usage of Intellisuite and Coventorware MEMS CAD tools.
- 2. List the important features of Coventorware MEMS CAD tool.



#### Syllabus

Glimpses of MEMS: Overview of MEMS, driving force for MEMS development, Application in wireless communications, space and defence applications, Benefits of Miniaturization and Scaling, RF MEMS in industry and academia, Commercial packages. Actuation MEMS: Electrostatic, Thermal and Magnetic. Micro fabrication Mechanisms in Techniques: MEMS Materials, Material Properties, Bulk and surface micromachining, Wet and dry etching Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating). Conventional IC fabrication processes. Packaging of RF MEMS: Role of MEMS packaging, Types of MEMS Packages, Reliability issues of MEMS packaging. RF MEMS Components: Case study 1: RF MEMS Switch: RF MEMS Series, Capacitive shunt switches, Electromagnetic modeling (Capacitance, Loss, Isolation), Current research, Examples of switches for various applications. Case Study 2: Tunable Capacitors and **Inductors:** Example of tunable capacitors and inductors and their applications in circuits, Effect of inductor layout, reduction of stray capacitance of planar inductor, Approaches for improving quality factor, Polymer based inductors, MEMS gap tuning, area tuning and dielectric tuning capacitors. Case Study 3: Micromachined phase shifters: Types of phase shifters and their limitations, MEMS phase shifters: Switched delay line phase shifters, Distributed phase shifters. Case Study 4: Micromachined antennas: Microstrip antennas, Micromachining techniques to improve antenna performance, Reconfigurable antennas. Computer aided design of MEMS: Commercial packages, usage of Intellisuite, Coventorware and Comsol CAD tools. Future trends in MEMS device design.

## Learning Resources

- Vijay K Varadhan ,K.J.Vinoy "RF MEMS and their Applications", John Wiley & Sons, 1998.
- K.J Vinoy, K.N Bhat, V.K Aatre "Micro and Smart Systems", John Wiley & Sons, 2010
- http://care.iitd.ac.in/People/Faculty/bspanwar/teaching.html
- http://nptel.ac.in/courses/'MEMS and Micro Systems'
- http://www.mecheng.iisc.ernet.in/~suresh/memscourse/pcontent.html

Module	Торіс	No. of	Course				
No.		Hours	Outcome				
1.	Glimpses of MEMS						
1.1	Overview of MEMS	1	CO1				
1.2	Driving force for MEMS development, Application in wireless communications, space and defence	1	CO1				

# **Course Contents and Lecture Schedule**

	applications		
1.3	Benefits of Miniaturization and Scaling	1	CO1
1.4	RF MEMS in industry and academia, Introduction to	1	CO1
1.4	Commercial packages	I	
2.	Actuation Mechanisms in MEMS		
2.1	Electrostatic Thermal and Magnetic	1	CO1
3.	Micro fabrication Techniques		CO1
3.1	MEMS Materials, Material Properties	1	CO1
3.2	Bulk and surface micromachining	0.5	CO1
3.3	Wet and dry etching	0.5	CO1
	Thin-film depositions (LPCVD, Sputtering,		CO1
3.4	Evaporation), other techniques (LIGA,	2	
	Electroplating), Conventional IC fabrication	_	
-	processes		001
4	Packaging of KF MEMS	4	
4.1	Role of MEMS packaging , Types of MEMS Packages	1	
4.2		1	CO1
5	RF WEWS COMPONENTS: Case Study 1: RF MEMS		
<u> </u>	SWITCH DE MEMS Series Conseitive abunt switches	1	<u> </u>
5.1	RF MEINS Selies, Capacitive situat switches	<u> </u>	<u> </u>
5.2	Lectromagnetic modelling (Capacitance, Loss,	Z	002
53	Current research. Examples of switches for various	1	<u> </u>
0.5	applications	I	002
6	Tunable Capacitors and Inductors		
	Example of tunable capacitors and inductors and their		CO3
6.1	applications in circuits	0.5	000
6.2	Effect of inductor layout	1	CO3
6.3	Reduction of stray capacitance of planar inductor	1	CO3
6.4	Approaches for improving quality factor	0.5	CO3
0.5	MEMS gap tuning. Area tuning and dielectric tuning	0	CO3
6.5	capacitors	2	
7	Micromachined phase shifters		
7.1	Types of phase shifters and their limitations	1	CO4
70	MEMS phase shifters: Switched delay line phase	2	CO4
1.2	shifters, Distributed phase shifters	Z	
8	Micromachined antennas		
8.1	Microstrip antennas	1	CO5
8.2	Micromachining techniques to improve antenna	1	CO5
	performance	I	
8.3	Reconfigurable antennas	1	CO5
9	Computer aided design of MEMS		
9.1	Overview of Commercial packages	1	CO6
9.2	Usage of Intellisuite, Coventorware and Comsol		000
	CAD tools	8	CO6
93	Future trends in MEMS device design	1	C.O.6
		1	000

•

- skmece@tce.edu Dr.S.Kanthamani •
  - Dr.B.Manimegalai naveenmega@tce.edu
- kvasudevan@tce.edu Dr.K.Vasudevan •

1	8	Ε	С	Ρ	Q0
---	---	---	---	---	----

Category	L	Т	Ρ	Credit
PE	2	1	0	3

#### Preamble

The objective of this course is to present the theory and applications of statistical signal processing methods. In this course, the key topics namely signal modelling, optimum linear filtering, spectral estimation and array processing are discussed in detail. The topics have been chosen based on the grounds of theoretical value and practical importance.

## Prerequisite

18EC440 Signal Processing

# Course Outcomes

On the successful completion of the course students will be able to

CO#				Col	urse (	Dutcor	ne Sta	ateme	nt					Wei	ghtage	in %
CO1	Ca	Calculate the first and second order moments of the given									10					
	sar	npling	distril	outions	6											
CO2	De	termin	e syst	em be	havio	our of a	All pol	e, All :	zer	o, and	pole	e-ze	ero		10	
	mo	dels o	f syste	ems w	ith rai	ndom	signal	s								
CO3	De	sign o	optimu	ım lir	ear	syster	ns fo	r line	ar	predi	ctior	n a	and		15	
	filte	Itering of random signals														
CO4	Det	Determine the power spectrum of given random signal using the sector of given random signal using the sector of th										ing		15		
	nor	non-parametric methods														
CO5	De	termin	e the	powe	r spe	ctrum	of giv	en ra	Ind	om sig	gnal	us	ing		15	
	par	ametr	ic met	hods		AE	GA	20/6	21	-						
CO6	De	termin	e the	powe	ower spe <mark>ctrum of given random</mark> signal using 20											
	Eig	Eigen Analysis method														
C07	Co	Compute the Direction of Arrival information of information with 15														
	the random samples collected using an array of sensors															
CO M	appir	ıg witl	n CDI	O Cur	riculu	um Fra	amew	ork								
	T	CE		Lea	rning	Doma	in Lev	/el		C	DIO	Cu	Irricu	ular Cor	nponer	nts
#	Profi	ciency	'   Co	gnitive	Affe	ective	Psyc	homot	or				(X	(.Y.Z)		
	S	cale														
CO1	T	PS3	ŀ	Apply	Valu	Je	Med	chanis	m	1.3, 2	.1.1,	, 2.	1.2,	2.4.1, 2	2.4.2	
CO2	TF	PS3	<i>F</i>	Apply	Valu	Je	Med	chanis	m	1.3, 2		, 2.	1.2,	2.4.1, 2	2.4.2	
CO3	TF	PS3	<i>F</i>	Apply	Valu	Je	Med	chanis	m	1.3, 2		, 2.	1.2,	2.4.1, 2	2.4.2, 3	.2.5
CO4	T	PS3	/	Apply	Valu	Je	Med	chanis	m	1.3, 2	.1.1,	, 2.	1.2,	2.4.1, 2	2.4.2, 3	.2.5
CO5	T	PS3	<i>F</i>	Apply	Valu	Je	Med	chanis	m	1.3, 2	.1.1,	, 2.	1.2,	2.4.1, 2	2.4.2, 3	.2.5
CO6	TF	PS3	<i>F</i>	Apply	Valu	Je	Med	chanis	m	1.3, 2	.1.1,	, 2.	1.2,	2.4.1, 2	2.4.2, 3	.2.5
C07	TF	PS3	ŀ	Apply	Valu	Je	Med	chanis	m	1.3, 2	.1.1,	, 2.	1.2,	2.4.1, 2	2.4.2, 3	.2.5
Марр	ing w	ith Pr	ogran	nme C	utco	mes a	nd Pr	ograr	nm	e Spe	cific	<b>C O</b>	utco	omes		
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PC	D9   PC   10	)   P( )   1 <sup>-</sup>	0	PO 12	PSO1	PSO2	PSO3

003										10	11	12			
CO1	S	М	L	-	Μ	-	-	-	М	-	-	-	М	-	L
CO2	S	М	L	-	Μ	-	-	-	М	-	-	-	М	-	L
CO3	S	М	L	-	Μ	-	-	-	М	-	-	-	М	-	L
CO4	S	М	L	-	Μ	-	-	-	М	-	-	-	М	-	L
CO5	S	М	L	-	Μ	-	-	-	М	-	-	-	М	-	L
CO6	S	М	L	-	Μ	-	-	-	М	-	-	-	М	-	L
CO7	S	М	L	-	М	-	-	-	М	-	-	-	Μ	-	L

S- Strong; M-Medium; L-Low

Cognitive Levels	Contir	uous Ass Tests	sessment		Assignme	End Semester Examination	
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	50	50	50	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0
Assessment P	attern P	svchomo	tor				

Assessment Fattern. Countieve Domai	Assessment	Pattern:	Cognitive	Domai
-------------------------------------	------------	----------	-----------	-------

Assessment Pattern: Psychomotor										
Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3							
Perception	-	-	-							
Set	-	-	-							
Guided Response	-	-	-							
Mechanism	50	50	50							
Complex Overt Responses	-	-	-							
Adaptation	-	-	-							
Origination	The	-	-							
Osmula Ossatisma fan Ossara	<b>O</b>									

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. The random process X(t) is define by  $X(t) = X \cos(2\pi f_0 t) + Y \sin(2\pi f_0 t)$  where X and Y are two zero mean independent Gaussian random variables each with variance  $\sigma^2$ . Find  $\mu_{x}(t)$ .
- 2. A zero-mean stationary process X(t) is applied to a linear filter whose impulse response

is defined by a truncated exponential:  $h(t) = \begin{cases} ae^{-at}, & 0 \le t \le T \\ 0, & otherwise \end{cases}$ . Show that the power density of the filter output Y(t) is spectral defined by  $S_{Y}(f) = \frac{a^{2}}{a^{2} + 4\pi^{2} f^{2}} (1 - 2\exp(-aT)\cos(2\pi fT) + \exp(-2aT)) S_{X}(f)$  Where  $S_{X}(f)$  is the power

spectral density of the filter input.

- 3. A stationary, Gaussian process X(t) with zero mean and power spectral density  $S_{x}(f)$ is applied to a linear filter whose impulse response h(t) shown in Figure. A sample Y is taken of the random process at the filter output at time T.
  - i) Determine the mean and variance of Y.
    - ii) What is the probability density function of Y?



# Course Outcome 2 (CO2):

- 1. Consider two linear random processes with systems function  $H(z) = \frac{1 0.81z^{-1} 0.4z^{-2}}{(1 z^{-1})^2}$ .
  - i) Find a difference equation that leads to a numerically stable simulation of each process.

- ii) Generate and plot 100 samples from each process, and look for indications of non stationarity in the obtained records.
- iii) Compute and plot the second difference of (i) and the first difference of (ii). Comment about the stationary of the obtained records.
- 2. Show that the spectrum of any PZ model with real coefficients has zero slope at  $\omega = 0$  and  $\omega = \pi$ .
- 3. Find a minimum phase model with autocorrelation  $\rho(0) = 1, \rho(\pm) = 1, and \rho(l) = 0$  for  $|l| \ge 2$ .

# Course Outcome 3 (CO3):

- 1. The Bartlett method is used to estimate the power spectrum of a signal x[n]. We know that the power spectrum consists of a single peak with a 3dB bandwidth of 0.01 cycles per sample, but we do not know the location of the peak.
  - i) Assuming that N is large, determine the value of  $M = \frac{N}{K}$  so that the spectral window is narrower that the peak.
  - ii) Explain why it is not advantageous to increase M beyond the value obtained in part (i)
- 2. Suppose we have N=1000 samples from a sample sequence of a random process.
  - i) Determine the frequency resolution of the Bartlett, Welch (50 % overlap) and Blackman-Tukey methods for a quality factor Q=10.
  - ii) Determine the record lengths (M) for the Bartlett, Welch (50 % overlap) and Blackman-Tukey methods.
- 3. A random signal is generated by passing zero-mean white Gaussian noise with unit variance through a filter with system function

$$H(z) = \frac{1}{\left(1 + az^{-1} + 0.99z^{-2}\right)\left(1 - az^{-1} + 0.98z^{-2}\right)}$$

- i) Sketch a typical plot of the theoretical power spectrum  $\Gamma_{xx}(f)$  for a small value of the parameter a (*i.e.*, 0 < a < 0.1). Pay careful attention to the value of the two spectral peaks and the value of  $P_{xx}(\omega)$  for  $\omega = \pi/2$ .
- ii) Let a = 0.1. Determine the section length M required to resolve the spectral peaks of  $\Gamma_{xx}(f)$  when using Bartlett's method.
- iii) Consider the Blackman –Tukey method of smoothing the periodogram. How many lags of the correlation estimate must be used to obtain resolution comparable to that of the Bartlett estimate considered in part (b)?

# Course Outcome 4 (CO4):

- 1. Determine the mean, and the autocorrelation of the sequence x[n], which is the output of a ARMA (1,1) process described by the difference equation x[n] = 0.5x[n-1] + w[n] - w[n-1] where w[n] is a white noise process with variance  $\sigma_w^2$ .
- 2. Determine the mean, and the autocorrelation of the sequence x[n], which is the output of a MA (2) process described by the difference equation x[n] = w[n] 2w[n-1] + w[n-1] where w[n] a white noise process with variance is  $\sigma_w^2$ .

3. An MA(2) process has the autocorrelation sequence  $\gamma_{xx}(m) = \begin{cases} 6\sigma_w, & m = 0 \\ -4\sigma_w^2, & m = \pm 1 \\ -2\sigma_w^2, & m = \pm 2 \end{cases}$ 

- Determine the coefficients of the MA(2) process that have the foregoing i. autocorrelation
- Is the solution unique? If not, give all possible solutions. ii.

# Course Outcome 5 (CO5):

- 1. Consider an optimum FIR filter specified by the input correlation matrix  $R = Toeplitz \left\{ 1, \frac{1}{4} \right\}$  and cross-correlation vector  $\mathbf{d} = \begin{bmatrix} 1 & \frac{1}{2} \end{bmatrix}^T$ 
  - i) Determine the optimum impulse response  $c_0$  and the MMSE  $P_0$ .
  - ii) Express  $c_0$  and  $P_0$  in terms of the eigen values and eigen vectors of **R**.
- 2. The first five samples of the autocorrelation sequence of a signal x(n) are r(0) = 1, r(1) = 0.8, r(2) = 0.6, r(3) = 0.4 and r(4) = 0.3. Compute the FLP, the BLP, the optimum symmetric smoother and the corresponding MMSE (a) by using normal equations method and (b) by using the inverse of the normal equations matrix.
- 3. Consider the signal x(n) = y(n) + y(n), where y(n) is a useful random signal corrupted
  - by noise v(n). The processes v(n) and v(n) are uncorrelated with PSDs

$$R_{y}\left(e^{j\omega}\right) = \begin{cases} 1, & 0 \le |\omega| \le \frac{\pi}{2} \\ 0, & \frac{\pi}{2} < |\omega| \le \pi \end{cases} \text{ and } R_{y}\left(e^{j\omega}\right) = \begin{cases} 1, & \frac{\pi}{4} \le |\omega| \le \frac{\pi}{2} \\ 0, & 0 \le |\omega| < \frac{\pi}{4} \text{ and } \frac{\pi}{2} < |\omega| \le \pi \end{cases} \text{ respectively.}$$

- i) Determine the optimum IIR filter and the MMSE
- ii) Determine a third order optimum FIR filter and the corresponding MMSE

# Course Outcome 6 (CO6):

- 1. Show that the pseudo spectrum for the MUSIC algorithm is equivalent to the minimumvariance spectrum in the case of an infinite signal-to-noise ratio.
- 2. Find a relationship between the minimum-norm pseudo spectrum and the all-pole model spectrum in the case of an infinite signal-to-noise ratio.
- 3. For the MUSIC algorithm, we showed a means of using the MUSIC pseudo spectrum to derive a polynomial that could be rooted to obtain frequency estimates, which is known as root-MUSIC. Find a similar rooting method for the minimum-norm frequency estimation procedure.

## Course Outcomes 7 (CO7):

- 1. Consider a narrowband spatially propagating signal with a speed of propagation c. The signal impinges on an M=2 element ULA from an angle  $\phi = 0^0$  with a spacing d between the elements. For illustration purposes, let the temporal content of the signal be a pulse.
  - Let the time of arrival of the pulse at the first sensor be t=0. At what time does i) the signal arrive at the second sensor?
  - ii) Do any other angles  $\phi$  produce the same delay between the two sensors? Whv?
- 2. The optimum beamformer weights with MVDR normalization are found by solving the following optimization

min 
$$P_{i+n}$$
  
subject to  $\mathbf{c}^H \mathbf{v}(\varphi_s) = 1$ 

Using Lagrange multipliers, show that MVDR optimum beamformer weight vector is

$$c_0 = \frac{\mathbf{R}_{i+n}^{-1} \mathbf{v}(\varphi_s)}{\mathbf{v}^H(\varphi_s) \mathbf{R}_{i+n}^{-1} \mathbf{v}(\varphi_s)}$$

 The frost sample by sample adaptive beamformer was derived for the MVDR beamformer. Extend the frost sample by sample adaptive beamformer for the case of multiple constraints in an LCMV adaptive beamformer



## Syllabus

Random variables and random processes: Random variables, random vectors, discrete time stochastic processes, linear systems with stationary random inputs, principles of estimation theory Linear Signal Models: All pole model, All zero model, pole-zero models, models with poles on unit circles. Optimum Linear Filters- Forward and backward linear prediction, solution of normal equations, AR lattice and ARMA lattice ladder filters, wiener filters for filtering and prediction. Channel Equalization in Data Transmission Systems Non-Parametric methods: Spectral analysis of deterministic signals, estimation of autocorrelation of stationary random signals, estimation of power spectrum of stationary random signals: Bartlett method, Welch method and Blackman Tukey method. Parametric methods: Yule Walker method, Burg method for AR model parameters, MA model for power spectrum estimation, ARMA model for power spectrum estimation, minimum variance spectral estimation. Eigen Analysis methods: Pisarenko Harmonic decomposition method, Eigen decomposition of the autocorrelation matrix for sinusoids in white noise, MUSIC algorithm, ESPRIT algorithm. Array Signal Processing - Narrowband model, multiple DoAs and multiple sources, sensor spacing design, spatial resolution and array aperture, beamforming and signal estimation, conventional beamforming, capon beamforming, multiple constraint beamforming, DoA estimation

#### Learning Resources

- Umberto Spagnolini, Politecnico diMilano, "Statistical Signal Processing in Engineering", John Wiley & Sons Ltd, 2018.
- Dimitris G. Manolakis, Vinay K. Ingle and Stephen M. Kogon, "Statistical and Adaptive Signal Processing", Artech House, 2005.
- John G.Proakis and Dimitris G.Manolakis, "Digital Signal Processing Principles, Algorithms and Applications", Prentice-Hall of India, Fourth Edition, 2006.
- Alexander D. Poularikas, "Discrete Random Signal Processing and Filtering Primer with MATLAB", CRC Press, 2009
- Sophocles J. Orfanidis, "Optimum Signal Processing", McGraw-Hill Publishing Company, 2007.
- Prof. Prabin Kumar Bora, IIT Guwahati, "Statistical Signal Processing", NPTEL Video Lectures: https://nptel.ac.in/courses/108/103/108103158/

No.	Торіс	No. of Hours	COs
1	Random variables and Random processes		
1.1	Random variables, random vectors.	1	CO1
1.2	discrete time stochastic processes	1	CO1
1.3	linear systems with stationary random inputs	1	CO1
1.4	principles of estimation theory	1	CO1
2	Linear Signal Models		
2.1	All pole model	1	CO2
2.2	All zero mode	1	CO2
2.3	pole-zero models	1	CO2
2.4	models with poles on unit circles	1	CO2
2.5	Tutorial	1	CO2
3	Optimum Linear Filters		
3.1	Forward and backward linear prediction	1	CO3
3.2	solution of normal equations	1	CO3
3.3	AR lattice and ARMA lattice ladder filters	1	CO3
3.4	wiener filters for filtering and prediction	1	CO3
3.5	Tutorial	1	CO3
4	Non Parametric methods	,,	
4.1	Spectral analysis of deterministic signals	1	CO4
4.2	Estimation of autocorrelation of stationary random signals	1	CO4
4.3	estimation of power spectrum of stationary random signals: Bartlett method	1	CO4
4.4	Welch method	1	CO4
4.5	Blackman Tukey method	1	CO4
4.6	Tutorial	1	CO4
5	Parametric methods		
5.1	Yule Walker method	1	CO5
5.2	Burg method for AR model parameters	1	CO5
5.3	MA model for power spectrum estimation	1	CO5
5.4	ARMA model for power spectrum estimation	1	CO5
5.5	Minimum variance spectral estimation.	1	CO5
5.6	Tutorial	1	CO5
6.	Eigen Analysis methods		
6.1	Pisarenko Harmonic decomposition method	1	CO6

# Course Contents and Lecture Schedule

6.2	Eigen decomposition of the autocorrelation matrix for sinusoids in	1	CO6
	white hoise		
6.3	MUSIC algorithm	1	CO6
6.4	ESPRIT algorithm	1	CO6
6.5	Tutorial	1	CO6
7	Array Signal Processing		
7.1	Narrowband model, multiple DoAs and multiple sources	1	CO7
7.2	sensor spacing design, spatial resolution and array aperture	1	CO7
7.3	beamforming and signal estimation	1	CO7
7.4	conventional beamforming, capon beamforming	1	CO7
7.5	multiple constraint beamforming, DoA estimation	1	C07
	Total	36	

## **Course Designers:**

•

- Dr.S.J.Thiruvengadam sjtece@tce.edu
- Dr.V.N.Senthilkumaran vnsenthilkumaran@tce.edu
- Dr.P.G.S.Velmurugan pgsvels@tce.edu



18ECPR0	LDPC AND POLAR CODES	Category	L	Т	P	Credit
		PEES	2	1	0	3

#### Preamble

The objective of the course on "LDPC and POLAR Codes" is to present the encoding and decoding techniques along with the corresponding mathematical theory for Low Density Parity Check (LDPC) and polar codes. These codes are used in 5G wireless communication systems. This course focuses on the key topics of encoder design of LDPC codes, decoding algorithms of LDPC codes, code construction for polar codes, decoding of polar codes, channel polarization, channel combining, channel splitting and performance of LDPC and polar codes, whose selection is based on the grounds of theoretical value and practical importance.

### Prerequisite

18EC530 Analog and Digital Communication Systems

#### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Encode and decode messages using Reed Muller code and	10
	Reed Solomon Code.	
CO2	Encode and decode messages using LDPC code.	10
CO3	Encode messages using the principles of construction of Polar	15
	encoder structures	
CO4	Decode the polar coded messages with the principles of	15
	Successive Cancellation Decoding (SCD) for polar codes	
CO5	Determine the capacity and mathematical framework of Polar	15
	coder and decoder.	
CO6	Compare the performance of Polar Codes and LDPC code	20
	naming with CDIO Counting lung From over all	

#### CO Mapping with CDIO Curriculum Framework

	- U	-													
CO	T	CE			Lear	ning D	omaii	n Leve	el			C	DIO Cu	ırricula	r
#	Profi	ciency	/ C	ogniti	ve	Affe	ctive	Psy	<i>ychorr</i>	notor		Components			
	So	cale		÷				-					(X.Y	.Z)	
CO1	TF	PS3		Apply	y	Value		Mec	hanis	m	1.3	, 2.	1.1, 2	2.1.2,	3.1.1,
											3.1	.2, 3	.2.5		
CO2	TPS3			Appl	y	Value		Mec	hanis	m	1.3	, 2.	1.1, 2	2.1.2,	3.1.1,
											3.1	.2, 3	.2.5		
CO3	TF	PS3		Appl	y	Value		Mec	hanis	m	1.3	, 2.	1.1, 2	2.1.2,	3.1.1,
											3.1.2, 3.2.5				
CO4	TF	PS3		Appl	y	Value		Mec	hanis	m	1.3	, 2.	1.1, 2	2.1.2,	3.1.1,
											3.1	.2, 3	.2.5		
CO5	TF	PS3		Appl	y	Value		Mec	hanis	m	1.3	, 2.	1.1, 2	2.1.2,	3.1.1,
											3.1	.2, 3	.2.5		
CO6	TF	PS4		Analyz	ze	Value		Corr	plex	Over	t 1.3	, 2.	1.1, 2	2.1.2,	2.1.3,
								Res	ponse	S	2.1	.4, 3	. <u>1.1, 3</u> .	1.2, 3.	2.5
Mappin	g witl	n Prog	gramn	<u>ne Ou</u>	tcom	ies an	d Pro	gram	me S	pecif	ic O	utcor	nes		
COs	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO	PO	PO	PSO1	PSO2	PSO3
CO1	S	М	1	_	-	_	-	-	-	-	-	-	М	_	_
CO2	9	M		_	M		_	_	М	_	_	_	M		1
<u> </u>	0			_			_	_	N/			_		_	
	3			-		-	-	-		-	-	-		-	
	S	IVI	L	-	IVI	-	-	-	IVI	-	-	-	M	-	
CO5	S	Μ	L	-	M	-	-	-	M	-	-	-	M	-	
CO6	S	S	Μ	L	M	-	-	-	M	-	-	-	S	L	L

S- Strong; M-Medium; L-Low

Cognitive Levels	Contir	nuous Ass Tests	sessment		Assignme	End Semester Examination	
	1	2	3	1	2		
Remember	20	0	0	0	0	0	0
Understand	20	20	20	40	0	0	20
Apply	60	80	60	60	50	25	60
Analyse	0	0	20	0	0	25	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	50	50
Complex Overt Responses	-	-	-
Adaptation	- monton	-	-
Origination	Father	-	-

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. Determine the Reed-Muller canonical expansion for the Boolean function in 4 variables  $(X_1, X_2, X_3, X_4)$  that corresponds to the vector having a 1 location (1111) and zero elsewhere.
- 2. Show that the Reed Muller code RM(0,m) is the Repetition code and determine the generator matrix and parity check matrix for the Reed-Muller code RM(2,4)
- 3. Determine the symbol-error correcting capability of (7,3) R-S code? How many bits are there per symbol? Use the generator polynomial for the (7,3) R-S code to encode the message 010110111 (rightmost bit is earliest bit) in systematic form. Use polynomial division to find the parity polynomial, and show the resulting codeword in polynomial form and in binary form.

# Course Outcome 2 (CO2):

- 1. Construct the (3,4) LDPC matrix assuming that the codeword length is 20. Using the tanh rule develop an iterative algorithm for decoding.
- 2. Consider a binary symmetric channel (BSC) with input and output alphabet  $\{\pm 1\}$ , as opposed to the usual alphabet  $\{0,1\}$ . Show that a posteriori LLR,  $\lambda_n$  with both intrinsic information and extrinsic information is except that of the channel reliability is  $\log((1-p)/p)$  instead of  $2/\sigma^2$ , where p is the cross over probability.
- 3. Consider an NR-LDPC code with base matrix of dimension  $42 \times 52$  and expansion factor z = 384. The first two message blocks are punctured. Assume that your message consists of only  $8 \times 384$  bits, and the transmitted bit dimension is  $40 \times 384$  bits. Obtain the number of parity bits that need to be punctured

## Course Outcome 3 (CO3):

- 1. Construct the polar encoder structure for N = 4 in a recursive manner, i.e. construct, W in a recursive manner using two  $W_2$  and one  $R_4$
- 2. Find the systematic form of the generator matrix of polar codes for N = 2, N = 4, N = 8, N= 16. and *N* = 32
- 3. Construct the syndrome table of the polar codes for N = 2, N = 4, N = 8, N = 16, and N = 1632

## Course Outcome 4(CO4):

1. Let *N*=16, and assume that the first 10 bits are decoded and the decoded bits are  $u_1^{10} = \begin{bmatrix} 0 & 0 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$  we want to decode the 11th bit, i.e.,  $u_{11}$ . Distribute the first decoded 10 bits to the tree nodes. Use generator matrices  $G_4$  and  $G_2$  for the bit distribution process (Fig.1)



- 2. For a binary erasure channel, if the erasure probability is  $\alpha = 0.3$ , calculate the channel capacities for N = 8.
- 3. Consider a polar encoder for N = 8, and assume that binary erasure channels with erasure probabilities  $\alpha = 0.5$  are employed for the transmission of code bits and the code rate is R = 0.5. The channel outputs are given as  $y_1^8 = \begin{bmatrix} 1 & 0 & -1 & 1 & 0 \\ 0 & -1 & 1 & 0 & -1 & 1 \end{bmatrix}$ . Decode the code bits using the received signal vector  $y^8$ , and determine the data bits used in encoding operation.

# Course Outcome 5(CO5):

- 1. Consider the successive cancellation decoder for a polar codeword length  $2^n$ . Determine the size of the belief vector received by the fifth node at depth, r.
- 2. Consider a (16,13) polar code constructed using the reliability sequence as provided in the 5G standard. Find the generator matrix for this code in systematic form:  $G_{sys} = \begin{bmatrix} I_{13} & P \end{bmatrix}$ , where  $I_{13}$  is the 13×13 identity matrix and P is a 13×13 matrix. Obtain

the systematic form by computing  $G_{16} = G_2^{\otimes 4}$ , where  $G_2 = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$  and  $\otimes$  denotes the

Kronecker product. From  $G_{16}$  remove the rows which corresponds to frozen bit positions to obtain the generator matrix, G. Then convert G to systematic form by performing Gaussian elimination without column swapping. The number of non-zero entries in the P part of the systematic generator matrix  $G_{sys} = \begin{bmatrix} I_{13} & P \end{bmatrix}$ . Determine the minimum distance of the code.

3. Consider a coded - BPSK transmission over an AWGN channel using the (16,8) polar code constructed using the reliability sequence as given in the 5G standard. The received vector is  $\begin{bmatrix} 0.8 & 2.0 & 0.6 & -2.2 & -1.25 & 1.3 \end{bmatrix}$  by an interior node. Consider decoding the received vector using the successive cancellation decoder. The nodes at each layer are numbered from left to right starting from 0. A node can be uniquely indexed by specifying the depth and the node number. Determine the frozen bit positions in this code.

# Course Outcome 6(CO6):

- 1. The random process  $\widetilde{X}(t)$  is defined as  $\widetilde{X}(t) = \widetilde{A}\cos(\omega t + \widetilde{\theta})$  where  $\widetilde{A}$  and  $\widetilde{\theta}$  are independent random variables. Find the mean value m(t) of this random process.
- 2. Show the path between the input and outputs of the split channels  $W_4^1, W_4^3$  and represent the paths by binary sequences, and calculate the probability of each path.

3. Consider the (3,1) repetition code. (a) Show that the Tanner graph has no cycle (b) Show that the message - passing algorithm converges to the true a posteriori LLR's after two iterations.



## Concept Map

## Syllabus

Fundamentals of 5G Error Control Codes: Channel Coding, Channel Models - B-DMC,BSC,BEC,AWGN, Reed Muller Codes - First order, Higher order, Reed - Solomon Codes - Finite Fields, Reed Solomon (R-S) Codes - Finite Fields, R-S Encoding, R-S Decoding, Encoder design and Decoding Algorithms for LDPC Codes: Construction of Parity Check Matrices, Decoding Algorithms - Sum-Product Algorithm, Min-Sum Algorithm. Information Theory Perspective of Polar Codes and Polar Encoding: The Philosophy of Polar Codes, Fundamental ideas of Polar Codes, Butterfly Structure, Polar Coding Operation, Recursive Construction of Polar Encoder Structures, Generator Matrix and Encoding for Polar Codes, Bhattacharyya Parameter, Frozen bits, Selection of Frozen bits. Decoding of Polar Codes: Kernel Encoder and Decoder Units of the Polar Codes, Decoding Tree for the Successive Cancellation Decoding of Polar Codes, Level Indices and Determination of Levels for Bit Distribution, Decoding Algorithm for Polar Codes, Determination of Frozen bit locations for Binary Erasure Channel (BEC), Decoding Operation with Frozen Bits. Polarization of Binary Erasure Channels and Mathematical Modelling of Polar Codes: Polarization of BEC - Split Channels and Capacity of Split Channels in the presence of Binary Erasure Channels - Capacity of Split Channels for N = 4 - Capacity bounds using Bhattacharyya parameter (B.P), Split Binary Erasure Channels, Mathematical Modelling of Polar Codes - Channel combining and recursive construction of Polar Encoder structures - Channel Splitting and Decoding of Polar Codes -Mathematical Description of Successive Cancellation Algorithm, Recursive Computation of the Successive Cancellation Algorithm. Performance of LDPC and Polar Codes: LDPC -Extrinsic Information Transfer Chart, Mutual Information based Upper and Lower Bounds on the BER, Performance Analysis of Polar Codes - Block Error Probability, Performance Comparison of LDPC codes and Polar Codes in 5G.

#### Learning Resources

- Bernard Sklar, "Digital Communications Fundamental and Applications", Prentice Hall PTR, second edition, 2001.
- Michele Franceschini, Gianluigi Ferrari, Riccardo Raheli, "LDPC Coded Modulations", Springer, 2009.
- Orhan Gazi ,"Polar Codes: A Non-Trivial Approach to Channel Coding", Springer , 2019.
- Andre Neubaur, Jurgen Freudenberger, Volker Kuhn, "Coding Theory Algorithms, Architectures and Applications", John Wiley & Sons, 2007.
- Sassan Ahmadi, "5G NR Architecture, Technology, Implementation, and operation of 3GPP New Radio Standards", Academic Press, 2019.

- E. Arıkan, "Channel polarization: a method for constructing capacity-achieving codes for symmetric binary-input memory less channels", IEEE Trans. Inf. Theory, Vol. 55, No.7, pp.3051–3073, July 2009.
- A. Andi, O. Gazi, "Fast decoding of polar codes using tree structure", IET Communications, Vol.13, No.14, Aug 2019.
- E. Arıkan, "Performance comparison of polar codes and Reed-Muller codes", IEEE Communication Letters., Vol. 12,No. 6,June 2008,pp.447-449.
- LDPC and Polar Codes in 5G Standard, Course in NPTEL: https://nptel.ac.in/courses/108/106/108106137/, - 2019, By Prof. Andrew Thangaraj, IIT Madras.

## Course Contents and Lecture Schedule

S.No.	Торіс	No. of Lectures	CO
1	Fundamentals of 5G Error Control Codes		
1.1	Channel Coding	1	CO1
1.2	Channel Models	1	CO1
1.3	Reed Muller Codes:		
1.3.1	First order R-M Code	1	CO1
1.3.2	Higher Order R-M Code	1	CO1
1.4	Reed Solomon Code:		
1.4.1	Finite Fields	1	CO1
1.4.2	R-S Encoding	1	CO1
1.4.3	R-S Decoding	1	CO1
2	Encoder design and Decoding algorithms for		
2.1	Construction of Darity Chack Matrices	2	<u> </u>
2.1	Deceding Algerithms :	2	002
2.2	Sum Droduct Algorithm	1	<u> </u>
2.2.1	Min Sum Algorithm	1	
2.2.2	Information Theory Perspective of Polar Codes at	d Dolor	002
3	Encoding	iu Polai	
3.1	The Philosophy of Polar Codes	1	CO3
3.2	Fundamental ideas of Polar Codes	1	CO3
3.3	Butterfly Structure	1	
3.4	Polar Coding Operation	1	CO3
3.5	Recursive Construction of Polar Encoder Structures	1	CO3
3.6	Generator Matrix and Encoding for Polar Codes	1	CO3
3.7	Bhattacharyya Parameter	1	CO3
3.8	Selection of Frozen bits	1	CO3
4	Decoding of Polar Codes		
4.1	Kernel Encoder and Decoder Units of the Polar Codes	1	CO4
4.2	Decoding Tree for the Successive Cancellation Decoding of Polar Codes	1	CO4
4.3	Level Indices and Determination of Levels for Bit	1	CO4
	Distribution		<b>.</b>
4.4	Decoding Algorithm for Polar Codes	1	CO4
4.5	Determination of Frozen bit locations for BEC Channels	1	CO4
4.6	Decoding Operation with Frozen Bits	1	CO4
5	Polarization of Binary Erasure Channels and Math modeling of Polar Codes	nematical	

5.1	Polarization of BEC :		CO5
5.1.1	Split Channels and Capacity of Split Channels in the	1	CO5
	presence of Binary Erasure Channels		
5.1.2	Capacity of Split Channels for $N = 4$	1	CO5
5.1.3	Capacity bounds using Bhattacharyya parameter	1	CO5
	(B.P),		
5.1.4	Split Binary Erasure Channels	1	CO5
5.2	Mathematical Modelling of Polar Codes:		CO5
5.2.1	Channel combining and recursive construction of	1	CO5
	Polar Encoder structures		
5.2.2	Channel Splitting and Decoding of Polar Codes	1	CO5
5.2.3	Mathematical Description of Successive	1	CO5
	Cancellation Algorithm		
5.2.4	Recursive Computation of the Successive	1	CO5
	Cancellation Algorithm		
6	Performance of LDPC and Polar Codes		
6.1	Performance Analysis of LDPC Code :		CO6
6.1.1	Extrinsic Information Transfer Chart	1	CO6
6.1.2	Mutual Information based Upper and Lower Bounds	1	CO6
	on the BER		
6.2	Performance analysis Polar Code :		CO6
6.3	Block Error Probability 🧹 🚺 🦾 🖉 🔪	1	CO6
6.4	Performance Comparison of LDPC and Polar	1	CO6
	Codes.		
	Total	36	
	STGU 9-		

# Course Designers:

1. Dr.S.J.Thiruvengadam

sjtece@tce.edu

Dr.M.N.Suresh
Dr.V.N.Senthilkumaran

mnsece@tce.edu vnsenthilkumaran@tce.edu

18ECPS0	PHYSICAL CHANNEL PROCESSING IN 5G	Category	L	Т	Ρ	Credit
	NR	PEES	2	1	0	3

## Preamble

The objective of the course on "Physical Channel Processing in 5G New Radio (NR)" is to present the communication techniques and procedures used in the physical layer of 5G new radio standards. The course covers 5G NR features, spectral requirements, frame structure, radio interface architecture, channel sounding, multi antenna, retransmission, power control, synchronization characteristics. This course would be more helpful in carrying out projects in recent telecommunication domain.

## Prerequisite

18EC530 Analog and Digital Communication Systems

#### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Compare the enhanced features of 5G NR over 4G LTE and	15
	Describe the Frame structure of 5G NR	
CO2	Determine suitable channel estimation algorithm for calculating	15
	parameters from channel sounding features of 5G NR	
CO3	Determine the receiver structure for transport channel	20
	processing of uplink and downlink in 5G NR	
CO4	Determine the receiver structure for control channel	20
	processing of uplink and downlink in 5G NR	
CO5	Describe the multi-antenna, retransmission, power control	15
	features of 5G NR	
CO6	Determine suitable frequency and timing estimation algorithms	15
	for initial access and synchronization features of 5G NR	

\*\*\* Weightage depends on Bloom's Level, number of contact hours

## CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	arning Domai	n Level	CDIO Curricular
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale				(X.Y.Z)
CO1	TPS2	Understand	Respond	Guided	1.3, 2.1.1,2.1.2, 2.4.6,
				Response	3.2.3
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,
		-			2.4.6, 2.5.1, 3.1.1, 3.2.3,
					4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,
		-			2.4.6, 2.5.1, 3.1.1, 3.2.3,
					4.5.5, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,
		-			2.4.6, 2.5.1, 3.1.1, 3.2.3,
					4.5.5, 4.6.2
CO5	TPS2	Understand	Respond	Guided	1.3, 2.1.1,2.1.2, 2.4.6,
				Response	3.2.3
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,
					2.4.6, 2.5.1, 3.1.1, 3.2.3,
					4.5.5, 4.6.2

# Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO 2	PO3	PO4	PO5	PO6	P07	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	М	L	-	-	-	-	-	-	-	-	-	-	М	-	-
CO2	S	Μ	L	-	-	-	-	-	-	-	-	-	М	-	-
CO3	S	Μ	L	-	-	-	-	-	-	-	-	-	М	-	-
CO4	S	Μ	L	-	S	-	-	-	S	S	-	-	М	-	М
CO5	Μ	Г	-	-	-	-	-	-	-	-	-	-	М	-	-
CO6	S	М	L	-	-	-	-	-	-	-	-	-	М	-	-

S- Strong; M-Medium; L-Low

# Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests				Assignme	nt	End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	100	50	50	80
Analyze	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception		-	-
Set	して、	-	-
Guided Response			-
Mechanism		50	50
Complex Overt Responses		-	-
Adaptation		-	-
Origination		-	-

## Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. List the requirements of 5G New Radio.
- 2. List out the various Uplink and Downlink 5G NR Operating bands. Also mention the duplex modes.
- 3. Compare Normal RS Structure and Wideband RS Structure in 5G NR Physical layer control signalling.

## Course Outcome 2 (CO2):

- 1. Draw the single port CSI-RS Structure consisting of a single resource element within RB.
- 2. Represent different spatial filters applied to different CSI-RS.
- 3. Draw the time and frequency structures of Sounding Reference Signalling.

## Course Outcome 3 (CO3):

- 1. Determine the receiver structures for PDSCH in 5GNR with single transmit and single receive antenna.
- 2. Determine the receiver structures for PUSCH in 5GNR with single transmit and single receive antenna.
- 3. Determine the receiver structures for PDSCH in 5GNR with single transmit and multiple receive antenna.

## Course Outcome 4 (CO4):

- 1. Explain the mapping of PUSCH and PUCCH information to physical resources.
- 2. Consider a PDCCH downlink control channel in 5GNR. It transmits information about the number of OFDM symbols used by control channels in a sub-frame. The 32 bit transmitting sequences for each values of CFI are listed below

CFI <b0, b1, ..., b31>

1<0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1)>

- 2 <1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0>
- 3<1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1>

Assuming that PDCCH uses single antenna port for the transmitter and receiver, derive expression for probability of error in detection of the CFI value.

3. In case of fixed group assignment the sequence group to use for PUCCH transmission is given by the physical-layer cell identity modulo 30, where the cell identity ranges from 0 to 63. Determine the group assignment for the given cell identities.

#### Course Outcome 5 (CO5):

- 1. Describe the multi antenna transmission modes in downlink 5G New Radio.
- Determine the Bit Error Rate for the Physical Downlink Hybrid ARQ Indicator channel (PDCCH) with SIMO processing.
- 3. Precoding is done for multi antenna transmission in 5G New Radio uplink. Determine the rank of the precoding matrix given below.

14.4	+1 0	[+1	0	0		+1	0	0	17T	0	01	
+ 3	+1 0	+1	0	0		-1	0	0	0	+1	0	
+1	0 +1	0	+1	0	,	0	+1	0	+1	0	0	
-1	0 -/	0	0	+1	1	0	0	+1	0	0	+1	

For the DFT spread OFDM in uplink, the allowed DFT sizes are 60, 72, and 96. However a DFT size of 84 is not allowed. Justify.

#### Course Outcome 6 (CO6):

1. Consider 4 length time domain transmitted sequence defined by

x(n) = [1+1j, 1-1j, 1+1j, 1-1j].

Consider a normalised frequency offset of 0.3. Determine the received sequence with ideal channel conditions. Apply schmidle Cox algorithm to determine the original frequency offset if  $\Delta f = 15 KHz$ .

- 2. Apply the Schmidle Cox algorithm for symbol timing estimation in 5G New Radio.
- 3. What do you mean by beta offset in 5GNR?

#### **Concept Map**



## Syllabus

5G Overview: 3GPP and the standardization of Mobile Communication, the next generation 5G New Radio, 5G Standardization, ITU-R Activities from 3G to 5G, 5G and IMT-2020, 3GPP Standardization, Spectrum for 5G, Frequency bands for NR, RF Exposure above 6GHz NR Overview: Higher Frequency Operation and Spectrum Flexibility, Ultra lean design, Forward compatibility, Transmission scheme, bandwidth parts and frame structure, Duplex schemes, Low latency support, Scheduling and data transmission, control channels, Beam centric design and Multi antenna transmission, Initial access, Interworking and LTE Coexistence Transmission scheme: Frequency domain location of NR Carrier, Carrier aggregation, Supplementary uplink, Duplex schemes, Antenna ports, Quasi co-location Channel sounding: Downlink channel sounding-CSI-RS, Downlink Measurements and reporting, Uplink channel sounding- SRS Transport channel processing: channel coding, Rate matching and physical layer hybrid ARQ Functionality, Scrambling, Modulation, Layer mapping, Uplink DFT Precoding, Multi antenna precoding, Resource mapping, Downlink reserved resources, Reference signals, Physical layer control signalling: Downlink, Uplink, Multi-antenna Transmission: Downlink Multi-antenna precoding, NR Uplink Multi-antenna precoding, Beam Management: Beam adjustment and Beam Recovery Retransmission Protocols, Uplink Power and Timing control, Initial access: Cell search, Random access.

## Learning Resources

- Sassan Ahmadi, "5G NR Architecture, Technology, Implementation, and operation of 3GPP New Radio Standards", Academic Press, 2019.
- Erik Dahlman, Stefan Parkvall, Johan Skold, "5G NR, The Next Generation Wireless Access Technology", Academic Press, 2018.
- 3GPP TS 23.502, Procedures for the 5G system (Release 15), April 2019.
- 3GPP TS 38.101-1, NR, User Equipment (UE) Radio Transmission and Reception; Part 1: Range 1 Standalone (Release 15), December 2018.
- 3GPP TS 38.101-2: NR, User Equipment (UE) Radio Transmission and Reception; Part 2: Range 2 Standalone (Release 15), December 2018.
- 3GPP TS 38.104, NR, Base Station (BS) Radio Transmission and Reception (Release 15), December 2018.
- 3GPP TS 38.202, NR, Services Provided by the Physical Layer (Release 15), December 2018.
- 3GPP TS 38.211, NR, Physical Channels and Modulation (Release 15), December 2018.
- 3GPP TS 38.212, NR, Multiplexing and Channel Coding (Release 15), December 2018.

• 5G New Radio, ShareTechNote. http://www.sharetechnote.com

**Course Contents and Lecture Schedule** 

No.	Торіс	No. of Hours	COs
1	5G Overview	· · ·	
1.1	3GPP and the standardization of Mobile Communication, the next generation 5G New Radio	1	CO1
1.2	5G Standardization	1	CO1
1.3	ITU-R Activities from 3G to 5G	1	CO1
1.4	5G and IMT-2020	1	CO1
1.5	3GPP Standardization	1	CO1
1.6	Spectrum for 5G, Frequency bands for NR, RF Exposure above 6GHz	1	CO1
2	NR Overview		
2.1	Higher Frequency Operation and Spectrum Flexibility, Ultra lean design	1	CO1
2.2	Forward compatibility, Transmission scheme, bandwidth parts and	1	CO1

	frame structure		
2.3	Duplex schemes, Low latency support, Scheduling and data	1	CO1
	transmission, control channels		
2.4	Beam centric design and Multi antenna transmission	1	CO1
2.5	Initial access, Interworking and LTE Coexistence	1	CO1
3	Transmission scheme		
3.1	Frequency domain location of NR Carrier	2	CO2
3.2	Carrier aggregation	2	CO2
3.3	Supplementary uplink, Duplex schemes	2	CO2
3.4	Antenna ports, Quasi co-location	1	CO2
4	Channel sounding		
4.1	Downlink channel sounding-CSI-RS	2	CO3
4.2	Downlink Measurements and reporting	2	CO3
4.3	Uplink channel sounding- SRS	2	CO3
5	Transport channel processing		
5.1	channel coding, Rate matching and physical layer hybrid ARQ	2	CO4
	Functionality		
5.2	Scrambling, Modulation, Layer mapping	1	CO4
5.3	Uplink DFT Precoding, Multi antenna precoding	1	CO4
5.4	Resource mapping, Downlink reserved resources	1	CO4
5.5	Reference signals	1	CO4
5.6	Physical layer control signalling: Downlink, Uplink	1	CO4
6	Multi antenna Transmission		
6.1	Downlink Multi antenna precoding	1	CO5
6.2	NR Uplink Multi antenna precoding	1	CO5
7	Beam Management		
7.1	Beam adjustment and Beam Recovery	2	CO5
8	Retransmission Protocols, Uplink Power and Timing control, In	itial acc	ess
8.1	Cell search, Random access	1	CO6
Total		36	
-	Bar Income and the second s		

• Dr.S.J.Thiruvengadam

am sjtece@tce.edu

Dr.M.N.Suresh mnsece@tce.edu

Dr.G.Ananthi gananthi@tce.edu
18ECPT0	DEEP LEARNING FOR SPEECH	Category	L	Т	Р	Credit
	PROCESSING	PE	2	1	0	3

#### Preamble

The objective of this course is to develop techniques which can enable machines to understand complex real-world signals like text and speech. This course covers methods which model, analyse, classify and detect the underlying information modalities present in real world signals. This course consists of descriptions of signal processing tools for learning patterns in speech signals as the description of a class of machine learning tools which have been successfully used for these signals.

#### Prerequisite

#### 18EC440 Signal Processing

#### **Course Outcomes**

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Process speech signals using machine learning algorithms to	10
	convert them to text and speech.	
CO2	Classify the text and speech signals using representations of	15
	these signals such as lexical, syntactic, semantic and	
	discourse.	
CO3	Identify the spoken word using digit dataset applied as input to	15
	supervised or unsupervised neural network architectures	
CO4	Map the speech data in various forms using convolutional	10
	neural networks.	
CO5	Extract past and future dependencies at a given point of the	20
	speech to enable more number of command recognitions using	
	RNN, Attention Mechanism and Memory Augmented Networks.	
CO6	Select the appropriate acoustic features to train and validate	15
	Automatic Speech Recognition systems.	
CO7	Design an end to end speech recognition system based on	15
	connectionists temporal classification techniques.	

\*\*\* Weightage depends on Bloom's Level, number of contact hours

### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	rning Domai	n Level	CDIO Curricular						
#	Proficiency	Cognitive	Affective	Psychomotor	Components						
	Scale	-		_	(X.Y.Z)						
CO1	TPS2	Understand	Respond	Guided	1.3, 2.1.1, 2.1.2						
				Response							
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.1.3,						
					2.5.1						
CO3	3 TPS3 Apply Value		Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,							
					2.4.6, 2.5.1, 3.1.1, 3.2.3,						
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,						
					2.4.6, 2.5.1, 3.1.1, 3.2.3,						
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,						
					2.4.6, 2.5.1, 3.1.1, 3.2.3,						
CO6	TPS4	Analyse	Organise	Complex Overt	1.3, 2.1.1, 2.1.2, 2.1.3,						
				Responses	2.1.4, 2.4.2, 2.4.6, 2.5.1,						
					3.1.1, 3.2.3, 4.5.5						
CO7	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,						
					2.4.6, 2.5.1, 3.1.1, 3.2.3,						
					4.5.5						

### Mapping with Programme Outcomes and Programme Specific Outcomes

	-	-					-								
COs	PO	PO	Р	PO	PO	PO	PO	PO	PO	Р	Р	Р	PSO	PSO	PSO
	1	2	0	4	5	6	7	8	9	0	0	0	1	2	3
			3							10	11	12			
CO1	М	L	-	-	S	-	-	-	L	-	-	-	L	-	-
CO2	S	М	L	-	-	-	-	-	-	-	-	-	М	-	-
CO3	S	М	L	-	S	-	-	-	L	-	-	-	М	-	-
CO4	S	М	L	-	S	-	-	-	L	-	-	-	М	-	-
CO5	S	М	L	-	-	-	-	-	-	-	-	-	Μ	-	-
CO6	S	S	Μ	L	-	-	-	-	-	-	-	-	S	-	-
C07	S	М	L	-	-	L	-	L	-	-	-	-	М	-	-

### S- Strong; M-Medium; L-Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Contin	uous Ass Tests	sessment		Assignme	End Semester Examination	
	1	2	3	1	2	3	]
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	60	60	50	50	50	60
Analyse	0	20	20	0	0	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3		
Perception	100-000	-	-		
Set	ALGU LE	-	-		
Guided Response	-	-	-		
Mechanism	50	50	50		
Complex Overt Responses		-	-		
Adaptation	-	-	-		
Origination	-	-	-		

#### Sample Questions for Course Outcome Assessment

#### Course Outcome 1 (CO1):

- 1. What are Machine Learning Pipelines?
- 2. What is the class called which transforms a set of columns in a speech data frame to a single Dense Vector representation in ML?
- 3. How the class is called which transforms a string class label to a class index in ML?

#### Course Outcome 2 (CO2):

- 1. Take a word, for example, "machine." Write it ten times. Also ask a friend to write it ten times. Analyzing these twenty images, try to find features, types of strokes, curvatures, loops, how you make the dots, and so on, that discriminate your handwriting from your friend's.
- 2. Assume we are given the task to build a system that can distinguish junk email. What is in a junk e-mail that lets us know that it is junk? How can the computer detect junk through a syntactic analysis? What would you like the computer to do if it detects a junk e-mail—delete it automatically, move it to a different file, or just highlight it on the screen?
- 3. List the various speech representations given to ML.

#### Course Outcome 3 (CO3):

- 1. What are some linear methods for dimensionality reduction?
- 2. Why Support Vector Machines are also called "maximum margin classifier"?
- 3. How are Random Forest different in re-sampling from Gradient Boosted Trees?

### Course Outcome 4 (CO4):

- 1. How to train Convolutional neural network to enhance the speech data?
- 2. How to deal with over fitting problem in speech signal analysis?
- 3. Can CNN and LSTM (Long Short Term Memory) use in speech emotion recognition? Justify.

### Course Outcome 5 (CO5):

- 1. Draw the simple RNN based speech classifier for sentiment classification.
- 2. Is Recurrent Neural Network used in Google Speech recognition system? If So, Explain.
- 3. What do you mean by Residual Long Short Term Memory?

### Course Outcome 6 (CO6):

1. Given the observable Markov model with three states  $s_1, s_2, s_3$ , initial probabilities

 $\Pi = \begin{bmatrix} 0.5 & 0.2 & 0.3 \end{bmatrix}^T \text{ and transition probabilities } A = \begin{bmatrix} 0.4 & 0.3 & 0.3 \\ 0.2 & 0.6 & 0.2 \\ 0.1 & 0.1 & 0.8 \end{bmatrix} \text{Generate } 3$ 

sequences of 5 states.

- 2. Standard telephone audio has a sampling rate of 8 kHz and 16-bit precision. CD quality is 44.1 kHz, 16-bit precision, while contemporary speech processing focuses on 16 kHz or higher. What is the bit rate? How do you model raw high dimensional speech signal?
- 3. List the types of filters or filter banks applicable for Mel Frequency Cepstral Coefficients (MFCC) in Automatic Speech Recognition system?

### Course Outcome 7 (CO7):

- 1. Explain the Neural attention model for Speech Command Recognition system.
- 2. Draw the statistical speech recognition system.
- 3. How do you fix the state alignment with feature observations in end to end speech recognition system?

### Concept Map



### Syllabus

Machine Learning Overview: Supervised learning, Unsupervised learning, Semisupervised learning, Active learning, Transfer learning, Multitask learning, Reinforcement learning, Text and Speech basics: Morphological analysis, Lexical Representations, Syntactic Representations, Semantic Representations, Discourse Representations, Language Models, Text classification, Text clustering, Machine translation, Automated speech recognition, Natural language processing, Speech processing Deep Learning algorithms: Multilayer Perceptron, Model Training, Unsupervised Deep Learning, Framework Considerations Convolutional Neural Networks: Basic building blocks of CNN, Forward and Backward Propagation in CNN, Text inputs and CNN, Classic CNN Architectures, Applications of CNN in NLP, Fast algorithms for Convolutions Recurrent Neural Networks: Basic building blocks of RNN, Applications of RNN in NLP Automatic Speech Recognition (ASR): Acoustic Features, Acoustic Model, Language Model, HMM Decoding, DNN/HMM Hybrid Model, Voice Technologies that use ASR **Deep Learning techniques for text and speech:** Attention Mechanism, Memory Augmented Networks **Transfer Learning:** Multitask learning, Zero shot, One shot and Few shot learning **End to End Speech Recognition:** Connectionist temporal classification, End to End decoding, Speech embeddings and unsupervised speech recognition

#### Learning Resources

- Uday Kamath, John Liu, James Whitaker, "Deep Learning for NLP and Speech Recognition", Springer, 2019.
- Max A Little, Machine Learning for Signal Processing: Data science, Algorithms and Computational Statistics,Oxford University Press, 2019.
- C.M.Bishop, "Pattern Recognition and Machine Learning", C.M. Bishop, 2nd Edition, Springer, 2011.
- I.Goodfellow, Y.Bengio, A.Courville, "Deep Learning", MIT Press, 2016.
- D.Yu,L. Deng, "Automatic Speech Recognition," Springer 2014.
- Ethem Alpaydın, "Introduction to Machine learning", The MIT Press Cambridge, Massachusetts, 2010
- Michael Bowles, "Machine learning in Python: Essential techniques for predictive analysis," John Wiley and sons, 2015.

### **Course Contents and Lecture Schedule**

No.	Торіс	No. of	COs
1	Machine Learning Overview	TIOUIS	
1.1	Supervised learning. Unsupervised learning	1	CO1
1.2	Semi- supervised learning. Active learning	1	CO1
1.3	Transfer learning, Multitask learning	1	CO1
1.4	Reinforcement learning	1	CO1
2	Text and Speech basics		
2.1	Morphological analysis, Lexical Representations	1	CO2
2.2	Syntactic Representations, Semantic Representations	1	CO2
2.3	Discourse Representations, Language Models	1	CO2
2.4	Text classification, Text clustering	1	CO2
2.5	Machine translation, Automated speech recognition	1	CO2
2.6	Natural language processing, Speech processing	1	CO2
3	Deep Learning algorithms		
3.1	Multilayer Perceptron	2	CO3
3.2	Model Training	2	CO3
3.3	Unsupervised Deep Learning, Framework Considerations	2	CO3
4	Convolutional Neural Networks		
4.1	Basic building blocks of CNN, Forward and Backward Propagation	2	CO4
	in CNN		
4.2	Text inputs and CNN, Classic CNN Architectures	2	CO4
4.3	Applications of CNN in NLP,	2	CO4
4.4	Fast algorithms for Convolutions	1	CO4
5	Recurrent Neural Networks		
5.1	Basic building blocks of RNN	1	CO5
5.2	Applications of RNN in NLP	1	CO5
6	Automatic Speech Recognition (ASR)	,,	
6.1	Acoustic Features, Acoustic Model,	1	CO6
6.2	Language Model, HMM Decoding	1	CO6
6.3	DNN/HMM Hybrid Model	1	CO6
6.4	Voice Technologies that use ASR	1	CO6
7	Deep Learning techniques for text and speech		
7.1	Attention Mechanism, Memory Augmented Networks	1	CO6

8	Transfer Learning		
8.1	Multitask learning, Zero shot	1	CO6
8.2	One shot and Few shot learning	1	CO6
9	End to End Speech Recognition		
9.1	Connectionist temporal classification	1	C07
9.2	End to End decoding	2	C07
9.3	Speech embeddings and unsupervised speech recognition	1	C07
Total		36	
<b>^</b>			

#### Course Designers:

•

- Dr.S.J.Thiruvengadam sjtece@tce.edu
  - Dr.K.Rajeswari rajeswari@tce.edu
- Dr.G.Ananthi gananthi@tce.edu



1	8	Ε	С	Ρ	U	0
	~	_	~		~	~

#### **VLSI DEVICE MODELING**

Category	L	Т	Р	Credit
PE	3	0	0	3

### Preamble

The present and future generation VLSI systems are all expected using MOSFETs. Over the years, the VLSI industry has systematically adapted to the use of only MOSFETs for all purposes. This course introduces the principles of device modeling, in which device physics and experimentally observed device performances characteristics are combined to lead predictable equations and expressions for device performance under scenarios of excitation.

### Prerequisite

18EC430 CMOS VLSI Systems

### **Course Outcomes**

On the successful completion of the course, students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Describe about the different modeling of MOS transistor.	15
CO2	Examine C-V and I-V characteristics of MOSFET.	20
CO3	Solve CMOS scaling issues and Short channel MOSFETs.	15
CO4	Apply technological remedies for short channel effects.	15
CO5	Build the different types of Non-Classical Transistors	20
CO6	Interpret TCAD design flow and classical models	15

#### CO Mapping with CDIO Curriculum Framework

CO	T	ČE			Lea	arning	ning Domain Level						CDIO Curricular			
#	Profi	ciency	/	Cogni	tive	A	ffectiv	e	Psychomotor			Components				
	S	cale				1	11	The second	1	0			(X.Y.Z)			
CO1	TF	PS2	U	Inder	stand	R	espoi	nd		-		1.3, 2.1.1, 2.1.2,				
						Saran B					2.4.1, 2.4.2, 2.4.5,					
							15	-				3.2	2.3, 3.2	.5		
CO2	TF	PS4		Anal	yse	0	rgani	se	Co	mple	ex	1.3	6, 2.1.1	, 2.1.2	,	
									C	Dvert	t	2.1	.3, 2.5	.1, 3.1	.1,	
									Res	pon	ses	3.2	2.3			
CO3	TF	PS3		Арр	ly		Value	<b>;</b>	Mec	han	ism	1.3	6, 2.1.1	, 2.1.2	,	
												2.5.1, 3.1.1, 3.2.3				
CO4	TF	PS3		Apply			Value	•	Mechanism			1.3, 2.1.1, 2.1.2,				
											2.5	5.1, 3.1	.1, 3.2	.3		
CO5	TF	PS3		Apply			Value Mechanism		ism	1.3	6, 2.1.1	, 2.1.2	,			
										2.5.1, 3.1.1, 3.2.3						
CO6	TF	PS2	U	Inder	stand	R	Respond Guided			d	1.3, 2.1.1, 2.1.2,					
									res	pon	se	2.4	.1, 2.4	.2, 2.4	.5,	
										•		3.2	2.3, 3.2	.5.		
Mapp	ing w	ith Pr	ogran	nme C	)utcoi	nes a	nd Pr	ogra	mme S	Spec	ific C	Dutco	omes			
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	
CO1	М	L	-	-	-	-	-	L	L	L	-	-	L	-	L	
CO2	S	S	Μ	L	-	-	-	L	L	L	-	-	S	-	L	
CO3	S	М	L	-	-	-	-	L	L	L	-	-	М	-	L	
CO4	S	Μ	L	-	-	-	-	L	L	L	-	-	М	-	L	
CO5	S	Μ	L	-	-	-	-	L	L	L	-	-	Μ	-	L	
CO6	М	L	-	-	L	-	-	-	L	L	-	-	L	-	L	

S- Strong; M-Medium; L-Low

Cognitive Levels	Contir	nuous Ass Tests	sessment		Assignme	End Semester Examination	
	1	2	3	1	2	3	]
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	30	80	80	100	100	60	60
Analyse	50	0	0	0	0	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

### Assessment Detterms Os within De

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	40
Complex Overt Responses	-	-	-
Adaptation	- Area	-	-
Origination	Faller	-	-

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. List out the requirements for MOSFET modeling for RF applications.
- 2. Explain in detail about the different modeling of MOS transistor.
- 3. Describe about simple charge control model with necessary equations.

#### Course Outcome 2 (CO2):

- 1. Investigate about Frequency dependent capacitance.
- 2. Analyse the effect of non-idealities on capacitance -voltage of MOSFET.
- Deduce parameter extraction from MOSFET C-V characteristics.

### Course Outcome 3 (CO3):

- 1. Illustrate the short channel effects of MOSFET.
- 2. Relate constant field scaling and constant voltage scaling.
- 3. Interpret about Channel length of MOSFET.

#### Course Outcome 4 (CO4):

- 1. Construct techniques to reduce short channel effects of MOS Devices.
- 2. Examine Strain engineering and Halo implants.
- 3. Interpret Quantum effects in MOSFETs.

### Course Outcome 5 (CO5):

- 1. Illustrate the operation of Multigate MOSFETs.
- 2. Calculate the electro static potential of given structure with the suitable boundary conditions.



- 3. Explain the electrostatics DG- MOS system with the suitable equations.
  - a. Gate Voltage effect.
  - b. Semiconductor thickness effect.
  - c. Asymmetry effect.
  - d. Oxide thickness effect.
  - e. Electron tunnel current.

### Course Outcome 6 (CO6):

- 1. Differentiate the various numerical solution methods in TCAD.
- 2. Describe in detail about Classical TCAD Models.
- 3. List the steps involved in the TCAD flow for IC design and Device simulation.

#### **Concept Map**



### Syllabus

Modeling of MOSFET: MOS Current Equation, Equivalent circuit representation of MOS Transistor, Types of Compact Models: Basic modeling, Advanced MOSFET modeling, DC model, RF modeling - Noise sources in MOSFET: Flicker and Thermal Noise modeling. Long Channel Effects: Ideal MOS C-V Characteristics, Effect of non-idealities on C-V, MOS Parameter extraction from C-V characteristics and I-V characteristics - MOSFET Channel Mobility - MOSFET capacitances, Inversion-Layer Capacitance effect and Frequencydependent capacitance. MOSFET Scaling and Short Channel Effects: CMOS Scaling theory - Threshold-Voltage Requirement - MOSFET Channel Length - Short Channel MOSFETs: Drain Induced Barrier Lowering, Channel Length Modulation, Velocity saturation, Punch through Effect, Hot Carrier effects, threshold roll-off, Sub-threshold conduction, Mobility Degradation. CMOS Engineering and Technological Remedies: Quantum effects, Volume inversion, Channel and Source / Drain engineering, High-k dielectric, Strain engineering, Multigate technology mobility, Gate stack Engineering, Halo implants. Non -Classical Transistors: SOI MOSFET structures, Partially Depleted (PD) and Fully Depleted SOI MOSFETs - Double Gate, Surrounding Gate, Multigate MOSFETs - FINFETs - TFETs - HEMTs - Silicon Nanowires - Junctionless FETs. TCAD Simulation: TCAD Flow for IC Process and Device Simulation, Numerical Solution Methods, Drift Diffusion Calculations, Energy Balance Calculation, Classical Models - Thermodynamic and Schrodinger Model -Random Dopant Fluctuations, Ballistic Transport.

### Learning Resources

- Y.Tsividis & Colin McAndrew, "The MOS Transistor", 3<sup>rd</sup> Edition, Oxford University Press, 2013.
- Y. Taur and T. H. Ning, "Fundamentals of Modern VLSI Devices", Cambridge University Press, Cambridge, United Kingdom, 2014.
- A.B.Bhattacharyya , " Compact MOSFET Models for VLSI Design", John Wiley & Sons Ltd, 2015
- Trond Ytterdal, Yuhua Cheng and Tor A. Fjeldly Wayne Wolf, "Device Modeling for Analog and RF CMOS Circuit Design", John Wiley & Sons Ltd, 2015
- Snowden C. M.," Introduction to Semiconductor Device Modeling", World Scientific Press, Singapore, 1986

- J.P.Colinge "FinFETs and other Multigate Transistors", Springer, Germany, 2010.
- Prof.S.Karmalkar, IIT Madras, Semiconductor Device Modeling, NPTEL video Lectures:https://nptel.ac.in/courses/117/106/117106033/
- Prof.K.N.Bhat, Dr.S.A.Shivashankar, Dr.Navakanta Bhat, IISC, Bangalore, Nano Electronics: Devices & Materials, NPTEL video Lectures:https://nptel.ac.in/courses/117/108/117108047/

Cours	Course Contents and Lecture Schedule							
No.	Торіс	No. of	COs					
		Hours						
1	Modeling Of MOSFET	,,						
1.1	MOS Current Equation, Equivalent circuit representation of MOS	1	CO1					
	Transistor							
1.2	Types of Compact Models							
1.2.1	Basic modeling	1	CO1					
1.2.2	Advanced MOSFET modeling	1	CO1					
1.2.3	DC model	1	CO1					
1.2.4	RF modeling	1	CO1					
1.3	Noise sources in MOSFET							
1.3.1	Flicker Noise modelling, Thermal Noise modeling	1	CO1					
2	Long Channel Effects	,,						
2.1	Ideal MOS C-V Characteristics	1	CO2					
2.2	Effect of non-idealities on C-V	1	CO2					
2.3	MOS Parameter extraction from C-V characteristics	1	CO2					
2.4	MOS Parameter extraction from I-V characteristics	1	CO2					
2.5	MOSFET Channel Mobility	1	CO2					
2.6	MOSFET capacitances, Inversion-Layer Capacitance effect,	1	CO2					
	Frequency dependent capacitance							
3	MOSFET Scaling and Short Channel Effects:							
3.1	CMOS Scaling theory	1	CO3					
3.2	Threshold-Voltage Requirement	1	CO3					
3.3	MOSFET Channel Length	1	CO3					
3.4	Short Channel MOSFETs							
3.4.1	Drain Induced Barrier Lowering, Channel Length Modulation	1	CO3					
3.4.2	Velocity saturation, Punch through Effect, Hot Carrier effects	1	CO3					
3.4.3	Threshold roll off, Subthreshold conduction, Mobility Degradation.	1	CO3					
4	CMOS Engineering and Technological Remedies:							
4.1	Quantum effects	1	CO4					
4.2	Volume inversion	1	CO4					
4.3	Channel and Source / Drain engineering	1	CO4					
4.4	High-k dielectric	1	CO4					
4.5	Strain engineering, Multigate technology mobility	1	CO4					
4.6	Gate stack Engineering, Halo implants	1	CO4					
5.	Non-Classical Transistors:	1						
5.1	SOI MOSFET structure, Partially Depleted (PD) and Fully	1	CO5					
	Depleted SOI MOSFETs							
5.2	Double Gate MOSFETs, Surrounding Gate MOSFETs	1	CO5					
5,3	Multigate MOSFETs, FINFETs	1	CO5					
5.4	TFETs	1	CO5					
5.5	HEMTs	1	CO5					
5.6	Silicon Nanowires, Junction less FETs.	1	CO5					
6	TCAD Simulation:	. 1						
6.1	TCAD Flow for IC Process and Device Simulation	1	CO6					
6.2	Numerical Solution Methods.	1	CO6					

6.3	Drift Diffusion Calculations		1	CO6
6.4	Energy Balance Calculation	1	CO6	
6.5	Classical Models			
6.5.1	Thermodynamic and Schrodi	1	CO6	
6.5.2	Random Dopant Fluctuations	1	CO6	
Cours	se Designers:			
• Dr	.N.B.Balamurugan	nbbalamurugan@tce.edu		
• Dr	.S.Rajaram	rajaram_siva@tce.edu		

- Dr. V.Vinoth Thyagarajan
- vvkece@tce.edu
- Dr.D.Gracia Nirmala Rani gracia@tce.edu
- Dr.V.R.Venkatasubramani venthiru@tce.edu



	18FCPV0	edit
PEES 3 0 0 3		3

#### Preamble

Increased levels of integration (increased functionality) and higher throughput under tight power budgets has led to the need for low power circuits and systems. Portable communication computation driven and have the need for low-power electronics. Recent progress has been made in creating tools for estimating power dissipation in CMOS circuits. The research approach is to use accurate and efficient power estimation techniques to drive the design of new low-power systems. Software tools for testing integrated circuits, rapid fault simulation, and failure analysis are also being developed. This course discusses design techniques, estimation and optimisation of power at various levels of design abstraction for designing energy-efficient digital systems.

#### Prerequisite

18EC430 CMOS VLSI Systems

#### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage
		in %
CO1	Calculate the dynamic and static power dissipation for CMOS Digital	15
	logic Circuits.	
CO2	Estimate the switching power in CMOS digital circuits using probabilistic	15
	and statistical techniques.	
CO3	Estimate the leakage current for the low voltage CMOS digital circuits.	15
CO4	Modify, at the algorithm level for minimum power consumption.	15
CO5	Optimize the given Digital logic and arithmetic circuits for reduced	15
	power consumption.	
CO6	Suggest circuit design techniques for the different elements of Memory	15
	to reduce power consumption.	
CO7	Describe the techniques to consider while designing software for a low	10
	power system	

### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lean	ning Domair	n Level	CDIO Curricular Components
#	Proficien	Cognitive	Affective	Psychomotor	(X.Y.Z)
	cy Scale				
CO1	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.3, 2.4.2, 2.5.1, 3.1.1,
					3.2.3
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.3, 2.4.6, 2.5.1, 3.1.1,
					3.2.3
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.3, 2.4.6, 2.5.1, 3.1.1,
					3.2.3
CO4	TPS4	Analyse	Organise	Complex	1.3, 2.1.1, 2.1.3, 2.1.5, 2.4.6, 2.5.1,
		-	_	Overt	2.5.4, 3.2.3
				Response	
CO5	TPS4	Analyse	Organise	Complex	1.3, 2.1.1, 2.1.3, 2.1.5, 2.4.6, 2.5.1,
		-	_	Overt	2.5.4, 3.2.3
				Response	
CO6	TPS4	Analyse	Organise	Complex	1.3, 2.1.1, 2.1.3, 2.5.1
				Overt	
				Response	
CO7	TPS2	Understand	Respond	Guided	1.3, 2.5.4, 3.2.6
				Response	

#### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	P01	PO2	PO 3	PO 4	РО 5	PO 6	PO 7	PO 8	РО 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	S	Μ	L	-	-	-	-	L	L	L	-	L	Μ	-	L
CO2	S	Μ	L	L	-	-	-	L	L	L	-	L	Μ	-	L
CO3	S	Μ	L	L	-	-	-	L	L	L	-	L	Μ	-	L
CO4	S	S	Μ	L	-	-	-	L	L	L	-	L	S	-	L
CO5	S	S	Μ	L	-	-	-	L	L	L	-	L	S	-	L
CO6	S	S	М	L	-	-	-	L	L	Ĺ	-	Ĺ	S	-	L
CO7	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-

#### S- Strong; M-Medium; L-Low

#### Assessment Pattern: Cognitive Domain

Accounting	, loovooniont i attorni oogintito Bonian										
Cognitive Levels	Continuous Assessment Tests			A	Assignment	End Semester Examination					
	1	2	3	1	2	3					
Remember	20	0	0	0	0	0	0				
Understand	20	20	20	0	0	0	20				
Apply	60	40	40 //	100	100	0	50				
Analyse	0	40	40	0	0	100	30				
Evaluate	0	0	0	0	0	0	0				
Create	0	0	0	0	0	0	0				

### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment 2	Assignment 3
Perception		-
Set	ALCON LE	-
Guided Response		-
Mechanism		-
Complex Overt Responses	and the second second	-
Adaptation	-	-
Origination	-	-

#### Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):

- 1. A 32 bit off-chip bus operating at 5V and 66 MHz clock rate is driving a capacitance of 25 pF/bit. Each bit is estimated to have a toggling probability of 0.25 at each clock cycle. What is the power dissipation in operating the bus?
- 2. The chip size of the CPU is 15mm\*25mm with the clock frequency of 300MHZ operating at 3.3.The length of the clock signal estimated to be twice the circumference of the chip. Assume that the clock signal is routed on a metal layer with the width of 1.2um and parasitic capacitance of the metal layer is 1Ff/um^2.What is the power dissipation of the clock signal?
- 3. Silicon is doped with boron to a concentration of  $N_A=4*10^{17}$  atoms/cm<sup>3</sup> and the semiconductor is used to form a junction with an aluminium metal with work function 4.1eV. Calculate the work function difference between the metal and semiconductor. Assume the intrinsic concentration carrier concentration of silicon is  $1.5*10^{10}$  cm<sup>-3</sup> at room temperature of T=300K.

### Course Outcome 2(CO2):

- 1. Find the dynamic Power Dissipation of a circuit operating at 500 MHZ with a supply voltage of 0.9 V and a capacitance value per unit area 150 pf/mm<sup>2</sup>. The chip size is 80mm<sup>2</sup>. Assume the activity factor to be 0.1.
- Find the area and power for the given function F1=ab+db+ce all inputs have equal probability = 0.5 The signal activities are D(a)=0.2; D(b)=0.3; D(c)=0.1; D(d)=2.5; D(e)=0.1;

 Calculate the power for the given function F2= ac+cd+be, whose primary inputs have equal probability of 0.5. The signal activities are D(a)=0.2; D(b)=0.3; D(c)=0.1; D(d)=2.5; D(e)=0.1.

### Course Outcome 3(CO3):

- 1. Draw a semiconductor MOSFET transistor showing the possible sources of leakage currents in it and also derive the expression for the CMOS leakage current.
- 2. Illustrate the process of overcoming the leakage current by explaining the operation of domino logic NAND gate.

### Course Outcome 4 (CO4):

- 1. Use the pass-transistor logic circuits to construct the logic function  $F = AB + \overline{B}C + \overline{A} \cdot \overline{B}$
- 2. Construct a logic function  $F = AB + AC + \overline{A}D\overline{E} + BE$  using CPL and DPTL and LEAP. Use binary decision diagram (BDD) to design the above logic function.
- Using and domino dynamic logic circuits, design a logic function *F* = *A* ⊕ *B* ⊕ *C* in one stage and two cascading stages. Analyse and discuss the transient performance of the circuit for load capacitances of 0.01pF, 0. 1pF, and 0.5pF, and at supply voltages of 5V, 3.3V, 2.5V, and 1.5V.

### Course Outcome 5 (CO5):

- 1. Use static CMOS logic circuits and complementary pass-transistor logic (CPL) to design the parallel adder. Which approach has the best speed performance (smallest propagation delay)? For the design with the best speed performance, is its throughput also the highest?
- 2. Compare the performance of the multipliers using Wallace tree reduction with 3-to-2 and 4-to-2 compressor, modified Booth encoder/decoder, and combining modified Booth encoder/decoder with Wallace tree reduction.

### Course Outcome 6(CO6):

- 1. List the factors that affect the initial voltage difference in the DRAM bit lines during the read cycle of the memory circuit.
- 2. When the supply voltage is lowered, examine the influence of initial voltage difference in the bit lines during the read cycle?

### Course Outcome 7(CO7):

- 1. Explain the average power dissipation associated with each instruction sequence of instruction set for ILPA.
- 2. Describe the instruction ordering and operand ordering techniques used for reducing the power dissipation associated with software synthesis.

#### Concept Map



### Syllabus

**Power Dissipation in CMOS:** Sources of power dissipation, Physics of power dissipation in CMOS FET devices: switching power and leakage power in deep submicrometer transistors, low power VLSI design limits and issues.

**Power Estimation:** Average power estimation techniques at logic level: probabilistic, statistical, Glitching power, Input vector compaction, Circuit level power estimation, Estimation of maximum power: Test generation based, steepest descent and genetic algorithm based approach, Estimation of leakage current.

**Power Optimization :** Algorithm level, Logical level and Circuit level power Optimization techniques, Techniques for reducing power consumption in arithmetic circuits, Low voltage circuit design techniques and multiple supply voltages.

**Low Power CMOS Circuits:** Reducing power consumption in static RAM: Memory cell, Bit lines, write driver circuit and sense amplifier circuits, Low power clock- Interconnect and layout design, Special techniques: Energy recovery techniques and pass transistor logic.

**Synthesis and Software Design for Low Power:** Sources of software power dissipation. Software power estimation, software power optimization, Co-design for low power.

#### Learning Resources

- Kaushik Roy and Sharat Prasad, "Low Power CMOS VLSI Circuit Design", Wiley India, Reprint 2009.
- Gary Yeap, "Practical Low Power Digital VLSI Design", Kluwer, 1998.
- A.P. Chandrakasan and R.W. Broadersen, "Low Power Digital CMOS Design", Kluwer,1995.
- Abdellatif Bellaouar, Mohamed. I. Elmasry, "Low Power Digital VLSI designs" Kluwer, 1995.
- Dimitrios Soudris, Chirstian Pignet, Costas Goutis, "Designing CMOS Circuits for Low Power", Kluwer, 2002.
- J.B. Kuo and J.H Lou, "Low voltage CMOS VLSI Circuits", Wiley, 1999.
- Wang, B. H. Calhoun and A. P. Chandrakasan, "Sub-threshold Design for Ultra Low-Power Systems", Springer, 2006.

#### **Course Contents and Lecture Schedule**

Module	Торіс	No. of	CO
No.		Lectures	
1	Power Dissipation in CMOS		
1.1	Sources of power dissipation	1	CO1
1.2	Physics of power dissipation in CMOS FET devices	2	CO1
1.3	switching power and leakage power in deep submicrometer transistors	2	CO1
1.4	low power VLSI design limits and issues	1	CO1
2	Power Estimation		
2.1	Probabilistic and statistical techniques	2	CO2
2.2	Glitching power and Input vector compaction	2	CO2
2.3	Circuit level power estimation: Test generation based, steepest descent	2	CO2
2.4	genetic algorithm based approach	1	CO3
2.5	Estimation of leakage current.	1	CO3
3.	Power Optimization		
3.1	Algorithm level power optimization	1	CO4
3.2	Logical level power optimization	1	CO4
3.3	Circuit level low power design	1	CO4
3.4	Techniques for reducing power consumption in arithmetic circuits	2	CO5
3.5	Low voltage circuit design techniques and multiple supply	2	CO5

	voltages		
4	Low Power CMOS Circuits		
4.1	Reducing power consumption in static RAM	3	CO6
4.2	Low power clock- Interconnect	2	CO6
4.3	Low power layout design	2	CO6
4.4	Energy recovery techniques and pass transistor logic	2	CO6
5	Synthesis and Software Design for Low Power		
5.1	Sources of software power dissipation	2	CO7
5.2	Software power estimation and software power optimization	2	CO7
5.3	Software co-design for low power	2	CO7
	Total Number of Hours	36	

### **Course Designers:**

- Dr. V. Vinoth thyagarjan
- Dr. S. Rajaram
- Dr. N.B. Balamurugan
- Dr. D.Gracia Nirmala Rani
- Dr. V. R.Venkatasubramani
- vvkece@tce.edu rajaram\_siva@tce.edu nbbalamurugan@tce.edu gracia@tce.edu venthiru@tce.edu



18ECPW0	CAD FOR VI SI	Category	L	Т	Ρ	Credit
		PEES	3	0	0	3

#### Preamble

The semiconductor industry has advanced tremendously over the last ten years with features sizes being downscaled from micrometer to nanometer regime today. Hence, Computer Aided Design (CAD) tools play an important role in delivering high system performance. This course introduces the techniques of modelling digital systems at various abstraction levels and exploring the various algorithms in VLSI physical design, which serve as a basis for the research and development of new Computer Aided Design (CAD) tools. **Prerequisite** 

### 18EC430 CMOS VLSI Systems

#### Course Outcomes

On the successful completion of the course students will be able to

•••••												
CO#	Course Outcome Statement	Weightage in %										
CO1	Use the knowledge of computational and optimization	10										
	algorithms and tools applicable to solving CAD related											
	problems											
CO2	Represent mechanism for Boolean functions that has	15										
	application in logic synthesis and Verification											
CO3	Partition or divide the system into smaller portions based on	15										
	the performance such as area, wirelength and cost matrices.											
CO4	Determine the approximate location of each module in a chip	20										
	area.											
CO5	Use Optimization algorithms in placement to determine the	20										
	best position for each module on the chip.											
CO6	Analyse the Optimizations algorithms in VLSI Global and	20										
	Detailed Routing process based on their wirelength and area											
	constraints.											

### CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	arning Domaii	n Level	CDIO Curricular				
#	Proficiency	Cognitive	Affective	Psychomotor	Components				
	Scale	-			(X.Y.Z)				
CO1	TPS3	Apply	Value	Mechanism	1.3, 2.1.1,				
					2.1.2,2.4.2,2.4.3, 2.4.6,				
					2.5.1,2.5.4,3.1.1				
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2,				
					2.4.2,2.4.3, 2.4.6, 2.5.1				
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2,				
					2.4.2,2.4.3, 2.4.6,				
					2.5.1,2.5.4 ,3.1.1,3.1.5				
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2,				
					2.4.2,2.4.3, 2.4.6,				
					2.5.1,2.5.4,3.1.1,3.1.5				
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2,				
					2.4.2,2.4.3, 2.4.6,				
					2.5.1,2.5.4,3.1.1, 3.1.5				
CO6	TPS4	Analyse	Organise	Complex	1.3, 2.1.1, 2.1.2,				
				Overt	2.4.2,2.4.3, 2.4.6,				
				Responses	2.5.1,2.5.4, ,3.1.1,3.1.5				

### Mapping with Programme Outcomes and Programme Specific Outcomes

		-					-								
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	М	L	-	M	-	-	L	L	L	-	L	Μ	-	L
CO2	S	М	L	-	Μ	-	-	L	L	L	-	L	М	-	L
CO3	S	М	L	-	M	-	-	L	L	L	-	L	Μ	-	L
CO4	S	Μ	L	-	M	-	-	L	L	L	-	L	Μ	-	L
CO5	S	Μ	L	-	M	-	-	L	L	L	-	L	Μ	-	L
CO6	S	S	М	L	М	-	-	L	L	L	-	L	S	-	L

S- Strong; M-Medium; L-Low

### **Assessment Pattern: Cognitive Domain**

Cognitive Levels	Contin	uous Ass Tests	sessment		Assignme	End Semester Examination	
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	60	70	30	30	60
Analyse	0	0	20	0	40	40	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0 🦯	0	0	0	0

### Assessment Pattern: Psychomotor

/ looooonione i altorini i oyonoi			
Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	NO SOUND	PA	-
Set		C	-
Guided Response		-	-
Mechanism	30	30	20
Complex Overt Responses		-	10
Adaptation	1-000	-	-
Origination		-	-
	-		

# Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. Differentiate DFS and BFS search methods.
- 2. Find the shortest path between "A" and "E" in the graph shown in Figure using Dijkstra's algorithm and also find the minimum spanning tree for the same graph using Prim's algorithm



- 3. Discuss on the VLSI Design methodologies used for IC layout design.
- 4. Explain the Gajski's Y-chart.

### Course Outcome 2 (CO2):

- 1. For the Boolean function f  $(x_1, x_2, x_3) = (0, 1, 2, 5, 6, 7)$ . Find its locally and globally minimal irredundant prime cover.
- 2. With suitable example, explain how ROBDD can be used in different applications.
- 3. Draw the ROBDD for the given function f = ab(c + d)

### Course Outcome 3 (CO3):

1. Explain how Kernighan-Lin algorithm is used for partitioning and using the algorithm, find the minimum cut for the graph shown in Figure.



2. Find the shortest path between "A" and "E" in the graph shown in Figure using Dijkstra's algorithm and also find the minimum spanning tree for the same graph using Prim's algorithm



3. Design a cost function for the general building block placement problem which considers the wire length, estimated area, module overlap, and aspect ratio of the entire layout.

#### Course Outcome 4 (CO4):

- 1. Prove that there is a one to one correspondence between a sliceable floorplan and a normalized Polish expression.
- 2. Given a Polish expression corresponding to a given a slicing floorplan, show that the expression 12-3-....-n- can be reached and vice versa.
- 3. Find an optimal implementation of modules M<sub>1</sub>,...,M<sub>8</sub> for sizing of the following sliceable floorplans.
  - Floor 1: 1 2 V 3 4 V H 5 6 V 7 8 V H V Floor 2: 1 2 V 3 4 V 5 H 6 V 7 H 8 V H

#### Course Outcome 5 (CO5):

1. Given: (1) placement P of blocks a-f and their pins (right) and (2) nets N1-N3 and their net weights.Estimate the total weighted wirelength of P using theRMST model.

N1 = 
$$(a1,b1,d2) w(N1) = 2$$
  
N2 =  $(c1,d1,f1) w(N2) = 4$   
N3 =  $(e1,f2) w(N3) = 1$ 

2. Given: (1) circuit with gates a-f (left), (2) 2 × 4 layout (right), and (3) initial vertical cut cut1. Find a placement with minimum wirelength using alternating cutline directions and theKL algorithm.



### Course Outcome 6 (CO6):

- 1. Show that left edge algorithm produces a solution, with a number of rows exactly equal to the density of the problem.
- 2. Draw the horizontal and vertical constraint graphs for the channel shown in below figure. Explain how to handle the net that exist the channel and its pseudo terminal.





#### Syllabus

VLSI Design Automation Tools: Evolution of CAD Tools, Importance of Design Automation, Design Abstraction Levels, Data Structures for the representation of Graphs: Representation of graphs using matrices; Paths, connectedness; circuits, cut sets, trees; Voltage and current spaces of a directed graph and their complementary orthogonally; Elementary graph algorithms involving BFS and DFS trees, such as finding connected and 2-connected components of a graph, the minimum spanning tree, shortest path between a pair of vertices in a graph. Logic Synthesis: Combinational Logic Synthesis, Binary Decision Diagrams, Reduced Ordered BDD principles, ROBDD Manipulation, Variable Ordering, Two Level Logic Synthesis. System Partitioning: Terminology, Optimization Goals, Partitioning Algorithms: Kernighan-Lin Algorithm, Extension of Kernighan-Lin Algorithm, Fiduccia Mattheyess Algorithm, Clustering, Multilevel Partitioning, System Partitioning onto Multiple FPGAs. Chip Planning: Terminology, Optimization Goals in Floorplanning, Floorplan Representations: Floorplan to a Constraint-Graph Pair, Floorplanning Algorithms: Floorplan Sizing, Cluster Growth, Simulated Annealing, Integrated Floorplanning Algorithms. Placement: Circuit Representation: bipartite Model, Clique Model, Wire length Estimation; Global Placement Algorithms: Min-cut Placement, Analytic Placement, and Simulated Annealing Algorithms. Routing: Maze Running, Line Searching, Steiner Trees; Global Routing: Sequential Approached, Hierarchical approaches, Integer Linear Programming, Detailed routing: Channel routing, switchbox routing. Routing in Field Programmable Gate Arrays: Array Based FPGAs and Row Based FPGAs. Learning Resources

• S.H. Gerez, Algorithms for VLSI Design Automation, Wiley-India, Reprint 2008

- N.A. Sherwani, Algorithms for VLSI Physical Design Automation, Kluwer Academic Publisher, 1998
- Andrew B.Khang,Lienig, Markov and Hu, "VLSI Physical Design: From Graph Partitioning to Timing Closure ", Springer, 2011
- Giovanni De Micheli, Synthesis and Optimization of Digital Circuits, Tata McGrawHill, 1994
- D.D Gajski et al., High Level Synthesis: Introduction to Chip and System Design, Kluwer Academic Publishers, 1992
- M. Sarrafzadeh and C.K. Wong, An Introduction to VLSI Physical Design, McGraw Hill, 1996.
- Weblink: https://www.coursera.org/learn/vlsi-cad-logic
- Weblink: https://nptel.ac.in/courses/106/106/106106088/

#### **Course Contents and Lecture Schedule**

No.	Торіс	No. of	COs
L .		Hours	
1	VLSI Design Automation Tools		
1.1	Evolution of CAD Tools, Importance of Design Automation	1	CO1
1.2	Design Abstraction Levels	1	CO1
1.3	Representation of graphs using matrices; Paths, connectedness; circuits, cut sets, trees	1	CO1
1.4	Voltage and current spaces of a directed graph and their complementary orthogonally	1	CO1
1.5	Elementary graph algorithms involving BFS and DFS trees, such as finding connected and 2-connected components of a graph	1	CO1
1.6	The minimum spanning tree, shortest path between a pair of vertices in a graph	1	CO1
2	Logic Synthesis	I I	
2.1	Combinational Logic Synthesis	1	CO2
2.2	Binary Decision Diagrams	1	CO2
2.3	Reduced Ordered BDD principles	1	CO2
2.4	ROBDD Manipulation, Variable Ordering	1	CO2
2.5	Two Level Logic Synthesis	1	CO2
	Assignment I: Implement the graph algorithms in VLSI Design		CO1,
	Problems using C/C++/python with Data structure concept.		CO2
3	System Partitioning		
3.1	Terminology, Optimization Goals	1	CO3
3.2	Partitioning Algorithms: Kernighan-Lin Algorithm	1	CO3
3.3	Extension of Kernighan–Lin Algorithm	1	CO3
3.4	Fiduccia Mattheyess Algorithm	1	CO3
3.5	Clustering, Multilevel Partitioning	1	CO3
3.6	System Partitioning onto Multiple FPGAs.		
4	Chip Planning		
4.1	Terminology, Optimization Goals in Floorplanning	1	CO4
4.2	Floorplan Representations: Floorplan to a Constraint-Graph Pair,	1	CO4
4.3	Floorplanning Algorithms: Floorplan Sizing	1	CO4
4.4	Cluster Growth	1	CO4
4.5	Simulated Annealing	1	CO4
4.6	Integrated Floorplanning Algorithms	1	CO4
	Assignment II: Implement the Partitioning/Floorplanning		CO3,
	Optimization Algorithm using C/C++/python with Data structure		CO4
5	Placement Algorithms		
5.1	Circuit Representation: bipartite Model. Clique Model	1	CO5
0.1		· · ·	000

5.2	Wire length Estimation	1	CO5
5.3	Global Placement: Min-cut Placement	1	CO5
5.4	Analytic Placement	1	CO5
5.5	Simulated Annealing Algorithms	1	CO5
6	Routing Algorithms		
6.1	Maze Running, Line Searching	1	CO6
6.2	Steiner Trees	1	CO6
6.3	Global Routing: Sequential Approached	1	CO6
6.4	Hierarchical approaches, Integer Linear Programming	1	CO6
6.5	Detailed routing: Channel Routing, switchbox Rouitng	2	CO6
6.6	Routing in Field Programmable Gate Arrays: Array Based FPGAs	2	CO6
	and Row Based FPGAs.		
	Assignment III: Compare the performance of various placement		CO5,
	and routing algorithms in VLSI Circuits using EDA Tools		CO6

### Course Designers:

- Dr.D.GraciaNirmala Rani
- Dr.S.Rajaram
- Dr.N.B.Balamurugan
- Dr.V.VinothThyagarajan
- Dr.V.R.Venkatasubramani

gracia@tce.edu rajaram\_siva@tce.edu nbbalamurugan@tce.edu vvkece@tce.edu venthiru@tce.edu



18FCPY0	ASIC DESIGN	Category	L	Т	Ρ	Credit
	AGIO DEGIGIN	PE	3	0	0	3

#### Preamble

The course aims at ASIC physical design flow, including partitioning, floor-planning, placement, routing and testing. Also the objective is to give the student an understanding of basics of System on Chip.

#### Prerequisite

Nil

#### **Course Outcomes**

On the successful completion of the course, students will be able to

CO#	Course Outcome Statement	Weightage
		in %
CO1	Describe the ASIC Design flow, ASIC types and Library design	15
CO2	Use algorithms to partition the ASIC to meet the given objectives	15
CO3	Use floorplanning and placement algorithms to place the logic cells inside the flexible blocks of an ASIC	20
CO4	Use global and detailed routing algorithms to route the channels in ASIC and apply techniques for circuit extraction	20
CO5	Use techniques to test ASIC	15
CO6	Explain System on Chip, On chip communication architectures and utilizing Platform based design.	15

### CO Mapping with CDIO Curriculum Framework

CO	TCE	Learn	ing Domain I	evel	CDIO Curricular				
#	Proficiency	Cognitive 🚿	Affective	Psychomotor	Components				
	Scale		Carlo I		(X.Y.Z)				
CO1	TPS2	Understand	Respond	_	1.3, 2.1.2, 2.4.1, 2.4.2				
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1,				
			1	200	2.4.2, 3.2.5				
CO3	TPS3	Apply	Value		1.3, 2.1.1, 2.1.2, 2.4.1,				
					2.4.2, 3.2.5				
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1,				
					2.4.2, 3.2.5				
CO5	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1,				
					2.4.2, 3.2.5				
CO6	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.2, 2.4.1,				
					2.4.2				

#### Mapping with Programme Outcomes and Programme Specific Outcomes

	<u> </u>		<u> </u>					<u> </u>							
COs	PO1	PO2	PO3	PO4	PO5	PO6	P07	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	М	L	-	-	-	-	-	L	L	L	-	L	L	-	L
CO2	S	Μ	L	-	-	-	-	L	L	L	-	L	Μ	-	L
CO3	S	Μ	L	-	-	-	-	L	L	L	-	L	М	-	L
CO4	S	Μ	L	-	-	-	-	L	L	L	-	L	М	-	L
CO5	S	Μ	L	-	-	-	-	L	L	L	-	L	Μ	-	L
CO6	Μ	L	-	-	-	-	-	L	L	L	-	L	L	-	L

S- Strong; M-Medium; L-Low

Assessment i duein. oogintive bondin											
Cognitive	sessment		Assignme	nt	End Semester						
Levels		Tests			-		Examination				
	1	2	3	1	2	3					
Remember	10	0	0	0	0	0	0				
Understand	40	20	40	50	0	50	30				
Apply	50	80	60	50	100	50	70				
Analyse	0	0	0	0	0	0	0				
Evaluate	0	0	0	0	0	0	0				
Create	0	0	0	0	0	0	0				

### Assessment Detterms Osmulting De

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	- monton	-	-
Origination	( alla	-	-

### Sample Questions for Course Outcome Assessment

### Course Outcome 1 (CO1):

- 1. Draw the flowchart for ASIC design flow.
- 2. Explain the different types of ASICs
- 3. Discuss about the significance of ASIC libraries.

#### Course Outcome 2 (CO2):

- 1. Explain about the steps in the iterative partitioning improvement algorithm.
- 2. Apply constructive partitioning algorithm to partition the given network to meet the following objectives.
  - Use no more than three ASICs •
  - Each ASIC is to contain no more than three logic cells.
  - Use minimum number of external connections for each ASIC



3. Use Kernighan-Lin algorithm to optimally partition the graph shown in figure below. The dotted line represents the initial partitioning. Assume all nodes have the same weight and all edges have the same priority.



### Course Outcome 3 (CO3)

- 1. Discuss about the goals and objectives of floorplanning.
- 2. Explain the steps involved in Mincut placement algorithm.
- 3. Represent the floorplan shown in the figure below as its
  - a) Floorplan tree.
  - b) Polar horizontal graph
  - c) Polar vertical graph



### Course Outcome 4 (CO4)

- 1. With neat diagrams, explain about 'a cycle' in vertical constraint graph for channel routing.
- 2. Three block a, b and c are given below along with their size options. Determine the shape function for each block a, b, c and construct the minimum area top level floorplan.

$$a: w_a = 5, h_a = 4$$
,  $b: w_b = 3, h_b = 1$  or  $w_b = 1, h_b = 3$ ,  
 $c: w_c = 2, h_c = 1$  or  $w_c = 1, h_c = 2$ 

3. Use Dogleg Left-Edge Algorithm to route a channel with the following pin connections (ordered left to right).

TOP = [A B 0 B A D C E], BOT = [B 0 C A C E D D]

#### **Course Outcome 5 (CO5)**

- 1. Discuss about Design for Testability.
- 2. With neat diagram, explain about Boundary Scan Test.
- 3. Use Automatic Test Pattern Generation (ATPG) technique to test a typical circuit.

#### **Course Outcome 5 (CO5)**

- 1. Draw the flowchart of a typical SoC design flow.
- 2. Discuss about the parameters that has to be considered for Low-Power SoC design.
- 3. Explain about the features of a typical Mobile processor.

#### Concept Map



#### Syllabus

ASIC Types and Library Design: ASIC Design Flow, Types of ASIC - Full Custom, Semi Custom – Standard Cell Based ASIC and Gate Array ASIC - Library cell design - Library architecture. System Partitioning: Measurement of Partitioning, Partitioning Algorithms -Constructive Partitioning, Iterative Partitioning Improvement Algorithms - Kernighan-Lin Algorithm, Ratio-Cut Algorithm, FPGA Partitioning. Floorplanning and Placement: Floor Planning Measurement and tools, I/O, Power and clock planning, Measurement of Placement, Placement Algorithms - Min-cut Placement, Eigen value Placement, Iterative Placement Improvement, Timing Driven Placement algorithms. Routing and Circuit Extraction: Global Routing Measurement - Measurement of Interconnect Delay using Elmore's constant, Global routing for CBIC and GA, Detailed Routing Measurement -Measurement of Channel Density, Detailed routing Algorithms - Lee Maze and High tower Algorithms, Circuit extraction process, Layout Design Rules, Technology related issues. **ASIC TESTING:** Fault Simulation, Test Pattern Generation, Design for Testability, Boundary Scan Test, Built-in-Self-Test. Modern ASICs: SoC Design Flow, Platform-based and IP based SoC Designs, On-Chip Communication Architecture Standards, Low-Power SoC Design, Case Studies - Canonic Signed Digit Arithmetic, Distributed Arithmetic, Modular Arithmetic, Mobile processor.

### Learning Resources

- Michael John Sebastian Smith, "Applications Specific Integrated Circuits", Pearson Education, 2013.
- H.Gerez, "Algorithms for VLSI Design Automation", John Wiley, 1999.
- Andrew B.Khang, Lienig, Markov and Hu, "VLSI Physical Design: From Graph Partitioning to Timing Closure ", Springer, 2011.
- J..M.Rabaey, A. Chandrakasan, and B.Nikolic, "Digital Integrated Circuit Design Perspective (2/e)", PHI 2003.
- Hoi-Jun Yoo, Kangmin Leeand Jun Kyong Kim, "Low-Power NoC for High-Performance SoC Design", CRC Press, 2008.
- S.Pasricha and N.Dutt," On-Chip Communication Architectures System on Chip Interconnect, Elsveir", 2008.
- Wayne Wolf, "Modern VLSI design" Addison Wesley, 1998.
- Prof. Santosh Biswas, IIT Guwahati, NPTEL Video Lecture on "Optimization Techniques for Digital VLSI Design", weblink:
- https://nptel.ac.in/courses/108/103/108103108/www.asic-design.com.
- Prof. Santosh Biswas, IIT Guwahati, NPTEL Video Lecture on "Design Verification and Test of Digital VLSI Circuits", weblink: https://nptel.ac.in/courses/106/103/106103116/
- Website: www.asic-world.com

#### **Course Contents and Lecture Schedule**

No.	Торіс	No. of Hours	COs
1	ASIC Types and Library Design		
1.1	ASIC Design Flow	1	CO1
1.2	Types of ASIC - Full Custom, Semi Custom	1	CO1
1.3	Standard Cell Based ASIC and Gate Array ASIC	2	CO1
1.4	Library cell design	1	CO1
1.5	Library architecture	1	CO1
2	System Partitioning		
2.1	Measurement of Partitioning	1	CO2
2.2	Partitioning Algorithms - Constructive Partitioning	1	CO2
2.3	Iterative Partitioning Improvement Algorithms- Kernighan-Lin	2	CO2
	algorithm		
2.4	Ratio-Cut Algorithm	1	CO2

2.5 FPGA Partitioning	1	CO2
3 Floorplanning and Placement		
3.1 Floor Planning Measurement and tools	1	CO3
3.2 I/O, Power and clock planning	1	CO3
3.3 Measurement of Placement	1	CO3
3.4 Placement Algorithms – Min-cut Placement	1	CO3
3.5 Eigen value Placement, Iterative Placement Improvement	1	CO3
3.6 Timing Driven Placement algorithms	1	CO3
4 Routing and Circuit Extraction		
4.1 Global Routing Measurement	1	CO4
4.2 Measurement of Interconnect Delay using Elmore's constant	1	CO4
4.3 Global routing for CBIC and GA	1	CO4
4.4 Detailed Routing Measurement-Measurement of Channel Density,	1	CO4
4.5 Detailed routing Algorithms - Lee Maze and High tower	1	CO4
Algorithms,		
4.6 Circuit extraction process, Layout Design Rules, Technology	1	CO4
related issues		
5 ASIC TESTING		1
5.1 Fault Simulation	1	CO5
5.2 Test Pattern Generation Test	1	CO5
5.3 Design for Testability, Boundary Scan Test	2	CO5
5.4 Built-in-Self-Test	2	CO5
6. Modern ASICs	<u>_ l</u>	
6.1 SoC Design Flow	1	CO6
6.2 Platform-based and IP based SoC Designs	1	CO6
6.3 On-Chip Communication Architecture Standards	1	CO6
6.4 Low-Power SoC Design	1	CO6
6.5 Case Studies - Canonic Signed Digit Arithmetic, Distributed	1	CO6
Arithmetic		
6.6 Modular Arithmetic, Mobile processor	1	CO6
Total	36	

### **Course Designers:**

- Dr.V.R.Venkatasubramani
- Dr.S.Rajaram
- Dr.N.B.Balamurugan
- Dr.V.VinothThyagarajan
- Dr.D.GraciaNirmala Rani

venthiru@tce.edu rajaram\_siva@tce.edu nbbalamurugan@tce.edu vvkece@tce.edu gracia@tce.edu

18ECPZ0	IOT SYSTEM AND APPLICATIONS	Category	L	Т	Ρ	Credit
		PE	3	0	0	3

#### **Preamble**

The objectives of this course are to provide in-depth understanding of the underlying concepts of Internet of things, building blocks, domain-specific IoT, and Design methodology for IoT. Also the course provides knowledge on Python coding to embed the coding in various open source hardware such as Raspberry Pi and Arduino. Eventually the course extends the students' knowledge up to the level of building cost effective IoT system for real world scenario with the open source hardware and software tool chains.

### Prerequisite

18EC350 Microprocessors and Microcontrollers

#### **Course Outcomes**

On the successful completion of the course, students will be able t

CO	Course Outcome Statement	Weightage
Number		IN %
CO1	Explain the terms and definitions of embedded system and networking with various protocols	20
CO2	Describe the functionality of architecture of IoT	20
CO3	Use different hardware and software tools for the IoT	20
	implementation	
CO4	Develop hardware building block for IoT system for the given scenario	20
CO5	Apply the software tools chains for the given real world scenario fulfilling the IoT requirements	10
CO6	Apply the features and operations of various open source hardware and software	10

CO Mapping with CDIO Curriculum Framework

CO#	TCE	Lear	ning Domain	Level	CDIO Curricular Components
	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale			-	
CO1	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.6,
					2.5.1, 3.1.1, 3.2.3
CO2	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.2, 2.5.1, 3.1.1,
					3.2.3
CO3	TPS3	Apply	Value	-	1.3,, 2.1.1, 2.1.2, 2.5.1, 3.1.1,
					3.2.3
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.5.1

Марр	Mapping with Programme Outcomes and Programme Specific Outcomes														
COs	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO	PO	PO	PS	PS	PS
										10	11	12	01	02	O3
CO1	М	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	М	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	M	L	-	L	-	-	L	L	L	-	L	М	-	L
CO4	S	M	L	-	L	-	-	L	L	L	-	L	М	-	L
CO5	S	M	L	-	L	-	-	L	L	L	-	L	М	-	L
CO6	S	М	L	-	L	-	-	L	L	L	-	L	М	-	L

S- Strong; M-Medium; L-Low

Assessment rattern. oognitive Domain										
Conti	nuous Ass	essment		Assignmer	End Semester					
	Tests				Examination					
1	2	3	1	2	3					
0	0	0	0	0	0	0				
60	20	20	100	0	0	40				
40	80	80	0	70	70	60				
0	0	0	0	0	0	0				
0	0	0	0	0	0	0				
0	0	0	0	0	0	0				
	Contin 1 0 60 40 0 0 0 0	Continuous Ass   Tests   1 2   0 0   60 20   40 80   0 0   0 0   0 0   0 0   0 0   0 0   0 0	Continuous Assessment   Tests   1 2 3   0 0 0   60 20 20   40 80 80   0 0 0   0 0 0   0 0 0   0 0 0   0 0 0   0 0 0	Continuous Assessment   Tests   1 2 3 1   0 0 0 0   60 20 20 100   40 80 80 0   0 0 0 0 0   0 0 0 0 0   0 0 0 0 0   0 0 0 0 0	Continuous Assessment Tests Assignmen   1 2 3 1 2   0 0 0 0 0 0   60 20 20 100 0   40 80 80 0 70   0 0 0 0 0   0 0 0 0 0   0 0 0 0 0   0 0 0 0 0   0 0 0 0 0	Continuous Assessment Tests Assignment   1 2 3 1 2 3   0 0 0 0 0 0 0   60 20 20 100 0 0 0 0   40 80 80 0 70 70 0<				

### Assessment Pattern: Cognitive Domain

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	30
Complex Overt Responses	- anton	-	-
Adaptation	Faller	-	-
Origination		-	-

### **Course Level Assessment Questions**

### Course Outcome 1(CO1)

- 1. Summarize the value proposition of IoT
- 2. Classify the key functions of IoT?
- 3. Illustrate the components for weather reporting with IoT.

#### Course Outcome 2 (CO2)

- 1. Interpret the advantages of a switch rather than a hub to interconnect several machines
- 2. Explain the use of cloud for IoT?
- 3. Explain the need of protocol for OSHW communication

#### Course Outcome 3 (CO3)

- 1. Develop building blocks in HW components of IoT
- 2. Construct a model for an IoT framework.
- 3. Develop a hardware circuit for IoT for different scenario?

#### Course Outcome 4 (CO4)

- 1. Plan for a flow for optimization in IoT.
- 2. Develop pseudo code for accessing sensors in python
- 3. Develop an Arduino code for accessing sensors and actuators

#### Course Outcome 5 (CO5)

- 1. Consider a point to point link 50 Km. in length. At what bandwidth would propagation delay equal transmit delay for 100 bytes packet? What about 512 byte packets?
- 2. Develop an IoT System with sensors for monitoring agriculture field
- 3. Develop an IoT System with sensors for street light monitoring and control

### Course Outcome 6 (CO6)

- 1. Develop a python code for accessing sensors and actuators
- 2. Measure the propagation delay of an IoT system when an algorithm is running with a defined rate with networking
- 3. Describe the model for IoT domain specific applications.



#### **Syllabus**

Internet of Things System: Characteristics, Physical design, Protocols, logical design, Enabling technologies and IoT Levels. Domain Specific IoT: Medical IoT vs M2M. Design Methodology: IoT systems management with NETCONF-YANG. IoT Design Methodology, IoT design Specifications, Model, Level and view Specifications, Device & Component Integration and Application Development. Logical Design and Physical Devices: Python packages of interest for IoT. Cloud for IoT -AWS, Google cloud and IBM cloud. Python web application framework, Basic building blocks of a IoT Device. Open Source Hardware: Raspberry PI physical devices, Raspberry Pi Interfaces, Programming, APIs / Packages, Web services, Intel Galileo-Arduino-Interfaces, Arduino Programming with IoT APIs. Case Studies: Smart lighting, home security, weather reporting BOT, smart irrigation and other real time applications of IoT with LORA -Connecting IoT to cloud.

#### Learning Resources

- Arshdeep Bahga, Vijay Madisetti, "Internet of Things A hands-on approach", Universities Press, 2015
- Peter Waher "Learning Internet of Things", Packt Publishing, UK, 2015.
- Miguel de Sousa", Internet of Things with Intel Galileo" ", Packt Publishing, UK, 2015.
- Marco Schwartz, "Internet of Things with the Arduino Yun", Packt Publishing, 2014.

### **Course Contents and Lecture Schedule**

Module No	Торіс	No. of Lectures	COs
1	Internet of Things System	20000100	
1.1	Definition & Characteristics and Physical Design of IoT	1	CO1
1.2	Logical Design, Functional Blocks and Communication Models	1	CO1
1.3	Enabling Technologies, Levels & Deployment Templates	1	CO1
1.4	Domain Specific IoTs	1	CO2
	(Medicals, Smart Lighting, Smart Appliances Intrusion Detection)		
1.5	IoT and M2M-differences	1	CO2
2	Design Methodology		
2.1	IoT systems management with NETCONF-YANG	1	CO3
2.2	IoT Design Specifications	1	CO3
2.3	Model, Level and view Specifications	1	CO3
2.4	Device & Component Integration	1	CO2
2.5	Application Development	1	CO2
2.6	Basic building blocks of an IoT Device	1	CO3

3	Logical Design and Physical Devices		
3.1	Introduction to Python	2	CO3
3.2	Control Flow Functions Modules Packages for IoT	2	CO3
3.3	Cloud for IoT	2	CO3
3.4	Python web application framework	2	CO4
3.5	Programming, APIs / Packages	2	CO4
4	Open Source Hardware		
4.1	Raspberry PI physical devices	3	CO4
4.2	Raspberry Pi Interfaces	3	CO4
4.3	Web services	3	CO5
4.4	Intel Galileo-Arduino-Interfaces	3	CO5
4.5	Arduino Programming with IoT APIs	3	CO5
5	Case Studies		
5.1	Smart Lighting	1	CO6
5.2	Home Security -Intrusion Detection	1	CO6
5.3	Weather Reporting BOT	1	CO6
5.4	Smart Irrigation	1	CO6

## **Course Designers:**

Dr. K.Hariharan •

khh@tce.edu



18ECRA0	REAL TIME EMBEDDED SYSTEMS	Category	L	Т	Ρ	Credit
		PE	3	0	0	3

#### Preamble

The course begins by embedded hardware components, general operating system and real time operating system fundamentals and discussing how and why it differs from the traditional sequential level programming. It covers the theory and practice of handling RTOS functions through a set of detailed examples. It discusses the concept of multitasking and scheduler in RTOS. Inter Tasks communication and synchronization and some examples. **Prerequisite** 

18EC350 Microprocessors and Microcontrollers

#### Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome Statement	Weightage
Number		in %
CO1	Describe the embedded hardware system	20
CO2	Distinguish between conventional operating system and a real-	20
	time operating system	
CO3	Measure the effectiveness of RTOS over conventional OS	20
CO4	Develop pseudo codes for multitasking scheduler	20
CO5	Develop a model for a real time embedded system	10
CO6	Apply methods and protocol for validation and testing	10

CO Mapping with CDIO Curriculum Framework

CO	TCE	Learning Dom	nain Level	24	CDIO Curricular
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale	•	100		(X.Y.Z)
CO1	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.2, 2.4.2,
					2.4.6, 2.5.1, 3.1.1, 3.2.3
CO2	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.2, 2.5.1,
					3.1.1, 3.2.3
CO3	TPS3	Apply	Value	-	1.3,, 2.1.1, 2.1.2, 2.5.1,
		_			3.1.1, 3.2.3
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.1.3,
		_			2.5.1
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.1.3,
		-			2.5.1
CO6	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.5.1
Mappi	na with Proar	amme Outcon	nes and Prod	ramme Specific	Outcomes

COs	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	М	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	М	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	М	L	-	L	-	-	L	L	L	-	L	М	-	L
CO4	S	М	L	-	L	-	-	L	L	L	-	L	М	-	L
CO5	S	М	L	-	L	-	-	L	L	L	-	L	М	-	L
CO6	S	М	L	-	L	-	-	L	L	L	-	L	М	-	L

S- Strong; M-Medium; L-Low

Cognitive Levels	Continu Tests	ious Asse	essment	Assignr	nent		End Semester Examination
	1	2	3	1	2	3	
Understand	60	20	20	100	0	0	40
Apply	40	80	80	0	100	70	60
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### Assessment Pattern: Cognitive Domain

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	30
Complex Overt Responses	- more	-	-
Adaptation	-	-	-
Origination		-	-
		2	

### **Course Level Assessment Questions**

#### Course Outcome 1 (CO1):

- 1. Illustrate a real-time embedded system.
- 2. Describe the characteristics of an conventional and real time system
- 3. Classify the real time embedded system?

### Course Outcome 2 (CO2)

- 1. Demonstrate various scheduler functions
- 2. Explain co-routine functions in a real time embedded system
- 3. Demonstrate a system call and it is implementation.

#### Course Outcome 3(CO3):

- 1. Identify the system functionality with real time application
- 2. Build an embedded system with the requirement of real time applications
- 3. Describe the various system call in a given scenario of real time situation

### Course Outcome 4 (CO4):

- 1. Compare the functions of base class to a derived class.
- 2. Experiment the interrupts with different priority cases
- 3. Develop a flow model of a context switching in OS function?

#### Course Outcome 5 (CO5):

- 1. Develop c code to implement a semaphore
- 2. Develop a c code to implement a ring buffer
- 3. Develop the pseudo code for the function of inter process communication.

#### Course Outcome 6 (CO6):

- 1. Develop pseudo code to implement a test cases
- 2. Develop an UML model to implement a ring buffer
- 3. Develop a Petri net for the function of inter process communication.



### Syllabus

**Real-Time Embedded Systems**: Embedded Systems and Real-Time Embedded System characteristics, Structure, Response, Concurrency, Predictability, Safety and Reliability, Hard and Soft Real-Time Embedded Systems. **Embedded Hardware Components**: Microprocessors, Microcontrollers, Field Programmable Gate Arrays, Digital Signal Processors, Multicore Processors and GPUs. **Functions of Operating Systems**: Process Management, Memory Management, Interrupts Management, Multitasking, File System Management, I/O Management. **Real-Time Operating Systems**: Characteristics of RTOS Kernels, Priority Scheduling, Intertask Communication and Resource Sharing, Real-Time Signals, Semaphores, Message Passing, Shared Memory, Memory Locking and RTOS Examples POSIX. **System modeling**: FSM, UML and Petri Nets. **Validation and testing**: Program Validation and Testing, Types of Testing, Evaluation of Function and Performance Testing, System Design Technique.

### Learning Resources

- Jiacun Wang" Real-Time Embedded Systems, "Wiley publication 1st edition 2017.
- Philip A. Laplante, "Real time systems Analysis and Design An Engineer's Handbook", IEEE computer society press PHI, 2nd Ed. 1997.
- Allan. V. Shaw, "Real Time systems and software", John Wiley & Sons, 2000.

### **Course Contents and Lecture Schedule**

No.	Торіс	No. of Lectures	Cos
1	Real-Time Embedded Systems:		
1.1	Embedded Systems and Real-Time Embedded System characteristics,.	2	CO1
1.2	structure, response, concurrency, predictability, safety and reliability	2	CO1
1.3	Hard and Soft Real-Time Embedded Systems	2	CO1

2	Embedded Hardware components:		
2.1	Microprocessors, Microcontrollers Digital Signal Processors,	2	CO2
2.2	Field-Programmable Gate Arrays,	3	CO2
2.3	Multicore Processors and GPUs	3	CO3
3	Functions of Operating Systems:		
3.1	Process Management, Memory Management	2	CO3
3.2	Interrupts Management,	2	CO3
3.3	Multitasking	2	CO4
3.4	File System Management, I/O Management	2	CO4
4	Real-Time Operating Systems		
4.1	Characteristics of RTOS Kernels,	2	CO2
4.2	Priority Scheduling,	1	CO2
4.3	Inter task Communication and Resource Sharing,	1	CO3
4.4	Real-Time Signals, Semaphores,	2	CO3
4.5	Message Passing,	1	CO3
4.6	Shared Memory, Memory Locking	1	CO4
4.7	RTOS Examples POSIX	2	CO4
5	System Modelling		
5.1	FSM. UML and petrinets	4	CO6
6	Validation and testing		
6.1	Program validation and testing	2	CO5
6.2	Types of testing	2	CO5
6.3	Evaluation of function and performance testing	1	CO6
6.4	System design technique	1	CO5

### **Course Designers:**

• Dr. K.Hariharan

• Dr.M.S.K.Manikandan

khh@tce.edu manimsk@tce.edu

1.

### 18ECRB0

#### ADHOC AND SENSOR NETWORKS

Category	L	I	Р	Credit
PEES	3	0	0	3

#### Preamble

The objective of this course is to introduce students with fundamental concepts, design issues and solutions to the issues – architectures and protocols - and the state-of-the-art research developments in ad hoc and sensor networks.

#### Prerequisite

14EC510 Data Communication Networks

### **Course Outcomes**

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Identify the necessity of Ad Hoc and Sensor networks	15
CO2	Use various MAC protocols for Adhoc Network	20
CO3	Use various routing protocols for Adhoc Network	20
CO4	Use appropriate network protocol to provide solutions for transport	20
	layer issues	
CO5	Analyze the MAC, routing issues in Ad hoc and sensor networks	15
CO6	Explain the applications and future trends in Wireless Sensor	10
	Network	

#### CO Mapping with CDIO Curriculum Framework

CO		ΓĊΕ			Lea	arning	Dom	ain Le	vel	6		(	CDIO C	urricul	ar	
#	Prof	iciend	;y <mark>⊂</mark>	Cognit	ive	Affec	tive	Ps	ychor	noto	r	Components				
	S	cale				10							(X.	Y.Z)		
CO1	T	PS2	ι ι	Inders	tand	Respo	ond						1.3, 2.1.1, 2.1.5			
CO2	T	PS3		Appl	у	Value	1	-				1.3, 2	2.2.22,	1.5, 3.2	,6	
CO3	T	PS3		Appl	у	Value						1.3, 2	2.1.1, 2	2.1.5, 3.	2,6	
CO4	T	PS3		Appl	у	Value	~					1.3, 2.1.1, 2.3.1				
CO5	T	PS4		Analy	ze	Organ	ise	-				1.3,	2.1.1,	2.1.5,	2.2.2,	
				-		-						2.3.1	, 3.2,6			
CO6	Т	PS2	l	Inderst	and	Respo	ond	-				1.3, 2	2.1.1, 2	2.1.5		
Марр	Mapping with Programme Outcomes and Programme Specific Outcomes															
Cos	PO	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO	PO	PO	PSO1	PSO2	PSO3	
	1									10	11	12				

	-							1							
CO1	М	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	М	L	-	-	-	-	-	-	-	-	L	М	-	-
CO3	S	М	L	-	-	-	-	-	-	-	-	L	М	-	-
CO4	S	М	L	-	-	-	-	-	-	L	-	L	М	-	-
CO5	S	S	М	L	L	-	-	-	-	L	-	L	S	-	-
CO6	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-

#### S- Strong; M-Medium; L-Low

#### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	0	0	0	0	0	0
Understand	40	40	40	0	0	0	40
Apply	40	60	40	100	100	70	40
Analyse	0	0	20	0	0	30	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor							
Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3				
Perception	-	-	-				
Set	-	-	-				
Guided Response	-	-	-				
Mechanism	-	-	-				
<b>Complex Overt Responses</b>	-	-	-				
Adaptation	-	-	-				
Origination	-	-	-				

### Course Level Assessment Questions

### Course Outcome 1 (CO1):

- 1. Define hidden terminal problem and how it is alleviated at the MAC layer?
- 2. Define loop-free property ensured in on-demand routing protocols?
- 3. Identify and elaborate some of the important issues in pricing for multi hop wireless communication.

#### Course Outcome 2 (CO2):

- 1. Identify the advantages and limitations of routing protocol that uses GPS information for an ad hoc wireless network for search and rescue operations.
- 2. Give application scenarios where contention-based, reservation-based and packet scheduling-based MAC protocols can be used.
- 3. Calculate the probability of data packet collision in the MACA protocol. Assume that Tc is the control packet transmission and propagation delay, Tw is the optimal maximum back-off time,  $\beta$  is the percentage of ready nodes, and R is the transmission range of each node.

#### Course Outcome 3 (CO3):

- 1. Find out the probability of a path break for an eight-hop path, given that the probability of a link break is .2.
- 2. Consider the third iteration of LEACH protocol. If the desired number of nodes per cluster is ten, what is the threshold calculated for a node during its random number generation?
- 3. In FPRP, can a situation occur where a requesting node is not able to detect collisions that have occurred in the reservation request phase? If so, suggest simple modifications to solve the problem.

### Course Outcome 4 (CO4):

- 1. Channel quality estimation can be done both at the sender and receiver. Which is more advantageous? Why?
- 2. In the CGSR protocol, the resources of the node chosen as the cluster-head get drained very quickly, more rapidly than the other nodes in the cluster. How can this problem be overcome?
- 3. Point out the implications of an extension of split TCP. Where every intermediate node acts as proxy node

### Course Outcome 5 (CO5):

- 1. During a research discussion, one of your colleagues suggested an extension of split-TCP where every intermediate node acts as proxy node. What would be the implications of such a protocol?
- 2. Determine the back-off calculation mechanism used in DWOP. Is it guaranteed to be accurate at all times? If not, explain why?
- 3. How does data gathering done in WSN?

### Course Outcome 6 (CO6):

- 1. Design a habitat monitoring system using sensor networks
- 2. Design and develop a Cross layer Design based sensor networks.
- 3. Analyze the effect of the carrier sensing zone of a transmission on the performance of a MAC protocol.


Ad-hoc Mac: Design Issues in Ad-Hoc Networks - MAC Protocols - Issues, Classifications of MAC protocols: Contention Based Protocols, Contention Based Protocols with reservation mechanisms, Contention Based Protocols with Scheduling Mechanism - MAC protocol with Directional Antenna - Multi channel MAC & Power control MAC protocol. Ad-Hoc Routing protocols and Ad-Hoc Transport layer: Issues - Classifications of routing protocols: Table Driven Protocols, On-Demand Routing Protocols, Hybrid Routing Protocols Hierarchical and Power aware Routing Protocols - Ad Hoc Transport Layer Issues, TCP Over Ad Hoc – Feedback based, TCP with explicit link, TCP-Bus, Ad Hoc TCP, and Split TCP. WSN: Introduction – Design Issues and challenges – Energy consumption – Clustering of sensors MAC protocols: Classifications of MAC protocols: Contention Based Protocols, Contention Free Protocols, Hybrid Protocols. Routing Protocols for Wireless Sensor **Networks:** Data Dissemination – Data Gathering – Routing Challenges and Design Issues in WSN - Routing Strategies in Wireless Sensor Networks: Flooding and Its Variants -Sensor Protocols for Information via Negotiation(SPIN) - Low-Energy Adaptive Clustering Hierarchy(LEACH) - Power-Efficient Gathering in Sensor Information Systems(PEGASIS) -Directed Diffusion - Geographical Routing - Location Discovery - QoS - Other issues: Energy Efficient Design, Synchronization, Transport layer issues, Security. Applications and Case studies in Wireless Sensor Networks: Target detection – Habitat Monitoring – Environment disaster Monitoring - Wireless Multimedia Sensor Networks - Cross-Layer **Design for Wireless Sensor Networks** 

### Learning Resources

- C.Siva Ram Murthy and B.S. Manoj, "Ad Hoc Wireless Networks Architectures and Protocols", Pearson Education, 2008.
- Jun Zheng and Abbas Jamalipour, "Wireless Sensor Network A Networking Perspective", A John Wiley & Sons, Inc., Publication, 2009.
- KazemSohraby, Daniel Minoli and TaiebZnati, "Wireless Sensor Networks: Technology, Protocols and Applications, A John Wiley & Sons, Inc., Publication, 2007.
- Carlos de Morais Cordeiro, Dharma Prakash Agrawal, "Ad Hoc and Sensor Networks, Theory and Applications", World Scientific 2006.
- Feng Zhao and Leonidas Guibas, "Wireless Sensor Networks", Morgan Kaufman Publishers, 2010.
- C.K.Toh, "Ad Hoc Mobile Wireless Networks", Pearson Education, 2008.

### **Course Contents and Lecture Schedule**

Module	Торіс	No. of	Course
No.		Hours	Outcome
1.	Ad hoc Mac		
1.1	Design Issues in Ad-Hoc Networks	1	CO1
1.2	MAC Protocols Issues	1	CO1

1.3	Classifications of MAC protocols: Contention Based	1	CO1
14	Contention Based Protocols with reservation	1	CO1
1.4	mechanisms Contention Based Protocols with	I	001
	Scheduling Mechanism		
1.5	MAC protocol with Directional Antenna	2	CO1
1.0	Multichannel MAC	1	001
17	Power control MAC protocol	1	
2.	Ad-Hoc Routing protocols and Ad-Hoc Transport lay	/er	
2.1	Issues. Classifications of routing protocols: Table	2	CO2
	Driven Protocols		
2.2	On-Demand Routing Protocols, Hybrid Routing	2	CO2
	Protocols		
2.3	Hierarchical and Power aware Routing Protocols	1	CO3
2.4	Ad Hoc Transport Layer Issues, TCP Over Ad Hoc	2	CO3
2.5	Feedback based, TCP with explicit link, TCP-Bus	1	CO3
2.6	Ad Hoc TCP, and Split TCP	1	CO3
3.	WSN: MAC protocols		
3.1	Introductionof WSN	1	CO4
3.2	Design Issues and challenges and Energy	1	CO4
	consumption		
3.3	Clustering of sensors	1	CO4
3.4	Classifications of MAC protocols: Contention Based	1	CO4
	Protocols		
3.5	Contention Free Protocols, Hybrid Protocols	1	
4.	Routing Protocols for Wireless Sensor Networks		
4.1	Data Dissemination, Data Gathering	1	CO5
4.2	Routing Challenges and Design Issues in WSN	1	CO5
4.3	Routing Strategies in Wireless Sensor Networks:	1	CO5
	Flooding and Its Variants		
4.4	SPIN , LEACH , PEGASIS	1	CO5
4.5	Directed Diffusion, Geographical Routing	1	
4.6	Location Discovery, QoS	1	
4.7	Other issues: Energy Efficient Design,	1	
	Synchronization, Transport layer issues, Security		
5	Applications and Case studies in Wireless Sens	or Network	S
5.1	l arget detection	1	CO6
5.2	Habitat Monitoring	1	CO6
5.3	Environmental disaster Monitoring	1	<u>CO6</u>
5.4	Wireless Multimedia Sensor Networks	1	<u>CO6</u>
5.5	Cross-Layer Design for Wireless Sensor Networks	1	CO6
	Total Hours	36	

### Course Designers:

•

- Dr. M.S.K. Manikandan manimsk@tce.edu
  - Dr. E. Murugavalli murugavalli@tce.edu
- Dr. S. Ponmalar
- spmece@tce.edu

18ECRC0	MULTIMEDIA COMPRESSION	Category	L	Т	Ρ	Credit
	TECHNIQUES	PEES	3	1	0	4

### Preamble

This course aims at understanding characteristics of various multimedia data and apply a suitable coding/compression technique to efficiently represent the data.

Prerequisite

NIL

### Course Outcomes

On the successful completion of the course, students will be able to

CO#		Course Outcome Statement									Weigh	ntage				
											in '	%				
CO1	Ch	Characterize Multimedia data and its Compression with								with	10	)				
<u> </u>	per	tormi	ance	meas	ures forma		of loo			proce	ion t	ochni	21100	21	-	
02			ie tr	ie per abla k	ionna Spath	ince (	or ios	siess	com stic a		iction	ecnnic	ques	23	0	
		dina dina	van		snyun	couii	iy, A		suc a			aiy-Do	aseu			
CO3	De	termir	he th	e perf	ormar	ice of	loss	v con	press	sion te	echnic	ques	such	20	)	
	as	scala	r and	l vecto	or qua	ntizat	ion ar	nd tra	nsforr	n cod	ling	10.00		_,		
CO4	Illu	strate	the	perfori	mance	e of In	nage	comp	ressio	on sta	ndarc	ls suc	h as	15	5	
	JPI	EG 20	)00 a	Ind JB	IG											
CO5	Illu	strate	the	perfor	manc	e of \	/ideo	comp	ressi	on sc	heme	s suc	h as	15	5	
	<u>H.2</u>	<u>261 ar</u>	nd M	PEG					<u> </u>						_	
CO6	Illu	strate	the	perforr	nance	e of A	udio c	ompr	essio	n tech	nique	es suc	ch as	15	5	
	G.	(26, mpro/	Voco	oder,	MPE	Au ز	dio,	Surro	und	sound	d and	d Sile	ence			
CO Ma	Compression															
	TCE								ricular	Compo	nents					
#	Prof	- iciena	v C	Coniti	ve ve		ctive	Psv	chom	otor		7)	noulai	Compe	nonto	
	Sca	le	· · · · ·	Jogina	•••			' ' '	onon			,				
CO1	TPS	52	l	Inders	tand	Res	pond	-			1.3,	2.4.6				
CO2	TPS	3	A	Apply		Valu	le	-			1.3,	3.2.4	, 3.3.1,	3.1, 4.1.2, 4.5.3		
CO3	TPS	53	A	Apply		Valu	le	-			1.3,	3.2.4	, 3.3.1,	.3.1, 4.1.2, 4.5.3		
CO4	TPS	3	A	Apply		Valu	le	-			1.3,	3.2.4	, 3.3.1,	4.1.2, 4	4.5.3	
CO5	TPS	3	l A	Apply		Valu	le	-			1.3,	3.2.4	, 3.3.1,	4.1.2, 4	4.5.3	
CO6	TPS	3	ļ	Apply	_	Valu	le	-			1.3,	3.2.4	<u>, 3.3.1,</u>	4.1.2, 4	4.5.3	
Mappi	ng wi	th Pro	ogra	mme	Outco	omes		84					DCC		DCC	
COs	PO 1	PO 2	PO 3		PO 5	PO 6	PO 7	90 8	PO	PO 10	PO	PO 12	PSO 1	PSO 2	PSO 3	
CO1	M		1		-	-	-	-	-	10	-	-		-	-	
CO2	S	M		<u> </u>	-	-	L	-	_		_	_	 	L	-	
CO3	S	M	L	M	-	-	L	-	-	L	-	-	M		-	
CO4	S	М	L	M	-	-	L	-	L	М	-	-	М	L	-	
CO5	S	М	L	M	-	-	М	L	L	Μ	-	-	М	L	-	
CO6	S	М	L	М	-	L	М	L	L	Μ	-	-	М	L	-	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain								
Cognitive Levels	Continuous Assessment Tests			As	signment	End Semester Examination		
	1	2	3	1	2	3		
Remember	0	0	0	0	0	0	0	
Understand	20	20	20	20	20	20	20	
Apply	80	80	80	80	80	80	80	
Analyse	-	-	-	-	-	-	-	
Evaluate	-	-	-	-	-	-	-	
Create	-	-	-	-	-	-	-	
Assessment Pattern: Psychomotor								
Psychomotor	Skill							

### Perception Set --**Guided Response** ---Mechanism \_ \_ \_ **Complex Overt Responses** \_ -\_ Adaptation ---Origination -\_ \_

## **Course Level Assessment Questions**

### Course Outcome 1 (CO1):

- 1. Using your own words, describe what is "multimedia"?
- 2. Is multimedia simply a collection of different types of media?
- 3. Identify three novel multimedia applications. Discuss why you think these are novel and their potential impact.
- 4. State entropy
- 5. Discuss redundancies
- 6. What is the term "compression Ratio" in compression?

### Course Outcome 2 (CO2):

- 1. How integer arithmetic could be used to generate binary code and examine the same for the typical scenario of u(n) = 54 and l(n) = 33 with m = 6.
- 2. For an alphabet A = {a1, a2, a3} with p(a1) = 0.7, p(a2) = 0.2, p(a3) = 0.1. Design a '3' bit Tunstall code.
- 3. Encode the following sequence by LZ77 approach with window = 14, LAB = 5 a b c a radabrarraadrr
- 4. A source emits letters from an alphabet A = {a1, a2, a3, a4, a5} with probabilities P(a1) = 0.15, P(a2) = 0.04, P(a3) = 0.26, P(a4) = 0.05 & P(a5) = 0.5
  - a. Calculate the entropy, b.Find Huffman code, c. Average length of the code and its redundancy

### Course Outcome 3 (CO3):

- 1. What is rate distortion theory?
- 2. Define vector quantization and give its merit.
- 3. Compute the covariance matrix of the following set of 4 vectors.
  - $[100]^{T}$ ,  $[000]^{T}$ ,  $[110]^{T}$ ,  $[111]^{T}$
- 4. The wavelet coefficients of the given image are shown in figure. Encode and decode the coefficients using SPIHT algorithm.

34	0	1	-1
0	0	-1	1
4	-4	10	-6
-4	4	6	-10

### Course Outcome 4 (CO4):

Passed in BoS Meeting 22.06.2021

- 1. Explain the bi-level lossless compression standard.
- 2. You are given a computer cartoon picture and a photograph. If you have a choice of using either JPEG compression or GIF, which compression would you apply for these two images? Justify your answer.
- 3. Is the JPEG2000 bitstream SNR scalable? Also, explain how it is achieved using the EBCOT algorithm.
- 4. Could we use wavelet-based compression in ordinary JPEG? How?

### Course Outcome 5 (CO5):

- 1. In block-based video coding, what takes more effort: compression or decompression? Explain why.
- As we know, MPEG video compression uses I-, P-, and B-frames. However, the earlier H.261 standard does not use B-frames. Describe a situation in which video compression would not be as effective without B-frames.
- 3. B-frames provide obvious coding advantages, such as increase in SNR at low bitrates and bandwidth savings. What are some of the disadvantages of B-frames?

### Course Outcome 6 (CO6):

- 1. Linear prediction analysis can be used to estimate the shape of the envelope of the short-time spectrum. Given ten LP coefficients a1,...,a10, how do we get the formant position and bandwidth?
- 2. Give a simple time domain method for pitch estimation based on the autocorrelation function. What problem will this simple scheme have when based on one speech frame? If we have three speech frames, including a previous frame and a future frame, how can we improve the estimation result?
- 3. Describe the ITU G.726 standard for ADPCM system.
- 4. What is the compression ratio of MPEG audio if stereo audio sampled with 16 bits per sample at 48 kHz is reduced to a bitstream of 256 kbps?



**Multimedia Data Representation:** Text, Graphics and Image data representation, Video data, Audio data, Need for Compression and Coding of Multimedia data, Measures of Performance.

**Multimedia Data Compression-Lossless Compression Techniques:** Run length coding-Variable Length Coding: Huffman Coding- Non binary Huffman coding- Extended Huffman-Adaptive Huffman, Golomb code- Tunstall Code, Arithmetic Coding, Dictionary Based Coding – Static Dictionary-Digram coding -Adaptive Dictionary-LZ77, LZ78, LZW.

**Lossy Compression Techniques:** Distortion Measures-The Rate-Distortion Theory-Quantization- Scalar and Vector Quantization, Transform Coding-Discrete Cosine Transform, Karhunen–Loève Transform, Wavelet Based Coding- Sub band coding - Embedded Zero tree of Wavelet Coding (EZW) -Set Partitioning in Hierarchical Trees (SPIHT) coders;

**Image Compression Standards:** JPEG 2000, Bilevel Image Compression Standards: JBIG; **Video Compression Standards:** Introduction to Video Compression-Video Compression Based on Motion Compensation-Search for Motion Vectors H.261, MPEG 1 -MPEG-2-MPEG-4-Object-Based Visual Coding in MPEG-4.

**Audio Compression Standards:** G.726, Vocoder-MPEG Audio- MPEG 1 Layer III(MP3)-MPEG 2 (AAC)- Surround sound - Dolby Digital- DTS X - Silence Compression.

### **Text Books**

- 1. Li, Ze-Nian, Mark S. Drew, and Jiangchuan Liu, "Fundamentals of multimedia" Springer, 2021.
- 2. Khalid Sayood, "Introduction to Data Compression" Fifth Edition, Morgan Kauffmann Publishers, Inc, Newnes, 2020.

### **Reference Books**

- 1. David Salomon, "Data Compression: The Complete Reference", Fourth Edition Springer Science & Business Media, 2007.
- 2. David Salomon, "A Guide to Data Compression Methods", Fourth Edition Springer Science & Business Media, 2013.
- 3. Darrel Hankerson, Greg A. Harris, and Peter D. Johnson Jr, "Introduction to information theory and data compression", CRC press, 2003.
- 4. Mark Nelson, Jean Louf Goilly, "The Data Compression Book", BPB Publications, 1995.

Module	Торіс	No. of lectures
No.		
1.	Multimedia- Data Representation	
1.1	What is Multimedia	1
1.2	Graphics and Image Data Representations	1
1.3	Video Data	1
1.4	Audio Data	1
1.5	Need for Compression and Coding of Multimedia data	0.5
1.6	Measures of Performance	0.5
2.	Multimedia Data Compression	
2.1	Lossless Compression Techniques	
2.1.1	Run length Coding	1
2.1.2	Variable Length Coding	1
2.1.2.1	Huffman Coding and its variations- Baseline, Non Binary,	4
	Extened and Adaptive Huffman	
2.1.3	Golomb code	1
2.1.4	Tunstall Code	1
2.1.5	Arithmetic coding	2
2.1.6	Dictionary Based Coding –Digrams, LZ77,LZ78, LZW	3
2.2	Lossy Compression Techniques	
2.2.1	Distortion Measures, Rate Distortion Theory	1

### Course Contents and Lecture Schedule

2.2.2	Scalar and Vector Quantization	2
2.2.3	DCT, KL Transform coding	2
2.2.4	Wavelet Based Coding	
2.2.4.1	Sub band coding	2
2.2.4.2	Embedded Zero tree of Wavelet coding	2
2.2.4.3	Set Partitioning in Hierarchical Trees (SPIHT)	2
3	Image Compression Standards	
3.1	JPEG 2000	2
3.2	Bi-level Image Compression Standards	
3.2.1	JBIG	2
4	Video Compression Standards	
4.1	H.261	2
4.2	MPEG 1	2
4.3	MPEG 2	1
4.4	MPEG 4	2
5.	Audio Compression Standards	
5.1	G.726	2
5.2	Vocoder	1
5.3	MPEG Audio- MP3	1
5.4	MPEG (AAC)	1
5.5	Surround Sound- Dolby Digital and DTS X	2
5.6	Silence Compression	1

### **Course Designers:**

- Dr.S.Md.Mansoor roomi
- Dr.B.Sathya Bama
- Dr.B.Yogameena

smmroomi@tce.edu sbece@tce.edu ymece@tce.edu

10	EC	D	n	n
10	LU		L	u

SIGNAL	PROCESSING	IN	5G	NR
JIGNAL	FRUCESSING	IIN	30	את

Category	L	Т	Ρ	Credit
PEES	3	1	0	4

### Preamble

The objective of the course on "Signal Processing in 5G New Radio (NR)" is to present the communication techniques, Procedures and Signal Processing Algorithms used in the physical layer of 5G new radio standards. The course covers 5G NR features, spectral requirements, frame structure, radio interface architecture, channel sounding, scheduling, multi antenna, retransmission, power control, synchronization characteristics. This course would be more helpful in carrying out projects in recent telecommunication domain.

### Prerequisite

18EC530 Analog and Digital Communication Systems

### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage
		in %
CO1	Compare the enhanced features of 5G NR over 4G LTE and describe	15
	the frame structure of 5GNR	
CO2	Determine suitable channel estimation algorithm for calculating	15
	parameters from channel sounding features of 5G NR	
CO3	Determine the receiver structure for transport channel processing of	20
	uplink and downlink in 5G NR	
CO4	Determine the receiver structure for control channel processing of	20
	uplink and downlink in 5G NR	
CO5	Describe the multi-antenna, retransmission, power control features of	15
	5G NR	
CO6	Determine suitable frequency and timing estimation algorithms for	15
	initial access and synchronization features of 5G NR	

### CO Mapping with CDIO Curriculum Framework

CO	TCE	Learr	ning Domai	n Level	CDIO Curricular
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale				(X.Y.Z)
CO1	TPS2	Understand	Respond	-	1.3,2.1.1,2.1.2,2.4.6,3.2.3
CO2	TPS3	Apply	Value	Mechanism	1.3,1.2.1, 2.1.1, 2.1.2,
					2.4.2, 2.4.6, 2.5.1, 3.1.1,
					3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.3,1.2.1, 2.1.1, 2.1.2,
					2.4.2, 2.4.6, 2.5.1, 3.1.1,
					3.2.3, 4.5.5, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.3,1.2.1, 2.1.1, 2.1.2,
					2.4.2, 2.4.6, 2.5.1, 3.1.1,
					3.2.3, 4.5.5, 4.6.2
CO5	TPS2	Understand	Respond	Guided	1.3,2.1.1,2.1.2,2.4.6,3.2.3
				Response	
CO6	TPS3	Apply	Value	Mechanism	1.3,1.2.1, 2.1.1, 2.1.2,
					2.4.2, 2.4.6, 2.5.1, 3.1.1,
					3.2.3, 4.5.5, 4.6.2

### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO	PO	PO	PSO1	PSO2	PSO3
										10	11	12			
CO1	Μ	L	-	-	-	-	-	-	-	-	-	-	Μ	-	-
CO2	S	М	L	-	-	-	-	-	-	-	-	-	M	L	-
CO3	S	М	L	-	-	-	-	-	-	-	-	-	Μ	L	-
CO4	S	М	L	-	S	-	-	-	S	S	-	-	Μ	L	-
CO5	Μ	L	-	-	-	-	-	-	-	-	-	-	Μ	-	-
CO6	S	М	L	-	-	-	-	-	-	-	-	-	М	-	-

S- Strong; M-Medium; L-Low

### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests				Assignme	End Semester Examination	
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	100	50	50	80
Analyze	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

### Sample Questions for Course Outcome Assessment

### Course Outcome 1 (CO1):

- 1. List the requirements of 5G New Radio.
- 2. Represent the 5G Spectrum defined by IMT Systems by the ITU-R.
- 3. List out the various Uplink and Downlink 5G NR Operating bands. Also mention the duplex modes.

### Course Outcome 2 (CO2):

- 1. Draw the single port CSI-RS Structure consisting of a single resource element within RB.
- 2. Represent different spatial filters applied to different CSI-RS.
- 3. Draw the time and frequency structures of Sounding Reference Signalling.

### Course Outcome 3 (CO3):

- 1. Determine the Receiver structure for PDSCH in 5GNR with single transmit and single receive antenna.
- 2. Determine the Receiver structure for PUSCH in 5GNR with single transmit and single receive antenna.
- 3. Determine the Receiver structure for PDSCH in 5GNR with single transmit and multiple receive antenna.

### Course Outcome 4 (CO4):

- 1. Explain the mapping of PUSCH and PUCCH information to physical resources.
- 2. Consider a PDCCH downlink control channel in 5GNR. It transmits information about the number of OFDM symbols used by control channels in a sub-frame. The 32 bit transmitting sequences for each values of CFI are listed below
  - CFI <b0, b1, ..., b31>

3. In case of fixed group assignment the sequence group to use for PUCCH transmission is given by the physical-layer cell identity modulo 30, where the cell identity ranges from 0 to 63. Determine the group assignment for the given cell identities.

### Course Outcome 5 (CO5):

1. Describe the multi antenna transmission modes in downlink 5G New Radio.

- 2. Determine the Bit Error Rate for the Physical Downlink Hybrid ARQ Indicator channel (PDCCH) with SIMO processing.
- 3. Precoding is done for multi antenna transmission in 5G New Radio uplink. Determine the rank of the precoding matrix given below.

14-14	+1 0	+1 0 0]	[+1 0 0]	[+1 0 0]
+ 1	+1 0	+1 0 0	-1 0 0	0 +1 0
+1	0 +1	0 +1 0	0 +1 0	+1 0 0
1-1	0 -/	0 0 +1	0 0 +1	0 0 +1

For the DFT spread OFDM in uplink, the allowed DFT sizes are 60,72,96. However a DFT size of 84 is not allowed. Justify.

### Course Outcome 6 (CO6):

1. Consider 4 length time domain transmitted sequence defined by

x(n) = [1+1j, 1-1j, 1+1j, 1-1j].

Consider a normalised frequency offset of 0.3. Determine the received sequence with ideal channel conditions. Apply schmidle-Cox algorithm to determine the original frequency offset if  $\Delta f = 15 KHz$ .

- 2. Apply the Schmidle Cox algorithm for symbol timing estimation in 5G New Radio.
- 3. What do you mean by beta offset in 5GNR?

### Concept Map



5G Overview: 3GPP and the standardization of Mobile Communication, the next generation 5G New Radio, 5G Standardization, ITU-R Activities from 3G to 5G, 5G and IMT-2020, 3GPP Standardization, Spectrum for 5G, Frequency bands for NR, RF Exposure above 6GHz NR Overview: Higher Frequency Operation and Spectrum Flexibility, Ultra lean design, Forward compatibility, Transmission scheme, bandwidth parts and frame structure, Duplex schemes, Low latency support. Scheduling and data transmission, control channels. Beam centric design and Multi antenna transmission, Initial access, Interworking and LTE Coexistence Transmission scheme: Frequency domain location of NR Carrier, Carrier aggregation, Supplementary uplink, Duplex schemes, Antenna ports, Quasi co-location Channel sounding: Downlink channel sounding-CSI-RS, Downlink Measurements and reporting, Uplink channel sounding- SRS Transport channel processing: channel coding, Rate matching and physical layer hybrid ARQ Functionality, Scrambling, Modulation, Layer mapping, Uplink DFT Precoding, Multi antenna precoding, Resource mapping, Downlink reserved resources, Reference signals, Physical layer control signalling: Downlink, Uplink, Multi-antenna Transmission: Downlink Multi-antenna precoding, NR Uplink Multi-antenna precoding. Beam Management: Beam adjustment and Beam Recovery Retransmission Protocols: Hybrid ARQ with Soft combining, Radio Link Control (RLC), Packet Data Convergence Protocol (PDCP), Uplink Power and Timing control: Uplink Power Control, Uplink Timing Control, Initial access: Cell search, Random access

### Learning Resources

- Sassan Ahmadi, "5G NR Architecture, Technology, Implementation, and operation of 3GPP New Radio Standards", Academic Press, 2019.
- Erik Dahlman, Stefan Parkvall, Johan Skold, "5G NR, The Next Generation Wireless Access Technology", Academic Press, 2018.
- 3GPP TS 23.502, Procedures for the 5G system (Release 15), April 2019.
- 3GPP TS 38.101-1, NR, User Equipment (UE) Radio Transmission and Reception; Part 1: Range 1 Standalone (Release 15), December 2018.
- 3GPP TS 38.101-2: NR, User Equipment (UE) Radio Transmission and Reception; Part 2: Range 2 Standalone (Release 15), December 2018.
- 3GPP TS 38.104, NR, Base Station (BS) Radio Transmission and Reception (Release 15), December 2018.
- 3GPP TS 38.202, NR, Services Provided by the Physical Layer (Release 15), December 2018.
- 3GPP TS 38.211, NR, Physical Channels and Modulation (Release 15), December 2018.
- 3GPP TS 38.212, NR, Multiplexing and Channel Coding (Release 15), December 2018.
- 5G New Radio, ShareTechNote. http://www.sharetechnote.com

No.	Торіс	No. of Hours	COs
1	5G Overview		
1.1	3GPP and the standardization of Mobile Communication, the next generation 5G New Radio	1	CO1
1.2	5G Standardization	1	CO1
1.3	ITU-R Activities from 3G to 5G	1	CO1
1.4	5G and IMT-2020	1	CO1
1.5	3GPP Standardization	1	CO1
1.6	Spectrum for 5G, Frequency bands for NR, RF Exposure above 6GHz	1	CO1
2	NR Overview		
2.1	Higher Frequency Operation and Spectrum Flexibility, Ultra lean design	1	CO1
2.2	Forward compatibility, Transmission scheme, bandwidth parts and frame structure	1	CO1

### Course Contents and Lecture Schedule:

2.3	Duplex schemes, Low latency support, Scheduling and data	1	CO1
	transmission, control channels		
2.4	Beam centric design and Multi antenna transmission	1	CO1
2.5	Initial access, Interworking and LTE Coexistence	1	CO1
3	Transmission scheme		
3.1	Frequency domain location of NR Carrier	2	CO2
3.2	Carrier aggregation	2	CO2
3.3	Supplementary uplink, Duplex schemes	2	CO2
3.4	Antenna ports, Quasi colocation	1	CO2
4	Channel sounding		
4.1	Downlink channel sounding-CSI-RS	2	CO3
4.2	Downlink Measurements and reporting	2	CO3
4.3	Uplink channel sounding- SRS	2	CO3
5	Transport channel processing		
5.1	Channel coding, Rate matching and physical layer hybrid ARQ	2	CO4
	Functionality		
5.2	Scrambling, Modulation, Layer mapping	2	CO4
5.3	Uplink DFT Precoding, Multi antenna precoding		CO4
5.4	Resource mapping, Downlink reserved resources	1	CO4
5.5	Reference signals	1	CO4
5.6	Physical layer control signaling: Downlink, Uplink	1	CO4
6	Multi antenna Transmission		
6.1	Downlink Multi antenna precoding	1	CO5
6.2	NR Uplink Multi antenna precoding	1	CO5
7	Beam Management		
7.1	Beam adjustment and Beam Recovery	2	CO5
8	Retransmission Protocols		
8.1	Hybrid ARQ with Soft combining	2	CO6
8.2	Radio Link Control (RLC)	2	CO6
8.3	Packet Data Convergence Protocol (PDCP)	2	CO6
9	Uplink Power and Timing control		
9.1	Uplink Power Control	2	CO6
9.2	Uplink Timing Control	2	CO6
10	Initial access		
10.1	Cell search, Random access	2	CO6
Total		48	
Cours	a Designers:		

• Dr.S.J.Thiruvengadam sjtece@tce.edu

• Dr.M.N.Suresh mnsece@tce.edu

Dr.G.Ananthi gananthi@tce.edu

1	8	Ε	С	R	Ε	0

ALGORITHMS FOR	VLSI	DESIGN
AUTOMAT	ION	

Category	L	Т	Ρ	Credit
PEES	3	1	0	4

### Preamble

The semiconductor industry has advanced tremendously over the last ten years with features sizes being downscaled from micrometer to nanometer regime today. Due to the increasing high complexity of modern VLSI chip design, Computer Aided Design (CAD) tools play an important role in delivering high system performance. This course introduces the techniques of modelling digital systems at various abstraction levels and exploring the various algorithms in VLSI physical design, which serve as a basis for the research and development of new Computer Aided Design (CAD) tools.

### Prerequisite

18EC260 – Digital System Design, 18EC430 – CMOS VLSI Systems

### Course Outcomes

On the successful completion of the course students will be able to

CO#		Cours	se Outcome S	Statement		Weightage in %			
CO1	Demonstrate	d optimization	10						
	algorithms an	d tools applic	able to solvir	ng CAD related p	problems				
CO2	Represent m	echanism for	Boolean fu	nctions that has	application in	15			
	logic synthesi	s and Verifica	ation						
CO3	Partition or o	divide the sy	stem into si	maller portions	based on the	15			
	performance	such as area,	, wire length a	and cost matrice	S.				
CO4	Determine the	e approximate	e location of e	each module in a	a chip area.	20			
CO5	Use Optimiza	tion algorithm	is in placeme	nt to determine t	he best position	20			
	for each modu	le on the chip.							
CO6	Analyse the	Optimizations	s algorithms	in VLSI Global	and Detailed	20			
	Routing process based on their wire length and area constraints.								
CO Map	Mapping with CDIO Curriculum Framework								
CO	TCE	Lea	arning Domai	n Level	CDIO Cu	rricular			
#	Proficiency	oficiency Cognitive Affective Psychomotor Compor							
	Scale				(X.Y	.Z)			
CO1	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.	.2, 2.4.2,			
					2.4.3, 2.4.6, 2.	5.1, 2.5.4,			
					3.1.1				
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.	.2, 2.4.2,			
					2.4.3, 2.4.6, 2.	.5.1			
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.	.2, 2.4.2,			
					2.4.3, 2.4.6, 2.	5.1, 2.5.4,			
					3.1.1, 3.1.5				
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.	.2, 2.4.2,			
					2.4.3, 2.4.6, 2.	5.1, 2.5.4,			
					3.1.1, 3.1.5				
CO5	TPS3 Apply Value Mechanism 1.3, 2.1.1, 2.1.1				.2, 2.4.2,				
	2.4.3, 2.4.6,								
					2.5.1,2.5.4,3.1	.1, 3.1.5			
CO6	TPS4	Analyse	Organise	Complex	1.3, 2.1.1, 2.1.	2, 2.4.2,			
				Overt	2.4.3, 2.4.6, 2.	5.1,2.5.4,			

,3.1.1,3.1.5

Responses

Mapping with Programme	Outcomes and Prog	gramme Specific Outcomes
------------------------	-------------------	--------------------------

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO	PO	PO	PSO1	PSO2	PSO3
										10	11	12			
CO1	S	M	L	-	L	-	-	L	L	L	-	L	М	-	L
CO2	S	M	L	-	L	-	-	L	L	L	-	L	М	-	L
CO3	S	Μ	L	-	L	-	-	L	L	L	-	L	М	-	L
CO4	S	M	L	-	L	-	-	L	L	L	-	L	М	-	L
CO5	S	M	L	-	L	-	-	L	L	L	-	L	М	-	L
CO6	S	S	Μ	L	L	-	-	L	L	L	-	L	S	-	L

S- Strong; M-Medium; L-Low

### **Assessment Pattern: Cognitive Domain**

Cognitive Levels	Contin	uous Ass Tests	sessment		Assignme	End Semester Examination	
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	60	100	30	30	60
Analyse	0	0	20	0	40	40	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	20
Complex Overt Responses	-	-	10
Adaptation	-	-	-
Origination	-	-	-
Origination	-	-	-

## Sample Questions for Course Outcome Assessment

### Course Outcome 1 (CO1):

- 1. Differentiate DFS and BFS search methods.
- 2. Find the shortest path between "A" and "E" in the graph shown in Figure using Dijkstra's algorithm and also find the minimum spanning tree for the same graph using Prim's algorithm



- 3. Discuss on the VLSI Design methodologies used for IC layout design.
- 4. Explain the Gajski Y-chart.

### Course Outcome 2 (CO2):

- 1. For the Boolean function f  $(x_1, x_2, x_3) = (0, 1, 2, 5, 6, 7)$ . Find its locally and globally minimal irredundant prime cover.
- 2. With suitable example, explain hoe ROBDD can be used in different applications.
- 3. Draw the ROBDD for the given function f = ab(c + d)

### Course Outcome 3 (CO3):

1. Explain how Kernighan-Lin algorithm is used for partitioning and using the algorithm, find the minimum cut for the graph shown in Figure.



2. Find the shortest path between "A" and "E" in the graph shown in Figure using Dijkstra's algorithm and also find the minimum spanning tree for the same graph using Prim's algorithm



3. Design a cost function for the general building block placement problem which considers the wire length, estimated area, module overlap, and aspect ratio of the entire layout.

### Course Outcome 4 (CO4):

- 1. Prove that there is a one-to-one correspondence between a sliceable floorplan and a normalized Polish expression.
- 2. Given a Polish expression corresponding to a given a slicing floorplan, show that the expression 12-3-....-n- can be reached and vice versa.
- 3. Find an optimal implementation of modules M<sub>1</sub>,.....M<sub>8</sub> for sizing of the following sliceable floorplans.

Floor 1: 1 2 V 3 4 V H 5 6 V 7 8 V H V Floor 2: 1 2 V 3 4 V 5 H 6 V 7 H 8 V H

### Course Outcome 5 (CO5):

1. Given: (1) placement P of blocks a-f and their pins (right) and (2) nets N1-N3 and their net weights. Estimate the total weighted wirelength of P using the RMST model.

2. Given: (1) circuit with gates a-f (left), (2) 2 × 4 layout (right), and (3) initial vertical cut cut1. Find a placement with minimum wirelength using alternating cutline directions and the KL algorithm.



### Course Outcome 6 (CO6):

- 1. Show that left edge algorithm produces a solution, with a number of rows exactly equal to the density of the problem.
- 2. Draw the horizontal and vertical constraint graphs for the channel shown in below figure. Explain how to handle the net that exist the channel and its pseudo terminal.





VLSI Design Automation: VLSI Design Cycle, New trends in VLSI Design cycle, Physical Design cycle, Design styles, Design Abstraction Levels, Evolution of CAD Tools, Importance of Design Automation. Data Structures and Basic Algorithms: Terminology, Data Structures for the representation of Graphs: matrices; Paths, connectedness; circuits, cut sets, trees: Voltage and current spaces of a directed graph and their complementary orthogonally; Complexity Issues and NP-hardness, Graph algorithms - Breadth First Algorithm, Depth First Algorithms, Spanning Tree Algorithms. Logic Synthesis: Combinational Logic Synthesis, Binary Decision Diagrams, Reduced Ordered BDD principles, ROBDD Manipulation, Variable Ordering, Two Level Logic Synthesis. System Partitioning: Terminology, Optimization Goals, Partitioning Algorithms: Kernighan-Lin Algorithm, Extension of Kernighan-Lin Algorithm, Fiduccia Mattheyess Algorithm, Clustering, Chip Planning: Terminology, Optimization Goals in Floorplanning, Floorplan Representations: Floorplan to a Constraint-Graph Pair, Floorplanning Algorithms: Floorplan Sizing, Cluster Growth, Simulated Annealing. Placement: Circuit Representation: Bipartite Model Clique Model, Wire length Estimation; Global Placement Algorithms: Min-cut Placement, Analytic Placement, and Simulated Annealing Algorithms. Routing: Maze Running, Line Searching, Steiner Trees, and Global Routing: Sequential Approaches, Hierarchical approaches, Detailed routing: Channel Routing. switchbox Routing. Clock and Power Routing: Clock Routing, Clocking Schemes, Design Considerations for the Clocking System, Problem Formulation, Clock Routing Algorithms: Htree Based Algorithm, Power and Ground Routing.

Passed in BoS Meeting 22.06.2021

### Learning Resources

- Naveed Sherwani, Algorithms for VLSI physical design Automation, Kluwer Academic Publishers, 2010.
- S.H. Gerez, Algorithms for VLSI Design Automation, Wiley-India, Reprint 2008
- Sung Kyu Lim, "Practice Problems in VLSI physical design Automation", Springer, 2008
- Charles J . Alpert, Dinesh P. Mehta, Sachin S. Sapatnekar, "Hand book of algorithms of Physical design Automation ", CRC press, 2009.
- Sadiq M .Sait, Habib Youssef, "VLSI Physical design automation theory and Practice", World Scientific Publishing, 1999
- M. Sarrafzadeh and C.K. Wong, *An Introduction to VLSI Physical Design*, McGraw Hill, 1996
- D.D Gajski et al., *High Level Synthesis: Introduction to Chip and System Design*, Kluwer Academic Publishers, 1992
- https://www.coursera.org/learn/vlsi-cad-logic
- https://nptel.ac.in/courses/106/106/106106088/

### **Course Contents and Lecture Schedule**

No.	Торіс	No. of	COs
		Hours	
1	VLSI Design Automation Tools		
1.1	VLSI Design Cycle, New trends in VLSI Design cycle, Physical	2	CO1
	Design cycle		
1.2	Design styles,	1	CO1
1.3	Design Abstraction Levels, Evolution of CAD Tools, Importance	1	CO1
	of Design Automation.		
1.4	Data Structures and Basic Algorithms: Terminology, Data	2	CO1
	Structures for the representation of Graphs: matrices; Paths,		
	connectedness; circuits, cut sets, trees;		
1.5	Voltage and current spaces of a directed graph and their	1	CO1
			004
1.6	Complexity issues and NP-nardness	2	<u> </u>
1.7	Graph algorithms – Breadth First Algorithm, Depth First	2	CO1
1.8	Spanning Tree Algorithms	2	CO1
2	Logic Synthesis		
2.1	Combinational Logic Synthesis	1	CO2
2.2	Binary Decision Diagrams	1	CO2
2.3	Reduced Ordered BDD principles	2	CO2
2.4	ROBDD Manipulation, Variable Ordering	1	CO2
2.5	Two Level Logic Synthesis	2	CO2
	Assignment I: Implement the graph algorithms in VLSI Design		CO1 &
	Problems using C/C++/python with Data structure concept.		CO2
3	System Partitioning		
3.1	Terminology, Optimization Goals	1	CO3
3.2	Partitioning Algorithms: Kernighan-Lin Algorithm	2	CO3
3.3	Extension of Kernighan–Lin Algorithm	1	CO3
3.4	Fiduccia Mattheyess Algorithm	2	CO3
3.5	Clustering	1	CO3
4	Chip Planning		
4.1	Terminology, Optimization Goals in Floorplanning	1	CO4
4.2	Floorplan Representations: Floorplan to a Constraint-Graph Pair	1	CO4
4.3	Floorplanning Algorithms: Floorplan Sizing	2	CO4
4.4	Cluster Growth	2	CO4

Approved in 61<sup>th</sup> Academic Council Meeting 03.07.2021

4.5	Simulated Annealing	1	CO4
	Assignment II: Implement the Partitioning/Floorplanning		CO3 &
	Optimization Algorithm using C/C++/python with Data structure		CO4
	concept.		
5.	Placement Algorithms		
5.1	Circuit Representation: bipartite Model, Clique Model	2	CO5
5.2	Wire length Estimation	1	CO5
5.3	Global Placement: Min-cut Placement	1	CO5
5.4	Analytic Placement	1	CO5
5.5	Simulated Annealing Algorithms	2	CO5
6	Routing Algorithms		
6.1	Maze Running, Line Searching	2	CO6
6.2	Steiner Trees	1	CO6
6.3	Global Routing: Sequential Approached	1	CO6
6.4	Hierarchical approaches	1	CO6
6.5	Detailed routing: Channel Routing, switchbox Routing	2	CO6
	Assignment III: Compare the performance of various placement		CO5 &
	and routing algorithms in VLSI Circuits using EDA Tools		CO6
Cours	a Designers:		

esigners: Dr.D.Gracia Nirmala Rani •

Dr.S.Rajaram

• •

Dr.N.B.Balamurugan

Dr.V.Vinoth Thyagarajan • Dr.V.R.Venkatasubramani •

gracia@tce.edu rajaram\_siva@tce.edu nbb@tce.edu vvkece@tce.edu

venthiru@tce.edu

### 18ECRF0

### LOW POWER VLSI DESIGN

Category	L	Т	Ρ	Credit
PEES	3	1	0	4

### Preamble

Increased levels of integration (increased functionality) and higher throughput under tight power budgets has led to the need for changes in the traditional way of designing circuits and systems. Portable communication and computation have driven the need for low-power electronics. Recent progress has been made in creating tools for estimating power dissipation in CMOS circuits. The research approach is to use accurate and efficient power estimation techniques to drive the design of new low-power systems. Software tools for testing integrated circuits, rapid fault simulation, and failure analysis are also being developed. This course discusses design techniques, estimation and optimisation of power at various levels of design abstraction for designing energy-efficient digital systems used in battery operated devices

### Prerequisite

18EC330 Electronic Circuits

### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage
		in %
CO1	Calculate the dynamic and static power dissipation for CMOS Digital	15
	logic Circuits.	
CO2	Estimate the switching power in CMOS digital circuits using	15
	probabilistic and statistical techniques.	
CO3	Estimate the leakage current for the low voltage CMOS digital circuits.	15
CO4	Optimize the given Digital logic and arithmetic circuits for reduced	15
	power consumption.	
CO5	Suggest circuit design techniques for the different elements of Memory	15
	to reduce power consumption.	
CO6	Modify the existing digital logic circuits and SRAM using the energy	15
	recovery techniques	
CO7	Describe the techniques to consider while designing software for a low	10
	power system	

### CO Mapping with CDIO Curriculum Framework

CO	TCE	Learr	ning Domair	n Level	CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale				
CO1	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.3, 2.4.2, 2.5.1,
		-			3.1.1, 3.2.3
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.3, 2.4.6, 2.5.1,
		-			3.1.1, 3.2.3, 4.4.3, 4.5.5
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.3, 2.4.6, 2.5.1,
		-			3.1.1, 3.2.3, 4.4.3, 4.5.5
CO4	TPS4	Analyse	Organise	-	1.3, 2.1.1, 2.1.3, 2.1.5, 2.4.6,
		-	_		2.5.1, 2.5.4, 3.2.3, 4.1.5, 4.3.3.
					4.5.5
CO5	TPS4	Analyse	Organise	-	1.3, 2.1.1, 2.1.3, 2.1.5, 2.4.6,
		-	_		2.5.1, 2.5.4, 3.2.3, 4.1.5, 4.3.3.
					4.5.5
CO6	TPS4	Analyse	Organise	-	1.3, 2.1.1, 2.1.3, 2.5.1
C07	TPS2	Understand	Respond	-	1.3, 2.5.4, 3.2.6

### Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	Μ	L	-	L	-	-	L	L	L	-	-	Μ	L	-
CO2	S	Μ	L	L	L	-	-	L	L	L	-	L	Μ	L	-
CO3	S	Μ	L	L	L	-	-	L	L	L	-	L	Μ	L	-
CO4	S	S	Μ	Μ	L	-	-	L	L	L	-	L	S	L	L
CO5	S	S	Μ	Μ	L	-	-	L	L	L	-	L	S	L	L
CO6	S	S	Μ	Μ	L	-	-	L	L	L	-	L	S	L	L
CO7	М	L	-	-	-	-	-	-	-	-	-	-	L	-	-

### S- Strong; M-Medium; L-Low

### **Assessment Pattern: Cognitive Domain**

Cognitive Levels	Continu	End Semester					
	1	2	3	1	2	3	Examination
Remember	20	0	0	-	-	-	0
Understand	20	20	20	-	-	-	20
Apply	60	40	30	100	100		50
Analyse	0	40	30	0	-	100	20
Evaluate	0	0	10	0	0	0	10
Create	0	0	0	0	0	0	0

### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment 2	Assignment 3
Perception	-	-
Set	-	-
Guided Response	-	-
Mechanism	-	-
Complex Overt Responses	-	-
Adaptation	-	-
Origination	-	-

# Sample Questions for Course Outcome Assessment

### Course Outcome 1(CO1):

- 1. A 32 bit off-chip bus operating at 5V and 66 MHz clock rate is driving a capacitance of 25 pF/bit. Each bit is estimated to have a toggling probability of 0.25 at each clock cycle. What is the power dissipation in operating the bus?
- 2. The chip size of the CPU is 15mm\*25mm with the clock frequency of 300MHZ operating at 3.3.The length of the clock signal estimated to be twice the circumference of the chip. Assume that the clock signal is routed on a metal layer with the width of 1.2um and parasitic capacitance of the metal layer is 1Ff/um^2.What is the power dissipation of the clock signal?
- 3. Silicon is doped with boron to a concentration of  $N_A=4*10^{17}$  atoms/cm<sup>3</sup> and the semiconductor is used to form a junction with an aluminium metal with work function 4.1eV. Calculate the work function difference between the metal and semiconductor. Assume the intrinsic concentration carrier concentration of silicon is  $1.5*10^{10}$  cm<sup>-3</sup> at room temperature of T=300K.

### Course Outcome 2(CO2):

- 1. Find the dynamic Power Dissipation of a circuit operating at 500 MHZ with a supply voltage of 0.9 V and a capacitance value per unit area 150 pf/mm<sup>2</sup>. The chip size is 80mm<sup>2</sup>. Assume the activity factor to be 0.1.
- Find the area and power for the given function F1=ab+db+ce all inputs have equal probability = 0.5. The signal activities are D(a)=0.2; D(b)=0.3; D(c)=0.1; D(d)=2.5; D(e)=0.1;

 Calculate the power for the given function F2= ac+cd+be. Whose primary inputs have equal probability of 0.5. The signal activities are D(a)=0.2; D(b)=0.3; D(c)=0.1; D(d)=2.5; D(e)=0.1.

### Course Outcome 3(CO3):

- 1. Draw a semiconductor MOSFET transistor showing the possible sources of leakage currents in it and also derive the expression for the CMOS leakage current.
- 2. Illustrate the process of overcoming the leakage current by explaining the operation of domino logic NAND gate.

### Course Outcome 4 (CO4):

- 1. Use the pass-transistor logic circuits to construct the logic function  $F = AB + \overline{B}C + \overline{A} \cdot \overline{B}$
- 2. Construct a logic function  $F = AB + AC + \overline{A}D\overline{E} + BE$  using CPL and DPTL and LEAP. Use binary decision diagram (BDD) to design the above logic function.
- Using and domino dynamic logic circuits, design a logic function *F* = *A* ⊕ *B* ⊕ *C* in one stage and two cascading stages. Analyse and discuss the transient performance of the circuit for load capacitances of 0.01pF, 0. 1pF, and 0.5pF, and at supply voltages of 5V, 3.3V, 2.5V, and 1.5V.

### Course Outcome 5 (CO5):

- 1. Use static CMOS logic circuits and complementary pass-transistor logic (CPL) to design the parallel adder. Which approach has the best speed performance (smallest propagation delay)? For the design with the best speed performance, is its throughput also the highest?
- 2. Compare the performance of the multipliers using Wallace tree reduction with 3-to-2 and 4-to-2 compressor, modified Booth encoder/decoder, and combining modified Booth encoder/decoder with Wallace tree reduction.

### Course Outcome 6(CO6):

- 1. List the factors that affect the initial voltage difference in the DRAM bit lines during the read cycle of the memory circuit.
- 2. When the supply voltage is lowered, examine the influence of initial voltage difference in the bit lines during the read cycle?

### Course Outcome 7(CO7):

- 1. Explain the average power dissipation associated with each instruction sequence of instruction set for ILPA.
- 2. Describe the instruction ordering and operand ordering techniques used for reducing the power dissipation associated with software synthesis.

### **Concept Map**



**Power Dissipation in CMOS:** Sources of power dissipation, Physics of power dissipation in CMOS FET devices, leakage mechanism, leakage current in deep submicrometer transistors, low power VLSI design limits and issues. **Power Estimation:** Average power estimation techniques at logic level: probabilistic, statistical, Glitching power, Input vector compaction, Circuit level power estimation, Estimation of maximum power: Estimation of leakage current.

**Power Optimization:** Algorithm level, Logical level and Circuit level power Optimization techniques, Techniques for reducing power consumption in digital circuits, Low voltage circuit design techniques and multiple supply voltages. Low Power Static RAM Circuits: Reducing power consumption in static RAM: Memory cell, Bit lines, write driver circuit and sense amplifier circuits. Energy Recovery Techniques: Transistor channel RC model, Energy recovery circuit design, Partially reversible logic, Adiabatic Dynamic logic, Energy recovery in SRAM core and peripheral circuits. Synthesis and Software Design for Low Power: Sources of software power dissipation. Software power estimation, software power optimization, Co-design for low power.

### Learning Resources

- Kaushik Roy and Sharat Prasad, "Low Power CMOS VLSI Circuit Design", Wiley India, Reprint 2009.
- Gary Yeap, "Practical Low Power Digital VLSI Design", Kluwer, 1998.
- A.P. Chandrakasan and R.W. Broadersen, "Low Power Digital CMOS Design", Kluwer, 1995.
- Abdellatif Bellaouar, Mohamed. I. Elmasry, "Low Power Digital VLSI designs" Kluwer, 1995.
- Dimitrios Soudris, Chirstian Pignet, Costas Goutis, "Designing CMOS Circuits for Low Power", Kluwer, 2002.
- J.B. Kuo and J.H Lou, "Low voltage CMOS VLSI Circuits", Wiley, 1999.
- A. Wang, B. H. Calhoun and A. P. Chandrakasan, "Sub-threshold Design for Ultra Low-Power Systems", Springer, 2006.

Course C	ontents and Lecture Schedule		
Module	Торіс	No. of	COs
No.		Lectures	
1	Power Dissipation in CMOS		
1.1	Sources of power dissipation	1	CO1
1.2	Physics of power dissipation in CMOS FET devices	2	CO1
1.3	switching power and leakage power in deep submicrometer transistors	2	CO1
1.4	low power VLSI design limits and issues	1	CO1
2	Power Estimation		
2.1	Probabilistic techniques	2	CO2
2.2	Statistical techniques	2	CO2
2.3	Glitching power	1	CO2
2.4	Input vector compaction	1	CO2
2.5	Circuit level power estimation	2	CO3
2.6	Estimation of leakage current.	2	CO3
3.	Power Optimization		
3.1	Algorithm level power optimization	2	CO4
3.2	Logical level power optimization	2	CO4
3.3	Circuit level low power design	2	CO4
3.4	Reducing power consumption in digital circuits	2	CO4
3.5	Low voltage circuit design techniques and multiple supply	2	CO4
	voltages		
4	Low Power CMOS Circuits		
4.1	Reducing power consumption in static RAM: Memory cell	2	CO5

4.2	Bit lines, write driver circuits	2	CO5
4.3	Sense amplifier circuits	2	CO5
5	Energy Recovery Techniques		
5.1	Transistor channel RC model	2	CO6
5.2	Energy recovery circuit design	2	CO6
5.3	Partially reversible logic	2	CO6
5.4	Adiabatic Dynamic logic	2	CO6
5.5	Energy recovery in SRAM core and peripheral circuits.	2	CO6
5	Synthesis and Software Design for Low Power		
5.1	Sources of software power dissipation	2	CO7
5.2	Software power estimation and software power optimization	2	CO7
5.3	Software co-design for low power	2	CO7
	Total Number of Hours	48	

### **Course Designers:**

- Dr. V. Vinoth thyagarjan
- Dr. V. R. Venkatasubramani
- Dr. S. Rajaram
- Dr. N.B. Balamurugan
- Dr. D. Gracia Nirmala Rani

vvkece@tce.edu venthiru@tce.edu rajaram\_siva@tce.edu nbbalamurugan@tce.edu gracia@tce.edu

SYLLABI FOR INDUSTRY SUPPORTED COURSES B.E. DEGREE PROGRAMME IN ELECTRONICS AND COMMUNICATION ENGINEERING ELECTRONICS AND COMMUNICATION ENGINEERING CADEMIC YEAR 2018-19 ONWARDS EDEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING (A Government Alded Autonomous Institution Affiliated to Anna University): MDURAL 625 015, TAMILMADU (A Government Alded Autonomous Institution Affiliated to Anna University): MDURAL 625 015, TAMILMADU		
SYLLABI FOR INDUSTRY SUPPORTED COURSES B.E. DEGREE PROGRAMME IN ELECTRONICS AND COMMUNICATION ENGINEERING FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2018-19 ONWARDS DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING (A Government ded Autonomous Institution Affiliated to Anna University) IMAGRAJAR COLLEGE OF ENGINEERING (A Government ded Autonomous Institution Affiliated to Anna University) IMAGRAJAR COLLEGE OF ANNUARDS		
FOR INDUSTRY SUPPORTED COURSES B.E. DEGREE PROGRAMME IN ELECTRONICS AND COMMUNICATION ENGINEERING ELECTRONICS AND COMMUNICATION ENGINEERING ACADEMIC YEAR 2018-19 ONWARDS DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING MADURAL - 625 015, TAMILNADU Madural - 625 015, TAMILNADU		SYLLABI
INDUSTRY SUPPORTED COURSES B.E. DEGREE PROGRAMME IN ELECTRONICS AND COMMUNICATION ENGINEERING ELECTRONICS AND COMMUNICATION ENGINEERING FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2018-19 ONWARDS DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING HIAGARAJAR COLLEGE OF ENGINEERING (A Government Aided Autonomous Institution Affiliated to Anna University) MADURAI – 625 015, TAMILNADU Phone : 0452 – 2482240, 41 Ex : 0452 24832427 Web : www.toe.edu		FOR
B.E. DEGREE PROGRAMME IN ELECTRONICS AND COMMUNICATION ENGINEERING FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2018-19 ONWARDS DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING MIAGARAJAR COLLEGE OF ENGINEERING (A Government Aided Autonomous Institution Affiliated to Anna University) MADURAI – 625 015, TAMILNADU Phone : 0452 – 2482240, 41 Fax : 0452 2483427 Web : www.toe.edu		INDUSTRY SUPPORTED COURSES
IN ELECTRONICS AND COMMUNICATION ENGINEERING ELECTRONICS AND COMMUNICATION ENGINEERING FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2018-19 ONWARDS DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING HIAGARAJAR COLLEGE OF ENGINEERING MADURAI – 625 015, TAMILNADU Phone: 0452 – 2482420, 41 Ex: 0452 2483427 Web: www.tce.edu		
IN ELECTRONICS AND COMMUNICATION ENGINEERING FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2018-19 ONWARDS DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING MAGARAJAR COLLEGE OF ENGINEERING MADURAI – 625 015, TAMILNADU MEN MEN MEN MEN MEN MEN MEN MEN MEN MEN		B.E. DEGREE PROGRAMME
ELECTRONICS AND COMMUNICATION ENGINEERING FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2018-19 ONWARDS DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING THIAGARAJAR COLLEGE OF ENGINEERING (A Government Aided Autonomous Institution Affiliated to Anna University) MADURAI – 625 015, TAMILNADU Phone : 0452 – 2482240, 41 Fax : 0452 2483427 Web : www.tce.edu		IN
FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2018-19 ONWARDS DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING HIAGARAJAR COLLEGE OF ENGINEERING (A Government Aided Autonomous Institution Affiliated to Anna University) MADURAI – 625 015, TAMILNADU Phone : 0452 – 2482240, 41 Fax : 0452 2483427 Web : www.tce.edu		ELECTRONICS AND COMMUNICATION ENGINEERING
FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2018-19 ONWARDS DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING HIAGARAJAR COLLEGE OF ENGINEERING (A Government Aided Autonomous Institution Affiliated to Anna University) MADURAI – 625 015, TAMILNADU Phone : 0452 – 2482240, 41 Fax : 0452 2483427 Web : www.tce.edu		
FOR THE STUDENTS ADMITTED IN THE ACADEMIC YEAR 2018-19 ONWARDS DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING HIAGARAJAR COLLEGE OF ENGINEERING (A Government Aided Autonomous Institution Affiliated to Anna University) MADURAI – 625 015, TAMILNADU Phone : 0452 – 2482240, 41 Fax : 0452 2483427 Web : www.tce.edu		
ACADEMIC YEAR 2018-19 ONWARDS DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING THIAGARAJAR COLLEGE OF ENGINEERING (A Government Aided Autonomous Institution Affiliated to Anna University) MADURAI – 625 015, TAMILNADU Phone : 0452 – 2482240, 41 Fax : 0452 2483427 Web : www.tce.edu		FOR THE STUDENTS ADMITTED IN THE
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING THIAGARAJAR COLLEGE OF ENGINEERING (A Government Aided Autonomous Institution Affiliated to Anna University) MADURAI – 625 015, TAMILNADU Phone : 0452 – 2482240, 41 Fax : 0452 2483427 Web : www.tce.edu		ACADEMIC YEAR 2018-19 ONWARDS
THIAGARAJAR COLLEGE OF ENGINEERING (A Government Aided Autonomous Institution Affiliated to Anna University) MADURAI – 625 015, TAMILNADU Phone : 0452 – 2482240, 41 Fax : 0452 2483427 Web : www.tce.edu	DEPART	MENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
MADURAI – 625 015, TAMILNADU Phone : 0452 – 2482240, 41 Fax : 0452 2483427 Web : www.tce.edu	(A Gov	THIAGARAJAR COLLEGE OF ENGINEERING ernment Aided Autonomous Institution Affiliated to Anna University)
Fax : 0452 2483427 Web : www.tce.edu		MADURAI – 625 015, TAMILNADU Phone : 0452 – 2482240, 41
		Fax : 0452 2483427 Web : www.tce.edu

18E	<b>C1</b>	A0
-----	-----------	----

Category	L	Т	Ρ	Credit
PEES	1	0	0	1

### Preamble

The advent of the Fifth Generation of Mobile Networks is creating a huge expectation in the enhancements of mobile services regarding higher throughput, low latency, ultra-high reliability, and higher connectivity density. The goal of field test is to determine the throughput and coverage that the 5G-range transceiver can achieve under real conditions. This course aims to provide solid foundation on basic understanding of RF test and measurements for 5G, base station RF parametric test, Interference troubleshooting, electromagnetic field measurements, Over the air test and Inter-RAT (Radio access technology).

### Prerequisite

NIL

### Course Outcomes

On the successful completion of the course students will be able to

CO#						Cour	se O	utcome	e Sta	temei	nt					Weig	htage
																in	%
CO1	Interpret RF test instruments, passive & active component test and											d	3	80			
	characterization																
CO2	Illus	Illustrate the base station test, EVM measurement, Interferen											erenc	e	3	0	
	troubleshooting with real time spectrum analysis																
CO3	Illustrate the EM field measurement test, OTA, Coverage test wit											th	4	0			
	phas	sed	arra	y an	tenn	a, Inte	er-R/	٩T									
CO Ma	pping	g wi	th C	DIO	) Cur	riculu	ım F	ramew	/ork								
CO	ר	ΓCE				Lea	<u>arnin</u>	g Dom	<u>ain L</u>	evel			С	DIO	С	urricula	ar
#	Prof	icier	псу		Cog	nitive		Affect	ive	Psyc	homo	tor		Com	pc	onents	
	S	cale	;				.							()	<u>( )</u>	<u>(.Z)</u>	
<u>CO1</u>		PS2	2		Unde	erstan	d	Respo	ond	-			<u>1.2.3,</u>	2.4.0	<u>,</u>	5.2.3	
CO2		PS3	3		A	oply		Value		Me	chanis	m	1.2.1, 2.1.1, 2			2.1.2, 2	2.4.2,
													2.4.6,	2.5.	1, : ว	3.1.1, 3	3.2.3,
<u> </u>												0400	24.2				
003		P 33	)		A	эріу		value		ivie	chanis	m	1.Z.1, 216	2.1.	1, 4 1 4	2.1.2,2	2.4.2,
													2. <del>4</del> .0, 4 5 5	2.5.	י, י כ	0.1.1, 0	5.2.5,
Маррі	na wi	th P	roa	ram	me C	Outco	mes	and P	roar	amm	e Spe	cific	Outco	omes	\$		
COs	PO	PC	)   P	0	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSC	<b>D</b>	PSO	PSO
	1	2	;	3	4	5	6	7	8	9	10	11	12	1		2	3
CO1	M	L		-	-	-	-	-	-	-	-	-	-	M		-	L
CO2	S	M			-	S	-	-	-	M	M	-	-	M		M	L
CO3	S				-	S	-	-	-	IVI	IVI	-	-	IVI		IVI	L
S- Stro	ong; ivi smon	I-IVIE	aiun	n; L-	LOW	itivo [	Jom	ain									
	unitiva			n. C	,ogiii 1000		2000	ment			leciu.	mer	nt	_	F	nd Se	mester
Le	vels		00		T	ests		mont		,	looigi					Exami	nation
		F	1			2		3		1	2		3				
Remer	mber		-			-		-			-		-			(	)
Under	stand		-			-		20	20 20				0				

80

-

\_

-

-

\_

-

-

\_

-

-

\_

-

\_

Apply

Analyze

Evaluate

Create

80

-

\_

-

80

0

0

0

**RF concepts and understanding of RF Test & RF Instruments** -Frequency vs Time domain analysis - testing active and passive devices **Base station RF Parametric Test** - Performance verification of gNB such as cable and antenna conditions, transmit power, RF spurious responses. **Interference troubleshooting with Real time Spectrum Analysis** - Detect 5G synchronization signals and interference with RTSA, EVM measurement, detection of SSB offset, subcarrier spacing. **Electromagnetic Field Measurement for total human RF exposure** - Measurement of total field strength, Pass/fail limit testing. **5G NR Over the air testing** - Capturing and demodulating over-the-air transmissions of 5G NR FR1 and FR2 control channels, key performance indicators, isolate power issues **Coverage test with phased array antenna** - Coverage testing of 5G base stations, collecting signal power data across azimuth and elevation. **Inter-RAT (Radio access technology) optimization** - RAT handovers between 4G and 5G networks in non-standalone (NSA) mode.

### Learning Resources

- Joel P. Dunsmore, Handbook of Microwave Component Measurements: with Advanced VNA Techniques, 2nd Edition, Wiley, 2020.
- Carvalho N, Schreurs D, Microwave and Wireless Measurement Techniques, Cambridge University Press, 2013.
- Allen W. Scott, Rex Frobenius, RF Measurements for Cellular Phones and Wireless Data Systems, Wiley-IEEE Press, 2011.

•	Richard Collier,	Doug Skinner	, Microwave	Measurements,	Third edition,	IET,	2007.

### **Course Contents and Lecture Schedule**

No.	Торіс	No. of Hours	COs
1.	RF concepts and basic understanding of RF Test & RF	2	CO1
	<b>Instruments</b> -Frequency vs Time domain, spectrum analysis		
2.	Testing active and passive devices, time domain analysis.	2	CO1
3.	Base station RF Parametric Test - Performance verification	2	CO2
	of gNB such as cable and antenna conditions, transmit power,		
	RF spurious responses.		
4.	Interference troubleshooting with Real time Spectrum	2	CO2
	Analysis - Detect 5G synchronization signals and interference		
	with RTSA, EVM measurement, detection of SSB offset,		
	subcarrier spacing		
5.	Electromagnetic Field Measurement for total human RF	1	CO3
	exposure - Measurement of total field strength, Pass/fail limit		
	testing.		
6.	5G NR Over the air testing - Capturing and demodulating	2	CO3
	over-the-air transmissions of 5G NR FR1 and FR2 control		
	channels, key performance indicators, isolate power issues.	0	000
1.	Coverage test with phased array antenna - Coverage testing	2	CO3
	of 5G base stations, collecting signal power data across		
		0	000
8.	Inter-RAT (Radio access technology) optimization - RAT	2	CO3
	nandovers between 4G and 5G networks in non-standalone		
		15	
	I Otal Hours	IJ	

### Course Designers:

• Mr.Ranganath Kumar, AcademicTechnical Consultant, ELMACK Engg. Services.

- Dr.S.Kanthamani, skmece@tce.edu
- Dr.K.Vasudevan, kvasudevan@tce.edu
- Dr.B.Manimegalai, naveenmegaa@tce.edu

18EC1B0 DEEP LEARNING WITH TENSORFLOW	Category	L	Т	Ρ	Credit	
	TENSORFLOW	PEES	1	0	0	1

### Preamble

Deep Learning has received a lot of attention over the past few years and has been employed successfully by companies like Google, Microsoft, IBM, Facebook, Twitter. Recent developments in deep learning approaches have significantly advanced the performance of many computer vision applications. This course is a deep dive into the details of deep learning architecture with a focus on learning end-to-end models for the image classification task. Students will gain a detailed understanding of neural networks and will learn to implement and train their neural networks.

### Prerequisite

NIL

### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage						
CO1	Illustrate the design of deep neural network architecture.	20						
CO2	Explore an entire TensorFlow deep learning pipeline.	25						
CO3	Construct the design of convolutional neural network architecture.	25						
CO4	Make use of the Alexnet deep convolutional model for image	30						
	classification.							

### CO Mapping with CDIO Curriculum Framework

CO	TCE	Learn	ing Domair	CDIO Curricular	
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale	-			(X.Y.Z)
CO1	TPS2	Understand	Respond	-	1.3, 2.4.6
CO2	TPS3	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2, 4.5.3
CO3	TPS3	Apply	Value	-	1.3, 3.2.4
CO4	TPS3	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2, 4.5.3

Mappi	Napping with Programme Outcomes and Programme Specific Outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Μ	L	-	-	-	-	-	-	L	-	-	Μ	L	L	L
CO2	S	Μ	L	-	Μ	-	-	-	М	-	-	Μ	М	L	М
CO3	S	М	L	-	Μ	-	-	-	Μ	-	-	Μ	М	L	Μ
CO4	S	М	L	-	Μ	-	-	-	Μ	-	-	Μ	М	L	Μ

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Con	tinuous Assessme		End Semester Examination			
Remember		0			0		
Understand		20			20		
Apply		80		80			
Analyse		0		0			
Evaluate		0			0		
Create		0			0		
Assessment Pattern:	Psychom	otor					
Psychomotor Skill							
Perception		-	-		-		
Set		-	-				

Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

**Learning Paradigms:** AI, Deep learning, ANN, Designing a Deep Neural Network, Architecture with one hidden layer, Loss function **Tensor flow and its elements:** Running a simple TensorFlow net and establishing a baseline, Improving the simple net in TensorFlow with hidden layers and Dropout, Testing different optimizers in TensorFlow, Increasing the number of epochs, Controlling the optimizer learning rate **Convolutional Neural Network:** CNN Architecture: Convolution, Stride, and padding in convolutional layers, Pooling layers, FCN, activation function, Pooling layers, Normalization, FCN, CNN for classification: Training, Testing, Validation **Deep Convolutional Model:** Alexnet Architecture, Anchor boxes, Loss functions **Case Study:** Alexnet based Image classification by Transfer learning with TensorFlow.

### Learning Resources

- Ian Goodfellow, Yoshua Benjio, Aaron Courville, "Deep Learning", The MIT Press, 2016.
- Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", John Wiley. 2<sup>nd</sup> Edition, 2007.
- Dr.Prabir Kumar Biswas, Deep Learning, NPTEL Video Lectures: https://nptel.ac.in/courses/106/105/106105215/
- https://www.coursera.org/specializations/deep-learning
- https://online.stanford.edu/courses/cs230-deep-learning

### **Course Contents and Lecture Schedule**

Mod.	Торіс	No. of	COs
No.		Hours	
1.	Learning Paradigms:		CO1
1.1	AI, Deep learning, ANN, Designing a Deep Neural Network: Neural	1	CO1
	Networks, Architecture with one hidden layer		
1.2	Activation function, Derivatives, Gradient Descent, Batch size,	1	CO1
	Scaling features, number of epochs, Optimization, Hyperparameters		
	tuning		
1.3	Batch Normalization, Drop out, Learning rate, Loss function,	1	CO1
	choosing the loss function: Regression loss (MSE), Binary		
	classification loss and Multi-classification loss (Cross entropy)		
2.	Simple neural network using TensorFlow:		CO2
2.1	Running a simple TensorFlow net and establishing a baseline	1	CO2
2.2	Improving the simple net in TensorFlow with hidden layers and	1	CO2
	Dropout		
2.3	Testing different optimizers in TensorFlow	0.5	CO2
2.4	Increasing the number of epochs, Controlling the optimizer learning	0.5	CO2
	rate		
3.	Convolutional Network		CO3
3.1	CNN Architecture: The structure of a convolutional network:	2	CO3
	Convolution,		
3.2	Stride and padding in convolutional layers, activation function,	1	CO3
	Pooling layers, Normalization, FCN		
3.3	CNN for classification: Training, Testing, Validation	1	CO3
4.	Deep Convolutional Model – Alexnet		CO4

4.1	Anchor boxes, Ground Truth Anchor boxes, Loss functions	0.5	CO4
4.2	Alexnet Model Architecture	1.5	CO4
4.3	Case Study: Alexnet based image classification	1	CO4
4.4	Image classification by Transfer learning with TensorFlow	1	CO4
Course	Designers:		

### Course Designers:

•	Dr. D.Antony Louis Piriyakumar	antony@piriyakumar.co.in
	Indian patent agent, Founder director – BudhiAI	(Gol recognized Startup)

- Dr.S.Md.Mansoor Roomi ٠
- Dr.R.A.Alaguraja
- Dr.B.Yogameena
- Dr.B.Sathyabama

- smmroomi@tce.edu alaguraja@tce.edu ymece@tce.edu
- sbece@tce.edu

### 18EC1C0

### SYNCHRONISATION IN 5G NEW RADIO

Category	L	Т	Ρ	Credit
PEES	1	0	0	1

### Preamble

The objective of the course on "Synchronization in 5G New Radio" is to present the synchronisation signals, algorithms and their hardware realisation in the physical layer of 5G new radio standards. This course would be more helpful in carrying out projects in state of art telecommunication domains

### Prerequisite

18EC530 - Analog and Digital Communication Systems

### Course Outcomes

On the successful completion of the course, students will be able to

CO#	Course Outcome Statement										
		in %									
CO1	Describe the	20									
CO2	Design frequ	uency and timin	g estimatio	n algorithms for	initial access and	30					
	synchroniza	tion features of	5G NR								
CO3	Describe th	e architecture	and progr	ramming capat	oilities of Analog	20					
	devices Adam Pluto Software Defined Radio (SDR) Platform										
CO4	Implement 5G NR Synchronization Signal Block on Pluto Software										
	Defined Radio (SDR) Platform										
CO Mapping with CDIO Curriculum Framework											
CO	TCE	Learn	ing Domain	Level	CDIO Curricular						
#	Proficiency	Cognitive	Affective	Psychomotor	Compone	ents					
	Scale				(X.Y.Z	<u>(</u> )					
CO1	TPS2	Understand	Respond	-	1.2.3, 2.4.6, 3.2.3	3					
CO2	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.4.2,						
					2.4.6, 2.5.1, 3.1.1	I, 3.2.3,					
		4.5.5, 4.6.2									
CO3	TPS2	Understand	Respond	-	1.2.3, 2.4.6, 3.2.3	3					
CO4	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.4.2,						
					2.4.6, 2.5.1, 3.1.1	I, 3.2.3,					

# Mapping with Programme Outcomes and Programme Specific Outcomes

mappi	happing with rogramme outcomes and rogramme opecine outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	М	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO4	S	М	L	-	S	-	-	-	S	S	-	-	Μ	Μ	L

S- Strong; M-Medium; L-Low

Assessment	Pattern:	Cognitive	Domain

Cognitive Levels	Continuous Assessment Tests				Assignme	End Semester Examination				
	1	2	3	1	2	3				
Remember	-	-	-	-	-	-	0			
Understand	-	-	20	-	-	20	20			
Apply	-	-	80	-	-	80	80			
Analyze	-	-	-	-	-	-	0			

Passed in BoS Meeting 22.06.2021

Evaluate	-	-	-	-	-	-	0
Create	-	-	-	-	-	-	0

5G NR overview: 5G NR Features, protocol stack, physical signals and procedures Synchronization in 5G NR: Synchronisation Signals and Algorithms Pluto SDR Platform: Architecture and Programming capabilities Hardware realization: Implementation of 5G NR SSS on Pluto SDR platform with near real time update of PSS, SSS and PBCH

### Learning Resources

- Sassan Ahmadi, "5G NR Architecture, Technology, Implementation, and operation of • 3GPP New Radio Standards", Academic Press, 2019.
- Erik Dahlman, Stefan Parkvall, Johan Skold, "5G NR, The Next Generation Wireless Access Technology", Academic Press, 2018.
- 3GPP TS 23.502, Procedures for the 5G system (Release 15), April 2019.
- 3GPP TS 38.211, NR, Physical Channels and Modulation (Release 15), December 2018.
- 5G New Radio, ShareTechNote. http://www.sharetechnote.com
- https://www.analog.com/en/design-center/evaluation-hardware-and-software/evaluationboards-kits/adalm-pluto.html
- Xinggin Lin et al.,"5G New Radio: Unveiling the Essentials of the Next Generation Wireless Access Technology", IEEE Communications Standards Magazine, September 2019.

### A.Omri et al., "Synchronization Procedure in 5G NR Systems", IEEE Access, April 2019. **Course Contents and Lecture Schedule**

No.	Торіс	No. of	COs
		Hours	
1	5G Overview		
1.1	5G NR Features and comparison with 4G features	1	CO1
1.2	Protocol stack	1	CO1
1.3	Physical signals and procedures	1	CO1
2	Synchronization in 5G NR		
2.1	Synchronization Signals and Algorithms	2	CO2
3	Adam Pluto SDR Platform		
3.1	Architecture of Pluto SDR Platform	3	CO3
3.2	Programming	3	CO3
4	Hardware Realization		
4.1	Implementation of 5G NR SSB on Pluto SDR platform with near real time update of PSS, SSS	2	CO4
4.2	Implementation of 5G NR SSB on Pluto SDR platform with near real time update of PBCH	2	CO4
Total		14	

### **Course Designers:**

Ms.S.Prathima

- Mr.Amarnadha Reddy
- amrar@lekhawireless.com
- prathima.s@lekhawireless.com
- sitece@tce.edu Dr.S.J. Thiruvengadam
- Dr.M.N.Suresh

•

Dr.G.Ananthi

- mnsece@tce.edu
- gananthi@tce.edu

18	FC1	
10	EUI	DU

Category	L	Т	Ρ	Credit
PEES	1	0	0	1

### Preamble

This course introduces the theory and implementation of modern Automatic Speaker Recognition (ASR) system. It presents a comprehensive overview of feature extraction, acoustic modeling and data modeling. Students will learn how to simulate and implement machine learning algorithms such as Hidden Markov Models and Deep Neural Networks in ASR. This course also extends its applications to Speech to Text and Text to Speech Systems. **Prerequisite** 

18EC440 – Signal Processing

### Course Outcomes

On the successful completion of the course, students will be able to

CO#	Course Outcome Statement											Weig	ghtage		
												ir	n %		
CO1	Des	cribe	the b	asic a	archite	ecture	of A	SR, 1	ext to	o Spe	ech (	TTS)	and		20
	Natu	iral La	angua	ge Pro	ocess	ing.									
CO2	Estimate and optimize the single variable and multivariable function											ction	2	20	
	using probability, calculus and optimization primer.														
CO3	Classify data and training methods based on different ASR system											stem	3	30	
	model using kaldi toolkit														
CO4	Dev	elop d	liffere	nt app	licatio	on of A	ASR s	system	ı base	ed on	Weigł	nted F	inite	3	30
	Stat	e Tra	nsduo	cer (V	VFST	) and	Lon	g Sh	ort-Te	rm N	lemor	y (LS	TM)		
	neur	al net	works	6											
CO Mapping with CDIO Curriculum Framework															
CO	T	CE			Learn	ing D	omair	Leve				CDIC	) Curr	icular	
#	Profi		y   C	Cognit	ive	Affe	Affective   Psychomotor				Components				
0.01	S		<u> </u>	(X.Y.Z)								)	0.4.0		
CO1		-52		Understand   Respond   -   1.2., 2.1.1, 2.1.2,							2.4.1,	2.4.2,			
<u> </u>		202		Ann	2.4.5, 5.2.5, 5.2.5						), 1 0	214			
	11	-00		Арр	iy	valu	е	ivie	chans	5111	1.2.1, 2.1.1, 2.				2.1.4,
											2.1.0, 2.2.2	2.4.	Ι, Ζ.	. <b>4</b> . <b>∠</b> ,	2.4.5,
CO3		063		۸nn	hy.	Valu	0	Mo	chanie	m	<u>3.2.3,</u> 1 2 1	<u> </u>	1 2	12	211
005	''	00		πрр	iy	vaiu	C		Ghana	5111	1.2.1, 215	2.1.	1, Z. 1 2	Δ2	2.1.4, 245
											323	325	I, Z.	. <b></b> ,	2.4.0,
CO4	Т	PS4		App	lv	Valu	e	Me	chanis	sm	<u>121</u>	21	1 2	12	213
		•••									4.1.	2.4.2.			
												3.2.5	), ),	,	
Mappi	pping with Programme Outcomes and Programme Specific Outcomes														
COs	PO	PO	PO	PO	PO	PO	Ρ	PO	PO	PO	PO	PO	PS	PS	PSO
	1	2	3	4	5	6	07	8	9	10	11	12	01	02	3
CO1	Μ	L	-	-	-	-	-	-	-	-	-	L	L	-	-
CO2	S	Μ	L	-	L	-	-	-	-	-	-	L	M	-	-
CO3	S	Μ	L	-	Μ	-	-	Μ	Μ	Μ	-	L	M	-	Μ
CO4	S	Μ	L	-	Μ	-	-	S	S	S	-	L	Μ	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain										
Cognitive Levels	Continuous Assessment Tests	Assignment	End Semester Examination							
	1	1								
Remember	0	0	0							
Understand	20	0	20							
Apply	60	50	60							
Analyse	20	0	20							
Evaluate	0	0	0							
Create	0	0								
Assessment Pa	attern: Psychomotor									
Psychomotor	r Skill	Assi	Assignment-1							
Perception			-							
Set			-							
Guided Resp	onse		-							
Mechanism			50							
Complex Ove	ert Responses		-							
Adaptation			-							
Origination			-							
0										

Speech Fundamentals: parametric modeling of quasi-stationary speech signal, Human speech production and perception mechanism, Feature extraction from speech signal: Mel-Frequency Cepstral Coefficient (MFCC), Linear Prediction Cepstral Coefficient (LPCC), natural language processing (NLP) systems. Basics of ASR and TTS: Evolution of ASR, Vector Quantization (VQ), Dynamic Time Warping (DTW), Hidden Markov Model (HMM), Deep Neural Network (DNN), Recurrent Neural Network (RNN), Evolution of TTS: concatenative phoneme-based model, HMM based model, Tacotron models, Vocoders for TTS. Estimation of Single and Multivariable: Probability Primer, Calculus and Optimization primer **Components of an ASR system:** Lexicon model, Language model, Acoustic model, context dependency model. Data Preparation and ASR Training: Monophone training, Triphone training, Maximum Linear transform, speaker adaptive training and DNN Training. Weighted finite state transducers: Types of WFST, Operations of WFST, Practical Implementation of ASR using WFST in Kaldi. ASR code walk through Applications of ASR: Text aligning, subtitling, pronunciation learning, Text to speech systems, Text Processing and NLP system building: word2Vec models, Internet classification, Finite state machines for chatbot modeling.

### Learning Resources

- L. R. Rabiner and R. W. Schafer, "Introduction to Digital Speech Processing", now Publishers Inc.,2007
- L. R. Rabiner and B. H. Juang, "Fundamentals of Speech Recognition". Prentice-Hall
- Dong Yu, and Li Deng, "Automatic Speech Recognition: A Deep Learning Approach" Springer, 2014
- https://kaldi-asr.org
- https://indianinstituteofsciencemy.sharepoint.com/:f:/g/personal/madhavaraja iisc ac in/EoGNtOQA7TIHi9-Yh4Kch94BQkVQlQyg0E6nbLCDBdxKGg?e=1CUkxv

No.	Торіс	No. d	of	COs
		Lecture	s	
1	Speech Fundamentals			
1.1	parametric modeling of quasi-stationary speech signal, Human	1		CO1
	speech production and perception mechanism			

### Course Contents and Lecture Schedule

1.2	Feature extraction from speech signal: Mel-Frequency Cepstral Coefficient (MFCC), Linear Prediction Cepstral Coefficient (LPCC), natural language processing (NLP) systems.	1	CO1
1.3	Basics of ASR and TTS: Evolution of ASR, Vector Quantization (VQ), Dynamic Time Warping (DTW),	1	CO1
1.4	Hidden Markov Model (HMM), Deep Neural Network (DNN), Recurrent Neural Network (RNN), Evolution of TTS: concatenative phoneme-based model, HMM based model, Tacotron models, Vocoders for TTS.	1	
2	Estimation of Single and Multivariable		
2.1	Probability Primer	1	CO2
2.2	Calculus and Optimization primer	1	CO2
3	Components of an ASR system	4	
3.1	Lexicon model, Language model, Acoustic model, context dependency model.	1	CO3
3.2	Data Preparation and ASR Training: Monophone training, Triphone training, Maximum Linear transform, speaker adaptive training and DNN Training.	1	CO3
3.3	Practical Implementation of ASR, Kaldi ASR code walk-through	1	CO3
4	Weighted finite state transducers:		
4.1	Types of WFST, Operations of WFST: Composition, Minimization, epsilon-removal, projection, weight pushing.	1	CO4
4.2	Practical Implementation of ASR using WFST in Kaldi, ASR code walk through	1	CO4
5	Applications of ASR		
5.1	Text aligning, subtitling, pronunciation learning	1	CO4
5.2	Text to speech systems	1	CO4
5.3	Text Processing and NLP system building: word2Vec models, Internet classification	1	CO4
5.4	Finite state machines for chatbot modeling	1	CO4
	Total	15	

### Course Designers:

• Dr.A.Madhavaraj, PDRF, IISC Bangalore, Founder, IndiaSpeaks Technologies, madhavaraja@iisc.ac.in

- Dr.S.J.Thiruvengadam , Professor and Dean (Academics Process), ECE Department, TCE, sjtece@tce.edu
- Dr.P.G.S.Velmurugan, Assistant Professor, ECE Department, TCE, pgsvels@tce.edu
- Dr K.Rajeswari, Assistant Professor, ECE Department, TCE, rajeswari@tce.edu

18EC1E0

### VLSI IMPLEMENTATION OF COMMUNICATION TRANSCEIVERS

Category	L	Т	Ρ	Credit
PEES	1	0	0	1

### Preamble

This course integrates VLSI architecture theory and algorithms for the implementation of communication transmitter and receiver. with low power consumption. This course also deals with the design of high-speed, low-area, and low-power VLSI systems for the implementation of communication systems. It covers pipelining and parallel processing architectures extensively as well as the concepts of PLL.

### Prerequisite

NIL

### Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in
		%
CO1	Explain the concept of RTL coding and Canonical Signed Digit	20
	representation	
CO2	Implement DSP algorithms using the concepts of pipelining and	40
	parallel architectures	
CO3	Implement FM transceiver, using the digital filters and PLL	40

### CO Mapping with CDIO Curriculum Framework

CO		TCE		Learning Domain Level							CDIO Curricular Components					
#	Pro	oficier	ncy	Cogi	nitive	Af	fectiv	e I	Psych	0			(X.Y.Z)			
		Scale	:						motor	r						
CO1		TPS3	5	Ap	oply	Va	ue		-	1	.2.1, 2	2.1.1, 2.1.2, 2.1.4, 2.1.5,				
										2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,					.2.5,	
CO2		TPS3		Ap	oply	Va	lue		-	1	.2.1, 2	2.1.1, 2	2.1.2, 2	2.1.4, 2	.1.5,	
										2	.4.1, 2	2.4.2, 2.4.5, 3.2.3, 3.2.5,				
CO3		TPS3		Ap	oply	Va	ue		-	1	.2.1, 2	2.1.1, 2	2.1.2, 2	2.1.3, 2	.1.4,	
										2	.1.5, 2	2.4.1, 2	2.4.2, 2	2.4.5, 3	.2.3,	
					<b>A</b> 11					3	.2.5.	<b>A</b> 1				
Mappi	ng wi	th Pro	ogra	mme		omes	and	Prog	ramm	le Sp	ecitic	Outc	omes			
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO	
<u> </u>	1		3	4	5 M	Ö	1	Ö	9	10	11	12	1		3	
	3 9					-	-	-	-	-	-	-			-	
CO2	<u>S</u>	M		M	M	-	-	-	-	-	-	-	M		-	
S- Stro	na M		ium:		/	ļ -	-	-	1 -	-	1-	-	111		-	
Asses	smen	t Pat	tern:	Coan	itive	Dom	ain									
Cognit	tive L	evels	; ;	(	Conti	nuou	s Ass	sessr	nent <sup>-</sup>	Tests	;		End S	emeste	ər	
												Examination				
Remer	nber						C	)						0		
Under	stand			20									20			
Apply	Apply 80								80							
Analys	se															
Evalua	ate															
Create	Create															
Assessment Pattern: Psychomotor																
Psyc	home	otor S	Skill			Ass	signm	nent-	1	Ass	ignme	ment-2 Assignment-3				
Perc	eptior	1					-				-			-		
Set					1		-									

Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

**Communication Transceivers:** introduction to communication receiver and transmitter, **Case study:** FM Transceiver with specific focus on digital filters and PLL. **Digital Design:** RTL Coding, the concepts of digital synthesis. **Examples of digital FIR filters:** RTL coding, synthesis and FPGA implementation. **Digital filters – architectures:** Pipelining of FIR digital filters, Parallel architecture, Canonical Signed Digit (CSD) implementation, Multi-rate filters – low power implementation, ALU-RAM based digital filter implementation. **PLL Basics:** Introduction - Applications in a Communication Transceiver, Integer and Fractional PLLs, Analog vs digital PLL-Tradeoffs, PLL metrics –Response time, Noise bandwidth, 1st and 2nd order PLL analysis, performance, **PLL advanced:** Specifications of PLL, Phase Noise, Reference Spurs, Phase noise in open loop and closed loop, PLL Phase noise contributors, **Building blocks:** VCO, PFD, TDC, Laboratory practices on Basic digital FIR filter FPGA emulation, Digital PLL on FPGA, ALU-RAM based multi-rate digital filter

### Learning Resources

- PLL Performance, Simulation and Design Handbook 4th Edition, National Semiconductor, http://www.national.com/analog/timing/pll\_designbook
- K K Parhi, "VLSI Digital Signal Processing Systems', Wiley India Pvt Ltd, 2007,
- B Razavi, "RF Microelectronics", Prentice Hall, 1998

### **Course Designers:**

- Mr.Sundarrajan, Texas Instruments
- Dr.N.B.Balamurugan, nbbalamurugan@tce.edu
- Dr.S.Rajaram, rajaram\_siva@tce.edu
- Dr.V.Vinoth Thyagarajan, vvkece@tce.edu
- Dr D.Gracia Nirmala Rami, gracia@tce.edu
- Dr.V.R.Venkatasubramani, venthiru@tce.edu
| 18EC1 | F0 |
|-------|----|
|-------|----|

EMBEDDED SYSTEM DESIGN

Category	L	T	P	Credit
PEES	1	0	0	1

#### Preamble

Microcontrollers are at the heart of almost every engineering system around us. It is essential that an applications engineer is equipped with the knowledge to understand and design an embedded system. This course provides insight on the key components of a microcontrollerbased system, focusing on the core peripherals and their interfacing to develop a complete solution. The course aims to bring a hands-on experience to developing firmware on a microcontroller using the latest IDEs and programming/debugging tools.

# Prerequisite

NIL

# Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage
		in %
CO1	Explain the architecture of PIC devices, AVR devices and the working	10
	of essential peripherals	
CO2	Develop embedded-c code for various peripherals	40
CO3	Use low power techniques, linking, compilation and start-up process	10
CO4	Implement a complete system by interfacing various peripherals, using	40
	latest development tools	

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	Learning	g Domain L	evel	CDIO Curricular Components
#	Proficiency	Cognitive	Cognitive Affective		(X.Y.Z)
	Scale	_		motor	
CO1	TPS3	Understand	Respond	-	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5,
					2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO2	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5,
					2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO3	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5,
					2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO4	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.3, 2.1.4,
					2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3,
					3.2.5.

# Mapping with Programme Outcomes and Programme Specific Outcomes

															(
COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Μ	L	L	L	Μ	-	-	-	-	-	-	-	L	L	-
CO2	S	Μ	L	L	Μ	-	-	-	-	-	-	-	М	L	-
CO3	S	Μ	L	Μ	Μ	-	-	-	-	-	-	-	М	L	-
CO4	S	Μ	L	Μ	Μ	-	-	-	-	-	-	-	М	L	-

S- Strong; M-Medium; L-Low

#### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests	End Semester Examination		
Remember	0	0		
Understand	20	20		
Apply	80	80		
Analyse	-	-		
Evaluate	-	-		
Create	-	-		

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

#### **Syllabus**

Introduction: Architecture Overview: AVR and PIC, 8-bit and 32-bit MCUs

Essential peripherals: Introduction to basic MCU peripherals and their purpose, Clocks, GPIOs, Timer and Counter, Waveform Generation (PWM), Lab-1, Serial Communication: Universal Asynchronous Receiver Transmitter (UART), Two Wire Interface (I2C), Lab-2

Low power design techniques: Sleep modes, Event System, Factors affecting low power, Lab-3, Hardware design considerations

Moving the design from concept to reality: Ecosystem (Development Tools), From Embedded-C to Microcontroller, Home Automation – Putting together a real-world application Learning Resources

- I2C(Master):http://ww1.microchip.com/downloads/en/AppNotes/00002480A.pdf
- I2C(Slave):http://ww1.microchip.com/downloads/en/AppNotes/atmel-2565-using-the-twimodule-as-i2c-slave applicationnote avr311.pdf
- USART: http://ww1.microchip.com/downloads/en/AppNotes/Atmel-1451-Using-the-AVR-USART-on-tinyAVR-and-megaAVR-devices ApplicationNote AVR306.pdf
- Efficient C coding for VR:http://ww1.microchip.com/downloads/en/AppNotes/doc1497.pdf •
- Low power techniques: http://ww1.microchip.com/downloads/en/AppNotes/00002515B.pdf
- Muhammad Ali Mazidi, The AVR microcontroller and embedded systems using assembly and C, Pearson Education, 2011.
- Ajay V. Deshmukh, Microcontrollers Theory and applications, TMH Publication, 2005.
- Fernando E. Valdes Perez, Microcontrollers-Fundamentals and applications with PIC, CRC Press, 2009.

#### **Course Designers:**

- Mr. Sanjyot Katti Manager, Corporate Applications, Sanjyot.Katti@Microchip.com
- Mr. Enoch Richbert, enochrichbert.jebakumar@micorchip.com
- Mr. Aniket Nigudkar, AniketChandrashekhar.Nigudkar@microchip.com •
- Dr.K.Hariharan, khh@tce.edu
- Dr M S K Manikandan, manimsk@tce.edu
- Dr.V.R. Venkatasubramani, venthiru@tce.edu



18ECGA0	CONSUMER ELECTRONICS	Category	L	Т	Ρ	Credit
		GE	3	0	0	3

# Preamble

This course aims to provide students to understanding the various electronic audio and video devices, smart office, digital home systems and automotive electronics systems.

# Prerequisite

# NIL

# Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage
Number		in %
CO1	Design the component value for cross over network	20
CO2	Describe various digital audio system.	10
CO3	Construct architecture of digital television system	20
CO4	Consturuct and Describe various display technologies and digital storage	20
CO5	Construct and Describe working principle and main feature of smart office and digital home systems	10
CO6	Construct automotive and consumer electronic circuits	20

# CO Mapping with CDIO Curriculum Framework

CO	TCE	Learn	ing Domain	Level	CDIO Curricular
#	Proficiency	Cognitive Affective I		Psychomotor	Components
	Scale				(X.Y.Z)
CO1	TPS2	Apply	Value	-	1.1.1, 2.1.5, 2.2.2, 2.3.1,
					4.4.3
CO2	TPS2	Understand	Respond	-	1.1.1, 2.1.5, 2.2.2, 2.3.1,
CO3	TPS2	Apply	Value	-	1.1, 2.1.5, 2.2.2, 2.3.1,
					4.4.3,
CO4	TPS2	Apply	Value	-	1.1, 2.1.5, 2.2.2, 2.3.1,
					4.4.3,
CO5	TPS2	Apply	Value	-	1.1, 2.1.5, 2.2.2, 2.3.1,
					4.4.3,
CO6	TPS3	Apply	Value	-	1.1.1, 2.1.5, 2.2.2, 2.3.1,
					4.4.3,

Марр	Mapping with Programme Outcomes and Programme Specific Outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	S	М	L	-	-	-	-	-	-	-	-	-	М	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	М	L	-	-	-	-	-	-	-	-	-	М	-	-
CO4	S	М	L	-	-	-	-	-	-	-	-	-	М	-	-
CO5	S	М	L	-	-	-	-	-	-	-	-	-	М	-	-
CO6	S	М	L	-	-	-	-	-	-	-	-	-	М	-	-

S- Strong; M-Medium; L-Low

Assessment H	Assessment Pattern: Cognitive Domain										
Cognitive Levels	Continu	ious Asse Tests	essment	As	signment	End Semester Examination					
	1	2	3	1	2	3					
Remember	0	0	0	0	0	0	0				
Understand	20	20	20	0	0	0	20				
Apply	80	80	80	100	100	100	80				
Analyse	0	0	0	0	0	0	0				
Evaluate	0	0	0	0	0	0	0				
Create	0	0	0	0	0	0	0				

# Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject/Assignment/Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	

#### Sample Questions for Course Outcome Assessment\*\*

# Course Outcome 1 (CO1):

- 1. Differentiate between Moving coil Microphone and Velocity Microphone.
- 2. An audio amplifier produces 20watt output across and 8 ohm resistance When a 5 millivolts signal is applied to its input across a 1 mega ohm resistor. Determine the decibel gain.
- 3. Design the component values for cross over network fs = 500 Hz and Z=8 ohms.

# Course Outcome 2 (CO2):

- 1. Differentiate SDTV and HDTV Standards.
- 2. List the components of digital TV System.
- 3. Explain set top box, DTH and Hometheatre system

# Course Outcome 3 (CO3):

- 1. Construct the Components of Digital audio player
- 2. Construct the format of internet audio and describe its function.
- 3. Construct the format of Digital media and describe its function.

# Course Outcome 4 (CO4):

- 1. Draw the hardware architecture of Digital Set top Box and explain its operation.
- 2. Construct the cable TV and cable TV in internet and explain the operation.

# Course Outcome 5 (CO5):

- 1. List the significance of LCD display and explain its operation
- 2. Construct the diagram of and describe the various addressing modes used in LED.
- 3. Construct the 3-D Display system and Describe its operation

# Course Outcome 6 (CO6):

- 1. Draw and explain the block diagram of a Telematics System and explain its operation.
- 2. Construct the In-vehicle Networking Applications and explain operation of Buses
- 3. Construct the block diagram of Automotive Software technologies for Implemented in a java-enabled device and explain its operation.



Analog Audio System: Microphones, their types: Carbon, velocity, crystal, condenser, cordless, Loud Speaker: Direct radiating, horn loaded woofer, tweeter, mid-range, multispeaker system, baffles and enclosures, Hi-Fi system, pre-amplifier, amplifier, Equalizer system, stereo amplifiers. Digital Audio System: Digital Audio player, storage audio formats, Internet Audio Formats, MP3 Portable Players, Internet Radio Digital Audio Radio Online Music Distribution, Digital Physical Media Formats. Digital Television System: Digital TV System and Standards, SDTV & HDTV System, MPEG-H, Hardware Architecture of a Digital Set-top Box, Home Theatre, DTH. Cable TV and Cable TV in internet and Digital Video Recorder. Digital Display System: Field Emission Displays, Organic LEDs, LCD, Plasma, Plasma Addressed LCD, and Liquid Crystal on Silicon, 3-D Displays, and Touchscreen standards. Digital Still Cameras, Digital Video/Versatile Disc. Smart Office & Digital Home Systems: Smart Phones and Screen phones, PDA, Smart Card Reader, Webcam, Broadband Networking and Residential Gateways. Automotive Electronics: Standards for In-vehicle Multimedia Electronics, Vehicle Area Network Bus, Car (or Controller) Area Networks, Auto SAR, Media-oriented Systems Transfer Technologies, Components of a Telematics System and Automotive Software Technologies

# Learning Resources

- Bali S.P, "Consumer Electronics", Pearson Education, 2008.
- The Digital Consumer Technology Handbook A Comprehensive Guide to Devices, Standards, Future Directions, and Programmable Logic Solutions by Amit Dhir, Xilinx Inc., Elsevier 2004.

Module No.	Торіс	No. of Hours	Course Outcome
1	Microphone & Loud Speaker System		
1.1	Microphones, their types: Carbon, velocity, crystal, condenser, cordless.	2	CO1
1.2	Loud Speaker: Direct radiating, horn loaded woofer,	1	CO1
1.3	tweeter, mid-range, multi-speaker system,	1	CO1
1.4	baffles and enclosures,	1	CO1

# **Course Contents and Lecture Schedule**

1.5   Hi-Fi system, pre-amplifier, amplifier	1	CO1
1.6 Equalizer system, stereo amplifiers	2	CO1
2 Digital Audio System		
2.1 Digital Audio player, storage audio formats, Interne	t 1	CO2
Audio Formats,	-	
2.2 MP3 Portable Players, Internet Radio Digital Audio	2	CO2
Radio Online Music Distribution		
2.3 Digital Physical Media Formats	1	CO2
2. Digital Television System	-	
3.1 Digital TV System and Standards, SDTV & HDTV	/ 1	CO3
System		
3.2 Hardware Architecture of a Digital Set-top Box,	2	CO3
3.3 Home Theatre, DTH.	2	
3.4 Cable TV and cable TV in internet and Digital Video	2	CO3
Recorder		
4 Digital Display System		
4.1 Field Emission Displays , Organic LEDs,	1	CO4
4.2 LCD, Plasma, Plasma Addressed LCD,	2	CO4
4.3 Liquid Crystal on Silicon, 3-D Displays ,	1	CO4
4.4 Touch-screen standards. Digital Still Cameras,	2	CO4
4.5 Digital Video/Versatile Disc	1	CO4
5 Smart Office & Digital Home Systems		
5.1 Smart Phones and Screen phone	1	CO5
5.2 PDA, Smart Card Reader,	1	CO5
5.3 Webcam, Broadband Networking and Residentia	1 2	CO5
Gateways		
6 Automotive Electronics		
6.1 Standards for In-vehicle Multimedia Electronics	1	CO6
6.2 Vehicle Area Network Bus, Car (or Controller) Area	a 2	CO6
Networks		
6.3 Media-oriented Systems Transfer Technologies	1	CO6
6.4 Components of a Telematics System and Automotive	2	CO6
Software Technologies		
Total No. of Hours	34	

# **Course Designers:**

• Mr.M.Senthilnathan msnece@tce.edu

18ECGB0	MULTIMEDIA SYSTEMS	Category	L	Т	Ρ	Credit
		GE	3	0	0	3

#### Preamble

Multimedia has become an indispensable part of modern computer technology. In this course, students will be introduced to principles and current technologies of multimedia systems. Issues in effectively representing, processing, and retrieving multimedia data such as sound and music, graphics, image and video will be addressed. Latest Web technologies will also be discussed.

# Prerequisite

NIL

# Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage***
Number		in %
CO1	Describe the standards for multimedia communication and networks	10
CO2	Represent multimedia data types - Text, Image, Audio and Video using digitization principles	15
CO3	Determine the performance parameters of text and image compression techniques	25
CO4	Analyze the compression ratio and data rate for Audio and video	30
CO5	Identify the need for different multimedia networks for the given applications	10
CO6	Determine the transport protocols of real time audio and video streaming applications	10

# CO Mapping with CDIO Curriculum Framework

CO	TCE	Learn	ing Domain	Level	CDIO Curricular Components
#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale	C C			
CO1	TPS2	Understand	Respond	-	2.1.1, 2.1.2, 2.4.2, 2.4.6,
					2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS2	Understand	Respond	-	2.1.1, 2.1.2, 2.5.1, 3.1.1,
					3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.5.1, 3.1.1,
		-			3.2.3, 4.5.5, 4.6.2
CO4	TPS4	Analyse	Organise	-	2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.1.3, 2.5.1
CO6	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.5.1

# Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO	PSO	PSO	PSO											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	Μ	L	-	-	-	-	-	-	-	-	-	-	L		
CO2	М	L	-	-	-	-	-	-	-	-	-	-	L		
CO3	S	Μ	L	-	L	-	-	Μ	Μ	М	-	-	М	L	L
CO4	S	S	Μ	L	L	-	-	M	Μ	М	-	L	М	L	L
CO5	S	М	L	-	-	-	-	M	Μ	М	-	-	М	L	
CO6	S	М	L	-	-	-	-	Μ	Μ	Μ	-	-	Μ		

S- Strong; M-Medium; L-Low

Cognitive Levels	Contir	uous Ass Tests	sessment		Assignme	End Semester Examination	
	1	2	3	1	2		
Remember	0	0	0	0	0	0	0
Understand	60	40	20	0	0	0	30
Apply	40	40	60	100	0	100	50
Analyse	0	20	20	0	100	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

# Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	the second second	-	-

# Sample Questions for Course Outcome Assessment

# Course Outcome 1(CO1):

- 1. Explain why a pair of modems is required to transmit a digital signal over a PSTN. With the aid of a diagram, show the location of the two modems when two digital devices communicate over a PSTN and the types of signal analog or digital -that are used over each part of the access circuit.
- 2. Explain why most data networks operate in a packet mode. Hence explain why services involving audio and video are supported.
- 3. With the aid of a diagram, explain the function of a telephony gateway in relation to internet telephony. Hence state the origin of the term "voice over IP" (VoIP).

# Course Outcome 2(CO2):

- 1. State the basic form of representation of: text, an image, audio, video. State the form of representation that is used when all are integrated together and give your reason.
- 2. State the aim of all broadcast television networks. With the aid of diagram, explain how additional services are provided with (i) a cable distributed network (ii) a satellite/ terrestrial broadcast network.
- 3. State the meaning of the term "dynamic range" as applied to an analog signal and show how this is expressed in decibels. How does this influence the number of bits to be used for the quantizer part of an ADC?

# Course Outcome 3(CO3):

1. Assuming a quantization threshold value of 16, derive the resulting quantization error for each of the following DCT coefficients:

127, 72, 64, 56, -56, -64, -72, -128.

2. Determine the encoded version of the following difference values which relate to the encoded DC coefficients from consecutive DCT blocks

3. Derive the binary form of the following run-length encoded AC coefficients: (0,6) (0,7) (3,3) (0,-1) (0,0)

Determine the Huffman-encoded version of the following difference values which relate to the encoded DCT coefficients from consecutive DCT blocks.

12.1.-2.0.-1

Use the default Huffman code words defined below:

Number of bits	Huffman
needed (SSS)	codeword

0	010
1	011
2	100
3	00
4	101
5	110
6	1110
7	11110
:	:
11	111111110

# Course Outcome 4 (CO4):

- 1. Derive the time to transmit the following digitized images at both 64kbps and 1.5 Mbps:
  - a 640 x 480 x 8 VGA-compatible image
  - a 1024 x 768 x 24 SVGA- compatible image.
- 2. Assuming the bandwidth of a speech signal is from 50Hz through to 10kHz and that of a music signal is from 15Hz through to 20 kHz, derive the bit rate that is generated by the digitization procedure in each case assuming the Nyquist sampling rate is used with 12 bits per sample for the speech signal and 16 bits per sample for the music signal. Derive the memory required to store a 10 minutes passage of stereophonic music.
- 3. Derive the scaling factors used for both the *U* and *V* (as used in PAL) and *I* and *Q* (as used in NTSC) colour difference signals in terms of the three *R*, *G*, *B* colour signals.

# Course Outcome 5 (CO5):

- 4. With the aid of the diagram, explain the principle operation of movie/Video- on- demand. Identify the bandwidth requirement associated with this type of application.
- 5. In relation to speech only interpersonal communications involving both public (PSTN/ISDN) and private (PBX) networks, with the aid of a diagram explain how voice mail and teleconferencing are supported. Include in your descriptions the role of a voice mail server and audio bridge.
- 6. Explain the role of an MCU in relation to a video conferencing session involving multiple geographically distributed video conferencing studios. Quantify the bandwidth implications of locating the MCU at one of the sites.

# Course Outcome 6(CO6):

- 4. Examine TCP state transition diagram to ensure reliable data transmission in Internet
- 5. How network layer limitations are overcome by transport layer protocols?
- 6. Identify and give a brief explanation of the four main functions performed by RTCP Concept Map



# Syllabus

**Multimedia communications:** Introduction, Multimedia information representation, Multimedia networks-telephone networks, data networks, broadcast television networks, integrated services digital networks, broadcast multiservice networks. Multimedia applications - interpersonal communications, interactive applications over the internet, entertainment application. Networking terminology- media types, communication modes, network types, network QoS, application QoS. Multimedia information representation: Digitization principles- analog signals, encoder design, decoder design. Text - unformatted text, formatted text, hypertext. Images- graphics, digitized documents, digitized pictures. Audio-PCM speech, CD quality audio, Video- Broadcast television. Text and image **compression:** Compression principles-source encoders and destination decoders, lossless and lossy compression, entropy encoding. Text compression- Huffman coding, Image compression – JPEG. Audio and video compression: Audio compression-differential pulse code modulation, adaptive differential PCM, adaptive predictive coding, linear predictive coding, code excited LPC, MPEG audio coders, Video compression - Principles, H.261, MPEG. Standards for multimedia communications: Reference models- TCP/IP reference model, protocol basics, Real time streaming transport protocols - RTP and RTCP, Standards relating to interpersonal communications-circuit mode networks, packet switched networks. Learning Resources

# Fred Halsall, "Multimedia Communications: Applications, Networks, Protocols and Standards", Addison-Wesley, 2012

- K. Rammohanarao, Z. S. Bolzkovic and D. A. Milanovic, "Multimedia Communication
- Ze-Nian Li and Mark S. Drew, "Fundamentals of Multimedia", Pearson Prentice Hall, October 2011.
- Yao Wang, Joern Ostermann, and Ya-Qin Zhang, "Video Processing and Communications", Prentice Hall, 2011.
- Stephen McGloughlin, "Multimedia: Concepts and Practice", November 2000, Prentice Hall, 2012

Module	Торіс	No. of	Course
No.		Hours	Outcome
1.	Multimedia communications		
1.1	Multimedia information representation, Multimedia networks-telephone networks, data networks	2	CO1
1.2	broadcast television networks, integrated services digital networks, broadcast multiservice networks.	1	CO1
1.3.	Applications: interpersonal and interactive applications over the internet, entertainment application	1	CO1
1.4	networking terminology- media types, communication modes, network types, network QoS, application QoS	2	CO1
2	Multimedia information representation		
2.1	Digitization principles- analog signals, encoder design, decoder design	2	CO2
2.2	Text - unformatted text, formatted text, hypertext	1	CO2
2.3	Images - graphics, digitized documents, digitized pictures	2	CO2
2.4	Audio - PCM speech, CD quality audio, Video - Broadcast television	2	CO2
3	Text and image compression		
3.1	Compression principles - source encoders and destination decoders, lossless and lossy compression, entropy encoding.	3	CO3
3.2	Text compression- Huffman coding	2	CO3
3.3	Image compression – JPEG	2	CO3

# Course Contents and Lecture Schedule

Approved in  $59^{\text{TH}}$  Academic Council Meeting 07.12.2019

4	Audio and video compression		
4.1	Audio compression-differential pulse code modulation, adaptive differential PCM	2	CO4
4.2	adaptive predictive coding, linear predictive coding, code excited LPC	2	CO4
4.3	MPEG audio coders	2	CO4
4.4	Video compression - Principles, H.261, MPEG	3	CO4
5	Standards for multimedia communications		
5.1	Reference models- TCP/IP reference model, protocol basics	2	CO6
5.2	Real time streaming transport protocols - RTP and RTCP	2	CO6
5.3	Standards relating to interpersonal communications- circuit mode networks, packet switched networks	3	CO5

# **Course Designers:**

- Dr MSK Manikandan manimsk@tce.edu
- Dr E Murugavalli murugavalli@tce.edu
- Dr S Ponmalar spmece@tce.edu



18ECGC0	TELECOMMUNICATION SYSTEMS	Category	L	Т	Ρ	Credit	
		GE	3	0	0	3	1

# Preamble

The objective of this course is to introduce the concepts of digital communication systems, satellite communication systems, Radio Detection and Ranging (RADAR) systems, Optical communication systems and wireless communication systems & Standards. In this course, mathematical techniques have been kept relatively at modest level, making it accessible to any discipline of Engineering.

Prerequisite

# NIL

# Course Outcomes

On the successful completion of the course, students will be able to

CO#	Course Outcome Statement	Weightage
		III 70
CO1	Describe a communication system model in terms of wavelength,	4004
	frequency, RF spectrum, modulation and demodulation, signal to	10%
	noise ratio, Decidel gain and loss ratios.	
CO2	Determine the communication system blocks in Digital	
	Communication, Radar Communication and Wireless	20%
	Communication Systems.	
CO3	Determine the signal to noise ratio (SNR) at the input of a digital	20%
	communication receiver and at the output of the detector.	2070
CO4	Determine a optical fiber communication link and the physical	200/
	structure and guiding properties of optical fibers.	20%
CO5	Determine the operation of Satellite communication system and	200/
	determine the SNR for both the uplink and downlink	20%
CO6	Describe the cellular concept of Wireless Communication Systems,	
	2G, 3G and 4G wireless standards for mobile communication, IEEE	10%
	802.11b, g Wireless Local area network (WLAN) standards.	

# CO Mapping with CDIO Curriculum Framework

CO	TCE	Lea	arning Dom	CDIO Curricular	
#	Proficiency	Cognitive	Affective	Psychomotor	Components
	Scale	-			(X.Y.Z)
CO1	TPS2	Understand	Respond	-	1.1.2, 2.3.1, 3.2.3
CO2	TPS3	Apply	Value	-	1.1.2, 2.3.1, 3.2.3
CO3	TPS3	Apply	Value	Guided Response	1.1.2, 2.3.1, 3.2.3
CO4	TPS3	Apply	Value	-	1.1.2, 2.3.1,2.3.2, 3.2.3
CO5	TPS3	Apply	Value	-	1.1.2, 2.3.1, 3.2.3
CO6	TPS2	Understand	Respond	-	1.1.2, 2.3.1, 3.2.3

Марр	Mapping with Programme Outcomes and Programme Specific Outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	М	L	-	-	-	-	-	L	L	L	-	L	S	-	L
CO2	S	М	L	М	-	-	-	L	М	М	-	L	S	-	L
CO3	S	S	М	М	-	-	-	L	М	М	-	L	S	L	L
CO4	S	S	М	М	-	-	-	L	М	М	-	L	S	L	L
CO5	S	S	М	М	-	-	-	L	М	М	-	L	S	L	L
CO6	М	М	L	L	-	-	-	L	L	L	-	L	S	-	L

S- Strong; M-Medium; L-Low Passed in BoS Meeting 16.11.2019

Assessment Pattern: Cognitive Domain											
Cognitive	A	Continu ssessmen	ous It Tests		Assignme	End					
Levels	1	2	3	1	2	3	Semester Examinatio				
							n				
Remember	20	20	20	0	0	0	20				
Understand	20	20	20	40	40	40	20				
Apply	60	60	60	60	60	60	60				
Analyse	0	0	0	0	0	0	0				
Evaluate	0	0	0	0	0	0	0				
Create	0	0	0	0	0	0	0				

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	30	30
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation		-	-
Origination		-	-

# Sample Questions for Course Outcome Assessmen

# Course Outcome 1 (CO1):

- 1. Draw the block diagram of a simplified model of a communication system
- 2. Define the term co channel interference and adjacent channel interference.
- 3. What are the re-use factors for the wireless standards namely AMPS, GSM and IS-95 systems?

# Course Outcome 2 (CO2):

1. A communication system has the following parameters:

 $P_t = 5W, G_t(dB) = 13dB, G_t(dB) = 17dB d = 80 km f = 3 GHz$ 

Determine the value of the receiver power using Friis transmission formula.

- A pulse radar system operates at a frequency of 10 GHz with a pulse repetition frequency of 2 kHZ and a pulse width of 6 μs. Determine (a) the maximum unambiguous range, and (b) the resolution or minimum range.
- 3. Determine Instantaneous cyclic frequency of Doppler RADAR transmitting sinusoidal cyclic frequency  $f_c$  and radian frequency  $\omega_c = 2\pi f_c$  leading to Doppler shift.

# Course Outcome 3 (CO3):

- The cascade system has three components. (a) Input line amplifier with power gain G<sub>1</sub>=5000, (b) long transmission line with a power loss factor L=2000, and (c) load amplifier with an absolute power gain G<sub>2</sub>=400. Impedances are matched at all junctions. Determine (i) net system absolute gain, (ii) system decibel gain using the result of (i), and (iii) system decibel gain from individual decibel values.
- 2. An analog system requires an antenna signal power of 50pW to meet the required signal to noise ratio. Other system parameters are given as follows:  $G_t(dB) = 3dB, G_r(dB) = 4dB, f = 500MHz, d = 80km$ . Assuming direct ray propagation, determine the minimum value of the transmitted power required.
- 3. Consider a PCM TDM system in which 19 signals are to be processed. Each of the signals has a baseband bandwidth W = 5 KHz and 8 bits are to be used in each word. Conventional NRZ L encoding will be used, and an additional 8 bit sync word will be placed in each frame. Determine theoretical minimum bandwidth required

# Course Outcome 4 (CO4):

- 1. A 50km long optical fiber has a total attenuation of 24dB. If  $500 \mu W$  of optical power get launched into the fiber, what is the output optical power level in dBm and in  $\mu W$ .
- 2. A step-index multimode fiber with numerical aperture of 0.20 supports approximately 1000 modes at an 850-nm wavelength. What is the diameter of its core? How many modes does the fiber support at 1320 nm and 1550 nm respectively?
- 3. Determine the normalized frequency at 820 nm for a step-index fiber having a  $25 \mu m$  core radius,  $n_1 = 1.48$  and  $n_2 = 1.46$ . How many modes propagate in this fiber at 820nm, 1320nm and 1550nm respectively? What percent of the optical power flows in the cladding in each case?

# Course Outcome 5 (CO5):

- 1. A satellite is to be placed in an orbit 1000 km above the earth's surface. Determine (a) required velocity (b) circumference of the rotation and (c) period of the rotation.
- 2. In a satellite communication system the uplink portion is analyzed. The output power of the ground transmitter is 200W. This power level at the ground antenna, which has a gain of 40dB. The transmitted signal is attenuated by a path loss of 200 dB. The receiver antenna gain is 20 dB. If the total noise level at the input to the satellite receiver is 8 dBf, determine the received signal to noise-ratio in dB.
- 3. The lowest downlink frequency for C band is 3.7GHz. Consider a satellite transmitter operating at this frequency providing coverage of the continental United States, which requires a 3 dB beamwidth of about 18<sup>°</sup>. Assuming an illumination efficiency of 70%, determine the diameter and the gain of the downlink antenna.

# Course Outcome 6 (CO6):

- Consider a transmitter which radiates a sinusoidal carrier frequency of 1850 MHz for a vehicle moving 60m/hr, Compute the received carrier frequency if the mobile is moving (i) Directly towards the transmitter (ii) Directly away from the transmitter, and in a direction which is perpendicular to the direction of arrival of the transmitter signal.
- 2. Explain the techniques that are intended to improve coverage area and capacity of cellular system.
- 3. Explain in detail about Global system for mobile and also explain the Frame structure and signal Processing in GSM.

# Concept Map



Approved in  $59^{\text{TH}}$  Academic Council Meeting 07.12.2019

# Syllabus

Introduction: Communication system model, Bandwidth and spectrum, modulation and demodulation, decibel gain and loss ratios, Signal to noise ratio and system level decibel analysis, Communication Link Analysis: Friis Link Equation, Decibel forms for the one way link equations, Line of Sight Propagation, Radar link equation, pulse radar, Doppler radar, Reflection and refraction, Ground wave propagation, Sky wave propagation Digital Communication Systems: Pulse Code Modulation (PCM), basic PCM encoding and quantization, companding, baseband encoding forms, Time Division Multiplexing, Binary digital modulation schemes (ASK, PSK, FSK), Bit Error rate Analysis. Fiber Optic **Communication System:** Optical Spectral bands, WDM Concepts, Key Elements of Optical Fiber Systems, Optical Fiber Modes and Configurations, Single – mode Fibers, Mechanical Properties of Fibers, Fiber Fabrication. Satellite Communication Systems: Orbital Mechanics, Satellite Alignment, Space craft communication Systems, Antennas Aboard Satellites and Earth Station, Satellite Link Analysis. Wireless Communication Systems: Cellular Concept: Frequency Reuse, Channel Assignment Strategies, Handoff Strategies, Interference, System Capacity, Wireless Standards: 2G, 3G, 4G and 5G Mobile Standards, IEEE 802.11b,g Wireless Local Area Network (WLAN) standards

# Learning Resources

- William D.Stanley amd John.M. Jeffords, " Electronic Communications Principles and Systems", Cengage Learning, 2009 (India Edition)
- B.P.Lathi, ZhiDing, Hari Mohan Gupta, "Modern Digital and Analog Communication Systems", Fourth Edition, Oxford University Press, 2017.
- Theddore S.Rappaport, "Wireless Communications: Principles and Practice", Second Edition, PHI,2006
- Gerd kaiser, "Optical Fiber Communications", Fifth Edition, TataMcGraw Hill Publishing Company Limited, 2013.
- George Kennedy, "Electronic Communication Systems", Tata McGraw Hill, Third Edition, 1996.
- Wayne Tomasi, "Advanced Electronic Communication Systems", Prentice Hall International Inc., Fourth Edition, 1998Book1 (Author(s), Title, edition, publisher, year of publication)
- Principles of Communication Systems Part 1 Course in NPTEL: http://www.digimat.in/nptel/courses/video/108104091/L25.html By Professor Aditya K Jagannatham, IIT Kanpur.
- Principles of Communication Systems Part 2 Course in NPTEL: https://nptel.ac.in/courses/108104098/#, By Professor Aditya K Jagannatham, IIT Kanpur.
- Satellite Communication Systems Course in NPTEL: https://nptel.ac.in/courses/117/105/117105131/, By Professor Kalyan Kumar Bandyopadhyay, IIT Kharagpur.
- Principles and Techniques of Modern RADAR Systems Course in NPTEL: https://nptel.ac.in/courses/108105154/ By Professor Amitabha Bhattacharya, IIT Kharagpur.
- Fiber Optic Communication Systems and Techniques Course in NPTEL: http://www.digimat.in/nptel/courses/video/117104127/L22.html By Professor Pradeep Kumar K, IIT Madras.
- Introduction to Wireless and Cellular Communications Course in NPTEL: https://nptel.ac.in/courses/106/106/106106167/ By Professor David Koilpillai, IIT Madras.

000136 0	Sourse contents and rectare ochedule											
Module	Торіс	No. of	Course									
No.		Hours	Outcome									
1.	Introduction to Telecom Systems											
1.1	Simplified Communication System Model	1	CO1									
1.2	Bandwidth and Spectrum, Modulation and	1	CO1									

# **Course Contents and Lecture Schedule**

	demodulation, decibel gain and loss ratios, Signal to		
	noise ratio and system level decibel analysis		
2.	Communication Link Analysis:	_	
2.1	Friis Link Equation, Decibel forms for the one way link equations,	2	CO2
2.2	Line of Sight Propagation,	1	CO2
2.3	Radar link equation, Pulse radar, Doppler radar	2	CO2
2.4	Reflection and refraction	2	CO2
2.5	Ground wave propagation and Sky wave propagation	1	CO2
3.	Digital Communication Systems:		
3.1	Pulse code modulation (PCM)	1	CO4
3.2	Basic PCM encoding and quantization,	2	CO4
3.3	Companding,	1	CO4
3.4	baseband encoding forms	1	CO4
3.5	Time Division Multiplexing	1	CO4
3.6	Binary digital modulation schemes (ASK, PSK, FSK)	2	CO4
3.7	Bit Error rate Analysis.	1	CO4
4.	Fiber Optic Communication System		
4.1	Optical Spectral Bands	1	CO3
4.2	Key elements of Optical Fiber System	1	CO3
4.3	Optical Fiber Modes and Configurations	1	CO3
4.4	Single – Mode Fibers	1	CO3
4.5	Fiber Materials, Fiber Fabrication, Fiber Optic Cables	2	CO3
5.	Satellite Communication Systems:		
5.1	Orbital Mechanics	1	CO5
5.2	Satellite Alignment	1	CO5
5.3	Space craft communication Systems, Antennas Aboard Satellites and Earth Station	1	CO5
5.4	Satellite Link Analysis	2	CO5
6.	Wireless Communication Systems:		
6.1	Cellular Concept:	1	CO6
6.2	Frequency Reuse, Channel Assignment Strategies	1	CO6
6.3	Handoff Strategies, Interference	1	CO6
6.4	System Capacity	1	CO6
6.5	Wireless Standards: 2G, 3G, 4G and 5G Mobile Standards	1	CO6
6.6	IEEE 802.11b, g Wireless Local area network (WLAN) standards	1	CO6
	Total Number of Hours	36	

# Course Designers:

• Dr.S.J.Thiruvengadam

sjtece@tce.edu

• Dr.V.N.Senthil Kumaran

• Dr.P.G.S.Velmurugan

vnsenthilkumaran@tce.edu pgsvels@tce.edu

18ECGD0	APPLIED IMAGE PROCESSING	Category	L	Т	Ρ	Credit
		GE	3	0	0	3

# Preamble

The course "18ECGD0: Applied Image Processing" is offered in the fifth semester. The purpose of this course is to provide the basic concepts and methodologies for digital Image Processing in three different levels. At the lower-level, the course introduces the terminology of image processing, image acquisition, digitization, formation, storage and the relationship between pixels. Further, it provides the image enhancement by improving the contrast and noise removal in spatial domain and applications of transformations for enhancement and coding. In the middle-level, it addresses region based segmentation, representation and description processes to extract meaningful information with geometrical operations. Morphological processing is introduced to clean up and cluster such regions for real world image processing applications.

# Prerequisite

Nil

# **Course Outcomes**

On the successful completion of the course, students will be able to

CO	Course Outcome Statement	Weightage
Number		%
CO1	Demonstrate the human visual perception, digital image acquisition and relationship between pixels for grayscale and color images.	20
CO2	Enhance the visual perception of the digital imagery from poor contrast and noise degradation in spatial domain.	15
CO3	Enhance the given image in frequency domain by applying image transforms such as Fourier and DCT.	15
CO4	Extract regions of interest from an image using thresholding, edge and region based segmentation algorithms.	15
CO5	Describe the segmented region using boundary as well as region representors and descriptors with the combination of morphological operations.	15
CO6	Develop image processing algorithms for detecting vehicle license plate, missing component, abnormality in CT/US images, Watermarking, fault analysis in power system, change detection in satellite images, DCT coding for image compression.	20

# CO Mapping with CDIO Curriculum Framework

CO	TCF	Learning Dor	nain I evel	-	CDIO Curricular
#	Proficiency	Cognitive	Affective Psychomotor		Components
	Scale				(X.Y.Z)
CO1	TPS2	Understand	Respond	Perception and Set	1.3, 2.4.6, 4.1.1
CO2	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4,
					3.3.1, 4.1.1, 4.1.2,
					4.5.3
CO3	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4,
					3.3.1, 4.1.1, 4.1.2,
					4.5.3
CO4	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4,
CO5	TPS2	Apply	Value	Mechanism	1.3 , 3.2.3, 3.2.4,
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.3.1,
					2.4.3, 2.4.4, 2.4.6,
					2.5.1, 3.1, 3.2.3,
					3.2.4, 3.2.6, 3.3.1,
					4.1.1, 4.1.2, 4.5.3

Марр	Mapping with Programme Outcomes														
COs	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	М	L	-	-	-	L	-	L	-	-		-	L	-	-
CO2	S	М	L	-	L	L	-	L	-	L	-	-	М	-	L
CO3	S	М	L	-	L	L	-	L	L	L	-	-	М	-	L
CO4	S	М	L	-	-	-	-	-	-	-	-	-	М	-	-
CO5	S	М	L	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	М	L	-	L	L	-	L	-	L	-	L	М	L	L

S- Strong; M-Medium; L-Low

# **Assessment Pattern: Cognitive Domain**

Cognitive	As	Continu sessmer	ious nt Tests		Assignm	End	
Levels	1	2	3	1	2	3	Semester Examinatio
Remember	10	10	0				0
Understand	10	10	20				20
Apply	80	80	80	50	50	50	80
Analyse	0	0	0	IN			0
Evaluate	0	0	0		5		0
Create	0	0	0	SAL			0

# **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment-I	Assignment-II	Assignment-III
Perception	Cardin and	-	-
Set	-	-	-
Guided Response		-	-
Mechanism	50	50	50
Complex Overt Responses	_	-	-
Adaptation	-	-	-
Origination	-	-	-

# Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

- 1. Distinguish CT and US imaging techniques and List the Pros and Cons.
- 2. Consider the image segment shown.

Let  $v = \{0,1\}$ , and obtain the shortest 8 and m-path between p and q. If a particular path does not exist between these two points state the reason. Repeat the same for  $v \{1,2\}$ .

- 3210(q)
- 2120
- 1111
- (p) 1012
- 3. Illustrate two dimensional sampling (down sample to 2X2) and 4 bit (16 gray levels) quantization for the following 8 bit sub image and state the reasons for the effects due to these processes?

255	255	255	255	255	255	255	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255

Passed in BoS Meeting 16.11.2019

Approved in 59<sup>TH</sup> Academic Council Meeting 07.12.2019

255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	255	255	255	255	255	255	255

# Course Outcome 2 (CO2):

1. Justify whether the image is poor in contrast. Identify the category of contrast. Is there any possibility to apply histogram equalization for the enhancement? If Yes, Justify and apply Histogram equalization for the following 6 bit image segment of size 6X6? Write the inference on image segment before and after equalization.

35	55	60	55	40	60
55	35	35	60	60	52
60	48	45	55	38	48
51	40	60	45	40	40
49	40	60	35	35	55
62	48	55	62	45	35

- 2. Demonstrate the following gray-level transformations for image enhancement via i) Gamma correction
  - ii) Log transformation
  - iii) Contrast Stretching
- 3. Suggest a suitable filter to remove noise but still preserve edges. Give the transfer function of it.

# Course Outcome 3 (CO3):

- 1. Illustrate the procedure step by step for JPEG image compression and write the significance of DCT.
- 2. Apply Discrete Fourier Transform for the following image data?
- [220 100; 120 250] [2x2] matrix. Write the significance of log function while visualizing the Fourier spectrum. Also, illustrate how Fourier transform properties are helpful in different digital image processing applications. Obtain it's inverse also.
- 3. Apply Discrete Cosine Transform for the following image data.
- [100 200; 150 200] [2x2] matrix. Also, illustrate how DCT is used for JPEG image Compression?

# Course Outcome 4 (CO4):

- 1. The region-growing algorithm starts with a seed pixel. Suggest a way or gray-level range to choose the seed pixel for the following two applications.
  - a. Segmenting the fractured portion of a leg in a X-Ray image
  - b. Segmenting defective welds for an image captured in industry
- 2. Demonstrate region split and merge algorithm and apply morphological algorithms to segment the satellite image into different regions.
- 3. Demonstrate how global thresholding is used in industrial inspection applications and discuss the effect of illumination on global thresholding.

# Course Outcome 5 (CO5):

- 1. Write the Euler number if the shape contains 4 edges, 3 faces and 5 vertices.
- 2. Obtain the shape number for the following fig. List the limitations towards boundary representation based on chain codes.



3. Sketch the signature plots for the following geometrical figures: Rectangle, Ellipse and 5- point star. How will it be Scale normalized?

# Course Outcome 6 (CO6):

- 4. Develop an algorithm to localize the license plate using suitable preprocessing, edge detection and morphological processing for intelligent traffic surveillance system to capture the vehicles which are not following the traffic rules.
- 5. Suggest an algorithm to find the change between two satellite images (taken in 2004 and 2014). The image captured the Madurai area. How will you find vaigai river has been encroached and how much encroached from the change detection algorithm.
- 6. The region-growing algorithm starts with a seed pixel. Suggest a way or gray level range to choose the seed pixel for the following application. Segment the cyst of a US kidney image. Assume the intensity values of one cyst is 220 and for the another cyst is 90.





# Syllabus

#### Theory:

**Image acquisition and Fundamentals:** Introduction to Image processing, Need and applications, Elements of visual perception, light and the Electromagnetic spectrum, Imaging modalities, X-Ray, Visible, Infrared, CT, Ultrasound, Thermal. Components of an Image processing system, Digital image model, Image file formats, Image Sampling and Quantization.

Basic relationship between pixels: Adjacency, Connectivity- 4, 8 and m connectivity, region, boundaries and Distance measures: Euclidean, city-block, chessboard. Full color image processing, Color model-RGB,CMY,HSI, Color space conversion, RGB to HSV and YCbCr, Extendible of grayscale methods into color.

**Image Enhancement:** Intensity Transformation functions, Image negatives, Contrast stretching, Log transformation, Gamma correction, Histogram Equalization, Color Histogram processing, Noise Removal: Noise models, Gaussian, Uniform, salt and pepper noise. **Spatial Filtering**: Smoothing: mean, Order statistics filter: median, min, max and mid-point filtering. Sharpening: Laplacian filter, unsharp masking.

**Frequency domain filtering**: Transformations:Fourier, Discrete cosine Transforms, Low pass and high pass filters in frequency domain. **Image Compression:** JPEG compression.

**Segmentation:** Thresholding: Local and global, Edge based: Point, Line and Edge detection, Prewitt, Sobel and Roberts operators. Region based segmentation: Region growing, Region splitting and merging. Gray-scale Morphological operations: Dilation and Erosion, Opening and Closing, Hole filling, Boundary extraction.

**Representation and Description:** Boundary representation: Chain codes, Signatures, Boundary descriptors: Shape numbers, Fourier descriptors, Regional Descriptors, Topological descriptors: Texture.

**Real world Applications:** Vehicle license plate detection, Digital image watermarking, Missing component detection for automatic industry inspection, Non-destructive testing, Detecting cyst/tumour in Ultrasound (US)/CT images, Fault analysis in power system, Remote sensing- change detection, building, road extraction in satellite images.

# Sample Assignments/Mini projects:

- 1. Image Contrast Enhancement.
- 2. Noise removal in spatial/frequency domain
- 3. Vehicle number plate detection.
- 4. Detecting cyst/tumour in US/CT images.
- 5. Industry inspection in IR/Thermal images (Non Destructive Testing).
- 6. Change detection between two remotely sensed satellite images.
- 7. Missing component detection in an automated industrial inspection application.
- 8. Digital Watermarking
- 9. Fault analysis in power systems

# Learning Resources

- Rafael.C.Gonzalez, Richard.E. Woods and Steven L. Eddins, "Digital Image Processing using Matlab", 2<sup>nd</sup> Edition, Gatesmark Publishing, 2009, ISBN 9780982085400.
- Al.Bovik, "The Essential Guide to Image Processing", Academic Press, 2009.
- Oge Marques, "Practical Image and Video Processing using MATLAB", Wiley-IEEE Press, 2011, ISBN: 978-0-470-04815-3.
- Anil K.Jain, "Fundamentals of Digital Image Processing", Pearson Education 2003.
- William K. Pratt, "Digital Image Processing", Third Edition, John Wiley & Sons, Inc., i. 2001, ISBNs: 0-471-37407-5.
- NPTEL course Digital Image Processing: https://nptel.ac.in/courses/noc18\_ee40/
- www.imageprocessingplace.com/
- http://www.mathworks.com/
- https://www.coursera.org/course/images

# **Course Contents and Lecture Schedule**

No.	Торіс	No. of	С
		Lectures	0
1	Introduction to the Course and course outcomes	1	1
1.1	Introduction to Image processing, Need and applications	1	1
1.2	Elements of visual perception	1	1
1.3	Light and the Electromagnetic spectrum	1	1
1.4	Imaging modalities- X-Ray, CT, Ultrasound, Visible, Infrared,	1	1
	Thermal		
1.5	Components of an Image processing system	1	1
1.6	Digital image Model, Image file formats, Color space conversion	1	1
1.7	Image Sampling and Quantization	1	1
1.8	Basic relationship between pixels, Adjacency, Connectivity- 4, 8		
	and m connectivity, region, boundary	1	1
1.9	Distance measures- Euclidean, city-block, chessboard	1	1
1.1	Full color image processing. Color model PCP CMV HSI	1	1
0			
1.1	Color models-RGB, CMY, HSI	1	1

1			
1.1	HVS and color space: (RGB to HSI, YCbCr color space),	1	1
2	Extendible of grayscale methods into color		
2.	Image Enhancement: Intensity Transformations, Image Negative,	1	2
	Contrast stretching		
2.1	Log transformation- Gamma correction	1	2
2.2	Histogram equalization, color histogram processing	1	2
	Assignment 1: Image contrast Enhancement		
2.3	Noise Removal-Spatial Filtering- Smoothing-Noise models –	1	2
	Salt and Pepper, Uniform, Gaussian		
2.4	Mean- Order statistics filter-median filters Min, Max and Mid-point	1	2
2.5	Spatial filtering – Sharpening- Laplacian filter, unsharp masking	1	2
3	Spectral representation for enhancement and coding:	1	
3.1	Fourier	2	3
3.2	Discrete cosine Transform	1	3
3.4	Low pass and high pass filters in frequency domain	1	3
3.5	JPEG compression	1	3
	Assignment II: Noise removal in spatial/frequency domain		
4	Segmentation: Thresholding – Local and global	1	4
4.1	Edges- Point, line detection, Edge detection, Prewitt, Sobel and	1	4
	Roberts operators		
4.2	Region based segmentation- Region growing, Region splitting and	1	4
	merging		
4.3	Gray-scale Morphological operations: dilation and erosion –	2	4
	opening and closing, Hole filling, Boundary extraction		
6.	Representation and Description:		
6.1	Boundary representation- Chain codes-Signatures	1	5
6.2	Boundary descriptors–Shape numbers-Fourier descriptors	1	5
6.3	Regional Descriptors-Topological descriptors-Texture	1	5
7.	Real world Applications:		
7.1	Vehicle number plate detection	1	6
7.2	Digital image watermarking, Missing component detection for	1	6
	automatic industry inspection	•	
7.3	Detecting cyst/tumour in Ultrasound/CT images	1	6
7.4	Fault analysis in power system		6
7.5	Remote sensing- change detection, building, road extraction in	1	6
	satellite images	<b>'</b>	
	Assignment III: Applications		
L	Total	36	

# Course Designers:

Dr.B.Yogameena ymece@tce.edu

• Dr.S.Md.Mansoor roomi smmroomi@tce.edu



18ECEA0	MEMS TECHNOLOGY	Category	L	Т	Р	Credit
ICECEAC		ES	3	0	0	3

# Preamble

MEMS has been identified as one of the most promising technologies for the 21st Century and has the potential to revolutionize both industrial and consumer products by combining silicon-based microelectronics with micromachining technology. This course starts with the glimpses of MEMS covering the introduction and origin of MEMS, driving force for MEMS development, commercial applications, fabrication process and packaging techniques. The latter half of the course will be devoted to provide a thumb rule in designing, modelling of micro sensors and micro actuators. They are also exposed to the MEMS CAD tools available in the Design centre. Special weight is given to design circuits and do simulation with Comsol, Intellisuite and Coventorware. By taking this course, students can make good preparations for their research in relevant areas.

# Prerequisite

#### Nil

# **Course Outcomes**

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage
Inumber	1 alpha 1	111 70
CO1	Summarize the Concept of miniaturization, need for MEMS in various applications, Micro fabrication techniques	20
CO2	Apply knowledge of micro fabrication techniques to design Micro sensors	20
CO3	Apply knowledge of micro fabrication techniques to design Micro actuators	10
CO4	Apply micro fabrication techniques to design a micro accelerometers	10
CO5	Apply the concepts of micro machining to design devices for diversifying areas	20
CO6	Acquire skills in computer aided design tools for modelling and simulating MEMS device	20
<b>AA H</b>		

#### CO Mapping with CDIO Curriculum Framework

CO	TC	E		Learn	ing Do	omain	Leve				CDIO Curricular Components				
#	Pro	oficien	су [	Cogni	tive	Aff	ective	Ps	ychor	notor	(X.Y.Z)				
	Sca	ale		_					-						
CO1	T	TPS2		Understand		Re	Respond		-		1.3, 2	.4.6			
CO2	T	PS3		Apply		Va	lue		-		1.3, 2	.1.1, 2	.1.2, 2	.1.3, 2.	5.1
CO3	T	PS3		Apply		Va	lue		-		1.3, 2	.4.6			
CO4	T	PS3		Apply		Va	lue		-		1.3, 2	.1.1, 2	.1.2, 2	.5.1	
CO5	T	PS3		Apply		Va	lue		- 1		1.3, 2.4.6				
CO6	Т	PS3		Apply		Va	Value		-		1.3, 2.1.1, 2		.1.2, 2	.5.1	
Марр	ing w	ith P	rogr	amme	Outc	omes	s and	Prog	ramn	ne Spe	cific C	Outcor	nes		
Cos	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	Μ	L	-	-	-	-	-	-	-	-	-	-	L	L	L
CO2	S	М	L	-	L	-	-	L	-	L	-	L	L	-	-
CO3	S	М	L	-	L	-	-	L	-	L	-	L	L	-	-
CO4	S	М	L	-	L	-	-	L	-	L	-	L	L	-	-
CO5	S	М	L	-	L	-	-	L	-	L	-	L	L	-	-
CO6	S	Μ	L	-	L	-	-	L	-	L	-	L	L	-	-

S- Strong; M-Medium; L-Low

Assessment														
Cognitive	Conti	nuous Asses Tests	ssment	As		End								
Levels	1	2	3	1	2	3	Semester Examination							
Remember	0	0	0	0	0	0	0							
Understand	50	40	20	50	0	0	20							
Apply	50	60	80	50	100	100	80							
Analyse	0	0	0	0	0	0	0							
Evaluate	0	0	0	0	0	0	0							
Create	0	0	0	0	0	0	0							

# Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	and the second	-	-
Adaptation	Carlos a	-	-
Origination		-	-

# Sample Questions for Course Outcome Assessment

# Course Outcome 1(CO1):

- 1. Tabulate the direct analogy of electrical and mechanical domains.
- 2. Classify MEMS packages. Based on the need for packaging of MEMS devices classify and differentiate various packaging methodologies.

# Course Outcome 2(CO2):

- 1. With neat diagram explain the functioning of micro pressure sensor.
- 2. Explain the working principle of a thermal flow sensor.

# Course Outcome 3 (CO3):

- 1. Explain in detail the ink jet printer head and its fabrication process flow in detail.
- 2. Explain the working principle of micro pumps.

# Course Outcome 4 (CO4):

- 1. Derive a formula for estimating the natural frequency of a micro accelerometer with negligible damping effect.
- 2. Determine the equivalent spring constant K and natural frequency Wm of a cantilever beam element in a micro accelerometer .The beam is made of silicon with a Young's modulus of 190 MPa, length of the beam is 100um, width is 10um and mass is 10 mg.

# Course Outcome 5 (CO5):

- 1. Discuss the integration of micro optics with MEMS
- 2. Explain the sensing mechanism used in biomedical micro systems

# Course Outcome 6(CO6):

- 1. Discuss the steps involved in developing a micro machined cantilever using any MEMS CAD tool (e.g. Coventorware software)
- 2. Given the following description of a micro machined accelerometer, draw the step-bystep process flow with cross-section diagrams. For your convenience, the cross-section of the final device is also given below.

In order to micro fabricate a micro machined accelerometer, combinations of bulk and surface micromachining techniques are used. The process has seven masks and involves double-sided processing utilizing silicon dioxide as a sacrificial layer. The device structure is defined by anisotropic etching at the end of the process.

The process begins with a shallow p++ boron diffusion, defining the proof-mass and supporting rim, on a <100> silicon wafer that is polished on both the sides. Then, 60 um deep trenches are DRIE etched in the silicon and are used later to form the vertical

electrodes. The trenches are then refilled completely with a combination of LPCVD silicon dioxide (sacrificial layer), silicon nitride, and doped polysilicon. The polysilicon trench refilling is used to form vertical sense/drive electrodes and high aspect ratio springs to support the proof mass. After polysilicon deposition, annealing is followed to alleviate any compressive stress in the polysilicon.

Next, the polysilicon and nitride films are etched using RIE and another LPCVD silicon dioxide (capping oxide) is deposited. The oxide is patterned to form contact openings to the bulk silicon for the subsequent etch in the EDP. Then, contact metal is electroplated. To minimize the etch-time in the EDP and help undercut the electrodes by the etchant, some of the single-crystal silicon is etched by DRIE. After the DRIE, EDP etch is followed not only to release the proof mass and the supporting rim but also to etch the unnecessary silicon around the sense/drive electrodes. This step is important to achieve high-sensitivity. Finally, the sacrificial oxide layer is removed by etching in HF.





#### Syllabus

Historical Background: Introduction, emergence, MEMS application, scaling issues, Silicon Pressure sensors, Micromachining, Micro fabrication. Micro Fabrication Techniques: MEMS Materials, Material Properties, Bulk and surface micromachining, Wet and dry etching Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating). Conventional IC fabrication processes. Physical Micro Sensors: Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples, Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical, Biosensors and underwater flow sensors. Micro Actuators: Electromagnetic and Thermal micro actuation, Micro actuator examples, micro valves, micro pumps, micro motors, Ink-Jet printer heads, Micro-mirror TV Projector. Micro Accelerometer: Capacitive and piezoresistive, Electronic interfaces. Application Areas: 3-D electromagnetic actuators and sensors, RF/Electronics devices, Optical/Photonic devices, Medical devices e.g. DNAchip, micro-arrays. Computer Aided Design of MEMS: Introduction to Commercial packages, Introduction and usage of Intellisuite, Coventorware and Comsol, Design and simulation of MEMS Sensors, actuators and accelerometers using CAD tools. Learning Resources

• Stephen D. Senturia, "Micro system Design" by, Kluwer Academic Publishers, 2001.

- Tai Ran Hsu, MEMS & Micro system Design and Manufacture, Tata McGraw Hill, New Delhi 2002
- Marc Madou, Fundamentals of Micro fabrication, CRC Press, 2ndEdition, 2002.
- Julian W. Gardner and Vijay K. Varadan, Micro sensors, MEMS, and Smart Devices, John Wiley & Sons Ltd, 1stEdition, reprinted 2007
- Fundamentals of Micro fabrication by, CRC Press, 1997.Gregory Kovacs, Micro machined Transducers Sourcebook WCB McGraw-Hill, Boston, 1998.
- M.-H. Bao, Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes by Elsevier, New York, 2000.
- http://nptel.ac.in/courses/'MEMS and Micro Systems.

#### Course Contents and Lecture Schedule

Module	Торіс	No. of	CO
No.		Hours	
1.	Historical Background		
1.1	Introduction, emergence, MEMS application	1	CO1
1.2	Scaling issues, Micromachining, Micro fabrication, Conventional	1	CO1
1.2	IC fabrication processes.	I	
1.3	Silicon Pressure sensors	1	CO1
2	Micro fabrication Techniques:		
2.1	MEMS Materials, Material Properties	1	CO1
2.2	Bulk and surface micromachining, Wet and dry etching	1	CO1
2.3	Thin-film depositions (LPCVD, Sputtering, Evaporation),	1	CO1
2.4	LIGA, Electroplating	1	CO1
3	Physical Micro sensors		
2.1	Classification of physical sensors, Integrated, Intelligent, or Smart	1	CO2
5.1	sensors,		
3.2	Sensor Principles and Examples, Thermal sensors	2	CO2
3.3	Electrical Sensors, Mechanical Sensors,	1	CO2
3.4	Chemical, Biosensors	1	CO2
3.5	Underwater flow sensors	2	CO2
4	Micro actuators		
4.1	Electromagnetic and Thermal micro actuation, Micro actuator	1	CO3
	examples		
4.2	Micro valves, micro pumps, micro motors,3D printing	6	CO3
4.3	Ink-Jet printer heads, Micro-mirror TV Projector	2	CO3
5	Micro accelerometer :,		
5.1	Capacitive and piezoresistive	1	CO4
5.2	Electronic interfaces	1	CO4
6	Application Areas:		
6.1	3-D electromagnetic actuators and sensors,	1	CO5
6.2	RF/Electronics devices,	1	CO5
6.2	Optical/Photonic devices, Medical devices e.g. DNA-chip, micro-	1	CO5
0.5	arrays	I	
7	Computer aided design of MEMS:		
7.1	Introduction to Commercial packages, Introduction and usage of	2	CO6
	Intellisuite, Coventorware and Comsol.		
7.2	Design and simulation of MEMS Sensors using CAD tools	3	CO6
7.3	Design and simulation of MEMS actuators using CAD tools	3	CO6
7.4	Design and simulation of MEMS accelerometers using CAD tools	3	CO6
	Total hrs	36	

#### **Course Designers:**

• Dr.S.Kanthamani

skmece@tce.edu

Dr.K.Vasudevan kvasudevan@tce.edu

18ECEB0	FUNDAMENTALS OF MACHINE	Category	L	Т	Ρ	Credit
	LEARNING	ES	2	1	0	3

# Preamble

The objective of this course is to provide the mathematical background necessary for developing Machine Learning Algorithms. In this course, mathematical topics namely linear algebra, analytical geometry, multivariate calculus and probability theory are covered. This course also covers dimensionality reduction, classification, density estimation and regression methods which are the building blocks of machine learning.

# Prerequisite

# NIL

# Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Calculate the prediction value of particular test data point using probability theory	15
CO2	Determine suitable matrix decomposition method for an intuitive interpretation of the data and more efficient learning	15
CO3	Determine the parameter that maximize the performance measure in machine learning using multivariate calculus	15
CO4	Determine the suitable linear regression function in a diverse range of research areas in machine learning.	15
CO5	Represent the data in compact form with Principal Component Analysis	15
CO6	Represent the characteristics of data compactly using probability distributions	15
CO7	Classify the data using Support Vector Machine	10

#### CO Mapping with CDIO Curriculum Framework

CO	TCE	L	earning Dom	ain Level	CDIO Curricular
#	Proficien	Cognitive	Affective	Psychomotor	Components
	cy Scale	-		-	(X.Y.Z)
CO1	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1,
		-			2.4.2, 3.1.1, 3.1.2
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.2, 3.1.1, 3.1.2
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.2, 3.1.1, 3.1.2
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.2, 3.1.1, 3.1.2
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.2, 3.1.1, 3.1.2
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.2, 3.1.1, 3.1.2
CO7	TPS2	Understand	Respond	Guided Response	1.3, 2.1.1, 2.1.2, 2.4.1,
					2.4.3

#### Mapping with Programme Outcomes and Programme Specific Outcomes

COs	P01	PO2	PO3	P04	P05	P06	P07	PO8	PO9	10 PO	PO 11	PO 12	PS01	PSO2	PSO3
CO1	S	М	L	-	-	-	-	-	М	-	-	-	М		L
CO2	S	М	L	-	-	-	-	-	М	-	-	-	М	-	L
CO3	S	Μ	L	-	-	-	-	-	М	-	-	-	М	I	L
CO4	S	М	L	-	Μ	-	-	-	S	-	-	-	М	-	Μ
CO5	S	М	L	-	М	-	-	-	S	-	-	-	М	-	M

CO6	S	М	L	-	М	-	-	-	S	-	-	-	М	-	М
C07	М	L	-	-	Μ	-	-	-	S	ï	-	-	Μ	-	Μ

S- Strong; M-Medium; L-Low

Assessm	ent P	attern:	Cognitive	Domain	

Cognitive Levels	Contir	nuous Ass Tests	sessment		Assignme	nt	End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	100	50	50	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

#### **Assessment Pattern: Psychomotor**

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	m the	-	-
Mechanism	( allo	50	50
Complex Overt Responses		-	-
Adaptation		-	-
Origination	AL LOND	A -	-

#### Sample Questions for Course Outcome Assessment Course Outcome 1 (CO1):

- 1. Consider a statistical experiment where we model a funfair game consisting of drawing two coins from a bag (with replacement). There are coins from USA (denoted as \$) and UK (denoted as £) in the bag, and since we draw two coins from the bag, there are four outcomes in total. Let us assume that the composition of the bag of coins is such that a draw returns at random a \$ with probability 0:3. Find the the probability mass function
- 2. Consider two random variables X and Y, where X has five possible states and Y has three possible states, as shown in Figure.1. We denote by  $n_{ij}$  the number of events with state

 $X = x_i$  and  $Y = y_i$  and denote by N the total number of events. The value c is the sum of

the individual frequencies for the ith column, that is,  $c_i = \sum_{j=1}^{3} n_{ij}$ . Similarly, the value  $r_j$  is the

row sum, that is,  $r_j = \sum_{i=1}^{3} n_{ij}$ . Using these definitions, compactly express the distribution of X and X

and Y .



Figure.1

3. Consider a random variable X with zero mean and also  $E[x^3] = 0$ . Let  $y = x^2$  (hence, Y is dependent on X). Compute the covariance between X and Y.

# Course Outcome 2 (CO2):

1. Compute the determinant of  $A = \begin{bmatrix} 1 & 2 & 3 \\ 3 & 1 & 2 \\ 0 & 0 & 1 \end{bmatrix}$  using the Laplace expansion along the first

row.

- 2. Compute the Eigen values, Eigen vectors and Eigen spaces of the  $2 \times 2$  matrix  $A = \begin{bmatrix} 4 & 2 \\ 1 & 3 \end{bmatrix}$ .
- **3.** Determine the orthogonal basis function for the matrix  $A = \begin{bmatrix} 3 & 2 & 2 \\ 2 & 3 & 2 \\ 2 & 2 & 3 \end{bmatrix}$

# Course Outcome 3 (CO3):

1. Consider the function in Figure.2 given by  $f(x) = \sin(x) + \cos(x) \in C^{\infty}$ . Find the Taylor series expansion of f at  $x_0 = 0$ .



- 2. Find the gradient for the function  $f(x_1, x_2) = x_1^2 x_2 + x_1 x_2^3 \in \Box$ .
- 3. Prove the negative entropy of  $f(x) = x \log_2 x$  is convex for x > 0.

# Course Outcome 4 (CO4):

- 1. Find the feature matrix for a second-order polynomial and N training points  $x_n \in \square$ ,  $n = 1, \dots N$ .
- 2. Let  $b \in \square^m \{\mathbf{0}_m\}$  and  $y \in \square^m$ . Prove that  $\|\mathbf{b}r \mathbf{y}\|$  is minimal when  $r = \frac{(\mathbf{y} \cdot \mathbf{b})}{\|\mathbf{b}\|^2}$ .
- 3. Let  $B = (\mathbf{b}^1, \cdots, \mathbf{b}^n) \in \square^{m \times n}$  be a matrix having orthogonal columns (in other words,  $i \neq j$  implies  $(b^i, b^j) = 0$ ) such that m > n. Prove that
  - i. Matrix **B** has full rank, that is  $rank(\mathbf{B}) = n$ .
  - ii. If **r** is the solution of the optimization problem that consists in minimizing the function  $f(r) = \|\mathbf{Br} \mathbf{y}\|^2$ , then  $r_j = \frac{(\mathbf{y} \cdot \mathbf{b}^j)}{\|\mathbf{b}^j\|^2}, 1 \le j \le n$ . In other words, the

components of the solution of linear regression do no influence each other.

# Course Outcome 5 (CO5):

1. Let us analyze the following 3-variate dataset with 10 observations. Each observation consists of 3 measurements on a wafer: thickness, horizontal displacement, and vertical

 $displacement. \mathbf{x} = \begin{bmatrix} 7 & 4 & 3 \\ 4 & 1 & 8 \\ 6 & 3 & 5 \\ 8 & 6 & 1 \\ 8 & 5 & 7 \\ 7 & 2 & 9 \\ 5 & 3 & 3 \\ 9 & 5 & 8 \\ 7 & 4 & 5 \\ 8 & 2 & 2 \end{bmatrix}.$  Compute the principal factors. 2. Consider a small 3 x 2 matrix,  $\begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$ , centers the data in the matrix, calculates the

covariance matrix of the centered data, and then the eigen decomposition of the covariance matrix. The eigen vectors and eigen values are taken as the principal components and singular values and used to project the original data.

- 3. Write a program in python to calculate the Principal Component Analysis on a dataset using the PCA () class in the scikit-learn library.
- Course Outcome 6 (CO6):
- 1. Compute the responsibilities  $r_{n,k}$  for the given Figure.3.



2. Prove the update of the mean parameters  $\mu_k, k = 1, \dots K$  of the Gaussian Mixture Model

given by  $\mu_k = \frac{\sum_{n=1}^{N} r_{nk} x_n}{\sum_{n=1}^{N} r_{nk}}$ , where  $r_{nk}$  is the responsibilities.

3. Prove the update of the covariance parameters  $\sum_{k}, k = 1, \dots K$  of the Gaussian Mixture Model given by  $\sum_{k}^{new} = \frac{1}{N_k} \sum_{n=1}^{N} r_{nk} (\mathbf{x}_n - \mu_k) (\mathbf{x}_n - \mu_k)^T$ .

# Course Outcomes 7 (CO7):

- 1. What is the distance between two parallel Hyperplanes  $\{x \in \Re^n | a^T x = b_1\}$  and  $\{x \in \Re^n | a^T x = b_2\}$ ?
- 2. Consider the data set D in  $\square^2$  shown in Figure.4, where C is a circle centred in (6,4) having radius 3. Define a transformation  $\phi:\square^2 \rightarrow \square^2$  such that  $\phi(D)$  is linearly separable.



3. Prove that if K is not linearly separable, then K is summable. Concept Map



#### Syllabus

Probability and Distribution – Continuous and probability space, Discrete and continuous probability, Sum rule, product rule and Bayes Theorem Matrix Decomposition-Determinant and trace, Eigen values and Eigen vectors, Cholesky decomposition, Eigen decomposition, Singular value decomposition Multivariate Calculus- Vector Calculus, Continuous optimization Regression – Parameter estimation, Bayesian linear regression, Maximum Likelihood as Orthogonal Projection Dimensionality Reduction with Principal Component Analysis (PCA) Maximum Variance perspective, Projection perspective, Eigenvector computation and low-rank approximations, PCA in high dimensions Density Estimation with Gaussian Mixture Models Gaussian mixture, Parameter learning via Maximum likelihood, EM algorithm Classification with Support Vector Machines Separating Hyperplanes, Primal support vector machine, dual support vector machine Learning Resources

- Marc Peter Deisenroth, A. Aldo Faisal and Cheng Soon Ong , " Mathematics for Machine Learning", Cambridge University Press, 2019
- Jason Brownlee, "Basics of Linear Algebra for Machine Learning", ebook, 2018
- Alpaydin, Ethem. "Introduction to Machine Learning", MIT Press, 2010.

• Dan Simovice, "Mathematical Analysis for Machine Learning and Data Mining", World Scientific, 2018.

•	Mehryar Mohri, Afshin R	lostamizadeh ar	nd Ameet	Talwalkar,	"Foundations	of	Machine
	Learning" MIT Press, 201	8.					

Cour	se Contents and Lecture Schedule								
No.	Торіс	No. of	COs						
		Hours							
1	Probability and Distribution								
1.1	Continuous and probability space	1	CO1						
1.2	Discrete and continuous probability	1	CO1						
1.3	Sum rule, product rule and Bayes Theorem	1	CO1						
1.4	Tutorial	1	CO1						
2	Matrix Decomposition								
2.1	Determinant and trace	1	CO2						
2.2	Eigen values and Eigen vectors	1	CO2						
2.3	Cholesky decomposition	1	CO2						
2.4	Eigen decomposition	1	CO2						
2.5	Singular value decomposition	1	CO2						
2.6	Tutorial	1	CO2						
3	Multivariate Calculus-,								
3.1	Vector Calculus	2	CO3						
3.2	Continuous optimization	2	CO3						
3.3	Tutorial	1	CO3						
4	Regression,								
4.1	Parameter estimation	1	CO4						
4.2	Bayesian linear regression	1	CO4						
4.3	Maximum Likelihood as Orthogonal Projection	2	CO4						
4.4	Tutorial	1	CO4						
5	Dimensionality Reduction with Principal Component Analysis (	PCA)							
5.1	Maximum Variance perspective	1	CO5						
5.2	Projection perspective	1	CO5						
5.3	Eigenvector computation and low-rank approximations	2	CO5						
5.4	PCA in high dimensions	1	CO5						
5.6	Tutorial	1	CO5						
6.	Density Estimation with Gaussian Mixture Models	1							
6.1	Gaussian mixture	1	CO6						
6.2	Parameter learning via Maximum likelihood	2	CO6						
6.3	EM algorithm	1	CO6						
6.4	Tutorial	1	CO6						
7	Classification with Support Vector Machines								
7.1	Separating Hyperplanes	1	CO7						
7.2	Primal support vector machine	2	CO7						
7.3	dual support vector machine	1	CO7						
7.4	Tutorial	1	CO7						
	Total	36							

# **Course Designers:**

- Dr.S.J.Thiruvengadam sjtece@tce.edu
- Dr.K.Rajeswari
- rajeswari@tce.edu
- Dr.P.G.S.Velmurugan pgsvels@tce.edu

1	8F	C	F(	20

#### **IOT SENSORS AND DEVICE**

Category	L	I	Р	Credit
ES	3	0	0	3

# Preamble

This course aims to provide students to course learn about the 'things' that get connected in the Internet of Things to sense and interact with the real world environment, and to explore and interact with the IoT bridge between the cyberand physical worlds.

# Prerequisite

NIL

# **Course Outcomes**

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage
Number		in %
CO1	Describe the IoT and Embedded hardware and software.	10
CO2	Demonstrate the ability to incorporate sensors and actuators into a	20
	circuit.	
CO3	Consturuct the IoT Intermediary devices and internet capable link.	10
CO4	Design and sketchprograms using IoT Virtual tool.	20
CO5	Apply the open and closed loop system transfer functions forIoT	20
	based system	
CO6	Design and Test the IoT based system using use case and test case.	20

# **CO Mapping with CDIO Curriculum Framework**

	TCE	Learr	ning Domain	CDIO Curricular Components	
CO#	Proficiency	Cognitive	Affective	Psychomotor	(X.Y.Z)
	Scale		100		
CO1	TPS2	Understand	Respond		1.3, 2.1.5, 2.2.2, 2.3.1,
CO2	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO3	TPS2	Understand	Respond		1.3, 2.1.5, 2.2.2, 2.3.1,
CO4	TPS3	Apply	Value		1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO5	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO6	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3

# Mapping with Programme Outcomes and Programme Specific OutcomesCosP01P02P03P04P05P06P07P08P09P010P011P012PS01PS02PS03

CO1	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	Μ	L	-	L	-	-	-	L	-	-	L	М	-	-
CO3	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO4	S	Μ	L	-	L	-	-	-	L	-	-	L	М	-	-
CO5	S	Μ	L	-	L	-	-	-	L	-	-	L	М	-	-
CO6	S	Μ	L	-	L	-	-	-	L	-	-	L	Μ	-	-

#### S- Strong; M-Medium; L-Low

#### Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			ļ	Assignment	End Semester Examination	
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	40	40	40	0	0	0	20
Apply	60	60	60	100	100	100	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

# AssessmentPattern: Psychomotor

Psychomotor Skill	Miniproject/Assignment/Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

# Sample Questions for Course Outcome Assessment

# Course Outcome1 (CO1):

- 1. Explain the range of IoT and Embedded System.
- 2. Describe the IoT hardware and software component.
- 3. Explain the role of an operating system in an IoT device.

# Course Outcome2 (CO2):

- 1. Design a circuit that lights an LED when it is sufficiently dark in a room. Demonstrate the circuit by covering the photo-resistor to darkness.
- 2. Design a grade separation a highway junction and a pedestrian road junction with a redundant audio alarm and a time and requests the green light by pressing the button the train can be detected by a special optical sensor.
- 3. Design a mobile robot, which can shoot objects in a basket at different angles in proper selection of sensor and motors and IoT Board.

# Course Outcome 3 (CO3):

- 1. List the Microcontroller based on a set of requirements,
- 2. Explain the architecture of Microcontroller to Microcontroller communication.
- 3. Explain the communication between Microcontrollers to Computer/Cloud.

# Course Outcome 4 (CO4):

- 1. Design a circuit and write a program that causes the built-in LED connected to pin 13 on the Arduino to blink, alternating between fast blinks and slow blinks.
- 2. Design a circuit and write a program that allows the user to control the LED connected to pin 13 of the Arduino. If the user sends the character '1' through the serial monitor then the LED should turn on. If the user sends the character '0' through the serial monitor then the LED should turn off.
- 3. Design a circuit that contains two push buttons, an LED, and any other basic components, the LED should turn on when either the first button or the second button is pressed.

#### Course Outcome 5 (CO5):

- 1. Design of an Unmanned Aircraft Vehicle (UAV) apply the both Yaw and Roll, pitch control and find step response, nyquist diagram, and magnitude and phase plot using open loop and closed loop system.
- 2. Design of an IoT based Temperature monitoring system the different ways IoT systems are controlled using open loop and closed loop system.

#### Course Outcome 6(CO6):

- 1. Design of an IoT based agricultural storage monitoring system with block diagram of following draft
  - Specification requirement document in user perspective and designer Perspective.
  - System design and option evaluation, option choice document.
  - Testing of Components and Integration testing document.
- 2. Design of an IoT based Implementation of Traffic Intersection Interface system with block diagram of following draft
  - Specification requirement document in user perspective and designer Perspective.
  - System design and option evaluation, option choice document.
  - Testing of Components and Integration testing document.
- 3. Design of an IoT based Temperature monitoring system with block diagram of following draft
  - Specification requirement document in user perspective and designer Perspective.
- System design and option evaluation, option choice document.
- Testing of Components and Integration testing document.



#### Syllabus

loT and Embedded system: Concept of the Internet of Things, Structure of embedded systems and interactions with the physical world, IoT hardware and software component, Role of an operating system in an IoT device, Networking enables devices and small local networks of IoT devices. IoT Sensors: Differentiate between different sensor types and application areas for a selected range of sensors and actuators, Incorporation sensors and actuators into a circuit. IoT Intermediary devices and internet capable link: Microcontroller based on a set of requirements, Communication protocols, Microcontroller to Microcontroller communication, Microcontroller to Computer/Cloud communication, Fog, Edge, and Cloud processing, Cellular networks, IoT Virtual Programming: Blink an LED with digital output, Blink multiple LED, Fading LED with Analog outputs, RGB LED Colour Mixing, Digital Input / Analog output, Push button, Potentiometer using serial monitor, PIR Motion Sensor, Photo resistor, Temperature sensor, Ultrasonic Distance Sensor. Processes and systems: Concept of both open loop and closed loop systems, Inputs, outputs, control and feedback for a system, Different ways that systems are controlled. IoT based system **Design:** Specification requirement document in user perspective and designer Perspective, System design and option evaluation, option choice document, Testing of Components and Integration testing, virtual circuit software tool to solve IoT problems.

#### Learning Resources

- Adrian McEwen, Hakim Cassimally "Designing the Internet of Things", Wiley Publishing,2015
- Arshdeep Bahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach", 2015 Web link : https://www.universitiespress.com/details?id=9788173719547
- Sudip Misra, IIT- Kharagpur, swayam course on "Introduction to Internet of Things" https://swayam.gov.in/nd1\_noc20\_cs66/preview
- Ian Harris, Professor, University of California, Irvine, Coursera, Course on "Introduction to the Internet of Things and Embedded Systems"
- Iain Murray, Cesar Ortega-Sanchez, Sivas' Khaksar, Curtin University, Perth, Edx course on "IOT2x – IoT Devices and Sensors"
- Online-Virtual circuit software tool web link: https://www.tinkercad.com/learn/projectgallery;collectionId=OMOZACHJ9IR8LRE
- Kallol Bosu Roy Choudhuri "Learn Arduino Prototyping in 10 days Your crash course to build innovative devices" Packt Publishing, 2017.

Course	Contents and Lecture Schedule		
Module	Торіс	No. of	Course
No.		Hours	Outcome
1	IoT and Embedded system		
1.1	Concept of the Internet of Things.	1	CO1
1.2	Structure of embedded systems.	1	CO1
1.3	IoT Interactions with the physical world.	1	CO1
1.4	IoT hardware and software component.	1	CO1
1.5	Role of an operating system in an IoT device.	1	CO1
1.6	Networking enables devices.	1	CO1
1.7	Small local networks of IoT devices.	1	CO1
2	IoT Sensors		
2.1	Differentiate between different sensor types	3	CO2
2.2	Application areas for a selected range of sensors and actuators	3	CO2
2.3	Incorporate sensors and actuators into a circuit	3	CO2
3.	IoT Intermediary devices and internet capable link		
3.1	Microcontroller based on a set of requirements.	1	CO3
3.2	Communication protocols.	1	CO3
3.3	Microcontroller to Microcontroller communication.	1	CO3
3.4	Microcontroller to Computer/Cloud communication.	1	CO3
3.5	Fog, Edge, and Cloud processing.	2	CO3
4	IoT Virtual Programming		
4.1	Blink an LED with digital output, Blink multiple LED.	1	CO4
4.2	Fading LED with Analog outputs, RGB, LED Colour Mixing.	1	CO4
4.3	Digital Input / Analog output, Push button, Potentiometer using serial monitor.	1	CO4
4.4	PIR Motion Sensor and Photo resistor, Temperature sensor, Ultrasonic Distance Sensor	2	CO4
5	Processes and systems		
5.1	Concept of open loop and closed loop systems, Inputs, outputs, control and feedback for a system.	2	CO5
5.2	Different ways that systems are controlled	1	CO5
6	IoT system Design		
6.1	Specification requirement in user and designer perspective,	2	CO6
6.2	System design and option evaluation, option choice and	2	CO6
	Testing of Components and Integration testing.		
6.3	Virtual circuit software tool to solve IoT problems.	2	CO6
	Total No. of Hours	36	
Course	Decignero		

Mr.M.Senthilnathan msnece@tce.edu

Category	L	Т	Р	Credit
ES	3	0	0	3

#### Preamble

Blockchain is an emerging technology platform for developing decentralized applications and data storage. This course includes the fundamental design and architectural primitives of Blockchain, the system and the security aspects, along with consensus mechanisms, crypto currencies, smart contracts, and problems of blockchain. The applications of Blockchain have now spread from crypto-currencies to various other domains, including business process management, smart contracts, IoT, trustworthy e-governance and so on. **Prerequisite** 

NIL

#### Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome Statement	Weightage
Number		in %
CO1	Determine the role of Hash functions, digital signature and	15
	distribution systems as blockchain primitives	
CO2	Describe the operations of crypto-currencies, Bitcoin and Ethereum	10
CO3	Apply the distributed consensus mechanisms of proof of work and	15
	proof of stake	
CO4	Use the scripting language to write smart contracts and blockchain	20
	platforms to develop hyperledgers	
CO5	Analyze the privacy, security and scalability problems of blockchain	20
CO6	Build the Blockchain use cases in finance, industry, IoT and e-	20
	dovernance.	

#### CO Mapping with CDIO Curriculum Framework

CO	TCE			Lea	rning	Doma	in Lev	/el			С	DIO Cu	urricular		
#	Proficier	ncy 🛛	Cogr	nitive	Af	fective	P	sychor	notor			Compo	onents	Í	
	Scale		_							(X.Y.Z)					
CO1	TPS3	;	Ар	ply	Val	ue		-		1.3, 2.1.1, 2.1.5					
CO2	TPS2	2	Unde	rstand	Res	Respond -				1.3					
CO3	TPS3	;	Ар	ply	Val	- Value				1.3	1.3, 2.1.1, 2.1.5				
CO4	TPS3	;	Ар	Val	ue		-			1.3, 2.1.1, 2.3.1, 3.2.4					
CO5	TPS4		Ana	lyze	Org	ganise		-			1.3, 2.1.1, 2.1.5, 2.2.2,				
										2.3	2.3.1, 3.2,6				
CO6	TPS3	5	Ар	ply	Val	lue -				1.3	3, 2.1	.5, 2.2.	2, 3.2.6	3	
Mapping with Programme Outcomes and Programme Specific Outcomes															
Cos	PO PO2 1	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	
004	0 14											N 4			

005	1									10	11	12			
CO1	S	М	L	-	-	-	-	-	-	-	-	L	М	-	-
CO2	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	М	L	-	-	-	-	-	-	-	-	L	М	-	-
CO4	S	М	L	-	S	-	-	-	-	L	-	L	М	-	L
CO5	S	S	М	L	-	-	-	-	-	L	-	М	S	-	L
CO6	S	М	L	-	L	-	-	-	-	Μ	-	L	М	-	М

S- Strong; M-Medium; L-Low

Cognitive Levels	Contin	nuous Ass Tests	sessment		Assignme	End Semester Examination	
	1	2	3	1	2	3	]
Remember	15	0	0	0	0	0	0
Understand	25	40	30	0	0	0	30
Apply	60	60	50	100	100	70	50
Analyse	0	0	20	0	0	30	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0
<b>Assessment P</b>	attern: P	sychomo	tor				

#### **Psychomotor Skill** Assignment-1 Assignment-2 Assignment-3 Perception ---Set ---Guided Response ---Mechanism ---Complex Overt Responses \_ Adaptation \_ \_ Origination --\_

# Sample Questions for Course Outcome Assessment

#### Course Outcome 1 (CO1):

- 1. Describe the requirements and characteristics of hash function.
- 2. User A wants to digitally sign his/her document to user B by using the global parameters, prime number p = 71 and its primitive root, alpha = 2. The signed document needs to be verified by user B. Assume that user A's private key, XA is 7, the random value k is 3 and its message is 10. Verify user A's digital signature in user B using appropriate public key method.
- 3. Consider an Elliptic Curve signature scheme. We have a global elliptic curve, prime p, and "generator" G. Alice picks a private signing key XA and forms the public verifying key YA = XAG. To sign a message M: Alice picks a value k. Alice sends Bob M, k and the signature S = MkXAG. Bob verifies that M = S + kYA.

a. Show that this scheme works. That is, show that the verification process produces equality if the signature is valid.

b. Show that the scheme is unacceptable by describing a simple technique for forging a user's signature on an arbitrary message.

#### Course Outcome 2 (CO2):

- 1. Explain design principles of Bitcoin and Ethereum.
- 2. Compare Blockchain, Crypto-currency and Token.
- 3. How to find a transaction in Blockchain and compare the types on blockchains.

#### Course Outcome 3 (CO3):

- 1. Design and deploy a distributed application.
- 2. Distinguish between proof-of-work and proof-of-stake consensus and write their security implications.
- 3. Explain the process of mining and how do miners make money?

#### Course Outcome 4 (CO4):

- 1. Write smart contracts for various transactions and explain why this is revolutionary and different from legal documents?
- 2. Develop a simple application using Solidity.
- 3. Develop projects using Hyperledger fabric platform, Plug-and-play platform

#### Course Outcome 5 (CO5):

- 1. How is scalability problem resolved?
- 2. Examine the security issues, failed currencies & blockchains and protection from attackers.

3. Evaluate security, privacy, and efficiency of a given blockchain system.

#### Course Outcome 6 (CO6):

- 1. How will you create your own blockchain and explain the necessary steps needed.
- 2. Design a use case for blockchain in a business case or area of interest. What problem is this trying to solve? What is the value proposition of solving this problem? How will a blockchain be applied to this use case? Which component pieces will be utilized?
- 3. Design Blockchain use cases for the following:
  - i. Digital Rights ownership and accessibility, education
  - ii. Industry healthcare, identity, finance
  - iii. Paradigm shift/future/big picture
  - iv. Elections and Voting: Auto execution of contracts, escrow, etc.

#### Concept Map



#### Syllabus

Cryptographic primitives in Blockchain: Secure, Collision-resistant hash functions, digital signature, public key cryptosystems - encryption schemes and elliptic curve cryptography, verifiable random functions, zero-knowledge proof systems **Distributed System concepts**: Need for Distributed Record Keeping, Modeling faults and adversaries, Consensus algorithms - scalability problems and distributed consensus Blockchain 1.0: Advantages over conventional distributed database, Blockchain Network, private and public, Mining Mechanism, Bitcoin blockchain, the challenges, operations and solutions, contemporary proof-of-work based consensus mechanisms, Proof of stake, alternatives to Bitcoin consensus, crypto-currency, Bitcoin scripting language and their use Blockchain 2.0: Ethereum and smart contracts and Turing complete blockchain scripting - Solidity, issues of correctness and verifiability. Ethereum platform and its smart contract mechanism Blockchain 3.0: Hyperledger fabric platform, Plug-and-play platform and mechanisms for consensus and smart contract evaluation engines **Beyond Crypto-currency**: Privacy, Security issues in Blockchain: Pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains – Sybil attacks, selfish mining and Sharding based consensus algorithms Blockchain Use Cases: Finance, Industry - supply chain management, e-governance, Land Registration, Internet of Things, Medical Record Management System, and Domain Name Service

#### Learning Resources

- Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder, "Bitcoin and Cryptocurrency Technologies: a comprehensive introduction", Princeton University Press, 2016.
- S.Shukla, M.Dhawan, S.Sharma, S.Venkatesan, "Blockchain Technology: Cryptocurrency and Applications", Oxford University Press, 2019.

- Josh Thompson, "Blockchain: The Blockchain for beginners guide to Blockchain technology and Blockchain programming", Create Space Independent Publishing Platform, 2017.
- Andreas M. Antonopoulos, "Mastering Bitcoin: Unlocking Digital Cryptocurrencies", O'Reilly Media, 2014.
- Gavin Wood, "ETHEREUM: A Secure Decentralized Transaction Ledger", Yellow paper, 2014.
- Nicola Atzei, Massimo Bartoletti, and Tiziana Cimoli, "A survey of attacks on Ethereum smart contracts" IACR Cryptology ePrint Arch., 2016.
- NPTEL Course on Blockchain architecture design and use cases:
- https://nptel.ac.in/courses/106/105/106105184/
- NPTEL Course on Introduction to Blockchain technology and applications: https://nptel.ac.in/courses/106/104/106104220/#
- Virtual Lab: http://vlabs.iitb.ac.in/vlabs-dev/labs/blockchain/

Cour	se Contents and Lecture Schedule		
No.	Торіс	No. of	COs
		Hours	
1	Primitives in Blockchain		
1.1	Secure, Collision-resistant hash functions, Properties	1	CO1
1.2	Hash Algorithms	1	CO1
1.3	Digital Signature, public key cryptosystems - encryption schemes	2	CO1
1.4	Elliptic Curve Cryptography	1	CO1
1.5	verifiable random functions, zero-knowledge proof systems	1	CO1
1.6	Distributed System concepts - Need for Distributed Record Keeping,	2	CO1
1.7	Modeling faults and adversaries,	1	CO1
1.8	Consensus algorithms - scalability problems and distributed consensus	1	CO1
2	Blockchain 1.0	. <u> </u>	
2.1	Blockchain Networks - private and public	1	CO2
2.2	Mining Mechanism, Bitcoin blockchain, the challenges, operations and solutions	2	CO2
2.3	contemporary proof-of-work based consensus mechanisms, Proof of stake	2	CO3
2.4	alternatives to Bitcoin consensus, crypto-currency	1	CO2
2.5	Bitcoin scripting language and their use	1	CO2
3	Blockchain 2.0	·	
3.1	Ethereum and smart contracts	1	CO3
3.2	Turing complete blockchain scripting – Solidity	2	CO3
3.3	Issues of correctness and verifiability	1	CO3
3.5	Ethereum platform and its smart contract mechanism	1	CO3
4	Blockchain 3.0	. <u> </u>	
4.1	Hyperledger fabric platform	2	CO4
4.2	Plug-and-play platform	1	CO4
4.3	mechanisms for consensus and smart contract evaluation engines	1	CO4
5	Beyond Crypto-currency	· · · ·	
5.1	Privacy, Security issues in Blockchain, Pseudo-anonymity vs. anonymity	1	CO5
5.2	Zcash and Zk-SNARKS for anonymity preservation	1	CO5
5.3	Attacks on Blockchains – Sybil attacks, selfish mining	1	CO5
5.4	Sharding based consensus algorithms	2	CO5

6.	Blockchain Use Cases		
6.1	Finance, Industry – supply chain management	2	CO6
6.2	e-governance, Land Registration	1	CO6
6.3	IoT, Medical Record Management System, and Domain Name	2	CO6
	Service		
	Total Hours	36	

### **Course Designers:**

- Dr. E. Murugavalli murugavalli@tce.edu
- Dr. M.S.K. Manikandan manimsk@tce.edu
- Dr. S. Ponmalar spmece@tce.edu



18ECEE0	5G WIRELESS NETWORKS	Category	L	T	Ρ	Credit	
		ES	3	0	0	3	

#### Preamble

The objective of this course is to introduce the students with a comprehensive understanding of current and 5G wireless Networks that includes 5G Fundamentals with its architecture, small cells, 5G Internets with Internet of Things and Software Defined Network. This course also includes cloud network and Security challenges in 5G network

### Prerequisite

NIL

CO5

CO6

#### **Course Outcomes**

On the successful completion of the course students will be able to

CO#		Cours	e Outcome	Statement		Weightage in %						
CO1	Discuss the o	concepts of cur	rent mobile	networks and 50	G networks	10						
CO2	Demonstrate	the ten pillars	of 5G			10						
CO3	Use the role play of Internet of Things and Software Defined Network 30 and Resource Provisioning in 5G Technology											
CO4	Determine capacity limits and Data Demands to identify the characteristics of small cells in 5G Networks.20											
CO5	Describe the concepts behind Mobile clouds and Mobile cloud enablers 15											
CO6	06 Examine the Security Issues and Challenges in 5G Systems											
CO M	apping with C	CDIO Curriculu	um Framew	/ork								
CO	TCE	Lean	ning Domaii	n Level	CDIO Cur	ricular						
#	Proficiency	Cognitive	Affective	Psychomotor	Compon	ents						
	Scale	-	SUCE.		(X.Y.2	<u>Z)</u>						
CO1	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.5							
CO2	TPS3	Apply	Value		1.3, 2.1.1, 2.2.2,	2.1.5, 3.2.6						
CO3	TPS3	Apply	Value	- 10 m	1.3, 2.1.1, 2.2.2,	2.1.5, 3.2.6						
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.2.2,	2.1.5, 3.2.6						

Mapping with Programme Outcomes and Programme Specific Outcomes

Respond

Organise

LOS	101	102	100	104	1.00	100	107	1.00	105	1010	1011	1012	1001	1002	1005
CO1	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	-	-	-	-	-	L	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	L	-	-	M	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	Μ	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO6	S	S	М	L	-	-	-	-	-	L	-	-	S	-	-

-

-

S- Strong; M-Medium; L-Low

TPS2

TPS4

#### **Assessment Pattern: Cognitive Domain**

Understand

Analyze

Cognitive	Continuous Assessment Tests			Assignment			End Semester
Levels	1	2	3	1	2	3	Examinatio n
Remember	30	20	0	0	0	0	0
Understand	40	40	50	0	0	0	40
Apply	30	40	30	100	100	70	40
Analyse	0	0	20	0	0	30	20
Evaluate	0	0	10	0	0	0	10
Create	0	0	0	0	0	0	0

1.3, 2.2.2, 2.3.1

1.3, 2.1.1, 2.1.5, 3.2.6

#### Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

#### Sample Questions for Course Outcome Assessment

#### Course Outcome 1(CO1):

- 1. Determine the challenges posed by these 5G wireless systems?
- 2. Discuss the specifications of different generation of wireless Systems.
- 3. Explain how cellular systems evaluate towards 5G communication systems?

#### Course Outcome 2(CO2):

- 1. Explain the ten pillars of 5G wireless Networks
- 2. Discuss the evolution of Existing RATs.
- 3. How Self organizing networks work in 5G Networks?

#### Course Outcome 3(CO3):

- 1. Using IoT, how 5G network is enabled?
- 2. Discuss the operation of SDN with example
- 3. How Network function virtualization works in 5G Networks?

#### Course Outcome 4 (CO4):

- 1. Compare different small cells types
- 2. Based on deployments, how cells are works in 5G networks?
- 3. Why Wi-Fi and Femto cells as candidates for 5G technology?

#### Course Outcome 5 (CO5):

- 1. How cooperation modes work in mobile user domain?
- 2. Examine wireless technologies from short range to wide area.
- 3. Explain with example, how mobile cloud participants share their resources in 5G Networks?

#### Course Outcome 6(CO6):

- 1. Discuss the security challenges in 5G Networks
- 2. How Mobile Botnets are functioning in 5G Networks?
- 3. How Femto cells attacks are overcome in 5G Networks?

#### Concept Map



#### Syllabus

**Drivers for 5G:** Historical Trend of Wireless Communications, Evolution of LTE Technology to Beyond 4G 5G Roadmap, 10 Pillars of 5G- Evolution of Existing RATs, Hyperdense Small Organising Network, Machine Type Communication, Developing Cell Deployment, Self Millimetre Wave RATs, Redesigning Backhaul Links, Energy Efficiency, Allocation of New Spectrum for 5G, Spectrum Sharing, 5G Architecture. The 5G Internet: Internet of Things -Networking Reconfiguration and Virtualisation Support -Software Context Awareness Defined Networking ,Network Function Virtualisation , Mobility-An Evolutionary Approach from the Current Internet, A Clean Slate Approach Quality of Service Control-Network Resource Provisioning, Aggregate Resource Provisioning, Emerging Approach for Resource Over• Provisioning -Control Information Repository, Service Admission Control Policies ,Network Resource Provisioning ,Control Enforcement Functions Network Configurations , Network Operations Small Cells for 5G Mobile Networks: Small Cells- Wi-Fi and Femto cells as Candidate Small Cell Technologies, Wi-Fi and Femto Performance - Indoors Vs. Outdoors, Capacity Limits and Achievable Gains with Densification- Gains with Multi Antenna Techniques, Gains with Small Cells, Mobile Data Demands-Approach and Methodology, Demand vs Capacity, Small Cell Challenges Mobile Clouds: Technology and Services for Future Communication Platforms: The Mobile Cloud-User Resources, Software Resources, Hardware Resources, Networking Resources, Mobile Cloud Enablers-The Mobile User Domain, Wireless Technologies Software and Middleware, Network Coding. Security for 5G Communications: Overview of a Potential 5G Communications System Architecture, Security Issues and Challenges in 5G Communications Systems-User Equipment, Access Networks, Mobile Operator's Core Network , External IP Networks

#### Learning Resources

- Jonathan Rodriguez, Fundamentals of 5G Mobile Networks, Wiley, 2015
- Stefan Rommer, Peter Hedman, Magnus Olsson, Lars Frid, Shabnam Sultana, Catherine Mulligan, 5G Core Networks, Elsevier, 2020.
- Savo Glisic, Advanced Wireless Networks, Technology and Business Models, Wiley 2012
- Fei Hu, "Opportunities in 5G Networks", CRC press 2016.
- Hrishikesh Venkatarman and Ramona Trestian, "5G Radio Access Networks: Centralized RAN, Cloud-RAN, and Virtualization of Small Cells", CRC press 2017.
- Yang Yang, Jing Xu, Guang Shi, Cheng-Xiang Wang, "5G Wireless Systems Simulation and Evaluation Techniques", Springer International Publishing AG 2018.
- Sassan Ahmadil, "LTE-Advanced: A Practical Systems Approach To Understanding 3gpp LTE Releases 10 And 11 Radio Access Technologies", Academic Press 2013.
  Course Contents and Lecture Schedule

obulse oblitents and Lecture ochedule					
Module	Торіс	No. of	Course		
No.		Hours	Outcome		
1.	Drivers for 5G				
1.1	Historical Trend of Wireless Communications,	1	CO1		
	Evolution of LTE Technology to Beyond 4G				
1.2	Roadmap, 10 Pillars of 5G- Evolution of Existing	1	CO1		
	RATs, Hyperdense Small Cell Deployment, Self				
	Organising Network				
1.3	Machine Type Communication, Developing Millimetre	1	CO1		
	Wave RATs				
1.4	Redesigning Backhaul Links, Energy Efficiency,	1	CO1		
	Allocation of New Spectrum for 5G				
1.5	Spectrum Sharing, 5G Architecture	2	CO1		
2.	The 5G Internet				
2.1	Internet of Things - Context Awareness Networking	2	CO2		
	Reconfiguration and Virtualisation Support				

2.2	Software Defined Networking ,Network Function Virtualisation, Mobility-An Evolutionary Approach from the Current Internet	3	CO2
2.3	A Clean Slate Approach Quality of Service Control- Network Resource Provisioning	1	CO3
2.4	Aggregate Resource Provisioning, Emerging Approach for Resource Over• Provisioning	2	CO3
2.5	Control Information Repository, Service Admission Control Policies ,Network Resource Provisioning	1	CO3
2.6	Control Enforcement Functions ,Network Configurations , Network Operations	1	CO3
3.	Small Cells for 5G Mobile Networks		
3.1	Small Cells- Wi-Fi and Femtocells as Candidate Small Cell Technologies,	1	CO4
3.2	Wi-Fi and Femto Performance – Indoors vs Outdoors,	1	CO4
3.3	Capacity Limits and Achievable Gains with Densification- Gains with Multi Antenna Techniques,	1	CO4
3.4	Gains with Small Cells, Mobile Data Demands - Approach and Methodology, Demand vs Capacity, Small Cell Challenges	1	CO4
4.	Mobile Clouds: Technology and Services for Com	munication F	Platforms
4.1	The Mobile Cloud-User Resources, Software Resources, Hardware Resources	1	CO5
4.2	Networking Resources, Mobile Cloud Enablers-	1	CO5
4.3	The Mobile User Domain, Wireless Technologies	1	CO5
4.4	Software and Middleware, Network Coding	1	CO5
5	Security for 5G Communications		
5.1	Overview of a Potential 5G Communications System Architecture	1	CO6
5.2	Security Issues and Challenges in 5G Communications Systems	2	CO6
5.3	User Equipment, Access Networks, Mobile Operator's Core Network	2	CO6
5.4	External IP Networks	1	CO6
	Total Hours	36	

## **Course Designers:**

- Dr. M.S.K. Manikandan manimsk@tce.edu
- Dr. E. Murugavalli

murugavalli@tce.edu

Dr.S. Ponmalar spmece@tce.edu

Passed in BoS Meeting 04.07.2020