SYLLABI

FOR

B.E. DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution Affiliated to Anna University)
MADURAI – 625 015, TAMILNADU
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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:

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).
PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

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	M	M	L
PEO2	L	S	M	M
PEO3	M	L	S	M

PEO-PO-PSO Mapping:

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PSO 1**	**PSO 2**	**PSO 3**
PEO1														
PEO2														
PEO3														

PO-GA Mapping:

	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11
PO1											
PO2											
PO3											
PO4											
PO5											
PO6											
PO7											
PO8											
PO9											
PO10											
PO11											

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

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

CREDIT DISTRIBUTION
(For the students admitted in the Academic Year 2022-23 onwards)

Sl. No.		Category	Credits	
			Regular	Lateral Entry
A.	**Foundation Courses (FC)**		**54 - 66**	**23 – 35**
	a.	Humanities and Social Sciences including Management Courses (HSMC)	09 - 12	06 - 09
	b.	Basic Science Courses (BSC)	24 - 27	09 - 11
	c.	Engineering Science Courses (ESC)	21 - 27	08 - 15
B.	**Professional Core Courses (PCC)**		**55**	**44**
C.	**Professional Elective Courses (PEC)**		**24 - 39**	**24 – 39**
	a.	Programme Specific Elective (PSE)	15 - 24	15 – 24
	b.	Programme Elective for Expanded Scope (PEES)	09 - 15	09 – 15
D.	**Open Elective Courses (OEC)**		**06 - 12**	**06 – 12**
	a.	Interdisciplinary Elective (IE)	03 - 06	03 – 06
	b.	Basic Science Elective (BSE)	03 - 06	03 – 06
E.	**Project Work (PW)**		**12**	**12**
F.	**Internship and Mandatory Audit Courses as per Regulatory authorities**		Non-Credit and not included in CGPA	Non-Credit and not included in CGPA
Minimum Credits to be earned for the award of the Degree			**160**	**120**
			From A to E and the successful completion of F	From A to E and the successful completion of F

SCHEDULING OF COURSES FOR STUDENTS JOINED FROM ACADEMIC YEAR 2022-23 ONWARDS (B.E. ECE Programme) *											
Sem	Theory / Theory cum Practical / Practical								CDIO courses	Audit Courses (Mandatory Non-credit}	Credit
	1	2	3	4	5	6	7	8			
I	22MA110 Calculus for Engineers (BSC-4)	22PH120 Physics (BSC-3)	22CH130 Chemistry (BSC-3)	22EG140 Technical English (HSMC-2)	22EC160 Computer Aided Engg. Graphics (TCP) (ESC-3)	22EG170 English Laboratory (HSMC-1)	22PH180 Physics Laboratory (BSC-1)	22CH190 Chemistry Laboratory (BSC-1)	22EC190 Engineering Exploration (TCP) (ESC-2)	22CHAA0 Environmental Science (AC-0)	20
II	22EC210 Matrices and Linear Algebra (BSC-3)	22EC220 Electronic Devices (ESC-3)	22EC230 Electric and Magnetic Circuits (PCC-4)	22EC240 Digital Circuit Design (TCP) (PCC-4)	22EC250 Field Theory and Transmission Lines (PCC-3)	22EC260 Problem Solving using Computers (TCP) (ESC-3)					20
III	22EC310 Probability and Statistics (BSC-3)	22EC320 Analog Circuit Design (TCP) (PCC-4)	22EC330 Network Analysis and Synthesis (BSC-3)	22EC340 Computer Organization and Microprocessor (TCP) (PCC-4)	22EC350 Signals and Systems (PCC-4)	22EC360 Object Oriented Programming (ESC-3)			22ES390 Design Thinking (ESC-3)		24
IV	22EC410 Optimization (BSC-3)	22EC420 Mixed Signal Circuit Design (PCC-3)	22EC430 RF Circuit Design (TCP) (PCC-4)	22EC440 Microcontrollers and Embedded Systems (TCP) (PCC-4)	22EC450 Discrete-Time Signal Processing (TCP) (PCC-4)	22EC460 Data Science (ESC-2)				22CHAB0 Constitution of India (AC-0)	20

V	22EC510 Data Communication Networks (ESC-3)	22EC520 VLSI Circuits and Systems (PCC-3)	22EC530 Antennas and Wave Propagation (TCP) (PCC-3)	22EC540 Sensors and Instrumentation (BSC-2)	22EC550 Analog and Digital Communication (PCC-3)	22EC570 Data Communication Networking Laboratory (ESC-1)	22EC580 Analog and Digital Communication Laboratory (PCC-1)	22YYGX0 Interdisciplinary Elective (IE-3)	22EC590 Project-I (PW-3)	22CHAC0 Essence of Indian Knowledge (AC-0)	22
VI	22EC610 Accounting and Finance (HSMC-4)	22EC620 Image Processing (TCP) (PCC-3)	23EC630 Wireless Communications (TCP) (PCC-4)	22ECXY0 PEC-1 (3)			22YYBX0 Basic Science Elective (BSE-3)	22EG660 Professional Communication (HSMC-2)	22EC690 Project-II (PW-3)		22
\VII	22EC710 Optical Fiber Communication System (ESC-2)	22ECXY0 PEC-2 (3)	22ECXY0 PEC-3 (3)	22ECXY0 PEC-4 (3)	22ECXY0 PEC-5 (3)	22ECXY0 PEC-6 (3)			22EC790 Project-III (PW-3)		20
VIII	22ECXY0 PEC-7 (3)	22ECXY0 PEC-8 (3)	22ECXY0 PEC-9 (3)						22EC890 Project-IV (PW-3)		12

This schedule shows an optimal way of completing the B.E. Degree programme successfully in 4 Years **_Total Credits for Curricular Activities: 160_**

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 2022-23 onwards)

FIRST SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week L	T	P	Credits
THEORY						
22MA110	Calculus for Engineers	BSC	3	1	-	4
22PH120	Physics	BSC	3	-	-	3
22CH130	Chemistry	BSC	3	-	-	3
22EG140	Technical English	HSMC	2	-	-	2
THEORY CUM PRACTICAL						
22EC160	Computer Aided Engineering Graphics	ESC	2	-	2	3
22EC190	Engineering Exploration	ESC	1	-	2	2
PRACTICAL						
22EG170	English Laboratory	HSMC	-	-	2	1
22PH180	Physics Laboratory	BSC	-	-	2	1
22CH190	Chemistry Laboratory	BSC	-	-	2	1
Total			**14**	**1**	**10**	**20**

SECOND SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week L	T	P	Credits
THEORY						
22EC210	Matrices and Linear Algebra	BSC	2	1	-	3
22EC220	Electronic Devices	ESC	2	1	-	3
22EC230	Electric and Magnetic Circuits	PCC	3	1	-	4
22EC250	Field Theory and Transmission Lines	PCC	2	1	-	3
THEORY CUM PRACTICAL						
22EC240	Digital Circuit Design	PCC	3	-	2	4
22EC260	Problem Solving using Computers	ESC	2	-	2	3
AUDIT COURSE						
22CHAA0	Environmental Science	BSC	1	-	1	0
Total			**15**	**4**	**5**	**20**

THIRD SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week L	T	P	Credits
THEORY						
22EC310	Probability and Statistics	BSC	2	1	-	3
22EC330	Network Analysis and Synthesis	BSC	2	1	-	3
22EC350	Signals and Systems	PCC	3	1	-	4
22EC360	Object Oriented Programming	ESC	3	-	-	3
22ES490	Design Thinking	ESC	1	-	2	3

THEORY CUM PRACTICAL						
22EC320	Analog Circuit Design	PCC	3	-	2	4
22EC340	Computer Organization and Microprocessor	PCC	3	-	2	4
Total			**17**	**3**	**6**	**24**

FOURTH SEMESTER

Course Code	**Name of the Course**	**Category**	**No. of Hours / Week**			**Credits**
			L	**T**	**P**	
THEORY						
22EC410	Optimization	BSC	2	1	-	3
22EC420	Mixed Signal Circuit Design	PCC	3	-	-	3
22EC460	Data Science	ESC	2	-	-	2
THEORY CUM PRACTICAL						
22EC430	RF Circuit Design	PCC	3	-	2	4
22EC440	Microcontrollers and Embedded Systems	PCC	3	-	2	4
22EC450	Discrete-Time Signal Processing	PCC	3	-	2	4
Total			**16**	**1**	**6**	**20**

Third and Fourth Semester Mathematics course for Lateral Entry Students

Course Code	**Name of the Course**	**Category**	**No. of Hours / Week**			**Credits**
			L	**T**	**P**	
THEORY						
22MA310	Essentials of Matrices and Calculus	BSC	2	1	-	3
22ECL10	Vector Spaces, Probability and Optimization	BSC	2	1	-	3

FIFTH SEMESTER

Course Code	**Name of the Course**	**Category**	**No. of Hours / Week**			**Credits**
			L	**T**	**P**	
THEORY						
22EC510	Data Communication Networks	ESC	3	-	-	3
22EC520	VLSI Circuits and Systems	PCC	3	-	-	3
22EC540	Sensors and Instrumentation	BSC	2	-	-	2
22EC550	Analog and Digital Communication	PCC	2	1	-	3
22YYGX0	Interdisciplinary Elective	IE	3	-	-	3
THEORY CUM PRACTICAL						
22EC530	Antennas and Wave Propagation	PCC	2	-	2	3
PRACTICAL						
22EC570	Data Communication Networking Laboratory	ESC	-	-	2	1
22EC580	Analog and Digital Communication Laboratory	PCC	-	-	2	1
PROJECT						
22EC590	Project-I	PW	-	-	6	3
Total			**15**	**1**	**12**	**22**

SIXTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22EC810	Accounting and Finance	HSMC	4	-	-	4
22ECXY0	PEC-1	PEC	3	-	-	3
22YYBX0	Basic Science Elective	BSE	3	-	-	3
THEORY CUM PRACTICAL						
22EC620	Image Processing	PCC	2	-	2	3
23EC630	Wireless Communications	PCC	3	-	2	4
22EG660	Professional Communication	HSMC	-	1	2	2
PROJECT						
22EC690	Project-II	PW	-	-	6	3
Total			**15**	**1**	**12**	**22**

SEVENTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22EC710	Optical Fiber Communication System	ESC	2	-	-	2
22ECXY0	PEC-2	PEC	3	-	-	3
22ECXY0	PEC-3	PEC	3	-	-	3
22ECXY0	PEC-4	PEC	3	-	-	3
22ECXY0	PEC-5	PEC	3	-	-	3
22ECXY0	PEC-6	PEC	3	-	-	3
PROJECT						
22EC690	Project-III	PW	-	-	6	3
Total			**17**	**0**	**6**	**20**

EIGTHTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
22ECXY0	PEC-7	PEC	3	-	-	3
22ECXY0	PEC-8	PEC	3	-	-	3
22ECXY0	PEC-9	PEC	3	-	-	3
PROJECT						
22EC690	Project-IV	PW	-	-	6	3
Total			**9**	**0**	**6**	**12**

BSC : Basic Science Courses
PCC : Professional Core Courses
ESC : Engineering Science Courses
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 2022-23 onwards)

FIRST SEMESTER

. #	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	22MA110	Calculus for Engineers	3	40	60	100	27	50
2	22PH120	Physics	3	40	60	100	27	50
3	22CH130	Chemistry	3	40	60	100	27	50
4	22EG140	Technical English	3	40	60	100	27	50
THEORY CUM PRACTICAL								
5	22EC160	Computer Aided Engineering Graphics	3	50	50	100	25	50
6	22EC190	Engineering Exploration	3	50	50	100	25	50
PRACTICAL								
7	22EG170	English Laboratory	3	60	40	100	18	50
8	22PH180	Physics Laboratory	3	60	40	100	18	50
9	22CH190	Chemistry Laboratory	3	60	40	100	18	50

SECOND SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE	Max. Marks	TE	Total
THEORY							
22EC210	Matrices and Linear Algebra	3	40	60	100	27	50
22EC220	Electronic Devices	3	40	60	100	27	50
22EC230	Electric and Magnetic Circuits	3	40	60	100	27	50
22EC250	Field Theory and Transmission Lines	3	40	60	100	27	50
THEORY CUM PRACTICAL							

22EC240	Digital Circuit Design	3	50	50	100	25	50
22EC260	Problem Solving using Computers	3	50	50	100	25	50
AUDIT COURSE							
22CHAA0	Environmental Science	-	50	50	100	25	50

THIRD SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE	Max. Marks	TE	Total
THEORY							
22EC310	Probability and Statistics	3	40	60	100	27	50
22MA310 (for LE students)	Essentials of Matrices and Calculus	3	40	60	100	27	50
22EC330	Network Analysis and Synthesis	3	40	60	100	27	50
22EC350	Signals and Systems	3	40	60	100	27	50
22EC360	Object-Oriented Programming	3	40	60	100	27	50
THEORY CUM PRACTICAL							
22EC320	Analog Circuit Design	3	50	50	100	22.5	50
22EC340	Computer Organization and Microprocessor	3	50	50	100	22.5	50

FOURTH SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE	Max. Marks	TE	Total
THEORY							
22EC410	Optimization	3	40	60	100	27	50
22ECL10 (for LE students)	*Vector Spaces, Probability and Optimization*	*3*	*40*	*60*	*100*	*27*	*50*
22EC420	Mixed Signal Circuit Design	3	40	60	100	27	50
22EC460	Data Science	3	40	60	100	27	50
22ES490	Design Thinking	3	40	60	100	27	50
THEORY CUM PRACTICAL							
22EC430	RF Circuit Design	3	50	50	100	22.5	50
22EC440	Microcontrollers and Embedded Systems	3	50	50	100	22.5	50
22EC450	Discrete-Time Signal Processing	3	50	50	100	22.5	50

FIFTH SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE	Max. Marks	TE	Total
THEORY							
22EC510	Data Communication Networks	3	40	60	100	27	50
22EC520	VLSI Circuits and Systems	3	40	60	100	27	50
22EC540	Sensors and Instrumentation	3	40	60	100	27	50
22EC550	Analog and Digital Communication	3	40	60	100	27	50
22YYGX0	Interdisciplinary Elective	3	40	60	100	27	50
THEORY CUM PRACTICAL							
22EC530	Antennas and Wave Propagation	3	50	50	100	25	50
PRACTICAL							
22EC570	Data Communication Networking Laboratory	3	60	40	100	18	50
22EC580	Analog and Digital Communication Laboratory	3	60	40	100	18	50
PROJECT							
22EC590	Project-I	-	50	50	100	25	50

SIXTH SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE	Max. Marks	TE	Total
THEORY							
22EC810	Accounting and Finance	3	40	60	100	27	50
22ECXY0	PEC-1	3	40	60	100	27	50
22YYBX0	Basic Science Elective	3	40	60	100	27	50
THEORY CUM PRACTICAL							
22EC620	Image Processing	3	50	50	100	25	50
23EC630	Wireless Communications	3	50	50	100	25	50
22EG660	Professional Communication	3	50	50	100	25	50
PROJECT-II							
22EC690	Project-II	-	50	50	100	25	50

SEVENTH SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE	Max. Marks	TE	Total
THEORY							
22EC710	Optical Fiber Communication System	3	40	60	100	27	50
PROJECT-II							
22EC690	Project-III	-	50	50	100	25	50

EIGHTH SEMESTER

Course Code	Name of the Course	Duration of TE in Hrs.	Marks			Min. Marks for Pass	
			CA*	TE	Max. Marks	TE	Total
PROJECT-II							
22EC690	Project-IV	-	50	50	100	25	50

TE – Terminal Examination, CA – Continuous Assessment
*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

CURRICULUM AND DETAILED SYLLABI

FOR

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

FIRST SEMESTER

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution Affiliated to Anna University)
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22MA110	CALCULUS FOR ENGINEERS

Category	L	T	P	Credit
BSC	3	1	0	4

Preamble

This course aims to provide technical competence of modeling engineering problems using calculus. In this course, the calculus concepts are taught 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 model and 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

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Cognize the concept of functions, limits and continuity	TPS2	75	70
CO2	Compute derivatives and apply them in solving engineering problems	TPS3	70	65
CO3	Employ partial derivatives to find maxima minima of functions of multi variables	TPS3	70	65
CO4	Demonstrate the techniques of integration to find the surface area of revolution of a curve.	TPS3	70	65
CO5	Utilize double integrals to evaluate area enclosed between two curves.	TPS3	70	65
CO6	Apply triple integrals to find volume enclosed between surfaces	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	L							L		L	
CO2	S	M	L						L		L	
CO3	S	M	L						L		L	
CO4	S	M	L						L		L	
CO5	S	M	L						L		L	
CO6	S	M	L						L		L	

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Assessment 1						Assessment 2						Terminal (%)			
	Written Test 1 (%)			Assignment 1 (%)			Written Test 2 (%)			Assignment 2 (%)						
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**TOTAL (%)**
CO1	20%			50%			-			-			-	10%	-	10%
CO2	32%						-			-			-	-	16%	16%
CO3	36%						-			-			-	-	18%	18%
CO4	12%			-			39%			50%			-	-	25%	25%
CO5	-			-			35%						-	-	17%	17%
CO6	-			-			26%						-	-	14%	14%
MATLAB	-			50%			-			50%						
TOTAL	**100%**			**100%**			**100%**			**100%**			**-**	**10%**	**90%**	**100 %**

* Assignment 1: (i)Application Problems in CO1, CO2 and CO3 (50%).
(ii) MATLAB Onramp & Introduction to symbolic Math with MATLAB (50%).

**Assignment 2: (i) Application Problems in CO4, CO5 and CO6 (50%).
(ii) Application problems using MATLAB. (50%).

Syllabus

DIFFERENTIAL CALCULUS

Functions - New functions from old functions - Limit of a function - Continuity - Limits at infinity - Derivative as a function - Maxima and Minima of functions of one variable – Mean value theorem - Effect of derivatives on the shape of a graph- Application problems in engineering using MATLAB.

FUNCTIONS OF SEVERAL VARIABLES:

Function of several variables- Level curves and level surfaces - Partial derivatives – Chain rule - Maxima and minima of functions of two variables –Method of Lagrange's Multipliers - Application problems in engineering using MATLAB.

INTEGRAL CALCULUS:

The definite integral – Fundamental theorem of Calculus – Indefinite integrals and the Net Change Theorem – Improper integrals – Area of surface of revolution - Volume of solid of revolution -Application problems in engineering using MATLAB.

MULTIPLE INTEGRALS:

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 using MATLAB.

Text Book

1) James Stewart, "Calculus Early Transcendentals", 9th Edition, Cengage Learning, New Delhi, 2019.
    a. **DIFFERENTIAL CALCULUS:** [Sections: 1.3, 2.2, 2.5, 2,6,2.8, 4.1, 4.2 and 4.3.]
    b. **FUNCTIONS OF SEVERAL VARIABLES:** [Sections: 14.1,14.3,14.5,14.7 and 14.8.]
    c. **INTEGRAL CALCULUS:** [Sections: 5.2, 5.3, 5.4, 7.8, 8.2 and 6.2.]
    d. **MULTIPLE INTEGRAL:** [Sections: 15.1-15.4, 15.6-15.9]
2) Lecture Notes on Calculus Through Engineering Application Problems and Solutions, Department of Mathematics, Thiagarajar College of Engineering, Madurai.

Reference Books& web resources

1) George B. Thomas, "Thomas Calculus: early Transcendentals", 14th edition, Pearson, New Delhi, 2018.

2) Howard Anton, Irl Bivens and Stephen Davis, "Calculus: Early Transcendentals", 12the, John Wiley & Sons, 2021.
3) Kuldeep Singh, "Engineering Mathematics Through Applications", 2nd edition, Blooms berry publishing, 2019.
4) Kuldip S. Rattan, Nathan W. Klingbeil, Introductory Mathematics for Engineering Applications, 2nd e John Wiley& Sons , 2021.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**DIFFERENTIAL CALCULUS**	
1.1	Functions and New functions from old functions	2
1.2	Limit of a function &Continuity of a function	1
	Tutorial	**1**
1.3	Limits at infinity	1
1.4	Derivative as a function	2
	Tutorial	**1**
1.5	Maxima and Minima of functions of single variable	2
1.6	The Mean value theorem and effect of derivatives on the shape of a graph of a function	1
	Tutorial	**1**
1.7	Application problems in engineering using MATLAB	1
2	**FUNCTIONS OF SEVERAL VARIABLES**	
2.1	Level curves and level surfaces	2
2.2	Partial derivatives – Chain rule	1
	Tutorial	**1**
2.3	Maxima and minima of functions of two variables	2
2.4	Method of Lagrange's Multipliers	1
	Tutorial	**1**
2.5	Application problems in engineering using MATLAB	1
3	**INTEGRAL CALCULUS**	
3.1	The definite integral	1
3.2	Fundamental theorem of Calculus	2
	Tutorial	**1**
3.3	Indefinite integrals and the Net Change Theorem	1
3.4	Improper integrals	2
	Tutorial	**1**
3.5	Area of surface of revolution	1
3.6	Volume of solid of revolution.	2
3.7	Application problems in engineering using MATLAB	1
4	**MULTIPLE INTEGRALS**	
4.1	Iterated integrals	1
4.2	Double integrals over general regions	2
	Tutorial	**1**
4.3	Double integrals in polar coordinates	1
4.4	Applications of double integrals (density, mass, moments & moments of inertia problems only)	2

Module No.	Topic	No. of Periods
	Tutorial	**1**
4.5	Triple integrals	1
4.6	Triple integrals in cylindrical coordinates	1
4.7	Triple integrals in spherical coordinates	1
	Tutorial	**1**
4.8	Change of variables in multiple integrals	1
4.9	Application problems in engineering using MATLAB	1
	Total	**48**

Course Designer(s):

1. Dr.B.Vellaikannan, bvkmat@tce.edu
2. Dr.C.S.Senthilkumar, kumarstays@tce.edu
3. Dr.S.P.Suriya Prabha, suriyaprabha@tce.edu
4. Dr.S.Saravanakumar, sskmat@tce.edu
5. Dr.M.Sundar, msrmat@tce.edu

22PH120	PHYSICS

Category	L	T	P	Credit
BSC	3	0	0	3

Preamble

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

Prerequisite

None

Course Outcomes

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

	Course Outcome	TCE Proficiency Scale	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Apply the vector calculus approach and Newton's law in polar coordinates to solve problems in mechanics	TPS3	85	80
CO2	Solve for the solutions and describe the behaviour of a damped harmonic oscillator and waves.	TPS3	85	80
CO3	Introduce Schrodinger equation to arrive at the energy values of particle in a box and linear harmonic oscillator	TPS3	85	80
CO4	Use the principle of quantum mechanics for quantum mechanical tunnelling, quantum confinement and quantum computation	TPS2	85	80
CO5	Use the laws of electrostatics and magnetostatics to explain electromagnetic wave propagation	TPS3	85	80
CO6	Explain the fundamentals of optical phenomena and its applications	TPS2	85	80

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L	-	-	-	-	-	L	L	-	-
CO2	S	M	L	-	-	-	-	-	L	L	-	-
CO3	S	M	L	-	-	-	-	-	L	L	-	-
CO4	M	L		-	-	-	-	-	L	L	-	-
CO5	S	M	L	-	-	-	-	-	L	L	-	-
CO6	M	L										

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II * (%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	8	15	22										6	6	10
CO2	8	10	15	100									4	3	10
CO3	4	5	13				-	-	15				-	2	15
CO4							4	15	-	100			4	6	-
CO5							-	-	35				-	3	15
CO6							16	15	-				6	10	-
Total	20	30	50	100			20	30	50	100			20	30	50

*Assignment I, II –Quiz/ Puzzle/ Case analysis/ Problem-solving/ Presentation/ Writing tasks

Syllabus

Mechanics of Particles:
Scalars and vectors under rotation transformation - Coordinate system - Cartesian, Polar, Spherical, Cylindrical - Newton's second law of motion - Forces in nature - 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

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 – Quantum confinement in 0D, 1D, 2D systems - Scanning tunnelling microscope - Quantum Cascade lasers - Quantum computation (qubit) - Entanglement - Teleportation

Electromagnetic Fields and Waves:
Electric potential and Electric field of a charged disc - Magnetic Vector potential - Maxwell's equation - Equation of continuity – Poynting Vector - Energy and momentum of EM waves - CT/MRI scan

Optics:
Ray paths in inhomogeneous medium and its solutions – Applications - Fibre optics - Numerical Aperture& Acceptance angle - Fibre optic sensors - Liquid Level & Medical Applications - Interference in non-reflecting films - Fabry-Perot interferometer - Diffraction - Fraunhofer diffraction due to double slit.

Text Books

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

Reference Books & web resources

MECHANICS OF PARTICLES

Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters – 4, 9 & 10).

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, 4^{th} Edition, Cengage, 2013. (Chapters - 5 & 6).
3. R. Shankar, Fundamentals of Physics – I, II, Yale University Press, 2014, 2016.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Mechanics of Particles**	**8**
1.1	Scalars and vectors under rotation transformation	2
1.2	Coordinate system - Cartesian, Polar, Spherical, Cylindrical	2
1.3	Newton’s second law of motion - Forces in nature - Central forces	2
1.4	Conservative and non-conservative forces - Work - Energy theorem - Conservation of angular momentum - Satellite manoeuvres	2
2	**Oscillations and Waves**	**6**
2.1	Simple harmonic oscillators - Energy decay in a Damped harmonic oscillator	2
2.2	Q factor- Impedance matching – Wave groups and group velocity	2
	CAT-I after 12 contact hours	
2.3	Non-dispersive transverse and Longitudinal waves	1
2.4	Waves with dispersion- Water waves -Acoustic waves – Earthquake and Tsunami waves	1
3	**Quantum Mechanics**	**10**
3.1	Wave nature of particles - wave function -probability current density and expectation values - Schrodinger wave equation	3
3.2	Uncertainty principle - Particle in a box in 1D – Linear harmonic oscillator	3
3.3	Quantum tunnelling – Quantum confinement in 0D, 1D, 2D systems - Scanning tunnelling microscope – Quantum Cascade lasers – Quantum computation (qubit) – Entanglement - Teleportation	4
	CAT-II after 12 contact hours	
4	**Electromagnetic Fields and Waves**	**6**
4.1	Electric potential and Electric field of a charged disc	1
4.2	Magnetic Vector potential – Maxwell’s Equations	2
4.3	Equation of continuity-Poynting Vector-Energy and momentum of EM waves	2
4.4	CT/MRI scan	1
5	**Optics**	**6**
5.1	Ray paths in inhomogeneous medium & its solutions–Applications – Fiber optics	2

5.2	Numerical Aperture& Acceptance angle - Fiber optic sensors - Liquid Level & Medical Applications	2
5.3	Interference in non-reflecting films - Fabry- Perot interferometer - Diffraction - Two slit Fraunhofer diffraction	2
	CAT-III after 12 contact hours	
	Total	**36**

Course Designer(s):

1. Dr. M. Mahendran, Professor, manickam-mahendran@tce.edu
2. Mr. V. Veeraganesh, Assistant Professor, vvgphy@tce.edu
3. Dr. A L. Subramaniyan, Assistant Professor, alsphy@tce.edu
4. Dr. A. Karuppusamy, Assistant Professor, akphy@ce.edu

22CH130	CHEMISTRY

Category	L	T	P	Credit
BSC	3	0	0	3

Preamble

The objective of this course is to bestow basic concepts of chemistry and its applications in engineering domain. It imparts knowledge on properties and treatment methods of water, spectroscopic techniques and their applications. This course provides exposure on electrochemical techniques for corrosion control, surface coatings and energy storage devices and also emphasis the properties and applications of engineering materials.

Prerequisite

Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the essential water quality parameters of water	TPS2	70	70
CO2	Determine hardness of water and identify suitable water treatment method	TPS3	70	70
CO3	Explain the electrochemical process involved in energy storage devices and corrosion of metals	TPS2	70	70
CO4	Interpret the electrochemical principles in modern energy storage devices and corrosion control methods	TPS3	70	70
CO5	Identify the appropriate spectroscopic technique for various applications	TPS3	70	70
CO6	Select the materials based on the properties for Engineering applications	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	M	L	-	-	-	-	-	-	-	-	-	-
CO2.	S	M	L	-	-	-	L	-	-	-	-	-
CO3.	M	L	-	-	-	-	-	-	-	-	-	-
CO4.	S	M	L	-	-	-	-	-	L	-	-	-
CO5.	S	M	L	-	-	-	L	-	L	-	-	-
CO6.	S	M	L	-	-	-	-	-	-	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						CAT2						Terminal					
TPS Scale	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	4	20	0										2	8				
CO2	4	0	20										2	4	10			
CO3	4	20	0										2	8				
CO4	8	0	20										2	4	10			
CO5							12	20	20				6	8	10			
CO6							8	20	20				6	8	10			

*****Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

CO	Assignment 1*						Assignment 2*					
TPS Scale	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1												
CO2			20									
CO3												
CO4			20									
CO5									20			
CO6									20			

*Assessment type: Quiz / Test /Presentation

Syllabus

Water: Water-sources- physical - characteristics - alkalinity - hardness of water – types - determination of hardness by EDTA method. Boiler trouble-Softening of water: Internal and External treatment methods. Waste water treatment process. **Electrochemical technologies for energy storage and surface engineering:** Electrochemistry and Energy storage: Basics of electrochemistry. Batteries **-** Primary and Secondary batteries. Fuel cells. Hydrogen generation and storage. Corrosion and Surface Engineering–Basics –Corrosion - causes- factors- types - corrosion of metal and computer components- Corrosion control. Electroplating - Electroless process. **Spectroscopic technique and applications:** Principle, instrumentation, and applications: X-ray-diffraction - UV–Visible spectroscopy- Atomic Absorption Spectroscopy - Fluorescence spectroscopy - Inductively Coupled Plasma - Optical Emission Spectroscopy- Infra-red spectroscopy - Nuclear magnetic resonance spectroscopy**. Engineering materials:** Bonding and their influences on the property of materials - melting point - brittleness, ductility – thermal, electrical, and ionic conductivity - optical – magnetic properties, hydrophobic, hydrophilic. **Polymer composites** - structure and properties- applications. **Ceramics and advanced ceramics** - types-properties-applications-**Nano-materials** – Synthesis, structure, and properties –applications.

Text Book

1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, Dhanpat Rai publications, New Delhi, 16thedition, 2015.

Reference Books& web resources

- S.S. Dara and S.S. Umare, “A Textbook of Engineering Chemistry”, S.Chand & Company, 12thEdition, Reprint, 2013.
- Shashi Chawla, “ A text book of Engineering Chemistry”, Dhanpat Rai & Co.(pvt) ltd, 3rd edition, reprint 2011.
- C. N. Banwell and E.M. McCash, “Fundamentals of Molecular Spectroscopy”, Tata McGraw-Hill (India), 5thEdition, 2013.

- W.F. Smith, Principles of Materials Science and Engineering: An Introduction; Tata Mc-Graw Hill, 2008.
- V. Raghavan, Introduction to Materials Science and Engineering; PHI, Delhi, 2005.
- M. Akay, 2015, An introduction to polymer matrix composites," from: https://www.academia.edu/37778336/An_introduction_to_polymer_matrix_composites

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Water**	
1.1	Importance of water, sources, standards for drinking water, (WHO, BIS & ICMR standards) physical, chemical & biological characteristics, Alkalinity (principle only)	1
1.2	Hardness of water - types, units. Determination of hardness by EDTA method and numerical problems	2
1.3	**boiler trouble:** Scale and sludge formation, boiler corrosion, priming and foaming, caustic embrittlement	1
1.4	**Internal treatment methods:** Carbonate, Phosphate, Colloidal, Calgon conditioning	1
1.5	**softening of water:** External treatment methods: Lime-soda process (concept only), zeolite process, ion exchange process	2
1.6	Desalination- reverse osmosis, electro dialysis, solar and multistage flash distillation, nano-filtration	1
1.7	Waste water treatment – primary, secondary, and tertiary treatment	1
2	**Electrochemical technologies for energy storage and surface engineering**	
2.1	**Electrochemistry and Energy storage**: Introduction**–** Basics of electrochemistry – Redox process, EMF	1
2.2	**Energy storage** – Batteries, Battery quality parameters	1
2.3	Primary battery – Dry cell and Alkaline cell	1
2.4	Secondary battery – Lead-acid battery, Lithium-ion battery	1
2.5	Fuel cells – Fundamentals, types and applications. Hydrogen generation and storage	1
2.6	**Corrosion and Surface Engineering**- Basics –Corrosion - causes- factors- types	1
2.7	chemical, electrochemical corrosion (galvanic, differential aeration), corrosion of metal and computer components-	1
2.8	Corrosion control - material selection and design aspects - electrochemical protection – sacrificial anode method and impressed current cathodic method	1
2.9	Electroplating –Introduction, Process, Applications (Gold and nickel plating). Electroless plating – Principle, process, Applications (PCB manufacturing)	1
3	**Spectroscopic technique and applications**	
3.1	Introduction to Electromagnetic Radiation, Types of atomic and molecular spectra	1
	Principle, Instrumentation and Applications:	1

Module No.	Topic	No. of Periods
3.2	X-ray-diffraction	
3.3	UV–Visible spectroscopy, Atomic Absorption Spectroscopy	2
3.4	Fluorescence spectroscopy, Inductively Coupled Plasma - Optical Emission Spectroscopy	2
3.5	Infra-red spectroscopy	2
3.6	Nuclear magnetic resonance spectroscopy – Magnetic resonance imaging	1
4	**Engineering materials**	
4.1	Bonding and its influence on the property of materials	1
4.2	Properties of materials- melting point - brittleness, ductility - thermal, electrical and ionic conductivity	1
4.3	optical – magnetic properties, hydrophobic, hydrophilic	1
4.4	**Polymer composites** - structure and properties	1
4.5	applications -automotive, aerospace, marine, biomedical, and defense	1
4.6	**Ceramics and advanced ceramics** - types-properties	1
4.7	applications- medicine, electrical, electronics, space	1
4.8	**Nano-materials –** Synthesis, structure and properties	1
4.9	applications - sensors, drug delivery, photo and electro-catalysis, and pollution control	1
	Total	36

Course Designer(s):

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7. Dr. B. Shankar bsrchem@tce.edu

22CH140	TECHNICAL ENGLISH

Category	L	T	P	Credit
HSMC	2	0	0	2

Preamble

The course aims at fostering the students' ability to communicate effectively in various academic, professional, and social settings through oral and written forms. Besides imparting the basic skills namely Listening, Speaking, Reading and Writing (LSRW), significant emphasis is placed on enriching their analytical, descriptive, and creative skills, enabling them to develop and demonstrate a holistic English language proficiency.

Prerequisite

NIL

Course Outcomes

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

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	**Relate** the fundamentals of language in terms of vocabulary, grammar and pronunciation in technical communication.	Understand	70%	80%
CO2	**Infer** ideas from technical and general contexts by identifying main ideas, specific details, predicting and note making	Understand	70%	80%
CO3	**Make use of** language in professional and social contexts with clarity and conciseness.	Apply	60%	70%
CO4	**Identify** specific contexts in technical writing, where appropriate lexical and grammatical functions are applied	Apply	60%	70%
CO5	**Develop** the skills such as understanding, evaluating, analysing and summarising the text and graphical representations.	Apply	60%	70%
CO6	**Organise** ideas with coherence, cohesion and precision in formal written communication	Apply	70%	80%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									M	S		S
CO2									M	S		S
CO3								L	M	S		S
CO4									M	S		S
CO5									M	S		S
CO6								L	M	S		S
S- Strong; M-Medium; L-Low												

Assessment Pattern

CO	Assessment 1						Assessment 2						Terminal (%)		
	Written Test 1 (%)			Assignment 1 (%)			Written Test 2 (%)			Assignment 2 (%)					
TPS	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1		24%									-		-	10%	-
CO2		34%			100%						-		-	20%	
CO3			14%						24%		-		-	-	20%
CO4			14%		-				34%				-	-	10%
CO5			14%		-						100%		-	-	20%
CO6					-				42%				-	-	20%
TOTAL	**100%**			**100%**			**100%**			**100%**			**100%**		

* Assignment 1: Speaking activities in CO1, CO2, and CO3 (100%).
**Assignment 2: Writing activities in CO4, CO5, and CO6 (100%).
*******Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus:

MODULE- I - Basics of Language (CO1)
Vocabulary - Word Building, Prefix, Suffix and Root Words, Basics of Grammar – Parts of Speech, Tenses, Phonetics - Phonemes, Syllables and Stress.

MODULE- II– Reading (CO2)
Reading- Skimming and Scanning of Short Comprehension Passages and Answering Questions or Cloze exercises based on the text prescribed for extensive reading, Note-Making.

MODULE- III–Functional English (CO3)
Framing Questions (WH and Yes/No), Modals, Manual Writing, Recommendations Writing, Agenda and Minutes of Meeting.

MODULE-IV – Technical Notions (CO4)
Technical Notions - Subject-Verb Agreement, Relative Clause, Phrasal Verbs, Impersonal Passive Voice, Noun Compounds, Classifications and Definitions, Cause and Effect, Purpose and Function, Numerical Adjectives.

MODULE-V – Analytical Writing and Business Correspondence (CO5 & CO6)
Summary Writing, Interpretation of Graphics, Jumbled Sentences, Paragraph Writing, Formal Letters (Seeking Permission for Industrial Visit / internship / Bonafide), E-mail Writing (BEC Vantage Writing Task I)

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,2013.
4. Dhanavel, S.P. English and Communication Skills for Students of Science & Engineering, Orient BlackSwan, Chennai: 2016.
5. Swan, Michael. Practical English Usage.4thEdn. OUP. 2017.
6. Elbow, Peter. Writing with Power: Techniques for Mastering the Writing Process. New York, Oxford University Press, 1998.

Extensive Reading:

1. Anthology of Select Five Short Stories
2. Tagore, Rabindranath. *Chitra, a Play in One Act.* London, Macmillan and Co., 1914.

Websites:

1. www.englishclub.com
2. owl.english.purdue.edu
3. www.oxfordonlineenglish.com
4. www.bbclearningenglish.com
5. tcesrenglish.blogspot.com

Course Contents and Lecture Schedule

S.No	Topic	No. of Hours
1.	Word Building, Prefix, Suffix and Root Words	1
2.	Parts of Speech	1
3.	Tenses	1
4.	Skimming and Scanning of Short Comprehension Passages	1
5.	Manual Writing	1
6.	Recommendations	1
7.	Note-Making	1
8.	Subject-Verb Agreement	1
9.	Phonemes	1
10.	Syllables and Stress	1
11.	Answering Questions or Cloze exercises based on the text prescribed for extensive reading	1
12.	Noun Compounds, Classifications and Definitions	1
13.	Cause and Effect, Purpose and Function	1
14.	Summary Writing	1
15.	Interpretation of Graphics	1
16.	Jumbled Sentences	1
17.	Formal Letters (Seeking Permission for Industrial Visit/internship/ Bonafide)	1
18.	Phrasal Verbs and Impersonal Passive Voice	1
19.	Numerical Adjectives	1
20.	Framing Questions (WH and Yes/No) and Modals	1
21.	Agenda and Minutes of Meeting	1
22.	Relative Clause	1
23.	E-mail Writing (BEC Vantage Writing Task I)	1
24.	Paragraph Writing	1
	Total	**24**

Course Designers:

1. Dr.A.Tamilselvi tamilselvi@tce.edu
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3. Dr.G. JeyaJeevakani gjjeng@tce.edu
4. Dr. R. TamilSelvi rtseng@tce.edu

22EC160	COMPUTER AIDED ENGINEERING GRAPHICS

Category	L	T	P	Credit
ESC	2	0	2	3

Preamble

Engineering Graphics is referred as language of engineers. An engineer needs to understand the 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 the existing drawings. This course covers manual drawing of points, straight lines and Computer aided Drawing of orthographic projection of planes & solids and isometric projection of simple and combined solids.

Prerequisite

Basic knowledge about geometry of objects.

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Draw Geometric constructions and projections of points (in all quadrants) and projection of Straight lines (in first quadrant) inclined to one reference plane. (Manual Drawing).	TPS 3	70	70
CO2	Draw the orthographic views (Front view, Top view and side view) of objects from the given isometric view. (Manual Drawing).	TPS 3	70	70
CO3	Draw the orthographic projections (Elevation and Plan) of plane surfaces inclined to any one reference plane using CAD software.	TPS 3	70	70
CO4	Draw the orthographic projections (Elevation and Plan) of regular solids (Prisms, Pyramids, Cylinder and Cone) with axis inclined to any one reference plane using CAD software.	TPS 3	70	70
CO5	Draw the isometric views of regular solids and combined solids (Prisms, Pyramids, Cylinder, Cone, frustum of pyramid, frustum of cone) using CAD software, by 3-D modelling.	TPS 3	70	70
CO6	Draw the isometric views of irregular solids from orthographic views using CAD software, by 3-D modelling.	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11	PO12
CO1	S	M	S	M	M	-	-	-	M	M	-	-
CO2	S	M	S	M	M	-	-	-	M	M	-	-
CO3	S	M	S	M	M	-	-	-	M	M	-	-
CO4	S	M	S	M	M	-	-	-	M	M	-	-
CO5	S	M	S	M	M	-	-	-	M	M	-	-
CO6	S	M	S	M	M	-	-	-	M	M	-	-
Overall	3	2	3	2	2	0	0	0	2	2	0	0
	S	M	S	M	M	-	-	-	M	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category /TPS Scale	Continuous Assessment Test	Terminal Examination
Remember / 1		
Understand / 2		
Apply / 3	100	100
Analyse / 4		
Evaluate / 5		
Create / 6		

Marks Allocation for Internal Assessment:

Sl. No	Description	Marks
1	Submission of Drawing sheets	60
2	Test	40
	Total	**100***

* The total marks secured out of 100 will be converted to 50 marks.

Syllabus

Introduction - Significance of engineering graphics, Use of drawing instruments, Standards, Lettering and dimensioning, Scales. Orthographic Projection- Principles of orthographic projections, First angle projection, Orthographic projection of objects from pictorial views.

Geometric constructions and projections of points (in all quadrants) and projections of straight lines (in first quadrant) inclined to one reference plane. (Manual Drawing).

Drawing orthographic views (Front view, Top view and side view) of objects from the given isometric view (Manual Drawing).

Projections (Elevation and Plan) of plane surfaces in first quadrant, inclined to any one reference plane by rotating object method using Computer Aided Drafting software.

Projection (Elevation and Plan) of regular solids (Prisms, Pyramids, Cylinder and Cone) in first quadrant, by rotating object method when the axis is inclined to one of the reference planes using Computer Aided Drafting software.

Isometric views of regular solids and combined solids (Prisms, Pyramids, Cylinder, Cone, frustum of pyramid, frustum of cone in vertical positions only) using CAD software, by 3-D modelling.

Isometric views of irregular solids from orthographic views by 3-D modelling using Computer Aided Drafting software.

Text Book

- Bhatt N.D., Panchal V.M. and Ingle P.R., (2014) "Engineering Drawing", Charotar Publishing House.
- CAD Software Theory and User Manuals (Technical Drawing with AutoCAD).

Reference Books

1. Shah M.B, and Rana B.C (2009) "Engineering Drawing and Computer Graphics", Pearson Education.
2. B.V.R. Gupta and M. Raja Roy, Engineering Drawing with AutoCAD, 3rd Edition, I.K.International Publications, 2009.

3. Natarajan K.V., “A text book of Engineering Graphics”, Dhanalakshmi Publishers, Chennai, 2012.
4. Basant Agarwal and Agarwal C.M., “Engineering Drawing”, Tata McGraw Hill Publishing Company Limited, New Delhi, 2019.
5. Venugopal K. and Prabhu Raja V., “Engineering Graphics”, New Age International (P) Limited, 2011.
6. Gopalakrishna K.R., “Engineering Drawing” (Vol. I&II combined), Subhas Publications, Bangalore, 2017.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours	Practice Hours
1	**Introduction**- Significance of engineering graphics, Use of drawing instruments –Standards, Lettering and dimensioning, Scales, Orthographic Projection-Principles of orthographic projections,	1	1
2	Geometric constructions, Projection (Elevation and Plan) of points located in all quadrants, Projection (Elevation and Plan) of straight lines (in first quadrant) inclined to one reference plane (HP / VP). (Manual Drawing).	3	3
3	Drawing orthographic views (Front view, Top view and side view) of objects from the given isometric view (Manual Drawing).	2	2
4	Projection (Elevation and Plan) of plane surfaces in first quadrant, inclined to HP by rotating object method using Computer Aided Drafting software.	3	3
5	Projection (Elevation and Plan) of plane surfaces in first quadrant, inclined to VP by rotating object method using Computer Aided Drafting software.	3	3
6	Projection (Elevation and Plan) of regular solids (Prisms, Pyramids, Cylinder and cone) in first quadrant, by rotating object method when the axis is inclined to HP using CAD software.	3	3
7	Projection (Elevation and Plan) of regular solids (Prisms, Pyramids, Cylinder and cone) in first quadrant, by rotating object method when the axis is inclined to VP using CAD software.	3	3
8	Isometric projection – Principle, isometric scale, Isometric views and Isometric views of single simple solids and combined solids (Prisms, Pyramids, Cylinder, Cone, frustum of pyramid, frustum of cone in vertical positions only) using CAD software.	3	3
9	Isometric views of irregular solids from orthographic views by 3-D modelling using Computer Aided Drafting software.	3	3
	TOTAL	**24**	**24**

Marks Allocation for Continuous Assessment:

Sl. No	Description	Marks
1	Manual Drawing sheets (A4) submission	15
2	Computer Aided Drafting (CAD) Exercises	20
3	Continuous Assessment Test (CAT) using CAD software	15
Total		**50**

Question Pattern for Terminal Examination (Using CAD software only):

Question Number	Description	Type	Marks
1	Projection (Elevation and Plan) of points in all quadrants and straight lines (in first quadrant) inclined to any one reference plane.	Either or type	10
2	Orthographic views (Front view, Top view and side view) of objects from the given isometric view.	Either or type	10
3	Projection (Elevation and Plan) of plane surfaces (in first quadrant) inclined to any one reference plane.	Either or type	20
4	Projection (Elevation and Plan) of solids (in first quadrant) inclined to any one reference plane.	Either or type	20
5	3-D modelling of combined solids (Prisms, Pyramids, Cylinder, Cone, frustum of pyramid, frustum of cone in vertical positions only) and their isometric view.	Either or type	20
6	3-D modelling of irregular solids from orthographic views and their isometric view.	Either or type	20
Total			**100**

Note:

1. **One test or two tests will be conducted locally by respective Faculty In - charges during regular class hours to account for continuous assessment test (CAT) marks.**
2. **Terminal Practical examination (3 hrs) will be conducted centrally by the office of Controller of Examinations.**

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22EC190	ENGINEERING EXPLORATION

Category	L	T	P	Credit
ESC	1	0	2	2

Preamble

The Course Electronics and Communication Engineering Exploration provide an introduction to Engineering and specifically to Electronics and Communication Engineering fields. It is designed to help the student to learn about engineering and how it affects our everyday lives. The students develop their fundamental understanding of critical concepts of Electronic controls in Consumer products and about Telecommunication through practical sessions.

Prerequisite

Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain technological & engineering development, change and impacts of engineering	TPS2	70	70
CO2	Demonstrate the basic concepts of Electronics and functional blocks of communication system	TPS3	70	70
CO3	Interpret the role of Electronic controls in Domestic appliances	TPS3	70	70
CO4	Apply the concept of Electronics and Communication Engineering Design Process for building an electronic hardware	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	M	L	-	-	-	-	-	-	-	-	-	-
CO2.	S	M	L	-	L	L	L	-	L	L	-	-
CO3.	M	L	-	-	-	-	-	-	-	-	-	-
CO4.	M	L	-	-	-	-	-	-	-	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assesment-1						**Assesment-2**			**Terminal Examination**		
	THEORY						**PRACTICAL**			**PRACTICAL**		
CO	**Case study**			**CAT-1**								
TPS Scale	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1		50			50							
CO2			50			50						
CO3									40			40
CO4									60			60

Syllabus

What is Engineering: Engineering Requirement, Engineering disciplines, Engineering advancements. **Electronics and Communication Engineering**: Evolution, Theme areas, Concepts in Electronics**-** Active and Passive Components, Signals and EM spectrum– Functional blocks of Wired and Wireless Communication, Communication systems/devices – PSTN, Mobile phone. **Consumer Electronics-** Electrical and Electronic aspects, Electronic controls in Domestic appliances, Audio and Video systems; **Engineering Design:** Problem definition, idea generation through brainstorming and researching, solution creation through evaluating and communicating, test/analysis, final solution and design improvement.

List of Experiments:

1. Identification of components, sources and measuring instruments - experimenting with active and passive components: resistor (voltage division/current division), capacitors and inductors
2. Domestic electrical wiring
3. Practicing soldering and de-soldering
4. Schematic and Layout preparation using CAD tool
5. Practicing PCB fabrication
6. Mini project based on Engineering Design Process demonstrating electronic controls in Domestic appliances

Reference Books

- Ryan A.Brown, Joshua W.Brown and Michael Berkihiser: “Engineering Fundamentals: Design, Principles, and Careers”, Goodheart-Willcox Publisher, Second Edition, 2014.
- Saeed Moaveni, “Engineering Fundamentals: An Introduction to Engineering”, Cengage learning, Fourth Edition, 2011.
- Lynford L. Goddard, Young Mo Kang, Steven J. McKeown, Alexandra Haser, Cori C. Johnson, Madison N. Wilson, “A Project-Based Exploration of Electrical and Computer Engineering” Goddard Independent Publishing, Second Edition, 2020.
- Bali S.P, “Consumer Electronics”, Pearson Education, 2017.
- William D.Stanley amd John.M. Jeffords, “ Electronic Communications Principles and Systems”, Cengage Learning, 2009 (India Edition).

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Engineering**	
1.1	Engineering Requirement, Engineering disciplines, Engineering advancements	1
1.2	**Electronics and Communication –** Evolution, Theme areas	1
1.3	Active and Passive Components	1
2	**Tele Communication System**	
2.1	Functional blocks of Wired and Wireless Communication	1
2.2	Communication System/devices – PSTN, Mobile phone	2
3	**Consumer Electronics**	
3.1	Electrical and Electronic aspects in Domestic appliances	1
3.2	Electronic controls in Domestic appliances	1
3.3	Audio and Video systems	1
4	**Engineering Design Process**	
4.1	Problem definition	1
4.2	Idea generation through brainstorming and researching	
4.3	Solution creation through evaluating and communicating	1

Module No.	Topic	No. of Periods
4.4	Test/Analysis	1
4.5	Final solution and design improvement	
	Theory	12
	Practical	24
	Total	**36**

Course Designers:

- Dr M N Suresh, mns@tce.edu
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22EG170	ENGLISH LABORATORY	Category	L	T	P	Credit
		HSMC	0	0	2	1

Preamble

This practical course enables the students to develop and evaluate their basic English language skills through individualized learning process at the Language Lab, using English Software and online resources. In addition, it 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

COs	Course Outcomes	TCE Proficiency Scale
CO1	Interpret words correctly through listening and watching general and technical online contents	TPS1
CO2	Develop appropriate pronunciation skills through listening and speaking practices	TPS3
CO3	Build and apply a wide range of lexicons in general and technical presentations	TPS3
CO4	Identify and apply the key ideas and spoken English features learnt through auditory and visual listening tools	TPS3
CO5	Experiment with inventiveness by creating a blog, vlog, or YouTube channel.	TPS3
CO6	Prepare and deliver oral and written presentations using digital tools.	TPS3

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									**M**	**S**		**S**
CO2									**M**	**S**		**M**
CO3								**L**	**M**	**S**		**S**
CO4								**L**	**M**	**S**		**M**
CO5								**L**	**M**	**S**		**S**
CO6								**L**	**S**	**S**		**S**

Assessment Pattern

Students' performance will be assessed in the language lab/ classroom as given below:

- Spoken Task - General / Technical Presentation / Picture Description :20 Marks
- Listening Task –(MCQs, Gap Filling Exercises) :10 Marks
- Written Test - Phonetics, Grammar, Vocabulary, Reading :20 Marks

External: Online Exam- Phonetics, Grammar, Vocabulary, Reading (45 Minutes): 50 Marks
Listening Test : 20 Marks
Submission of Students' Record on Practical Tasks in the Class and Lab :10 Marks
BEC Vantage Speaking Tasks I and II : 20 Marks

List of Experiments

S.No	Topic	Hours
	LAB ACTIVITIES (12 Hours)	
1	Listening to TED Talks/ Podcasts/ Product Advertisements/ News Bulletins.	2
2	Phonetics – Tutorials through Online Repositories, English Movie Clips and Software in the Lab(S-net)	2
3	Vocabulary Development through Movies / Short Films/ Documentaries	2
4	Language Development through English software S-net and Online Content (T Voices, SV Agreement, Prepositions, Coherence Markers, Relative Clauses, M Punctuation)	2
5	Reading Comprehension – I (General / Technical, BEC Vantage Reading Task	2
6	Creating a Blog/Vlog/YouTube Channel –Uploading MP3/MP4 – Practice (Movie/Book/ Gadget Review, General/Tech Talks, Interview with Celebrities)	1
7	Revision – Model Online Aptitude Test	1
	CLASSROOM ACTIVITIES (12 Hours)	
8	Introduction of Spoken English Features	1
9	Self-introduction and Introducing others	1
10	Video Comprehension – Brainstorming and Note-Taking	2
11	Role-Play, Picture/Movie Description	1
12	Reporting the events from Media / Newspapers – Discussion	1
13	Interactive Games for Language Development	1
14	Reading / Note Making (Extensive Reading – News Paper Reports)	1
15	Presentation – I (Book /Movie Review, Story Telling, General Presentations)	2
16	Presentation – II (Technical Presentations)	2
	Total	24

Software Used:

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

Teaching Resources and Websites:

1. Open Online Repositories from Oxford / Cambridge / British Council/ Voice of America
2. Free Video Downloads from YouTube
3. www.ted.com
4. tcesrenglish.blogspot.com

Course Designers:

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22PH180	PHYSICS LABORATORY

Category	L	T	P	Credit
BSC	0	0	2	1

Preamble

This course ensures that students are able 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.

Prerequisite

NIL

Course Outcomes

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

	Course Outcome	TCE Proficiency Scale	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Analyze the mechanical & electrical oscillations and determine their resonance frequency	TPS3	85	90
CO2	Analyse the interference and diffraction patterns for micron sized objects	TPS3	85	90
CO3	Investigate the V-I characteristics of photodiode, phototransistor under dark and bright illumination conditions	TPS3	85	90
CO4	Determine the Planck's constant using LEDs	TPS3	85	90
CO5	Plot the VI characteristics of solar cell and find the fill factor	TPS3	85	90
CO6	Determine the reversibility of classical and quantum logic gates	TPS3	85	90
CO7	Identify the variation of magnetic field with distance for circular coils	TPS3	85	90

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	S	M	L	-	M	-	-	-	S	-	-	L
CO2.	S	M	L	-	M	-	-	-	S	-	-	L
CO3	S	M	L	-	M	-	-	-	S	-	-	L
CO4	S	M	L	-	M	-	-	-	S	-	-	L
CO5	S	M	L	-	M	-	-	-	S	-	-	L
CO6	S	M	L	-	M	-	-	-	S	-	-	L
CO7	S	M	L	-	M	-	-	-	S	-	-	L

S- Strong; M-Medium; L-Low

List of Experiments

1. Quantum Logic Gate-Toffoli gate
2. Study of Optoelectronic Devices- Photodiode, Phototransistor.
3. Solar cell VI characteristics, fill factor & Optical Fibre - Determination of numerical aperture.

4. Torsional pendulum – Determination of rigidity modulus of wire and moment of inertia of regular objects.
5. Laser Diffraction - Determination of wave length of the laser using grating and determination of micro particle size. (Observing diffraction pattern due to single and double slit)
6. Air wedge – Determination of thickness of a thin sheet/wire.
7. Determination of Planck's constant through V-I characteristics of LED.
8. Determination of magnetic field-Stewart and Gees.
9. LCR Circuit – Determination of resonant frequency

Course Designer(s):

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2. Dr A. L . Subramaniyan, Assistant Professor, alsphy@tce.edu
3. Dr P.K. Kannan, Assistant Professor, akphy@ce.edu

22CH190	CHEMISTRY LABORATORY

Category	L	T	P	Credit
BSC	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.

Prerequisite

Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale
CO1	Estimate the chemical water quality parameters of sample water / effluent	TPS3
CO2	Demonstrate presence of calcium ions in milk sample	TPS3
CO3	Determine the surface tension of solvent mixtures	TPS3
CO4	Estimate pH and acid content of samples using pH metric and conductometric titrations	TPS3
CO5	Illustrate the strength of oxidisable materials present in given sample by potentiometric method	TPS3
CO6	Determine Fe^{2+} ion in effluent using colorimetric method	TPS3
CO7	Calculate the efficiency of electroplating	TPS3
CO8	Determine the rate of corrosion of metal & alloy using potentio-dynamic polarisation method	TPS3

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	S	M	L	-	M	-	-	-	L	-	-	-
CO2.	S	M	L	-	M	-	-	-	L	-	-	-
CO3.	S	M	L	-	M	-	-	-	L	-	-	-
CO4.	S	M	L	-	M	-	-	-	L	-	-	-
CO5.	S	M	L	-	M	-	-	-	L	-	-	-
CO6.	S	M	L	-	M	-	-	-	L	-	-	-
CO7.	S	M	L	-	M	-	-	-	L	-	-	-
CO8.	S	M	L	-	M	-	-	-	L	-	-	-

S- Strong; M-Medium; L-Low

List of Experiments/Activities with CO Mapping

Experimental List	CO
Quantitative Analysis	
Estimation of total hardness of water sample	CO1
Estimation of COD of industrial effluent	CO1
Determination of calciumion inmilk sample	CO2

Determination of surface tension of solvent mixture	CO3
Electrochemical and Photochemical Analysis	
Determination of the Phosphoric acid content in soft drinks using conductometric titration	CO4
Determination of pH of soil by pH metric titration	CO4
Potentiometric redox titration ($K_2Cr_2O_7$ vs FAS, $KMnO_4$ vs FAS)	CO5
Estimation of iron content in water sample using colorimeter	CO6
Estimation of current density of electroplating process using Hull cell	CO7
Determination of rate of corrosion of metal and alloy using potentiodynamic polarisation technique (TAFEL)	CO8

Learning Resources

1. Vogel's Textbook of Quantitative Chemical Analysis (8THedition, 2014)
2. LaboratoryManual – Department of Chemistry, Thiagarajar College of Engineering (2022)

Course Designers:

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22TAAA0 தமிழர் மரபு

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அலகு I: <u>மொழி மற்றும் இலக்கியம்:</u> **3**

இந்திய மொழிக் குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள் –சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் – திருக்குறளில் மேலாண்மைக் கருத்துக்கள் – தமிழ்க் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் – பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் – சிற்றிலக்கியங்கள் – தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி – தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II: மரபு – பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை – சிற்பக் கலை: **3**

நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள்– பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் – தேர் செய்யும் கலை – சுடுமண் சிற்பங்கள் – நாட்டுப்புறத் தெய்வங்கள் – குமரிமுனையில் திருவள்ளுவர் சிலை – இசைக் கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III: <u>நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்:</u> **3**

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

அலகு IV: <u>தமிழர்களின் திணைக் கோட்பாடுகள்:</u> **3**

தமிழகத்தின் தாவரங்களும், விலங்குகளும் – தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் – தமிழர்கள் போற்றிய அறக்கோட்பாடு – சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் – சங்ககால நகரங்களும் துறை முகங்களும் – சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V: <u>இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு:</u> **3**

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் – தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book

and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

22TAAA0 HERITAGE OF TAMILS

1. Language and Literature: Language Families in India - Dravidian Languages – Tamil as a Classical Language - Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan.

2. Heritage - Rock art paintings to modern art - Sculpture: Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple car making - - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.

3. Folk and Martial arts - Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leatherpuppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.

4. Thinai concept of Tamils – Flora and Fauna of Tamils & Aham and Puram Concept from Tholkappiyam and Sangam Literature - Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas.

5. Contribution of Tamils to Indian National Movement and Indian Culture: Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay)

(Publishedby: The Author)

11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

CURRICULUM AND DETAILED SYLLABI

FOR

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

SECOND SEMESTER

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution Affiliated to Anna University)
MADURAI – 625 015, TAMILNADU

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22EC210	MATRICES AND LINEAR ALGEBRA

Category	L	T	P	Credit
BSC	2	1	0	3

Preamble

Mathematical functions can be viewed in many different ways and one way of viewing them is through vectors. Most of the algebraic manipulation of functions from an m dimensional space to an n dimensional space can be done using matrices and the tools from linear algebra. This course aims at giving through knowledge on matrices and linear algebra and enables the students to solve problems occurring in an n dimensional space.

Prerequisite

NIL

Course Outcomes

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Demonstrate vector space and subspace	TPS 3	70	60
CO2	Use rank nullity theorem to determine the dimension of the range space	TPS 3	70	60
CO3	Compute the nearest possible solution to the given system of equation	TPS 3	70	60
CO4	Determine an orthonormal basis for the given basis.	TPS 3	70	60
CO5	Use properties of Eigen values to determine Eigen values for higher powers of a matrix.	TPS 3	70	60
CO6	Decompose the given matrix into a product of unitary matrix and singular matrix and determine the Eigen values numerically	TPS 3	70	60
CO7	Determine the matrix representation of a linear transformation and solve the linear system of equations numerically	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	S	M	L	-	-	-	-	-	-	-	-	S	L	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	S	L	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	S	L	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	S	L	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	S	L	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	S	L	-	-
CO7	S	M	L	-	-	-	-	-	-	-	-	S	L	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

TPS / CO	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I (%)			CAT – II (%)			Assg. II (%)					
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	-	17	-	-		-	-	-	-	-	-	-	-	8
CO2	3	10	15	-	-		-	-	-	-	-	-	-	6	8
CO3	-	-	17	-	-	100	-	-	-	-	-	-	-	-	8
CO4	4	10	8	-	-		-	-	-	-	-	-	-	6	5
CO5	3	-	13	-	-		-	-	-	-	-	-	-	-	8
CO6	-	-	-	-	-	-	7	10	33	-	-	100	-	9	16
CO7	-	-	-	-	-	-	3	10	37	-	-		-	9	17
Total	**10**	**20**	**70**	**-**	**-**	**100**	**10**	**20**	**70**	**-**	**-**	**100**	**-**	**30**	**70**

Syllabus

Vector Spaces: Vector space, Subspaces, linear independence of vectors, basis and dimension, Row space and Column space, Rank and nullity theorem. [8 hours]

Orthogonality: Orthogonal subspaces, Least square problem, Inner product spaces, Orthonormal sets, The Gram-Schmidt orthogonalization process. [7 hours]

Matrix Eigen Value Problem: Eigen values and Eigen vectors, Properties of eigen values and eigen vectors, orthogonal matrices, Diagonalization, Quadratic forms and Canonical Form, Singular value decomposition, Jacobi method, Power method, Determining Eigen values using matlab. [12 hours]

Linear Transformations: Definition and Examples, Matrix Representations of Linear Transformations, Similarity , Gauss Elimination method, Gauss Jordan method, Solving linear system of equations using matlab [9 hours]

Text Book

- Steven.J. Leon, "Linear Algebra with Applications", 8th edition, Pearson, 2010
- Erwin Kreszig, "Advanced Engineering Mathematics", 9th edition, Wiley, 2017.
- Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, New Delhi, 2018.
- S. R. K. Iyengar, R. K. Jain, Mahinder Kumar Jain, "Numerical methods for Scientific and Engineering Computations", New Age International publishers, 6th Edition, 2012.

Reference Books& web resources

- David C. Lay, "Linear Algebra and its applications", Pearson Addison – Addison Wesley, 3 rd. edition, 2006.
- Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 44th Edition, New Delhi, 2012.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods	COS
1	**Vector Spaces**		
1.1	Vector space	1	CO1
1.2	Subspaces	1	CO1
	Tutorial	**1**	
1.3	Linear independence of vectors	1	CO2
1.4	Basis and dimension	1	CO2
1.5	Row space and Column space, Rank and nullity theorem	2	CO2
	Tutorial	**1**	

2	**Orthogonality**		
2.1	Orthogonal subspaces	1	CO3
2.2	Least square problem	1	CO3
	Tutorial	**1**	
2.3	Inner product spaces	1	CO4
2.4	Orthonormal sets	1	CO4
2.5	The Gram-Schmidt orthogonalization process	1	CO4
	Tutorial	**1**	
3	**Matrix Eigen Value Problem**		
3.1	Eigen values and Eigen vectors	1	CO5
3.2	Properties of Eigen values and Eigen vectors	1	CO5
	Tutorial	**1**	
3.3	Orthogonal matrices	1	CO6
3.4	Diagonalization	1	CO6
3.5	Quadratic forms and Canonical Form	1	CO6
3.6	Singular value decomposition	1	CO6
	Tutorial	**1**	
3.7	Jacobi method	1	CO6
3.8	Power method	2	CO6
	Determining Eigen values using matlab	**1**	
4	**Linear Transformations**		
4.1	Definition and Examples	1	CO7
4.2	Matrix Representations of Linear Transformations	2	CO7
4.3	Similarity	2	CO7
	Tutorial	**1**	
4.4	Gauss Elimination method	1	CO7
4.5	Gauss Jordan method	1	CO7
	Solving linear system of equations using matlab	**1**	
	Total	36	

Course Designers:

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- Dr. L. Muthusubramanian lmsmat@tce.edu
- Dr. S. Suriyakala ssamat@tce.edu

22EC220	ELECTRONIC DEVICES

Category	L	T	P	Credit
ESC	2	1	0	3

Preamble

This is an introduction course to electronic devices. The course begins with a discussion on how electron energy bands are formed in semiconductors; followed by discussions on equilibrium statistics of electrons and holes, drift, diffusion currents, and generation and recombination processes. It then examines the principles and operations of essential semiconductor devices used in today's electronics: diodes, light detectors and emitters, bipolar junction transistors and MOSFETs. It includes the need for small signal model and large signal model 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

CO	Course Outcome Statement	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the energy band diagram of Silicon Semiconductors.	TPS 2	70	70
CO2	Examine the model parameters from the diode data Sheet	TPS 3	70	70
CO3	Interpret the model parameters from the BJT data Sheet	TPS 3	70	70
CO4	Calculate the current gain of the transistors using semiconductor parameters	TPS 3	70	70
CO5	Classify the types of FET based internal structure and operation.	TPS 3	70	70
CO6	Explain the internal structure and principle of operation of photo and power devices.	TPS 2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO2	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	S	M	L	L	-	-	L	L	L	-	L	S	-	L
CO5	M	L	-	-	-	-	-	-	L	L	-	L	S	-	L
CO6	S	S	M	M	L	-	-	-	-	-	-	-	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II * (%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-				-	-	-		-		-	4	12
CO2	-	10	30		100		-	-	-		-		-	4	10
CO3	-	10	30				-	-	-		-		-	4	10
CO4	-	-	-		-		-	10	20				-	4	10
CO5	-	-	-		-		-	10	30		100		-	4	10
CO6	-	-	-		-		-	20	20				-	4	10
Total	-	**40**	**60**		**100**		**-**	**30**	**70**		**100**		**-**	**28**	**72**

Syllabus

Semiconductors: Conductors, Semiconductors, Silicon Crystals, Intrinsic Semiconductors, Two Types of Extrinsic Semiconductors, Energy band structure, Energy Levels, Energy Hills **PN Junction Diodes:** Unbiased Diode, Forward Bias, Reverse Bias, Breakdown, Diode current, Current equation, Transition and Diffusion capacitance, Reading Diode datasheet, Rectifier circuit, Zener Diode. **Bipolar Junction Transistors**: Unbiased Transistor, Biased Transistor, Transistor Currents, CE Connection, Base Curve, Collector Curve, Transistor Approximations, Understanding BJT Data Sheet. **Field Effect Transistors**: JFETs, Drain and Transconductance Characteristics, MOSFETs, Depletion Mode MOSFET, Enhancement Mode MOSFET, Ohmic region, Understanding FET Datasheet. **Photo and Power Devices**: Photo diode, LED, LDR, SCR, DIAC, TRIAC.

Text Book

- Albert Paul Malvino and David J Bates,” Electronic Principles”, 8th Edition, McGraw Hills, 2020.

Reference Books & web resources

- Robert L. Boylestad, Louis Nashelsk, “Electronic Devices and Circuit Theory”, 11th Edition, Pearson, 2013
- David A. Bell, “Electronic Devices and Circuits”, Oxford University Press, Fifth Edition, 2008.
- Adel S. Sedra and Kenneth C. Smith, “Microelectronic Circuits”, Oxford University Press Seventh Edition, 2015.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**SEMICONDUCTOR**	
1.1	Conductors, Semiconductors, Silicon Crystals	1
1.2	Intrinsic Semiconductors	1
1.3	Two Types of Extrinsic Semiconductors	1
1.4	Energy band structure	1
1.5	Energy Levels, Energy Hills	3
2	**P-N JUNCTION**	
2.1	Unbiased Diode, Forward Bias, Reverse Bias,	1
2.2	Breakdown, Diode current	1
2.3	Current equation, Transition and Diffusion capacitance,	1
2.4	Reading Diode datasheet	1
2.5	Rectifier circuit	2
2.6	Zener Diode.	2

3	**BIPOLAR JUNCTION TRANSISTOR (BJT)**	
3.1	Unbiased Transistor	1
3.2	Biased Transistor	1
3.3	Transistor Currents, CE Connection	2
3.4	Base Curve, Collector Curve	2
3.5	Transistor Approximations	1
3.6	Understanding BJT Data Sheet.	1
4	**FIELD EFFECT TRANSISTORS (FET)**	
4.1	JFETs	1
4.2	Drain and Transconductance Characteristics	2
4.3	MOSFETs, Depletion Mode MOSFET	1
4.4	Enhancement Mode MOSFET	1
4.5	Ohmic region	1
4.6	Understanding FET Datasheet	1
5	**PHOTO AND POWER DEVICES**	
5.1	Photo diode, LED, LDR	3
5.2	SCR, DIAC, TRIAC	3
	Total	36

Course Designers:

- Dr.N.B.Balamurugan nbbalamurugan@tce.edu
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- Dr.D.Gracia Nirmala Rani gracia@tce.edu
- Dr.V.R.Venkatasubramani venthiru@tce.edu
- Mrs J Shanthi jsiece@tce.edu

22EC230	ELECTRIC AND MAGNETIC CIRCUITS

Category	L	T	P	Credit
PCC	3	1	0	4

Preamble

This course is an introduction to electrical and magnetic circuits. It starts with the basic quantities used to characterize circuit operation (like current, voltage, and power) and then enforce several physical laws to form the basis of DC and AC electric circuit analysis. Electric circuits will be examined in time domain under transient and sinusoidal steady-state conditions. Simple magnetic circuit analysis will be done with respective Laws and the operation of transformer will also be studied.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Apply the knowledge of basic circuit laws to simplify DC circuits.	TPS 3	70	70
CO2	Solve DC circuits by using KVL and KCL.	TPS 3	70	70
CO3	Apply network theorems for the analysis of electrical circuits.	TPS 3	70	70
CO4	Determine Complex Impedance, Power factor of single phase and Three phase AC Circuits.	TPS 3	70	70
CO5	Obtain the transient and steady-state response of electrical circuits in Time domain.	TPS 3	70	70
CO6	Apply circuit analysis methods applicable to magnetic circuits.	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	L	-	-	L	M	M	-	-	S	L	L
CO2	S	M	L	L	L	-	-	L	M	M	-	-	S	L	L
CO3	S	M	L	L	-	-	-	L	M	M	-	-	S	-	L
CO4	S	M	L	L	-	-	-	L	M	M	-	L	S	-	L
CO5	S	M	L	L	-	-	-	L	M	M	-	L	S	-	L
CO6	S	M	L	L	-	-	-	L	M	M	-	-	S	-	L
Over all	3	2	1	1	0	0	0	1	2	2	0	0	3	0	1
	S	M	L	L	-	-	-	L	M	M	-	-	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II * (%)					
CO \ TPS Scale	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	10				-						-	4	6
CO2	-	10	20		100		-						-	4	14
CO3	-	10	40				-						-	4	15
CO4	-						-	8	25				-	4	15
CO5	-						-	4	30		100		-	-	20
CO6	-						-	8	25				-	4	10
Total	**-**	**30**	**70**		**100**		**-**	**20**	**80**		**100**		**-**	**20**	**80**

Syllabus

Electric circuit Elements and Kirchhoff's laws: Charge, Voltage, Current and Power; Voltage ,current sources; series and parallel circuit, Voltage and current Divider; KCL and KVL ; **DC Circuit Analysis:** Mesh, super mesh, Node and super Node Analysis **Theorems:** Source Transformation; Superposition; Thévenin's and Norton's equivalent Circuits; Maximum power transfer Theorem; Tellegen's Theorem; Reciprocity Theorem; Δ ↔ Y conversion; **AC Components & Circuits:** Inductor; Capacitor; AC sources, Complex impedance, RL, RC & RLC series and parallel circuits and Phasors; power and Power factors; Duality in Electrical circuits; **Poly Phase circuits:** Single-Phase Three-Wire Systems; Three-Phase Y-Y Connection; The Delta Connection; **AC Steady State Analysis in Time domain :** Mesh, Node Analysis & Theorems on AC circuits ; Resonance. **Transient Analysis in Time domain :** Source Free, DC Driven RL, RC & RLC circuits; **Magnetically coupled circuits:** Self and Mutual Inductance; Dot convention, Energy considerations, Linear transformer; Ideal transformer and Impedance matching; Tuned circuits.

Text Book

- W. H Hayt, J. E Kemmerly and S.M Durbin, "Engineering Circuit Analysis" by 9th Edition (2020), McGraw Hill.

Reference Books

- A. Sudhakar and Shyammohan S. Palli, "Circuits and Networks: Analysis and Synthesis", 5th Edition (2017), McGraw Hill.
- Charles K. Alexander, Matthew N. O. Sadiku "Fundamentals of Electric Circuits" 7th Edition (2022), McGraw Hill.
- Mahmood Nahvi and Joseph Edminister, "Schaum's Outline of Electric Circuits", 7th Edition (2017) McGraw-Hill.
- NPTEL, SC Dutta Roy, Circuit Theory, IITD, http://nptel.iitm.ac.in/video.php?subjectId=10810204
- NPTEL Nagendra Krishnapura, Basic Electrical Circuits, IITM, https://onlinecourses.nptel.ac.in/noc20_ee64/preview

Course Contents and Lecture Schedule

#	Topic	Lecture Hours	Tutorial
1	**Introduction**	1	-
2	Charge, Voltage, Current and Power, Voltage ,current sources	1	-
3	Series and parallel circuit, Voltage and current Divider;	1	1
4	Mesh, super mesh, Node and super Node Analysis	4	1
	Theorems		
5	Source Transformation; Superposition Theorem	1	1
6	Thévenin's and Norton's equivalent Circuits;	2	1

7	Maximum power transfer Theorem; Tellegens Theorem; Reciprocity Theorem;	2	-
8	$\Delta \leftrightarrow$ Y conversion	1	1
	AC Components & Circuits:		
9	Inductor; Capacitor; AC sources,	1	-
10	AC sources, Complex impedance, RL, RC & RLC series and parallel circuits	2	1
11	Phasors; power and Power factors;	3	-
12	Duality in Electrical circuits;	1	-
	Poly Phase circuits:		
13	Single-Phase Three-Wire Systems;	2	
14	Three-Phase Y-Y Connection; The Delta Connection	2	2
	AC Steady State Analysis in Time domain:		
15	Mesh, Node Analysis & Theorems on AC circuits	2	1
16	Resonance	2	
	Transient Analysis in Time domain		
17	Source Free,	1	1
18	DC Driven RL, RC & RLC circuits	2	1
	Magnetically coupled circuits:		
19	Self and Mutual Inductance	1	-
20	Dot convention, Energy considerations,	1	1
21	Linear and Ideal transformer and Impedance matching	2	-
22	Tuned Circuits	1	
	TOTAL	**36**	**12**

<u>Marks Allocation for Assignment:</u>

Sl. No	Description	Marks
1	Assignment 1 – a) Tutorial Submission b) Experimental Verification of Kirchoff's Laws and Theorems	40
2	Assignment 2 – a) Tutorial Submission b) Power calculations of each electrical and electronic appliances at Residence	40
Total		**80**

Course Designers:

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- Dr. B.Sathyabama, sbece@tce.edu

22EC240	DIGITAL CIRCUIT DESIGN

Category	L	T	P	Credit	TE
PCC	3	0	2	4	Theory

Preamble

The course is offered as theory cum practical course in concurrent with the course on "Electronic Devices". Cell phones and handheld devices of various kinds offer new, competing features almost daily. Underneath the attractive graphicaluser interface of all of these devices sits a digital system that processes data in a binary format. Hence, this course is to give hands on training for the students to understand the knowledge 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 standard ICs.

Prerequisite

NIL

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the of Digital information Systems and number systems.	TPS2	70	70
CO2	Use Boolean algebra and graphical methods to simplify the Logic functions.	TPS3	70	70
CO3	Design a combinational circuit using logic gates.	TPS3	70	70
CO4	Design of synchronous sequential Circuits for a given specification	TPS3	70	70
CO5	Design of asynchronous sequential Circuits for a given specification	TPS3	70	70
CO6	Analyse the Sequential circuits in Moore / Mealy FSM Models	TPS4	70	70

Mapping with Programme Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O2
CO1	M	L		-	-	-	-	L	L	L	-	L	L	-	L
CO2	S	M	L	-	-	-	-	L	L	L	-	L	M	L	L
CO3	S	M	L	-	S	-	-	L	L	L	-	L	M	L	L
CO4	S	M	L	L	S	-	-	L	L	L	-	L	M	L	L
CO5	S	S	M	L	-	-	-	L	L	L	-	L	S	-	L
CO6	S	S	M	L	S	-	-	L	L	L	-	L	S	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I			Assessment - II			Terminal Exam (Theory) (%)		
	CAT – I (%)			CAT – II (%)					
CO \ TPS	1	2	3	1	2	3	1	2	3
CO1	5	10					-	5	
CO2	5	10	20				-	5	20
CO3		10	40				-	5	20
CO4					-	30	-	5	20
CO5					-	30	-		10
CO6					-	40	-		10
Total	**10**	**30**	**60**	**-**	**-**	**100**		**20**	**80**

Syllabus

Theory:

Digital Information Processing: Basis of Digital System, 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 Paritygenerator and Checker, Standard IC Data Sheets and its Descriptions, HDL implementation of combinational circuits. **Synchronous Sequential circuits:** Bistable elements, Latches and flip flops- S-R, JK, D and Master-Slave JK FF, Analysis and Design of Clocked Sequential Circuits, State Minimization and State Assignment, Shift Registers, Counters. HDL implementation of sequential circuits. **Asynchronous Sequential Circuits:** Design and Analysis of asynchronous sequential circuits, cycles, races, and Hazard- Static and Dynamic. Design and Analysis of Moore/Mealy FSM Models

Practical:

1. Verification of Basic and Universal Logic Gates and Boolean Laws and Theorems.
2. Introduction to HDL Coding and simulation of Logic Gates.
3. Design and Implementation of Arithmetic Circuits a. Adder b. Subtractor
4. Design and Implementation of combinational circuits – Multiplexer and Demultiplexer using MSI chips
5. Design and Simulation of Encoder and Decoder using HDL code.
6. Design and Implementation of code converters a) Gray code to Excess-3 code. b) BCD to Seven segment display
7. Design and Simulation of Latches and Flip-flips using HDL Code.
8. Design and Implementation of Shift Registers
9. Design and Implementation of Synchronous Mod counters
10. Design and HDL Implementation of Sequence Detectors using FSM Approaches.

Text Books

- Wakerly, John, Digital Design: Principles and Practice (5th edition), Pearson, 2021.
- M. Morris Mano and Michael D. Ciletti, "Digital Design: With an Introduction to the Verilog HDL VHDL, and System Verilog, Sixth Edition, Pearson, 2018.

Reference Books & web resources

- D. D. Givone, Digital Principles and Design, Tata Mc-Graw Hill, New Delhi, 2017.
- Charles. H. Roth, Jr., Fundamentals of Logic Design, Enhanced Seventh Edition,2020
- Thomas L. Floyd, Digital Fundamentals, 11th Edition, Pearson, 2015
- William I. Fletcher," An Engineering Approach to Digital Design,1st Edition reprint 2015.
- NPTEL course Digital Circuits: https://nptel.ac.in/courses/117106086/

Course Contents and Lecture Schedule

Module No.	Topic	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	2	CO2
2.4	Simplification of switching functions – Karnaugh Map	2	CO2
2.5	Quine-McCluskey Tabular methods	2	CO2
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 and Checker	2	CO3
3.4	Standard IC Data Sheets and its Descriptions	2	CO3
4	**Synchronous Sequential Logic Design**		
4.1	Bistable elements, Latches	1	CO4
4.2	Flip-flops: - S-R, JK, D and T, Master Slave Flipflop	2	CO4
4.3	Analysis and Design of Clocked Sequential Circuits, State Minimization and State Assignment	3	CO6
4.4	Shift register, Counters.	3	CO4
4.5	HDL implementation of sequential circuits.	2	CO4
5	**Asynchronous Sequential Circuits**		
5.1	Design of asynchronous sequential circuits	2	CO5
5.2	Analysis of asynchronous sequential circuits	2	CO5
5.3	Cycles and races, Hazard- Static and Dynamic.	1	CO5
5.4	Design and Analysis of Moore/Mealy FSM Models	1	CO6
	Total	**36**	
Practical Sessions			
5.1	Verification of Basic and Universal Logic Gates and Boolean Laws and Theorems.	2	CO1

5.2	Introduction to HDL Coding and simulation of Logic Gates.	4	CO1
5.3	Design and Implementation of Arithmetic Circuits a. Adder b. Subtractor	2	CO3
5.4	Design and Implementation of combinational circuits – Multiplexer and Demultiplexer using MSI chips	2	CO3
5.5	Design and Simulation of Encoder and Decoder using HDL code.	2	CO3
5.6	Design and Implementation of code converters a) Gray code to Excess-3 code. b) BCD to Seven segment display	4	CO3
5.7	Design and Simulation of Latches and Flip-flips using HDL Code	2	CO4
5.8	Design and Implementation of Shift Registers	2	CO4
5.9	Design and Implementation of Synchronous Mod counters	2	CO5
6	Design and HDL Implementation of Sequence Detectors using FSM Approaches.	2	CO6
	Total	**24**	

Course Designers:

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- Dr.S.Rajaram rajaram_siva@tce.edu
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- Dr. V.Vinoth Thyagarajan vvkece@tce.edu
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22EC250	FIELD THEORY AND TRANSMISSION LINES

Category	L	T	P	Credit
PCC	2	1	0	3

Preamble

The objective of this course is to provide a conceptual understanding of fundamentals of electromagnetic field theory and transmission lines with an emphasis on their applications in the design and operation of practical communication systems.

Prerequisite

NIL

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Interpret the characteristics of two-wire transmission line and determine its electrical parameters	TPS3	70	65
CO2	Calculate the transmission and reflection parameters of a transmission line	TPS3	70	65
CO3	Understand the fundamentals of vector calculus and coordinate system	TPS2	70	65
CO4	Apply the EM laws to solve the electrostatic problems	TPS3	70	65
CO5	Apply the EM laws to solve the magnetostatic problems	TPS3	70	65
CO6	Apply the maxwell's equations to solve time varying fields	TPS3	70	65

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Assessment 1						Assessment 2						Terminal (%)			
	CAT- 1 (%)			Assignment 1 (%)			CAT- 2 (%)			Assignment 2(%)						
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	TOTAL (%)
CO1	-	10	30	-			-			-			-	4	10	24
CO2	-	10	30	-	100		-			-			-	4	10	24
CO3	-	20		-			-			-			-	-	-	-
CO4	-	-	-	-	-	-	-	10	25	-			-	4	20	24
CO5	-	-	-	-	-	-	-	10	25	-	100		-	4	20	24
CO6	-	-	-	-	-	-	-	10	20	-			-	4	20	24
TOTAL	**100**			**100**			**100**			**100**			**-**	**20**	**80**	**100**

* Assignment 1: (i) Application based problems in CO1, CO2 and CO3
**Assignment 2: (ii) Application based problems in CO4, CO5 and CO6

Syllabus

Introduction – Transmission Lines, types, terminated lossless two-wire line – characteristic impedance, propagation constant, input impedance, VSWR, reflection and transmission co-efficients, return loss, quarter-wave transformer. **Coordinate Systems -** Fundamentals of scalars and vectors, Coordinate systems. **Electrostatics -** Charge and Current Distributions, Coulomb's Law, Gauss's Law, Electric Scalar Potential, Electric Boundary Conditions, Capacitance, Electrostatic Potential Energy. **Magnetostatic -** Magnetic Forces and Torques, Biot–Savart Law, Maxwell's Magnetostatic Equations, Vector Magnetic Potential, Magnetic Boundary Conditions, Inductance, Magnetic Energy. **Maxwell's equations and EM waves -** Equation of continuity, Maxwell's equations for time varying fields, influence of medium, boundary conditions. Wave equation, EM waves in conducting medium, Uniform plane wave equation.

Text Books

- Fawaz T. Ulaby, Umberto Ravaioli, Fundamentals of Applied Electromagnetics, Seventh Edition, Pearson Education, 2015.
- G. S. N. Raju, Electromagnetic Field Theory and Transmission Lines, Pearson education 2009.
- David M. Pozar," Microwave Engineering," John Wiley & Sons, Fourth Edition, 2015.

Reference Books & web resources

- William H. Hayt, John A. Buck, Jaleel M. Akhtar, Engineering Electromagnetics, 9^{th} edition, McGraw-Hill Education, 2020.
- Matthew N. O. Sadiku, Elements of Electromagnetics, Seventh edition, Oxford University Press, 2018.
- Nannapaneni Narayana Rao, Elements of Engineering Electromagnetics, Sixth Edition, Pearson Prentice Hall, 2004.
- D.K. Cheng, Field and wave electromagnetics, Second edition, Pearson (India), 2002.
- John D Kraus and Daniel A Fleisch, Electromagnetics with applications, Fifth Edition, McGraw-Hill, 1999.
- NPTEL course on 'Electromagnetic Waves in Guided and Wireless Media', by Prof. Pradeep Kumar, IIT Kanpur.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction**	
1.1	Transmission Lines, types, terminated lossless two-wire line – characteristic impedance, propagation constant, input impedance	3
1.2	VSWR, reflection and transmission co-efficients, return loss, quarter-wave transformer	3
	Tutorial	2
2	**Coordinate Systems**	
2.1	Fundamentals of scalars and vectors, Coordinate systems	2
	Tutorial	2
3	**Electrostatics**	
3.1	Charge and Current Distributions, Coulomb’s Law, Gauss’s Law,	3
3.2	Electric Scalar Potential, Electric Boundary Conditions, Capacitance, Electrostatic Potential Energy	3
	Tutorial	2
4	**Magnetostatics**	
4.1	Magnetic Forces and Torques, Biot–Savart Law, Maxwell’s Magnetostatic Equations	3
4.2	Vector Magnetic Potential, Magnetic Boundary Conditions, Inductance, Magnetic Energy	3
	Tutorial	2
5	**Maxwell’s equation and EM waves**	
5.1	Equation of continuity, Maxwell’s equations for time varying fields, influence of medium	3
5.2	boundary conditions. Wave equation, EM waves in conducting medium, Uniform plane wave equation	3
	Tutorial	2
	Total	36

Course Designers

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22EC260	PROBLEM SOLVING USING COMPUTERS	Category	L	T	P	Credit	TE
		ESC	2	0	2	3	Practical

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

CO	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Use constructs of C programming language in problem solving.	TPS3	70%	70%
CO2	Develop algorithms to perform sorting, searching and text processing.	TPS3	70%	70%
CO3	Use function and recursion to establish modularity in programming	TPS3	70%	70%
CO4	Use pointers and derived data types like structures and union in solving complex problems.	TPS3	70%	70%
CO5	Write programs to create text and database files.	TPS3	70%	70%
CO6	Apply problem solving methodology in implementing mathematical and engineering problems.	TPS3	70%	70%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	M	-	S	-	-	-	S	M	-	-	M	-	L
CO2	S	M	M	-	S	-	-	-	S	M	-	-	M	-	L
CO3	S	M	M	-	S	-	-	-	S	M	-	-	M	-	L
CO4	S	M	M	-	S	-	-	-	S	M	-	-	M	-	L
CO5	S	M	M	-	S	-	-	-	S	M	-	-	M	-	L
CO6	S	M	M	-	S	-	-	-	S	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	Assessment-1 CAT1						Assessment-2 CAT2						Terminal - Practical					
TPS Scale	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	-	12	28	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-
CO2	-	4	16	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-
CO3	-	4	36	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-
CO4	-	-	-	-	-	-	-	12	28	-	-	-	-	-	20	-	-	-
CO5	-	-	-	-	-	-	-	4	16	-	-	-	-	-	10	-	-	-
CO6	-	-	-	-	-	-	-	4	36	-	-	-	-	-	20	-	-	-
Total	-	20	80	-	-	-	-	20	80	-	-	-	-	-	100	-	-	-

Syllabus

Theory:

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 expression, Control Structures: Selection structure, looping Structure. **Array and string handling algorithms:** 1-D, 2-D arrays, **strings sorting:** bubble sort, searching: linear and binary search, text processing: key word search, text editing. **Modular Programming and Functions:** Function declaration, function definition, function call-call by value - call by reference, storage classes, Recursive functions, library functions. **Pointers & Memory management:** Pointers and memory addressing, Arrays and pointer, Pointers and Functions, Pointers to pointers, pointer and string arrays, Void and function pointers, use of malloc - realloc-free- heaps in memory management. **Derived data types**: structures- Arrays of Structures – Passing Structures to Functions – Structure with Pointers, enum, typedef **File Handling:** read, write and update text files

Practical:

List of Experiments

1. Programs to explore fundamental programming constructs
    a. Find the 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
    a. Print twin prime numbers in a given range
    b. Finding greatest common divisor using Euclid’s method
3. Programs using 1-D and 2-D arrays
    a. Bubble sort algorithms
    b. Matrix multiplication
    c. Histogram
4. Programs using strings
    a. Linear pattern search
    b. Text editing
5. Programs using recursive and non-recursive functions
    a. Binary search
    b. Finding n^{th} Fibonacci number
6. Programs using pointers
    a. Implement experiments 2- 5 (Selective programs) using pointers
    b. Programs using memory allocation
7. Programs to create database files using file structures
8. Solving numerical methods/engineering problems (sample)
    a. Linear convolution
    b. Bitwise operations to set specific bit fields

Text Book

- Kernighan, Brian, and Dennis Ritchie. “The C Programming Language”, 2nd ed. Upper Saddle River, NJ: Prentice Hall, 1988.

Reference Books & web resources

- Yashwanth P Kanetkar, “Let us C”, 18^{th} ed., BPB edition, 2021.
- Schildt Herbert, “C: The Complete Reference”, 4^{th} Edition, Mc Graw Hill, 2017.
- George S. Tselikis, Nikolaos D. Tselikas, “C: From Theory to Practice”, 2nd ed., CRC Press, 2017.
- Randal E. Bryant and David R. O'Hallaron, Computer Systems: A Programmer's Perspective, Third Edition, Pearson, 2016.
- Paul Deitel, Harvey Deitel, “C: How to program”, 7th ed., ", Pearson Education, 2013.
- Adam Hoover, “System Programming with C and Unix”, 1st ed., Pearson Education, 2010.
- V. Rajaraman, Computer Programming in C, PHI Learning, 2004.
- E. Balagurusamy, Programming in Ansi C, 3rd ed., Tata McGraw-Hill Publication, New Delhi, 2004.
- Paul Anderson and Gail C Anderson, “Advanced C: Tips and Techniques”, Hayden Book,1988.
- NPTEL Course on Introduction to programming in C by Prof Satyadev Nandakumar, IIT Kanpur https://nptel.ac.in/courses/106104128
- NPTEL Course on Problem Solving through Programming in C by Prof Anupam Basu, IIT Kharagpur: https://nptel.ac.in/courses/106105171

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Problem Solving Methodology**	
1.1	Problem specification and analysis, algorithm design, flowchart, programs, program testing and verification	1
2	**Basics of Programming**	
2.1	Data types and its representation, variables, keywords,	1
2.2	Operators, operator precedence, types of expressions	
2.3	**Branching and Looping**	
2.4	Conditional Expression and control structures – IF, IF-else, Switch	2
2.5	Looping Structure- While Loops, Do-While Loops, For Loops	2
2.6	Jumping statements- Break and Continue, Goto	1
3	**Arrays and Array handling algorithms**	
3.1	1-D arrays	1
3.2	Sorting: selection sort, bubble sort	1
3.3	Searching: linear and binary search	1
3.4	2-D arrays	1
3.5	Character array – Strings	1
3.6	Text processing: key word search, text editing	1
4	**Functions**	
4.1	Function declaration, function definition, function call-call by value, Using arrays as function arguments	1
4.2	Recursive functions	1
4.3	Library functions	1
4.4	Storage classes	1
5	**Pointers &Memory management**	
5.1	Pointers and memory addressing, Arrays and pointer	1

	arithmetic	
5.2	Pointers and Functions- call by reference, Pointers to pointers	1
5.3	Pointer and string arrays, Void and function pointers	1
5.4	Memory management functions: malloc, calloc, realloc, free - use of heap in memory management	1
6	**Derived data types & File Handling**	
6.1	Structures- Union- typedef - Arrays of Structures - Passing Structures to Functions	1
6.2	Structure Pointers – Structures within Structures	1
6.3	Read, write and modify text files	1
	Theory	24
	Practical	24
	Total	48

Course Designer(s):

- Dr.R.A.Alaguraja alaguraja@tce.edu
- Dr.M.Senthilarasi msiece@tce.edu

22CHAA0	ENVIRONMENTAL SCIENCE

Category	L	T	P	Credit
BS	1		1	0

(Common to all branches)

Preamble

The objective of this course is to make the students learn the basic concepts of environment, ecology, and to create awareness on current environmental issues, and develop
a sustainable environment by participating in various activities on conserving natural resources and protecting the environment.

Prerequisite

Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment Level %
CO1	Describe the importance and progression of ecological system	TPS2	A	80
CO2	Explain the significance of natural resources	TPS2	A	80
CO3	Examine the effects of pollution on environment and human beings	TPS3	A	80
CO4	Practice the suitable solid waste management for segregation and reuse of waste	TPS3	A	80
CO5	Explain renewable energy resources for sustainable environment	TPS2	A	80
CO6	Perform Environment oriented group activities	TPS4	A	80

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	M	L	-	-	-	L	S	-	-	-	-	-
CO2.	M	L	-	-	-	-	L	L	-	-	-	-
CO3.	S	M	L	-	-	-	S	-	-	-	-	-
CO4.	M	M	L	-	-	-	S	L	L	-	-	-
CO5.	M	L	-	-	-	-	S	-	L	-	-	-
CO6.	S	S	M	L	M	M	M	M	S	M	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT						Assignment#						Terminal***					
TPS Scale	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1		20					NA						Presentation on case study report					
CO2		20																
CO3			20															
CO4			20															
CO5		20																
CO6																		

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

*** Case study presentation and evaluation

- ❖ Each group comprise 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)Internal assessment

S.No	Description	Max.marks	Final conversion
1	CAT	60	30
2	Assignment marks (from Review I&II)	2×20 =40	20
Total			50

b) End semester examination – Case study presentation

Performance Index	Marks per Individual
Originalityof the work	20
Data collected	20
Suggestion to overcomefor the identified issues	20
FinalPresentation	40
Total	100

Model Titles for Case Study:

1. Environmental impacts of rubber industry in Virudhunagar district
2. Solid waste and waste water management in TCE hostel.
3. Status of workers in fireworks industry in Sivakasi region
4. A study on impacts of tanneries on ground water and soil quality in Dindigul district.
5. Effect of pharmaceutical industry on groundwater quality in poikaraipatty village, AlagarKovil.
6. Environmental impacts of quarry industries in MelurTaluk.
7. Environmental effect of Kudankulam atomic power plant.
8. Effect on ground water and soil quality by dyeing industries in Tiruppur.
9. Effect of textile wastes in Karur District.
10. Segregation of waste and its recycling by Madurai Municipality at Vellakkal

Syllabus

Environment and Ecosystem - Multidisciplinary nature of environment- Ecosystem-Structure and Functions, Energy flow in ecosystem-Ecological succession- Natural resources -Over exploitation, Conservation. **Environmental pollution and control -** Environmental pollution – Types (Air, Water, Soil)and Effects–Control measures, Solid waste management, Environmental Impact Assessment.**Sustainable Environment–**Carbon footprint, Carbon and water neutrality, Sustainable development goals, Renewable energy resources (Solar, Wind, Tidal, Biomass), Atom economy,Carbon vs Hydrogen economy, Linear economy vs Circular economy, Environmental ethics – issues, solution

Awareness and activities:

- ✓ Lectures by Environmentalist
- ✓ Group meeting on water management
- ✓ Awareness on modern pollution control measures
- ✓ Drive on e-waste segregation and disposal
- ✓ Field visit to treatment systems
- ✓ Preparation of seed ball and plantation
- ✓ Slogan, Poster, Essay writing, Role play events

Text Book

1. Kaushik, A &Kaushik, C.P, Environmental Science and Engineering, 6thEdition, New Age International, 2018.
2. ErachBharucha, Text book of Environmental studies for Undergraduate courses, 2ndEdtion, UGC, 2013.

Reference Books& web resources

1. O.P. Gupta, Elements of Environmental Pollution Control, Khanna Publishing House, New Delhi
2. Metcalf & Eddy, Waste Water Engineering, Mc-Graw Hill, New York, 2013, ISBN: 077441206.
3. Aldo Vieira, Da Rosa, Fundamentals of renewable energy processes, Academic Press Oxford, UK; 2013. ISBN: 9780123978257.
4. www.indiaenvironmentportal.org.in
5. www.teriin.org
6. www.cpcp.nic.in
7. www.sustainabledevelopment.un.org
8. www.conserve-energy-future.com

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Environment and Ecosystem**	
1.1	Multidisciplinary nature of environment	1
1.2	Structure and Function of Ecosystem. Energy flow in ecosystem – Universal energy flow model	2
1.3	Ecological succession	1
1.4	Natural resources - Over exploitation, Conservation	1

Module No.	Topic	No. of Periods
2	**Environmental pollution and control**	
2.1	Environmental pollution – Types(Air, Water, Soil) and Effects	2
2.2	Control measures: Air pollution (Bag filter, Cyclone separator, Electrostatic Precipitator)	1
2.3	Industrial waste water treatment – Primary, Secondary, Tertiary	1
2.4	Solid waste management	1
2.5	Environmental Impact Assessment – Components, Processes and methods	1
3	**Sustainable Environment**	
3.1	Concept of carbon credit and carbon foot print, Carbon and water neutrality	1
3.2	Sustainable development goals – An overview	1
3.3	Renewable energy resources – Solar, Wind, Tidal, Biomass	2
3.4	Sustainable environment: Atom economy, Carbon vs Hydrogen economy, Linear economy vs Circular economy,	1
3.5	Environmental ethics: Issues and solution	1
4	**Awareness and activities**	
4.1	Lectures by environmentalist	1
4.2	Awareness on modern pollution control measures	1
4.3	Group activity on waste management	1
4.4	Drive on e-waste segregation and disposal	1
4.5	Field visit to treatment systems	1
4.6	Plantation using seed ball	1
4.7	Slogan, Poster, Essay writing, Role play events	1
	Total	24

Course Designer(s):

1. Dr.M.Kottaisamy hodchem@tce.edu
2. Dr. V. Velkannan velkannan@tce.edu
3. Dr. M. Velayudham mvchem@tce.edu

22TAAB0 **தமிழரும் தொழில்நுட்பமும்** L T P C
1 0 0 1

அலகு I: **நெசவு மற்றும் பானைத் தொழில்நுட்பம்:** 3
சங்க காலத்தில் நெசவுத் தொழில் – பானைத் தொழில்நுட்பம் – கருப்பு சிவப்பு பாண்டங்கள் – பாண்டங்களில் கீறல் குறியீடுகள்.

அலகு II: **வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்:** 3
சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு– சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் – சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் – மாமல்லபுரச் சிற்பங்களும், கோவில்களும் – சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் – நாயக்கர் காலக் கோயில்கள் – மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் – செட்டிநாட்டு வீடுகள் – பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ–சாரோசெனிக் கட்டிடக் கலை.

அலகு III: **உற்பத்தித் தொழில் நுட்பம்:** 3
கப்பல் கட்டும் கலை – உலோகவியல் – இரும்புத் தொழிற்சாலை – இரும்பை உருக்குதல், எஃகு – வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் – நாணயங்கள் அச்சடித்தல் – மணி உருவாக்கும் தொழிற்சாலைகள் – கல்மணிகள், கண்ணாடி மணிகள் – சுடுமண் மணிகள் – சங்கு மணிகள் – எலும்புத்துண்டுகள் – தொல்லியல் சான்றுகள் – சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV: **வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்:** 3
அணை, ஏரி, குளங்கள், மதகு – சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் – கால்நடை பராமரிப்பு – கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் – வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் – கடல்சார் அறிவு – மீன்வளம் – முத்து மற்றும் முத்துக்குளித்தல் – பெருங்கடல் குறித்த பண்டைய அறிவு – அறிவுசார் சமூகம்.

அலகு V: **அறிவியல் தமிழ் மற்றும் கணித்தமிழ்:** 3
அறிவியல் தமிழின் வளர்ச்சி –கணித்தமிழ் வளர்ச்சி – தமிழ் நூல்களை மின்பதிப்பு செய்தல் – தமிழ் மென்பொருட்கள் உருவாக்கம் – தமிழ் இணையக் கல்விக்கழகம் – தமிழ் மின் நூலகம் – இணையத்தில் தமிழ் அகராதிகள் – சொற்குவைத் திட்டம்.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)

11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

PAPER – 2
22TAAB0 TAMILS AND TECHNOLOGY

1. **Weaving and Ceramic Technology**: Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW) – Graffiti on Potteries.

2. **Design and Construction Technology:** Designing and Structural construction House & Designs in household materials during Sangam Age - Building materials and Hero stones of Sangam age – Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period - Type study (Madurai Meenakshi Temple)- Thirumalai Nayakar Mahal - Chetti Nadu Houses, Indo - Saracenic architecture at Madras during British Period.

3. **Manufacturing Technology**: Art of Ship Building - Metallurgical studies - Iron industry - Iron smelting, steel -Copper and gold- Coins as source of history - Minting of Coins – Beads making-industries Stone beads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gem stone types described in Silappathikaram.

4. **Agriculture and Irrigation Technology:** Dam, Tank, ponds, Sluice, Significance of Kumizhi Thoompu of Chola Period, Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing - Knowledge of Sea - Fisheries – Pearl - Conche diving - Ancient Knowledge of Ocean - Knowledge Specific Society.

5. **Scientific Tamil & Tamil Computing**: Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books – Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sorkuvai Project.

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services

Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

CURRICULUM AND DETAILED SYLLABI

FOR

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

THIRD SEMESTER

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution Affiliated to Anna University)
MADURAI – 625 015, TAMILNADU

Phone : 0452 – 2482240, 41
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22EC310	PROBABILITY AND STATISTICS

Category	L	T	P	Credit
BSC	2	1	0	3

Preamble

An electronics and communication engineering student needs to have some basic statistical tools and techniques to apply in diverse applications in digital signal processing communications systems and networks, radar systems, power systems that requires an understanding of Probability distributions, Joint probability distributions, covariance, correlation and Testing of Hypotheses. The course is designed to impart the knowledge and understanding of the above concepts to Electronics and Communication Engineers and apply them in their areas of specialization.

Prerequisite

NIL

Course Outcomes

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

Cos	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Apply the concept of probability and conditional probability to solve real world problems	TPS3	70	60
CO2	Use standard distributions to find the expected life time of electrical components.	TPS3	70	60
CO3	Apply the concept of Joint Probability Distributions and covariance, correlation of Joint Probability Distributions and random samples random samples.	TPS3	70	60
CO4	Apply the concepts of two functions of two random variables.	TPS3	70	60
CO5	Apply the concept of testing the hypotheses for single samples by using various tests for difference of proportions and means.	TPS3	70	60
CO6	Apply the concept of testing the hypotheses for two samples by using various tests for difference of proportions and means.	TPS3	70	60

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	S	S	S	S	-	M	-	-	M	-	-	S	S	-	-
CO2	S	S	S	S	-	M	-	-	M	-	-	S	S	-	-
CO3	S	S	S	S	-	M	-	-	M	-	-	S	S	-	-
CO4	S	S	S	S	-	M	-	-	M	-	-	S	S	-	-
CO5	S	S	S	S	-	M	-	-	M	-	-	S	S	-	-
CO6	S	S	S	S	-	M	-	-	M	-	-	S	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

TPS / CO	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I (%)			CAT – II (%)			Assg. II (%)					
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	3	10	20	-	-		-	-	-	-	-		-	6	11
CO2	7	10	28	-	-	70	-	-	-	-	-		-	6	15
CO3	-	-	22	-	-		-	-	10	-	-		-	6	11
CO4	-	-	-	-	-		3	10	20	-	-	70	-	6	11
CO5	-	-	-	-	-		3	-	25	-	-		-	6	8
CO6	-	-	-	-	-		4	10	15	-	-		-	-	14
MATLAB	-	-	-	-	-	30				-	-	30	**-**	**-**	**-**
Total	**10**	**20**	**70**	**-**	**-**	**100**	**10**	**20**	**70**	**-**	**-**	**100**	**-**	**30**	**70**

Syllabus

Probability Distributions: Introduction to Probability**:** Sample space and events - Definition and axioms of probability - Conditional Probability - Baye's theorem - Independent events - Random variables - Expected Values – Discrete Probability distribution: Binomial Distribution - Poisson Distribution – Continuous Probability distribution: Normal and Exponential Distributions - Higher Order Moments - Moment generating function. [14 hours]

Joint Probability Distributions: Jointly distributed Random Variables – Two Discrete Random Variables -Two Continuous Random Variables –Independent Random Variables – Conditional Distributions – Expected Values, Covariance and Correlation: Covariance – Correlation. [6 hours]

Functions of random Variables: Functions of one random variable – Sums of independent random variables – Sum of discrete random variables – Minimum of two independent random variables - Maximum of two independent random variables – Laws of large numbers – The central limit theorem. [6 hours]

Tests of Hypothesis Based on a Single Sample: Hypotheses and Test Procedures – z-Tests for Hypotheses about a Population Mean – The One Sample t test – Test Concerning a Population Proportion. [5 hours]

Inferences Based on Two Samples: zTests and Confidence Intervals for a Difference between Two Population Means – The Two Sample t-test and Confidence Interval – Inferences Concerning a Difference Between Population Proportions [5 hours]

Text Book

- Jay L. Devore, Probability and Statistics for Engineering and the Sciences, 9th Edition, Cengage Learning India Pvt Ltd, New Delhi, 2014.
- Oliver C. Ibe, Fundamentals of Applied Probability and Random Processes, Elsevier, 2015.
- Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, "Probability & Statistics for Engineers & Scientists", Pearson, New Delhi, 2016.

Reference Books& web resources

- Richard A. Johnson, "Miller &Freund's, Probability and Statistics for Engineers", Prentice Hall, New Delhi, 2017.
- Douglas C. Montgomery and George C. Runger, "Applied Statistics and Probability for Engineers", Wiley India, New Delhi,2018.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Probability Distribution**	
1.1	Introduction to Probability**:** Sample space and events, Definition and axioms of probability	1
1.2	Conditional Probability, Baye's theorem	2

Module No.	Topic	No. of Periods
	Tutorial	1
1.3	Independent events	1
1.4	Random variables, Expected Values	**1**
1.5	Discrete Probability distribution: Binomial, Poisson distributions	2
	Tutorial	1
1.6	Continuous Probability distribution: Normal Distributions Exponential Distributions	2
	Tutorial	1
1.9	Higher order moments, Moment generating function	2
2	**Joint Probability Distributions**	
2.1	Jointly distributed Random Variables – Two Discrete Random Variables	1
2.2	Two Continuous Random Variables - Independent Random Variables	1
	Tutorial	1
2.3	Conditional Distributions	1
2.4	Expected Values, Covariance	1
2.5	Correlation	1
3	**Functions of random Variables**	
3.1	Sums of independent random variables, Sum of discrete random variables	1
3.2	Minimum of two independent random variables, Maximum of two independent random variables	1
	Tutorial	**1**
3.3	Two functions of two random variable	1
3.4	Laws of large numbers – The central limit theorem.	1
	Tutorial	**1**
4	**Tests of Hypothesis Based on a Single Sample**	
4.1	Hypotheses and Test Procedures	1
4.2	z-Tests for Hypotheses about a Population Mean	1
	Tutorial	**1**
4.3	The One Sample t test	1
4.4	Test Concerning a Population Proportion.	1
5	**Inferences Based on Two Samples**	
5.1	Z Tests and Confidence Intervals for a Difference between Two Population Means	1
5.2	The Two Sample t-test and Confidence Interval	2
	Tutorial	**1**
5.3	Inferences Concerning a Difference Between Population Proportions	1
	Total	36

Course Designers:

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- Dr. L. Muthusubramanian lmsmat@tce.edu
- Dr. S. Suriyakala ssamat@tce.edu

22EC320	ANALOG CIRCUIT DESIGN	Category	L	T	P	Credit	TE
		PCC	3	0	2	4	Theory

Preamble

This course is an introduction to basic knowledge about the principle of operation of semiconductor electronic devices like diodes, transistors. It 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

Basic knowledge on Electronic Devices.

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Compute the impedance and gain parameters of transistor amplifier circuits.	TPS 3	70	70
CO2	Understand the frequency response of transistor amplifier circuits.	TPS 2	70	70
CO3	Demonstrate the effect of negative feedback on amplifier performance parameters.	TPS 3	70	70
CO4	Use the condition for oscillation in a transistor circuit to establish sustained oscillation.	TPS 3	70	70
CO5	Calculate the power conversion efficiency of large signal amplifiers.	TPS 3	70	70
CO6	Construct the inverting and non-inverting mode applications of operational amplifier.	TPS 3	70	70
CO7	Calculate the component values for the given timing specification for multivibrator circuit using IC 555.	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	L	-	-	-	L	L	-	-	S	L	L
CO2	S	M	L	L	L	-	-	-	L	L	-	-	S	L	L
CO3	S	M	L	L	L	-	-	-	L	L	-	-	S	-	L
CO4	S	M	L	L	L	-	-	-	L	L	-	L	S	-	L
CO5	S	M	L	L	L	-	-	-	L	L	-	L	S	-	L
CO6	S	M	L	L	L	-	-	-	L	L	-	-	S	-	L
CO7	S	M	L	L	L	-	-	-	L	L	-	-	S	-	L
Overall	3	2	1	1	1	0	0	1	1	1	0	0	3	0	1
	S	M	L	L	L	-	-	L	M	M	-	-	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I CAT – I (%)			Assessment - II CAT – II (%)			Terminal Exam (%)		
CO \ TPS	1	2	3	1	2	3	1	2	3
CO1	-	10	10	-			-	4	10
CO2	-	10	20	-			-	4	10
CO3	-	05	20	-			-	4	15
CO4	-	05	20	-			-	2	15
CO5	-			-	4	30	-	2	10
CO6	-			-	8	25	-	2	10
CO7	-			-	8	25	-	2	10
Total	**-**	**30**	**70**	**-**	**20**	**80**	**-**	**20**	**80**

Psychomotor Skill	**Practical**
Perception	-
Set	-
Guided Response	-
Mechanism	100
Complex Overt Responses	-
Adaptation	-
Origination	-

Syllabus

Small Single Amplifiers: Q- Point, Self-bias- CE and CS, h-model of BJT and MOSFET, Small signal analysis of Amplifiers, Low frequency, Midband frequency and High frequency model of Transistors. [8]

Feedback Amplifiers and Oscillators: Feedback concept, negative and Positive feedback, voltage/ current, series/shunt feedback, Bark hausen criterion, Colpitts, Hartley's, Phase shift, Wein bridge and crystal oscillators. [8]

Large Signal Amplifiers: Class A, B, AB, C, Conversion Efficiency. [4]

Operational Amplifier: Ideal OPAMP, Differential Amplifier, Constant Current Source (Current Mirror), Open and Closed loop Circuits, Inverting and Non-Inverting amplifiers, Voltage follower, Buffer circuit. [6]

Applications of Operational Amplifier: Adder, Integrator and Differentiator, Comparator, Schmitt Trigger, Instrumentation Amplifier, Log and Anti-Log Amplifiers, Voltage to current and Current to voltage converter. [5]

Multivibrators: Bistable, Astable, Monostable multivibrators using IC 555 Timer, Applications of 555 Timer. [5]

Practical:

1. Design, simulate and demonstrate a single stage amplifier.
2. Design, simulate and demonstrate a series and shunt feedback amplifier.
3. Design, simulate and demonstrate a LC oscillator.
4. Design, simulate and demonstrate a RC oscillator.
5. Design, simulate and demonstrate a class-B power amplifier.
6. Design, simulate and demonstrate a Differential Amplifier using Op-amp.
7. Design, simulate and demonstrate an inverting and non-inverting amplifier.
8. Design, simulate and demonstrate application of operational amplifier circuits.
9. Design, simulate and demonstrate Astable and Monostable multivibrators.

Text Book

- Boylested and Nashelsky, "Electronic Devices and Circuit Theory", 11th edition, Pearson Education India, 2015.

Reference Books& web resources

- Adel S. Sedra and Kenneth C. Smith, "Microelectronic Circuits: Theory and Application",7th Edition, Oxford University Press, 2017.

- Serigo Franco, "Design with Operational Amplifiers & Analog Integrated Circuits", 4th edition, McGraw Hill, 2014.
- https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-012-microelectronic-devices-and-circuits-fall-2009/readings/.
- NPTEL video lecture on "Analog Electronic Circuits" https://nptel.ac.in/courses/108102095/.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours	Practical
	Small Signal Amplifiers		-
1.	Q-Point, Self-Bias-CE and CS	2	-
2.	h-model of BJT and MOSFET	2	-
3.	Small signal analysis of Amplifiers	1	2
4.	Low frequency model of Transistor	1	2
5	Midband frequency and High frequency model of Transistor	2	-
	Feedback Amplifiers and Oscillators		
6.	Feedback concepts	1	-
7.	Negative and Positive feedback	1	-
8.	Voltage/Current feedback	1	2
9.	Series/Shunt feedback	1	-
10	Barkhausen criterion, Colpitts Oscillator	1	2
11.	Hartley Oscillator	1	-
12.	Phase shift Oscillator	1	2
13.	Wein bridge and crystal oscillator	1	-
	Large Signal Amplifiers		-
14.	Class A amplifier	1	-
15.	Class B amplifier	1	2
16.	Class AB amplifier	1	-
17.	Class C and Conversion Efficiency	1	-
	Operational Amplifiers		
18.	Ideal OPAMP	1	-
19.	Differential Amplifier	1	2
20.	Constant current source (Current mirror)	1	-
21.	Open and Closed loop circuits	1	-
22.	Inverting and Non-inverting Amplifiers	1	-
23.	Voltage follower, Buffer circuit	1	2
	Applications of Operational Amplifier		
24.	Adder, Integrator and Differentiator	1	-
25.	Comparator and Schmitt trigger	1	2
26.	Instrumentation Amplifier	1	-
27.	Log and Anti-Log Amplifiers	1	-
28.	Voltage to current and Current to voltage converter.	1	2
	Multivibrators		
29.	Bistable multivibrators using IC 555 Timer	1	-
30.	Astable and Monostable multivibrator using IC 555 Timer	2	2
31.	Application of 555 Timer	2	2
	TOTAL	**36**	**24**

Course Designers:

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- Dr. V.Vinoth Thyagarajan vvkece@tce.edu

22EC330	NETWORK ANALYSIS AND SYNTHESIS

Category	L	T	P	Credit
BSC	2	1	0	3

Preamble

The goal of this course is to broaden the student's understanding of network analysis beyond the basic concepts. It covers sophisticated network analysis in frequency domain, understanding pole-zero concept, analysis of two-port networks, synthesis of simple networks and basics of filter design.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Apply Laplace transform to formulate and solve electric network problems	TPS 3	70	60
CO2	Identify the properties and characteristics of network functions with respect to pole zero plot	TPS 3	70	60
CO3	Determination of two port network Z, Y, h and ABCD parameters	TPS 3	70	60
CO4	Determine network function of Advanced Networks - Ladder, Lattice, Bridged T Networks	TPS 3	70	60
CO5	Synthesize passive one-port networks using standard Foster and Cauer forms.	TPS 3	70	60
CO6	Apply two-port network analysis in the design of filters.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	L	-	-	L	M	M	-	-	M	L	L
CO2	S	M	L	L	L	-	-	L	M	M	-	-	M	L	L
CO3	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	-	-	-	L	M	M	-	L	M	-	L
CO5	S	M	L	L	-	-	-	L	M	M	-	L	M	-	L
CO6	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L
Overall	3	2	1	1	0	0	0	1	2	2	0	0	2	0	1
	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20				-						-	4	10
CO2	-	10	20		100		-						-	4	10
CO3	-	10	30				-						-	4	15
CO4	-						-	10	20				-	-	15
CO5	-						-	10	30		100		-	4	15
CO6	-						-	10	20				-	4	15
Total	-	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Laplace transform- Laplace transform of Electrical signals: step, Impulse and periodic functions- Initial and final value Theorem- Inverse transform- Analysis of electric DC networks. **S- Domain Analysis of AC Networks:** Interpretation of complex frequency- Network function for one-port and two-port, poles and zeros with restrictions for driving point functions and transform functions, stability by Routh-Hurwitz criterion. **Two Port Parameters:** Z-Y-h-ABCD parameters - Equivalent circuit model- Interrelationship of different parameters Interconnection of two port networks- calculation of network function for ladder and Lattice networks. **Network Synthesis**: Positive and real function (PRF), properties of PRF, testing of driving point functions, even and odd function, one terminal pair network driving point synthesis with LC, RL and RC elements, Foster and Cauer form. **Synthesis of Filters:** Low pass filters, high pass filters, band pass filters, band reject filters, constant k- and m-derived filters.

Text Book

- Van Valkenburg M.E., —Introduction to Modern Network Synthesis, Wiley Eastern, 1960 (reprint 1986).
- Van Valkenburg M.E, —Network Analysis, Prentice Hall India, 2014

Reference Books

- Ravish R. Singh, "Network Analysis and Synthesis", McGraw-Hill Education, 2013
- Abhijit Chakrabarti, “Circuit Theory Analysis and Synthesis” Dhanpat Rai & Co.; Seventh - Revised edition- 2018.
- Franklin Kuo, —Network Analysis and Synthesis||, 2nd Ed.,Wiley India,2006.
- Sudhakar, A. Shyammohan, “Circuits and Network”, 5th Edition, Tata McGraw Hill, 2015.
- S. K. Bhattacharya, —Network Analysis and Synthesis, || Pearson Education India.2015.
- “Network Analysis and Synthesis”, Wadhwa, New Age,2007.
- Dr. K.M. Soni, “Fundamentals of Network Analysis & Synthesis”, S.K. Kataria & Sons, 9th Edition,2019.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours	Tutorial
	Introduction to the Course, COs POs	1	-
1	**Laplace Transform (6)**		
2	Definition of Laplace Transform	1	-
3	Basic Theorems of Laplace Transform, Laplace transform of some basic functions	1	-
4	Application of Laplace transforms in solving Integro-differential equations and simultaneous differential equations	1	
5	Application of Laplace Transform Method to DC Circuit Analysis	1	2
	S- Domain Analysis of AC Networks: (6)		
6	Interpretation of complex frequency in S-Plane	1	-
7	Network function for one-port and two-port Networks,	1	-
8	Pole -Zero Diagram, Significance of Poles and Zeros	1	-
9	Poles and zeros with restrictions for driving point functions and transform functions,	1	-
10	Stability by Routh-Hurwitz criterion	1	1
	Two Port Parameters: (6)		
11	Relationships of Two-Port Variables	1	-
12	Two Port Parameters – z,y,h and ABCD, Image Impedance Equivalent circuit Model	1	1
13	Conditions for Reciprocity and Symmetry	1	-
14	Interrelationships between Two-Port Parameters	1	-
15	Terminated Two-Port Networks	1	-
	Ladder and Lattice Networks (5)		

16	Interconnection of Two-Port Networks	1	
17	Ladder Networks, Lattice and Bridged T Networks	1	2
18	Image Parameters of Two port Networks	1	-
	Network Synthesis: **(6)**		
19	Elements of Realizability, Positive Real Functions (PRF) Properties of PRF	1	
20	Basic Realization Procedures	1	1
21	Synthesis of one port networks with two kinds of elements-RL,RC,LC & Properties of Functions	1	2
	Synthesis of Filters: (6)		
22	Classification of Filters, Filter Networks, Characteristic Impedances	1	
23	Constant K Filters	1	2
24	m-derived Filters	1	1
	TOTAL	**24**	**12**

Marks Allocation for Assignment:

Sl. No	Description	Marks
1	Assignment 1 – a) Tutorial Submission b) Identification of Real world Two port networks	40
2	Assignment 2 – a) Tutorial Submission b) Synthesis of Networks using C	40
Total		**80**

Course Designers:

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22EC340	COMPUTER ORGANIZATION AND MICROPROCESSOR

Category	L	T	P	Credit	TE
PCC	3	0	2	4	Theory

Preamble

This course on Computer Organization and Microprocessor is designed as a theory and practical course that aims to provide students with a deep understanding of computer system architecture and organization. The course covers various topics, including the evolution and performance of computer systems, central processing units and computer hardware, x86 and MIPS32 processors, and multi-core architecture. Through experiments, students will gain hands-on experience in designing and implementing programs for data transfer, arithmetic operations, floating-point arithmetic, code conversion, stack implementation, array handling, recursion programs, and IO system service calls using x86 and MIPS32 architectures. Upon completion of the course, students will have a strong foundation in computer organization and microprocessor architecture and be equipped to design efficient and optimized programs for modern computer systems.

Prerequisite

Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the evolution, performance, organization, and architecture of computer systems.	TPS2	70	70
CO2	Understand the structure and function of CPU and computer hardware components.	TPS2	70	70
CO3	Apply the knowledge of x86 processors, to frame ASM coding for data transfer and arithmetic computations.	TPS3	70	70
CO4	Apply knowledge of MIPS32 architecture to design and optimize efficient programs for maximum performance and resource utilization.	TPS3	70	70
CO5	Apply knowledge of vector processors, multicore processors, network on chip, and Raspberry Pi SBC building blocks to design and implement efficient parallel programs	TPS3	70	70
CO6	Apply the principles of BIOS system calls and I/O system service calls to effectively communicate with and control computer hardware devices.	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO2
CO1	M	L	-	-	-	-	-	L	L	L	L	L	L	-	L
CO2	M	M	L	L	-	-	-	L	L	L	L	L	-	L	L
CO3	S	M	L	-	S	-	-	L	L	L	L	L	M	L	L

CO 4	S	M	L	L	S	L	-	L	L	L	L	L	M	L	L
CO 5	S	M	L	L	-	L	-	L	L	L	L	L	M	-	L
CO 6	S	L	L	L	-	-	-	L	L	L	L	L	-	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I			**Assessment - II**			**Terminal Exam** (%)		
	CAT – I (%)			**CAT – II** (%)					
TPS / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	20	-	-	-	-	-	20	-
CO2	-	20	20	-	-	-	-	-	20
CO3	-	20	20	-	-	-	-	20	-
CO4	-	-	-	-	30	15	-	-	20
CO5	-	-	-	-	30	15	-	-	15
CO6	-	-	-	-		10	-	-	5
Total	-	**60**	**40**	**-**	**60**	**40**	**-**	**40**	**60**

Psychomotor Skill	**Practical**
Perception	-
Set	-
Guided Response	-
Mechanism	100
Complex Overt Responses	-
Adaptation	-
Origination	-

Syllabus

Computer System: Evolution and Performance, organization and architecture. Structure and Function, Generations of computer. IAS computer Structure and operation. CISC and RISC, Evolution of the Intel x86 and ARM architecture. Performance assessment [5]

Central Processing Unit and Computer Hardware: CPU building blocks and its functions, ALU, Register organization. Instruction sets, Addressing modes and functions. Instruction Pipelining. Bus interconnection. Memory Management**:** Cache and its organization, Internal External memory and virtual memory and DMA [8]

x86 Processors: Architecture and Modes of operations, memory segments and Programming mode. Instruction sets, assembler directives. Stack, and interrupts. Memory Banking. ASM Coding for data transfer and arithmetic computations. Introduction to IA32 architecture. [6]

MIPS32 Architecture: MIPS32 instructions, programming model, CPU performance measuring. Pipelining of the Mips32 Data Path, Amadhal laws, Multi-cycle Operations in MIPS32 and exploiting Instruction Level Parallelism [9]

Multi-Core Architecture: Vector Processors, Introduction to Tiled Chip Multicore Processors, Network On Chip and Raspberry PI SBC-Buliding Blocks. [8]

Practical:

1. x86 programming for data Transferring and arithmetic operation [2]
2. x86 Floating point arithmetic operations [2]
3. x86 BIOS system call for Input/output device [2]
4. MIPS32 Integer arithmetic operation [2]
5. MIPS32 Logical operations [2]

6. MIPS32 Floating point arithmetic [2]
7. Implementing of code conversions in MIPS32 [2]
8. MIPS32 Stack implementation [2]
9. Array handling in MIPS32 [2]
10. Recursion Program [2]
11. IO System Service Calls [2]
12. Handling Interrupts in MIPS32 [2]

Note:

- Experiments 1, 2 and 3 will be carried out by EMU8086 simulator which runs on all recent computers.
- Experiments 4 to 12 will be carried out by QTSPIM simulator runs on Windows, and Linux computers.

Text Book

- William Stallings, Computer Organisation and Architecture- Designing for Performance", 9th Edition, Pearson Education series, 2014.
- Robert Britton, "MIPS Assembly Language Programming", Pearson/Prentice Hall, 2004

Reference Books& web resources

- K. Bhurchandi, A. K. Ray, Advanced Microprocessor and Peripherals, McGraw Hill Education, 3rd Edition, 2017.
- Patterson, D. A., and J. L. Hennessy. Computer Organization and Design: The Hardware/Software Interface, 5th ed. San Mateo, CA: Morgan Kaufman, 2013. ISBN: 1558606041.
- https://onlinecourses.nptel.ac.in/noc22_cs88/course.
- https://onlinecourses.nptel.ac.in/noc21_cs82/course.

Course Contents and Lecture Schedule

Module No.	Topic	No.of Lectures	CO
1	**Computer System**		
1.1	Evolution and Performance, organization and architecture. Structure and Function, Generations of computer.	2	CO1
1.2	IAS computer Structure and operation. CISC and RISC,	2	CO1
1.3	Evolution of the Intel x86 and ARM architecture. Performance assessment	1	CO1
2	**Central Processing Unit and Computer Hardware**		
2.1	CPU building blocks and its functions, ALU, Register organization.	2	CO2
2.2	Instruction sets, Addressing modes and functions.	2	CO2
2.3	Instruction Pipelining. Bus interconnection.	2	CO2
	Memory Management: Cache and its organization, Internal External memory and virtual memory and DMA	2	CO2
3	**x86 Processors**		
3.1	Architecture and Modes of operations, memory segments and Programming mode.	2	CO3

3.2	Instruction sets, assembler directives.	1	CO3
3.3	Stack, and interrupts. Memory Banking. ASM Coding for data transfer and arithmetic computations.	2	CO3
	Introduction to IA32 architecture.	1	CO3
4	**MIPS32 Architecture**		
4.1	MIPS32 instructions, programming model, CPU performance measuring.	3	CO4
4.2	Pipelining of the Mips32 Data Path	2	CO4
4.3	Amadhal laws, Multi-cycle Operations in MIPS32	2	CO4
4.4	exploiting Instruction Level Parallelism	2	CO6
5	**Multi-Core Architecture**		
5.1	Vector Processors	2	CO5
5.2	Introduction to Tiled Chip Multicore Processors.	2	CO5
5.3	Network On Chip	2	CO5
5.4	Raspberry PI SBC-Building Blocks	2	CO5
Total		**36**	
Practical			
6	x86 programming for data Transferring and arithmetic operation	2	CO3
7	x86 Floating point arithmetic operations	2	CO3
8	x86 BIOS system call for Input/output device	2	CO6
9	MIPS32 Integer arithmetic operation	2	CO4
10	MIPS32 Logical operations	2	CO4
11	MIPS32 Floating point arithmetic	2	CO4
12	Implementing of code conversions in MIPS32	2	CO4
13	MIPS32 Stack implementation	2	CO4
14	Array handling in MIPS32	2	CO4
15	Recursion Program	2	CO4
16	IO System Service Calls	2	CO6
17	Handling Interrupts in MIPS32	2	CO6
Total		**24**	

Course Designers:

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22EC350	SIGNALS AND SYSTEMS

Category	L	T	P	Credit
PCC	3	1	0	4

Preamble

Signals and Systems arise in a wide variety of fields such as communications, aeronautics astronautics, acoustics, seismology, biomedical engineering and speech processing. Signals are functions of one or more independent variables. Signals contain information about the behaviour or nature of some phenomenon. They vary continuously in time or at discrete points in time. Systems respond to particular signals by producing other signals or some desired behaviour. Systems that respond to or process signals lead 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. In this course, students will be able to analyse signals and systems and design systems to enhance or restore signals that have been degraded.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Characterize and classify the given continuous and discrete signals and systems	TPS 3	70	70
CO2	Carry out time domain analysis of continuous time systems	TPS 3	70	70
CO3	Carry out time domain analysis of discrete time systems	TPS 3	70	70
CO4	Analyze continuous time periodic signals using Fourier Series.	TPS 4	70	70
CO5	Analyze continuous time non-periodic signals using Fourier Transform.	TPS 4	70	70
CO6	Convert a continuous time signal into discrete time sequence using Nyquist Sampling Theorem	TPS 3	70	70
CO7	Carry out discrete time analysis using z-Transform.	TPS 3	70	70

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	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO2	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO3	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO4	S	S	M	L	S	-	-	-	-	M	-	-	S	M	-
CO5	S	S	M	L	S	-	-	-	-	M	-	-	S	M	-
CO6	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO7	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
Overall	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern:

	Assessment – I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assignment I (%)			CAT – II (%)			Assignment II (%)					
CO \ TPS	**2**	**3**	**4**	**2**	**3**	**4**	**2**	**3**	**4**	**2**	**3**	**4**	**2**	**3**	**4**
CO1	10	10	-	100			-	-	-	-			2	10	-
CO2	10	20	-				-	-	-	-			2	10	-
CO3	10	20	-				-	-	-	-			2	-	10
CO4	-	-	20				-	-	-	-			4	-	10
CO5	-	-	-	-			-	10	20	100			4	10	-
CO6	-	-	-	-			10	20	-				2	20	-
CO7	-	-	-	-			10	30	-				4	10	-
Total	**30**	**50**	**20**	**100**			**20**	**60**	**20**	**100**			**20**	**60**	**20**

Syllabus

Signals and Systems: Signals, Signal Operations, Classification of Signals, Continuous time Signal Models, Systems, Classification of continuous time Systems, Signal operations on discrete time signals, Discrete Signal Models, Classification of discrete time systems, **Time-Domain Analysis of Continuous-Time Systems:** System response to internal conditions: the zero-input response, Unit impulse response, *System response to external input: zero-state response*: Convolutional Integral, Interconnected System; *System stability*: BIBO and Asymptotic Stability, *Intuitive Insights into System Behaviour*: Time Constant, Resonance Phenomenon, **Time-Domain Analysis of Discrete-Time Systems:** System response to internal conditions: the zero-input response, unit impulse response, *System response to external input: zero-state response:* Convolutional Sum, Properties of convolution sum, Interconnected Systems, *System stability:* BIBO and Asymptotic Stability, *Intuitive Insights into System Behaviour:* Time Constant, Resonance Phenomenon, **Continuous-Time Signal Analysis-The Fourier Series:** Periodic signal representation by trigonometric Fourier series, Existence and convergence of the Fourier series, Exponential Fourier series, LTIC response to periodic inputs, Generalized Fourier series: Signals as vectors, **Continuous-Time Signal Analysis-The Fourier Transform:** Aperiodic signal representation by Fourier integral, Fourier Transforms of useful functions, Properties of Fourier Transform, Signal transmission through LTIC systems, **Sampling:** Sampling Theorem, Signal Reconstruction, **Discrete-Time System Analysis Using the z-Transform:** Properties of z-Transform, z-Transform Solution of Linear Difference Equations, Frequency Response of Discrete-Time Systems, Frequency Response from Pole-Zero Location, Connection between the Laplace Transform and the z-Transform, The Bilateral z-Transform.

Text Book

- Principles of Linear Systems and Signals: B.P. Lathi (2nd Edition), Oxford University Press, 2009.

Reference Books& web resources

- Alan V.Oppenheim, Alan S.Willsky and S.Hamid Nawab, “Signals & Systems”, PrenticeHall of India, Second Edition, 2011.
- James H.McClellen, Ronald W.Schafer, Mark A.Yoder ,”Signal Processing First”, Pearson Education, 2003.
- Rodger E.Ziemer, William H.Tranter and D.Ronald Fannain “Signals & Systems Continuous and Discrete”, Pearson Education, 2002.
- Simon Haykin, Barry Van Veen,” Signals and Systems”, Wiely, 2nd Edition, 2002.
- Sophocles J.Orfanidis “Introduction to Signal Processing”, Prentice Hall, 1996.
- Ashok Ambardar, “Digital Signal Processing: A Modern Introduction”, Nelson Engg, 2007.
- https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/index.htm

Course Contents and Lecture Schedule

No.	Topic	Lecture/ Tutorial Hours	COs
1	Signals and Systems		
1.1	Signals, Signal Operations, Classification of Signals	1	CO1
1.2	Continuous time Signal Models, Systems	2	CO1
1.3	Classification of continuous time Systems	1	CO1
1.4	Signal operations on discrete time signals	1	CO1
1.5	Discrete Signal Models, Classification of discrete time systems	2	CO1
2	**Time-Domain Analysis of Continuous-Time Systems**		
2.1	System response to internal conditions: The zero-input response, Unit impulse response	1	CO2
2.2	System response to external input: zero-state response	1	CO2
2.3	Convolutional Integral, Interconnected System	2	CO2
2.4	System stability**:** BIBO and Asymptotic Stability	2	CO2
2.5	Intuitive Insights into System Behaviour: Time Constant, Resonance Phenomenon	2	CO2
3	**Time-Domain Analysis of Discrete-Time Systems**		
3.1	System response to internal conditions: the zero-input response unit impulse response	2	CO3
3.2	System response to external input: zero-state response- Convolutional Sum	2	CO3
3.3	Properties of convolution sum, Interconnected Systems	1	CO3
3.4	System stability**:** BIBO and Asymptotic Stability	2	CO3
3.5	Intuitive Insights into System Behaviour**:** Time Constant, Resonance Phenomenon	1	CO3
4	**Continuous-Time Signal Analysis-The Fourier Series**		
4.1	Periodic signal representation by trigonometric Fourier series	2	CO4
4.2	Existence and convergence of the Fourier series	2	CO4
4.3	Exponential Fourier series	2	CO4
4.4	LTIC response to periodic inputs, Generalized Fourier series: Signals as vectors	2	CO4
5	**Continuous-Time Signal Analysis-The Fourier Transform**		
5.1	Aperiodic signal representation by Fourier integral	2	CO5
5.2	Fourier Transforms of useful functions	2	CO5
5.3	Properties of Fourier Transform, Signal transmission through LTIC systems	3	CO5
6	**Sampling**		
6.1	Sampling Theorem, Signal Reconstruction	3	CO6
7	**Discrete-Time System Analysis Using the z-Transform**		
7.1	Properties of z-Transform, z-Transform Solution of Linear Difference Equations	2	CO7
7.2	Frequency Response of Discrete-Time Systems, Frequency Response from Pole-Zero Location	2	CO7
7.3	Connection between the Laplace Transform and the z-Transform, The Bilateral z-Transform	3	CO7
Total		**48**	

Course Designers:

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- Dr.K.Rajeswari rajeswari@tce.edu
- Dr.G.Ananthi gananthi@tce.edu

22EC360	OBJECT ORIENTED PROGRAMMING

Category	L	T	P	Credit
ESC	3	0	0	3

Preamble

This course aims to provide students with broad theoretical and practical skills in object-oriented programming. This course focuses on various OOP concepts like Class, Object, Encapsulation, Inheritance and Polymorphism. It also focuses on various libraries and Swing for programming an interactive real-world application.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency %	Expected Attainment %
CO1	Use programming constructs like Data types, Control structures, looping statements.	TPS 3	70	70
CO2	Construct object-oriented programs for the given scenario using object-oriented concepts like abstraction, encapsulation, polymorphism and inheritance.	TPS 3	70	70
CO3	Apply JAR, package, and exception handling mechanism for the given problem.	TPS 3	70	70
CO4	Implement various libraries like String, I/O, Collection classes and JDBC.	TPS 3	70	70
CO5	Develop interactive, user friendly software for real world applications using swing and Event Handling.	TPS 3	70	70
CO6	Construct Java based solutions with functional programming and design patterns for various domain areas	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L		L			M				M	M	L	
CO2	S	M	L		L			M				M	M	L	
CO3	S	M	L		L			M				M	M	L	
CO4	S	M	L		S			M				M	M	M	M
CO5	S	M	L		S			S	S	S		S	M	M	M
CO6	S	M	L		S			S	S	S		S	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II * (%)					
TPS / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	10				-						-	4	6
CO2	-	10	20		100		-						-	4	14
CO3	-	10	40				-						-	4	15
CO4	-						-	10	40				-	4	15
CO5	-						-	10	20		100		-	-	20
CO6	-						-	10	40				-	4	10
Total	**-**	**30**	**70**		**100**		**-**	**20**	**80**		**100**		**-**	**20**	**80**

Syllabus

Programming Constructs: Data types, Arrays, Control structures- Selection, Looping and Jump statements **Object Oriented Programming Concepts:** Object Oriented Paradigms, Encapsulation Object, Class, Method, Inheritance, Polymorphism–Method overloading, Method overriding, dynamic method dispatch, Abstract class and Interfaces **Exception Handling:** JAR, Create and import packages, Exception handling, Exception hierarchy- Try and Catch, Multiple catch, Nested try, throw, Built in exceptions and User defined exceptions **Libraries:** User-defined packages, String Handling - Methods, I/O – File Reading and Writing, StringTokenizer, Collections – Arraylist, linked list, HashSet, Linked Hashset, Tree Set, JDBC **Swing & Event Handling:** Swing components, Event handling, Event ListenersInterfaces - Action Listener, Focus Listener, Item Listener, Key Listener, Mouse Listener, Text Listener, AWT components - Frame, Label, Button, TextField, CheckBox, CheckBoxGroup, Choice, List, Layout – grid, card **Design Patterns:** Creational, Structural and Behavioral Design Patterns **Functional Programming:** Lambda expressions, functional interfaces, Stream API, immutability, pure functions, higher order functions, Recursion.

Text Book

- Herbert Schildt, “Java: The Complete Reference”, McGraw-Hill. Ninth Edition, 2014.

Reference Books

- Tony Gaddis, Starting Out with Java: From Control Structures through Objects, 4/E, Addison-Wesley, 2009.
- Grady Booch, Robert Maksimchuk, Michael Engel, Bobbi Young, Jim Conallen, Kelli Houston: Object Oriented Analysis and Design with Applications, Third Edition, May 2007.
- H.M. Deitel and P.J. Deitel, C How to program Introducing C++ and Java, Fourth Edition, Pearson Prentice Hall, 2005.
- Paul Deitel and Harvey Deitel, “Java How to Program (Early Objects)”, Pearson, Eleventh Edition, 2017.
- E.Balagurusamy, “Programming with Java” , McGraw-Hill, Fifth Edition, 2014.
- Kathy Sierra, “Head First Java”, Shroff publications, Second edition, 2005.
- Cay S. Horstmann and Gary Cornell, “Core Java, Volume I - Fundamentals”, Prentice Hall, Ninth Edition, 2013.
- Cay S. Horstmann and Gary Cornell, “Core Java, Volume II – Advanced Features : 2”, Prentice
- Erich Gamma. Richard Helm, Ralph Johnson, John Vlissides, “Design Patterns- Element of Reusable Object-Oriented Software”, Pearson Education India, 2004.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**Introduction**	**1**
2	**Programming Constructs:** Data types, Arrays	1
3	Control structures- Selection	1
4	Control structures- Looping and Jump statements	1
	Object Oriented Programming Concepts:	
5	Object Oriented Paradigms	1
6	Encapsulation Object, Class, Method	2
7	Inheritance	1
8	Polymorphism–Method overloading, Method overriding, dynamic method dispatch	2
9	Abstract class and Interfaces	2
	Exception Handling:	
10	JAR	1
11	Create and import packages	1

12	Exception handling, Exception hierarchy- Try and Catch	1
13	Multiple catch and Nested try	2
14	throw	1
	Built in exceptions	1
15	User defined exceptions	1
	Libraries:	
16	User-defined packages, String Handling - Methods	1
17	I/O – File Reading and Writing	1
18	String Tokenizer	
19	Collections – Array list, linked list Hash Set, Linked Hash set, Tree Set	1
20	JDBC	1
	Swing & Event Handling:	
21	Swing components, Event handling, Event Listeners Interfaces - Action Listener, Focus Listener, Item Listener, Key Listener, Mouse Listener, Text Listener	2
22	AWT components - Frame, Label, Button, TextField, CheckBox, CheckBoxGroup, Choice, List, Layout – grid, card	2
	Design Patterns:	
23	Creational Design Patterns	2
24	Structural and Behavioral Design Patterns	2
	Functional Programming:	
25	Lambda expressions, functional interfaces	2
26	Stream API, immutability, pure functions	1
27	Higher order functions, Recursion.	1
	TOTAL	**36**

Course Designers:

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- Dr.R.A.Alaguraja, alaguraja@tce.edu

22ES390	DESIGN THINKING

Category	L	T	P	Credit
ESC	1	-	4	3

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 Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Identify a specific social need to be addressed	TPS 3	70	80
CO2	Identify stakeholder's requirements for the societal project	TPS 3	70	80
CO3	Develop measurable criteria in which design concepts can be evaluated	TPS 3	70	80
CO4	Develop prototypes of multiple concepts using user's feedback	TPS 3	70	80
CO5	Select the best design solution among the potential solutions with its functional decomposition	TPS 5	70	80

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L	-	-	M	M	M	L	M	M	S
CO2	S	M	L	-	-	M	M	M	L	M	M	S
CO3	S	M	L	-	-	M	M	M	L	M	M	S
CO4	S	M	L	-	M	M	M	M	L	M	M	S
CO5	S	S	M	L	M	M	M	M	L	M	M	S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Phases	Deliverables	Marks	Course Outcomes
Continuous 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, CO4 and CO5
Poster Presentation	Poster	40	

- 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 No.	Topic	No. of Hours		Course Outcome
		In-Class	Hands-on	
1.	**Project Identification**: Introduction to Human-Centered Design	1	-	CO1
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	CO4
3.3	Creation of Prototypes for Multiple Concepts	1	2	CO4
3.4	Refinement of design Specification on users' feedback		2	CO4
3.5	Evaluation of Potential Solutions	1	2	CO5
3.6	Selection of best design		2	CO5
	Total	12	34	

Course Designers:

1. Dr.S.J.Thiruvengadam sjtece@tce.edu

CURRICULUM AND DETAILED SYLLABI

FOR

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

FOURTH SEMESTER

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution Affiliated to Anna University)
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22EC410	OPTIMIZATION

Category	L	T	P	Credit
BSC	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. 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 “Optimization”. Because of the complexity of most real-world 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. The course is designed to impart the knowledge and understanding the concepts on optimization techniques.

Prerequisite

NIL

Course Outcomes

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

Cos	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Formulate mathematical models of Linear Programming (LP),	TPS3	70	60
CO2	Solve Linear Programming Problems (LPP) by appropriate techniques and evaluate the behaviour under different range of parameters.	TPS3	70	60
CO3	Determine the optimum solutions of transportation and assignment problems	TPS3	70	60
CO4	Determine the optimum values of non-linear programming problems using search methods.	TPS3	70	60
CO5	Determine the optimum values of non-linear programming problems using descent methods	TPS3	70	60
CO6	Apply the concepts of convex optimization	TPS3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	S	S	S	M	-	-	-	-	-	-	S	S	-	-
CO2	S	S	S	M	M	-	-	-	-	-	-	S	S	-	-
CO3	S	S	S	S	M	-	-	-	-	-	-	S	S	-	-
CO4	S	S	S	S	M	-	-	-	-	-	-	S	S	-	-
CO5	S	S	S	M	-	-	-	-	-	-	-	S	S	-	-
CO6	S	S	S	M	-	-	-	-	-	-	-	S	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

TPS / CO	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I (%)			CAT – II (%)			Assg. II (%)					
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	-	17	-	-		-	-	-	-	-	-	-	-	8
CO2	7	10	33	-	-	70	-	-	-	-	-	-	-	12	13
CO3	3	10	20	-	-		-	-	-	-	-	-	-	6	11
CO4	-	-	-	-	-	-	3	10	15	-	-		-	6	8
CO5	-	-	-	-	-	-	-	-	28	-	-	70	-	-	14
CO6	-	-	-	-	-	-	7	10	27	-	-		-	6	16
MATLAB	-	-	-	-	-	30	-	-	-	-	-	30	-	-	-
Total	**10**	**20**	**70**	**-**	**-**	**100**	**10**	**20**	**70**	**-**	**-**	**100**	**-**	**30**	**70**

Syllabus

Linear Programming: Formulation - Graphical Method and Simplex Method – Big-M Method – Two Phase Method - Primal-Dual Relations - Dual Simplex Method [12 hours]

Transportation problems: Transportation problems and solutions (North-West Corner Rule, Least Cost Method, Vogel's Approximation Method) – Solution using MODI Method - Assignment problems – Solution using Hungarian Method – Travelling Salesman Problems. [6 hours]

Nonlinear Programming: Unimodal Function – Fibonacci Method – Golden Section Method - Univariate Method – Steepest Descent (Cauchy) Method - Conjugate Gradient (Fletcher–Reeves) Method**.** **Convex Optimization:** Introduction to convex programming problem **-** Kuhn-Tucker Conditions – Cutting plane method - Basic Approach of the Penalty Function Method – Penalty Function Method for Problems with Mixed Equality and Inequality Constraints [18 hours]

Text Books

- Singiresu S. Rao, "Engineering Optimization Theory and Practice", 5th edition, John Wiley & Sons, Inc, 2020.
- Hamdy A. Taha, "Operations Research - An Introduction", 10th Edition, Pearson Education Limited 2017.

Reference Books & web resources

- Frederick Hillier, Gerald Lieberman, "Introduction to Operations Research" Tenth Edition, Tata McGraw Hill, 2015.
- Winston, Wayne L, and Jeffrey B. Goldberg, "Operations Research: Applications and Algorithms", 7th edition, Thomson/Brooks/Cole Belmont, CA, 2004.
- Ravindran, Don. T. Philips and James J. Solberg, "Operations Research- Principles and Practice", Second Edition, John Wiley and Sons, 2007.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Linear Programming**	
1.1	Introduction-Linear Programming, Formulation	2
	Tutorial	1
1.2	Graphical Method	1
1.3	Simplex Method	1
	Tutorial	**1**
1.4	Big-M Method	1
1.5	Two Phase Method	1
	Tutorial	1
1.6	Primal-Dual Relations	1

1.7	Dual Simplex Method	2
2	**Transportation problems**	
2.1	Introduction - Transportation problems and solutions, North-West Corner Rule	1
2.2	Least Cost Method, Vogel's Approximation Method	1
	Tutorial	1
2.3	Solution using MODI Method	1
2.4	Assignment problems - Solution using Hungarian Method	1
2.5	Travelling Salesman Problems.	1
3	**Nonlinear Programming:**	
3.1	Introduction-Nonlinear programming Unimodal Function	1
3.2	Fibonacci Method	1
	Tutorial	1
3.3	Golden Section Method	1
3.4	Univariate Method	1
3.5	Steepest Descent (Cauchy) Method	2
	Tutorial	1
3.6	Conjugate Gradient (Fletcher–Reeves) Method.	2
3.7	Introduction to convex programming problem, Kuhn-Tucker Conditions – -–	2
	Tutorial	1
3.8	Cutting plane method	1
3.9	Basic Approach of the Penalty Function Method	1
3.10	Penalty Function Method for Problems with Mixed Equality and Inequality Constraints	2
	Tutorial	1
	Total	36

Course Designers:

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- Dr. S. Suriyakala ssamat@tce.edu

22ECL10	**VECTOR SPACES, PROBABILITY AND OPTIMIZATION** (for Lateral entry students)	Category	L	T	P	Credit
		BSC	2	1	0	3

Preamble

An electronics and communication engineering student needs to have Mathematical functions can be viewed in many different ways and one way of viewing them is through vectors. Most of the algebraic manipulation of functions from an m dimensional space to an n-dimensional space can be done using matrices and the tools from linear algebra. Some basic statistical tools and techniques to apply in diverse applications in digital signal processing communications systems and networks that requires an understanding of Probability distributions. 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. The course is designed to impart the knowledge and understanding of the above concepts and apply them in their areas of specialization.

Prerequisite

NIL

Course Outcomes

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

Cos	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Demonstrate vector space and subspace	TPS3	70	65
CO2	Determine an orthonormal basis for the given basis	TPS3	70	65
CO3	Solve the linear programming using graphical and simplex method	TPS3	70	65
CO4	Determine the optimum solutions of transportation and assignment problems	TPS3	70	65
CO5	Apply the concept of probability and conditional probability to solve real world problems	TPS3	70	65
CO6	Use standard distributions to find the expected life time of electrical components.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	-	-	-	S	S	L	-	-
CO2	S	M	L	-	-	-	-	-	-	-	S	S	L	-	-
CO3	S	M	L	-	-	-	-	-	-	-	S	S	L	-	-
CO4	S	M	L	-	-	-	-	-	-	-	S	S	L	-	-
CO5	S	M	L	-	-	-	-	-	-	-	S	S	L	-	-
CO6	S	M	L	-	-	-	-	-	-	-	S	S	L	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

TPS CO	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I (%)			CAT – II (%)			Assg. II (%)					
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	4	10	19	-	-	30	-	-	-	-	-	-	-	6	11
CO2	3	-	31	-	-	40	-	-	-	-	-	-	-	3	14
CO3	3	10	20	-	-	30	-	-	-	-	-	-	-	3	14
CO4	-	-	-	-	-	-	4	10	19	-	-	30	-	6	11
CO5	-	-	-	-	-	-	3	-	25	-	-	30	-	3	10
CO6	-	-	-	-	-	-	3	10	26	-	-	40	-	9	10
Total	**10**	**20**	**70**	-	-	**100**	**10**	**20**	**70**	-	-	**100**	-	**30**	**70**

Syllabus

Vector Spaces: Vector space, Subspaces, linear independence of vectors, basis and dimension **Orthogonality**: Orthonormal sets, The Gram-Schmidt orthogonalization process. [12 hours]

Linear Programming: Graphical Method and Simplex Method **Transportation problems:** Transportation problems and solutions (Vogel's Approximation Method) – Optimal Solution using MODI method - Assignment problems: Solution using Hungarian Method. [12 hours]

Probability: Introduction to Probability**:** Sample space and events - Definition and axioms of probability - Conditional Probability - Baye's theorem **Random variables and Distributions:** Random variables - Expected Values – Discrete Probability distribution: Binomial Distribution - Continuous Probability distribution: Normal distribution [12 hours]

Text Book

- Steven.J. Leon, "Linear Algebra with Applications", 9th edition, Pearson, 2015
- P.K.Gupta and D.S.Hira, "Operations Research", 7th edition, S.Chand and company Pvt Ltd, Inc, 2014
- Jay L. Devore, Probability and Statistics for Engineering and the Sciences, 9th Edition, Cengage Learning India Pvt Ltd, New Delhi, 2014.

Reference Books & web resources

- David.C.Lay, "Linear Algebra and its applications", Pearson Addison – Addison Wesley, 3 rd edition, 2006.
- Richard A. Johnson, "Miller &Freund's, Probability and Statistics for Engineers", Prentice Hall, New Delhi, 2017.
- Singiresu S. Rao, "Engineering Optimization Theory and Practice", 5th edition, John Wiley & Sons, Inc, 2020.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Vector Spaces**	
1.1	Vector space	2
	Tutorial	1
1.2	Subspaces	1
1.3	Linear independence of vectors	1
1.4	Basis and dimension	1

Module No.	Topic	No. of Periods
1.5	**Orthogonality**: Orthonormal sets	2
	Tutorial	1
1.6	The Gram-Schmidt orthogonalization process	2
	Tutorial	1
2	**Linear Programming**	
2.1	Graphical Method	2
	Tutorial	1
2.2	Simplex Method	3
2.3	Transportation problems and solutions - Vogel's Approximation Method	1
2.4	Optimal Solution using MODI method	2
	Tutorial	1
2.5	Assignment problems: Solution using Hungarian Method	2
3	**Probability**	
3.1	Introduction to Probability**:** Sample space and events Definition and axioms of probability	1
3.2	Conditional Probability	1
	Tutorial	1
3.3	Baye's theorem	2
3.4	**Random variables and Distributions** - Random variables	1
3.5	Expected Values	2
	Tutorial	1
3.6	Discrete Probability distribution: Binomial Distribution	1
3.7	Continuous Probability distribution: Normal distribution	2
	Total	**36**

Course Designer(s):

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22EC420	MIXED SIGNAL CIRCUIT DESIGN

Category	L	T	P	Credit
PCC	3	0	0	3

Preamble

This course is to knowledge of link between analog world and digital world as in the name of mixed signal circuit. It is performed by sampling and hold circuit, DAC and ADC. The course mainly presents state-of-the-art Sample and hold circuits, digital-to-analog converters, a range of analog-to-digital converters, and phase locked loop concepts.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Demonstrate the performance parameters of Sample and Hold Circuits	TPS 3	70	70
CO2	Demonstrate the performance parameters of comparators	TPS 3	70	70
CO3	Interpret Data Converter Specifications	TPS 3	70	70
CO4	Design Digital-to-analog converters	TPS 3	70	70
CO5	Design Analog-to-digital converters	TPS 3	70	70
CO6	Understand the Phase locked loop concepts	TPS 2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	-	-	-	-	-	M	-	-	M	-	-
CO2	S	M	L	L	-	-	-	-	-	M	-	-	M	-	-
CO3	S	M	L	L	-	-	-	-	-	M	-	-	M	-	-
CO4	S	M	L	L	-	-	-	-	-	M	-	-	M	-	-
CO5	S	M	L	L	-	-	-	-	-	M	-	-	M	-	-
CO6	S	M	L	L	-	-	-	-	-	M	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II * (%)					
TPS / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20				-						-	4	10
CO2	-	10	20		100		-						-	4	10
CO3	-	10	30				-						-	4	15
CO4	-						-	10	20				-	4	15
CO5	-						-	10	30		100		-	4	15
CO6	-						-	30	-				-	15	-
Total	**-**	**30**	**70**		**100**		**-**	**50**	**50**		**100**		**-**	**35**	**65**

Syllabus

Sample and Hold Circuits: Performance of sample-and-hold circuits – Testing of sample and holds, MOS sample-and-hold basics, CMOS sample and hold circuits, Switch capacitor amplifiers, Switch capacitor power amplifiers, Switch capacitor filters. [8]

Comparators: Comparator specifications – input offset and noise, hysteresis. Opamp as a comparator – input-offset voltage errors, charge-injection errors, making charge-injection signal independent, minimizing errors due to charge-injections. [6]

Data Converter Specifications: Ideal D/A converter, ideal A/D converter, quantization noise, deterministic approach, stochastic approach, signed codes, performance limitations, resolution, offset and gain error, accuracy and linearity [5]

Digital-to-analog converters (DAC): Decoder-based converters – resistor string converters, folded resistor-string converters, binary-weighted resistor converters, R-2R-based converters, Thermometer-code converters [5]

Analog-to-digital converters (ADC): Integrating converters, flash converters, Successive-approximation converters, Pipelined A/D converters and Sigma Delta Converters [6]

Phase locked loop: Basic phase-locked loop architecture, voltage-controlled oscillator, divider, phase detector, loop filer, the PLL in lock [6]

Text Book

- Tony Chan Carusone, D avid A. Johns, Kenneth W. Martin “Analog Integrated Circuit Design”, Wiley, 2nd Edition, 2011.
- David A. Johns and Ken Martin: Analog Integrated Circuit Design, Wiley India, 2008.
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Reference Books & web resources

- Phillip Allen and Douglas R. Holberg “CMOS Analog Circuit Design” Elsevier, 2011.
- Willy M. C. Sansen “Analog Design Essentials” Springer, 2006.
- Behzad Razavi “Design of Analog CMOS Integrated Circuits” McGraw Hill, 2nd Edition, 2015.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Sample and Hold Circuits	
1	Performance of sample-and-hold circuits	2
2	Testing of sample and holds	1
3	MOS sample-and-hold basics, CMOS sample and hold circuits,	2
4	Switch capacitor amplifiers, Switch capacitor power amplifiers.	2
5	Switch capacitor filters	1
	Comparators	
6	Comparator specifications	1
7	Input offset and noise	1
8	Hysteresis	1
9	Opamp as a comparator – input-offset voltage errors	1
10	Charge-injection errors, making charge-injection signal independent, minimizing errors due to charge-injections	2
	Data Converters Specifications	
11	Ideal D/A converter	1
12	Ideal A/D converter	1
13	Quantization noise, deterministic approach, stochastic approach	1
14	Signed codes, performance limitations	1
15	Resolution, offset and gain error, accuracy and linearity	1

	Digital-to-Analog Converters (DAC)	
16	Decoder-based converters – resistor string converters	1
17	Folded resistor-string converters, binary-weighted resistor converters	2
18	R-2R-based converters, Thermometer-code converters	2
	Analog-to-Digital Converters (ADC)	
19	Integrating converters	2
20	Flash converters, Successive-approximation converters	2
21	Pipelined A/D converters and Sigma Delta Converters	2
	Phase Locked Loop	
22	Basic phase-locked loop architecture	2
23	Voltage-controlled oscillator, divider	2
24	Phase detector, loop filer, the PLL in lock	2
	TOTAL	**36**

Course Designers:

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- Dr V R Venkatasubramani, venthiru@tce.edu

22EC430	RF CIRCUIT DESIGN	Category	L	T	P	Credit	TE
		PCC	3	0	2	4	Theory

Preamble

The subject begins with the introduction of basic building blocks of the RF front-end and their functionalities from the perspective of mobile phone architecture. The microwave network analysis and its application were introduced in the second module. The third module covers the impedance matching between the interconnects and the terminating components/devices. The scattering parameter-based design and analysis of RF passive devices were given in fourth module. The final module provides stability criteria, design and analysis of active devices such as amplifiers and oscillators. The design theory is validated with the CAD simulation, fabrication and measurements in the laboratory.

Prerequisite

Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the RF front-end blocks in a GSM cellular phone and the component behaviour at RF/Microwave frequencies	TPS2	70	70
CO2	Design and validate the lumped and distributed matching networks	TPS3	70	70
CO3	Design and validate Power divider and Coupler	TPS3	70	70
CO4	Design and validate Filters for GSM frequencies	TPS3	70	70
CO5	Design and develop linear amplifier for the GSM applications	TPS3	70	70
CO6	Design an oscillator for the given specifications	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L		-	-	-	-	L	L	L	-	L	L	-	L
CO2	S	M	L	-	M	-	-	L	L	L	-	L	M	L	L
CO3	S	M	L	-	M	-	-	L	L	L	-	L	M	L	L
CO4	S	M	L	-	M	-	-	L	L	L	-	L	M	L	L
CO5	S	M	L	-	M	-	-	L	L	L	-	L	M	L	L
CO6	S	M	L	-	M	-	-	L	L	L	-	L	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I			Assessment – II			Terminal Exam (%)		
	CAT – I (%)			CAT – II (%)					
TPS / CO	1	2	3	1	2	3	1	2	3
CO1	-	20	-	-	-	-	-	6	-
CO2	-	10	30	-	-	-	-	2	16
CO3	-	10	30	-	-	-	-	4	16
CO4	-	-	-	-	10	20	-	2	16
CO5	-	-	-	-	15	20	-	4	16
CO6	-	-	-	-	15	20	-	2	16
Total	-	**40**	**60**	-	**40**	**60**	-	**20**	**80**

Psychomotor Skill	Practical
Perception	-
Set	-
Guided Response	-
Mechanism	100
Complex Overt Responses	-
Adaptation	-
Origination	-

Syllabus

Introduction: RF front-end blocks and functionalities in mobile phone, microwave sources and waveguides, EM Spectrum, RF/Microwaves versus DC and Low AC signals, behaviour of electronic components at microwave frequencies. [5]

Microwave Network Analysis: S-parameters, ABCD parameters – examples. [3]

Matching Networks: Lumped and Single stub matching – LC matching, Stub matching - Series and Shunt type. [6]

RF Passive Devices: Power dividers: Properties of dividers, Design of equal and un-equal power divider. Couplers: Properties of couplers, Design of Quadrature hybrid couplers and Rat-race coupler. Filters: Filter parameters and types, Filter design by insertion loss method, Butterworth filter transformations - Design of lumped and stepped impedance filters. [12]

RF Active Devices: RF/Microwave Linear Amplifiers: Amplifier parameters, transistor topologies, Stability criterion, Design of maximum gain amplifier (MGA) design, Gain-bandwidth product, Gain and Power budget analysis. **Oscillators:** Oscillator versus amplifier design, Condition of stable oscillations, One-port negative resistance oscillator design. [10]

Practical:

- Design and synthesis of planar transmission lines [2 Hours]
- Design & Simulation of L-section matching [2 Hours]
- Design & Simulation of Single-Stub matching [2 Hours]
- Design & Simulation of equal and un-equal power divider [2 Hours]
- Design & Simulation of Quadrature hybrid couplers and Rat-race coupler [4 Hours]
- Design & Simulation of Lumped and Distributed low pass filter [4 Hours]
- Design & Simulation of a linear amplifier [2 Hours]
- Study of Spectrum and Network analysers [2 Hours]
- PCB prototype fabrication and measurement of RF passive devices for GSM applications [4 Hours]

Text Book

- David M. Pozar, “Microwave Engineering”, John Wiley & Sons, Fourth Edition, 2015.
- 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.

Reference Books& web resources

- Matthew M. Radmanesh, "Radio frequency and Microwave Electronics Illustrated", Pearson Education Asia, 2001.
- G L Matthaei, L Young, and E M T Jones, “Microwave filters, impedance matching networks and coupling structures”, Artech House, 1985.
- Dr. Grish Kumar, Microwave theory and techniques, NPTEL.

Course Contents and Lecture Schedule

Module No.	Topic	No.of Lectures	CO
1	**INTRODUCTION**		
1.1	RF front-end blocks and functionalities in mobile phone	1	CO1
1.2	microwave sources and waveguides, EM Spectrum, RF/Microwaves versus DC and Low AC signals	2	CO1
1.3	Behaviour of electronic components at microwave frequencies	2	CO1
2	**MICROWAVE NETWORK ANALYSIS**		
2.1	S-parameters, ABCD parameters – examples	3	CO2
3	**MATCHING NETWORKS**		
3.1	Lumped and Single stub matching – LC matching	3	CO2
3.2	Stub matching - Series and Shunt type	3	CO2
4	**RF PASSIVE DEVICES**		
4.1	Power dividers: Properties of dividers	1	CO3
4.2	Design of equal and un-equal power divider	3	CO3
4.3	Couplers: Properties of couplers, Design of Quadrature hybrid couplers and Rat-race coupler.	4	CO3
4.4	Filters: Filter parameters and types, Filter design by insertion loss method	1	CO4
4.5	Butterworth filter transformations - Design of lumped and stepped impedance filters	3	CO4
5	**RF ACTIVE DEVICES**		
5.1	RF/Microwave Linear Amplifiers: Amplifier parameters, transistor topologies, Stability criterion	3	CO5
5.2	Design of maximum gain amplifier (MGA) design, Gain-bandwidth product, Gain and Power budget analysis	3	CO5
5.3	Oscillators: Oscillator versus amplifier design, Condition of stable oscillations	2	CO6
5.4	One-port negative resistance oscillator design	2	CO6
	Total	**36**	

Practical Sessions			
3.1	Design and synthesis of planar transmission lines	2	CO2
3.2	Design & Simulation of L-section matching	2	CO2
3.3	Design & Simulation of Single-Stub matching	2	CO2
4.1	Design & Simulation of equal and un-equal power divider	2	CO3
4.2	Design & Simulation of Quadrature hybrid couplers and Rat-race coupler	4	CO3
4.3	Design & Simulation of Lumped and Distributed low pass filter	4	CO4
5.1	Design & Simulation of a linear amplifier	2	CO5
5.2	Study of Spectrum and Network analysers	2	CO2,CO3,CO4,CO5
5.3	PCB prototype fabrication and measurement of RF passive devices for GSM applications	4	CO2,CO3,CO4
Total		**24**	

Course Designers:

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22EC440	MICROCONTROLLER AND EMBEDDED SYSTEM	Category	L	T	P	Credit	TE
		PCC	3	0	2	4	Theory

Preamble

This course on Microcontrollers and Embedded Systems provides an in-depth understanding of the architecture, programming, and interfacing of microcontrollers and embedded systems. Students will learn the fundamental concepts of microcontroller-based system design, including the basics of assembler, compilers, and interpreters, data types, syntax, preprocessors, and debugging techniques. The course also covers the organization and mapping of memory in ARM-based embedded systems, communication protocols, GPIOs, timers, and ADC and DAC peripherals. Practical programming skills in developing and debugging programs for embedded systems using 8051 and ARM microcontrollers will be emphasized. By the end of the course, students will be equipped with the knowledge and skills to design and develop efficient and effective embedded systems.

Prerequisite

Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the architecture of microcontrollers, including internal and external memory, registers, and instruction sets.	TPS2	70	70
CO2	Apply the basics of assemblers, compilers, interpreters, and debugging techniques, and apply this knowledge to write efficient and effective code in C for embedded systems.	TPS3	70	70
CO3	Understand the architecture of ARM microcontrollers, including general purpose and special registers, exceptions, interrupts, and stack operations.	TPS2	70	70
CO4	Apply the knowledge of ARM system design to develop programs for ARM-based embedded systems and interface with peripherals such as GPIOs, timers, ADC, and DAC.	TPS3	70	70
CO5	Apply knowledge of synchronous and asynchronous communication, as well as UART, SPI, I2C, and CAN, to develop programs for embedded systems that involve communication peripherals.	TPS3	70	70
CO6	Apply interrupt handling and embedded system programming for reliable and efficient firmware development in microcontroller-based systems.	TPS3	70	70

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O2
CO1	M	L		-	-	-	-	M	M	L	L	L	L	-	L
CO2	S	M	L	L	-	L	-	M	M	L	L	L	M	L	L
CO3	M	L	L	-	S	-	-	M	M	L	L	L	L	L	L
CO4	S	M	L	L	S	L	-	M	M	L	L	L	M	L	L
CO5	S	M	L	L	-	L	-	M	M	L	L	L	M	-	L
CO6	S	M	L	L	-	L	-	M	M	L	L	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I			**Assessment - II**			**Terminal Exam** (%)		
	CAT – I (%)			**CAT – II** (%)					
CO \ **TPS**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	20	-	-	-	-	-	20	-
CO2	-	20	20	-	-	-	-	-	20
CO3	-	20	20	-	-	-	-	20	-
CO4	-	-	-	-	30	15	-	-	20
CO5	-	-	-	-	30	15	-	-	15
CO6	-	-	-	-		10	-	-	5
Total	-	**60**	**40**	**-**	**60**	**40**	**-**	**40**	**60**

Psychomotor Skill	**Practical**
Perception	-
Set	-
Guided Response	-
Mechanism	100
Complex Overt Responses	-
Adaptation	-
Origination	-

Syllabus

8051 Microcontroller Architecture: Introduction and Overview of microprocessor and microcontrollers. Internal architecture and registers. Internal and External memory. Instructions sets and Addressing modes. Interrupts and Peripherals: GPIOs, Timers. UART. Applications of microcontrollers. Interface Programming [10]

Embedded C programming: Assembler, Compilers and interpreter. Data types and its syntax, preprocessors. IDE and refereeing to its manuals. Startup code. Continuous while loop. Accessing of internal, external memory of code and data memory. Look up tables. Debugging techniques. Build system [4]

ARM-Microcontroller: Thumb-technology and applications of ARM, Architecture of ARM Evolution of ARM. General Purpose Registers, Special Registers, exceptions, interrupts, stack operation, reset sequence. Instruction set and CMSIS and HAL Library. Programming concepts [7]

ARM Embedded system and Interfacing: ARM system design, Memory organization and memory mapping. AMBA Bus architecture protocols. Peripherals GPIOs, Timers with various modes of operation. Accessing ADC and DAC [8]

Communication Peripherals: Introduction to synchronous and Asynchronous communication. UART with RS232 and RS485 signal scheme, SPI, I2C and CAN. Interrupt handling and Embedded system programming [7]

Practical:

1. Programming in cross compiler Keil for 8051microcontroller (CO2)
   - Assembling and simulating an ASM code for accessing GPIO and external memory
   - Develop the user define a function to a switch connected in PORT1 and outputting the data to the LEDs connected in PORT0 using appropriate argument and return type
   - Methods to invoke breakpoints and step-by-step execution of the code
   - Calculating the delay for the given clock frequency
2. Embedded C programming in cross-compiler Keil for 8051 microcontrollers (CO2)
   - Compiling and simulating the embedded C code for performing the computation like root of the equation, and performing 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
3. Developing the C program for accessing GPIO and Timer peripherals in 8051 boards (CO2)
   - Develop a 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 a 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
4. Invoking interrupt services in the Embedded C programming and to realize it in 8051/ARM target board (CO6)
   - Control the LEDs in PORT-0 by the external interrupts INT0 and INT1
   - Blink the LEDs using a Timer peripheral interrupt which runs periodic time of intervals
5. Establishing serial communication between target board and computer (CO4)
   - Develop a user function in the C code for serial transmission with a defined baud rate to transmit a character and a string as an argument. Use interrupt-driven and polling methods
   - Develop a user function in the C code for serial reception with a defined baud rate to transmit a character and a string as an argument. Use interrupt-driven method
6. Accessing analog signal into the 8051/ARM 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 sent data to LEDs
   - Show the analog input data in CRO
7. 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
8. Design a display system to display the numbers and characters in LCD module (CO5)
   - 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

Text Book

- "The 8051 Microcontroller and Embedded Systems Using Assembly and C" by Muhammad Ali Mazidi, Rolin D. McKinlay, and Janice G. Mazidi
- ARM System Developer's Guide Designing and Optimizing System Software Andrew N. Sloss Dominic Symes Chris Wright. ELSEVIER inc 2005.

Reference Books& web resources

- https://www.nxp.com/docs/en/data-sheet/LPC1769_68_67_66_65_64_63.pdf
- NPTEL Video Lecture on "Microprocessor and Microcontroller", weblink: https://onlinecourses.nptel.ac.in/noc19_ee11/course
- Virtual Lab on "Real Time Embedded System", weblink: https://nptel.ac.in/courses/108102045/24

Course Contents and Lecture Schedule

#	Topic	No. of Lectures	CO
1	**8051 Microcontroller Architecture**		
1.1	Introduction and Overview of microprocessor and microcontrollers.	2	CO1
1.2	Internal architecture and registers. Internal and External memory.	2	CO1
1.3	Instructions sets and Addressing modes.	2	CO1
1.4	Interrupts and Peripherals: GPIOs, Timers. UART.	2	CO1
1.5	Applications of microcontrollers. Interface Programming	2	CO1
2	**Embedded C programming**		
2.1	Assembler, Compilers and interpreter. Data types and its syntax, preprocessors.	1	CO2
2.2	IDE and refereeing to its manuals. Startup code. Continuous while loop.	1	CO2
2.3	Accessing of internal, external memory of code and data memory. Look up tables. Debugging techniques. Build system	2	CO2
3	**ARM-Microcontroller**		
3.1	Thumb-technology and applications of ARM, Architecture of ARM Evolution of ARM.	2	CO3
3.2	General Purpose Registers, Special Registers, exceptions, interrupts, stack operation, reset sequence.	2	CO3
3.3	Instruction set and CMSIS and HAL Library.	2	CO3
3.4	Programming concepts	1	CO3
4	**ARM Embedded system and Interfacing**		
4.1	ARM system design, Memory organization and memory mapping.	2	CO4
4.2	AMBA Bus architecture protocols.	2	CO4
4.3	Peripherals GPIOs, Timers with various modes of operation.	2	CO4
4.4	Accessing ADC and DAC	2	CO4
5	**Communication Peripherals**		
5.1	Introduction to synchronous and Asynchronous communication.	2	CO5
5.2	UART with RS232 and RS485 signal scheme programming	2	CO5
5.3	SPI, I2C and CAN	2	CO5
5.4	Interrupt handling and Embedded system	1	CO6
	Total	**36**	
Practical			
6	Programming in cross compiler Keil for 8051microcontroller	**3**	CO2
7	Embedded C programming in cross-compiler Keil for 8051 microcontrollers	**3**	CO2
8	Developing the C program for accessing GPIO and Timer peripherals in 8051 boards	**3**	CO2
9	Invoking interrupt services in the Embedded C programming and to realize it in 8051/ARM target board	**3**	CO6

10	Establishing serial communication between target board and computer	**3**	CO5
11	Accessing analog signal into the 8051 system through ADC	**3**	CO4
12	Design a setup for a display system to display the data in 7 segment LED	**3**	CO5
13	Design a setup for a display system to display the numbers and characters in LCD module	**3**	CO5
Total		**24**	

Course Designers:

- Dr.K.Hariharan khh@tce.edu
- Dr.G.Prabhakar gpece@tce.edu

22EC450	DISCRETE TIME SIGNAL PROCESSING	Category	L	T	P	Credit	TE
		PCC	3	0	2	4	Theory

Preamble

Signal Processing is the field that deals with use of digital computers and processors to perform a wide variety of operations to alter and process digitally recorded signals. In this course, both an in-depth and an intuitive understanding of the theory behind modern discrete-time signal processing systems and applications are provided. This course lays down foundation to be able to gain understanding of specialized courses like speech signal processing, image processing, radar signal processing and data analysis. Further, in practical session, hands on training are given to the students in understanding the theory of signals and systems and practicing the algorithms used in discrete time signal processing.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Determine the frequency domain representation of aperiodic discrete time signals.	TPS 3	70	70
CO2	Compute DFT and IDFT coefficients of a given discrete time sequence using Fast Fourier Transform algorithms	TPS 3	70	70
CO3	Design FIR and IIR filters for the given specifications using Window method and bilinear transformation & impulse invariant techniques respectively	TPS 3	70	70
CO4	Design FIR and IIR filters based on pole-zero placements in z-domain	TPS 3	70	70
CO5	Draw the implementation structure of FIR and IIR discrete time systems using block diagram and signal flow graph representation.	TPS 3	70	70
CO6	Compute statistical parameters like mean, correlation and power spectral density of a given random variable or random processes at the output of LTI system	TPS 3	70	70
CO7	Apply sampling rate conversion and multi-rate signal processing in the digital domain based on the given application.	TPS 3	70	70

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	M	L	-	S	-	-	M	M	-	-	-	M	L	-
CO2	S	M	L	-	S	-	-	M	M	-	-	-	M	L	-
CO3	S	M	L	-	S	-	-	M	M	-	-	-	M	L	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	S	-	-	M	M	-	-	-	M	L	-
CO6	S	M	L	-	S	-	-	M	M	-	-	-	M	L	-
CO7	S	M	L	-	S	-	-	M	M	-	-	-	M	L	-
Overall	S	M	L	-	S	-	-	M	M	-	-	-	M	L	-

S- Strong; M-Medium; L-Low

Assessment Pattern:

	Assessment - I			Assessment - II			Terminal Exam (%)		
	CAT – I (%)			CAT – II (%)					
TPS / CO	1	2	3	1	2	3	1	2	3
CO1	-	10	20	-	-	-	-	2	10
CO2	-	20	20	-	-	-	-	4	10
CO3	-	10	20	-	-	-	-	4	15
CO4	-	-	-	-	5	20	-	2	10
CO5	-	-	-	-	5	20	-	2	10
CO6	-	-	-	-	5	20	-	4	15
CO7	-	-	-	-	5	20	-	2	10
Total	-	**40**	**60**	**-**	**20**	**80**	**-**	**20**	**80**

Psychomotor Skill	Practical
Perception	-
Set	-
Guided Response	-
Mechanism	100
Complex Overt Responses	-
Adaptation	-
Origination	-

Syllabus

Fourier Analysis of Discrete-Time Signals: Discrete-time Fourier Transform (DTFT), Properties of DTFT, LTI discrete-time system analysis by DTFT **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. **Discrete Time Filters:** Filter specifications, LTI Systems as frequency selective filters, Design of FIR filters by Windowing, Design of Discrete-Time IIR Filters from Continuous-Time Filters, Filter Design by Impulse Invariance, Bilinear Transformation, Design of Discrete-Time Butterworth Filter, Filter design based on Pole/zero: Linear Phase filter, Averaging filters, Comb Filters, Notch Filters, Resonators. **Structures for Discrete Time Systems** Basic Structures for IIR Systems: Direct Forms, Cascade Form, Parallel Form, Basic Network Structures for FIR Systems: Direct Form, Structures for Linear-Phase FIR Systems. **Random Signal Processing:** 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, noise reduction and signal enhancement, Optimum Linear filters: Wiener filter and linear prediction. **Multirate Signal Processing:** Review of Sampling theorem, Decimation, Interpolation, Sampling rate conversion by a rational factor I/D, Quadrature Mirror Filter, Polyphase Filter Structures.

Practical:

1. Time Domain response of LTI System (Convolution, Correlation)
2. Frequency response of LTI System (DTFT, z-Transform)
3. Fourier Analysis of Signals Using the Discrete Fourier Transform (DFT, FFT)
4. FIR Filter Design using windowing and frequency sampling methods
5. IIR Filter Design: Butterworth and Chebyshev filters
6. Filter design based on Pole-zero: Average Filter, Comb, Notch, Resonators
7. Random Signal Processing: Wiener filters, Linear Prediction

8. Random Signal Processing: Noise reduction and signal enhancement filter
9. Multirate Signal Processing: Decimation, Interpolation, Sampling rate conversion by I/D
10. Real Time Signal Processing Applications: Data acquisition using ADALM 1000
11. Real Time Signal Processing Applications: Filtering using DSP processor

Text Book

- Alan V.Oppenheim, Ronald W. Schafer, "Discrete time signal processing", Prentice Hall, Third Edition, 2010.
- John G.Proakis and Dimitris G.Manolakis, "Digital Signal Processing Principles, Algorithms and Applications", Prentice-Hall of India, Fourth Edition, 2006.

Reference Books& web resources

- Buck, Daniel, Singer, "Computer Explorations in Signals and Systems Using MATLAB", Prentice Hall, 2nd Ed., 2001.
- Vinay K. Ingle, John G.Proakis, "Digital Signal Processing using MATLAB" Cengage Learning, Third Edition, 2012.
- 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.
- https://archive.nptel.ac.in/courses/117/105/117105134/

Course Contents and Lecture Schedule

No.	Topic	Lecture Hours	COs
1	**Fourier Analysis of Discrete-Time Signals**		
1.1	Discrete-time Fourier Transform (DTFT)	1	CO1
1.2	Properties of DTFT	2	CO1
1.3	LTI discrete-time system analysis by DTFT	1	CO1
2	**Discrete Fourier Transform (DFT)**		
2.1	Fourier representation of Finite duration sequences	1	CO2
2.2	Properties of DFT	2	CO2
2.3	Linear Convolution using DFT, Direct computation of the DFT	1	CO2
2.4	Decimation-in Time and Decimation in frequency FFT algorithms.	2	CO2
3	**Discrete Time Filters**		
3.1	Filter specifications, LTI Systems as frequency selective filters	1	CO3
3.2	Design of FIR filters by Windowing	1	CO3
3.3	Design of Discrete-Time IIR Filters from Continuous-Time Filters	1	CO3
3.4	Filter Design by Impulse Invariance, Bilinear Transformation,	1	CO3
3.5	Design of Discrete-Time Butterworth Filter	1	CO3
3.6	Filter design based on Pole/zero: Linear Phase filter	2	CO4
3.7	Averaging filters, Comb Filters	2	CO4
3.8	Notch Filters, Resonators	1	CO4
4	**Structures for Discrete Time Systems**		
4.1	Basic Structures for IIR Systems: Direct Forms	1	CO5
4.2	Cascade Form, Parallel Form	1	CO5
4.3	Basic Network Structures for FIR Systems:	1	CO5
4.4	Direct Form, Structures for Linear-Phase FIR Systems	1	CO5
5	**Random Signal Processing**		
5.1	Random process: definition, stationary process, mean	1	CO6
5.2	correlation and covariance functions ergodic process	1	CO6

5.3	transmission of random process through LTI systems, power spectral density	1	CO6
5.4	Gaussian process, noise, narrow band noise	2	CO6
5.5	noise reduction and signal enhancement	1	CO6
5.6	Optimum Linear filters: Wiener filter and linear prediction.	2	CO6
6	**Multirate Signal Processing**		
6.1	Review of Sampling theorem, Decimation	1	CO7
6.2	Interpolation, Sampling rate conversion by a rational factor I/D	1	CO7
6.3	Quadrature Mirror Filter	1	CO7
6.4	Polyphase Filter Structures	1	CO7
	Total Hours	**36**	
Practical Sessions			
1	Time Domain response of LTI System (Convolution, Correlation)	2	CO1
2	Frequency response of LTI System (DTFT, z-Transform)	2	CO1
3	Fourier Analysis of Signals Using the Discrete Fourier Transform (DFT, FFT)	2	CO2
4	FIR Filter Design using windowing and frequency sampling methods	2	CO3
5	IIR Filter Design: Butterworth and Chebyshev filters	2	CO3
6	Filter design based on Pole-zero: Average Filter, Comb, Notch, Resonators	2	CO4
7	Random Signal Processing: Wiener filters, Linear Prediction	2	CO6
8	Random Signal Processing: Noise reduction and signal enhancement filter	2	CO6
9	Multirate Signal Processing: Decimation, Interpolation, Sampling rate conversion by I/D	2	CO7
10	Real Time Signal Processing Applications: Data acquisition using ADALM 1000	2	CO7
11	Real Time Signal Processing Applications: Filtering using DSP processor	4	CO7
	Total Hours	**24**	

Course Designers:

1. Dr.S.J.Thiruvengadam sjtece@tce.edu
2. Dr.M.N.Suresh mnsece@tce.edu
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22EC460	DATA SCIENCE

Category	L	T	P	Credit
ESC	2	0	0	2

Preamble

Data science is an interdisciplinary field that draws on skills from mathematics, computer science, and statistics. This course will enable students to learn the fundamental concepts circumventing data science, and its applications.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the taxonomy of Data	TPS 2	70	70
CO2	Explore the current practices in Data Analytics	TPS 2	70	70
CO3	Identify the key roles for the Data Ecosystem	TPS 2	70	70
CO4	Identify the Key roles for a successful analytics project	TPS 2	70	70
CO5	Apply the Data Analytics Life Cycle components to data science projects.	TPS 3	70	70
CO6	Apply data preparation and modelling techniques to data science related problem specifications.	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO3	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO4	M	L	L	-	-	-	-	-	-	-		-	L		-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II								
	CAT – I (%)			Ass. I * (%)			CAT – II (%)			Ass. II * (%)			Terminal Exam (%)		
TPS / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	5	20			100		-	-	-		-		4	5	-
CO2	10	25					-	-	-		-		4	5	-
CO3	15	25					-	-	-		-		4	5	-
CO4	-	-	-				10	10			100		4	5	-
CO5	-	-	-		-		5	10	20				2	5	20
CO6	-	-	-		-		5	10	30				2	5	30
Total	**30**	**70**	**-**		**100**		**20**	**30**	**50**		**100**		**20**	**30**	**50**

Syllabus

Taxonomy of Data: Basics of Data Structures **-** Overview of Big Data –Introduction to analytics - Data Repositories. **Data Analytics**- Overview - Analytics in a Data Science Project - Key roles for a successful analytics project. **Data Analytics Life Cycle (DALC) –** Overview- Different phases in a DALC**. Phase I Discovery**- Learning the Business Domain, Resources, Framing the Problem, identifying key stakeholders, Interviewing the Analytics Sponsor, Developing initial hypotheses, Identifying potential data Sources. **Phase II-Data Preparation**-Preparing the analytic Sandbox, Performing ETLT, Learning about the data, Data conditioning, Survey and Visualize data using common tools for the Data Visualization Phase. **Phase III-Model Planning-** Data exploration and variable selection, Model selection, Common tools for the model planning phase. **Phase IV-Model Building**- Common tools for the model building phase, **Phase V-Communicate Results, Phase VI-Operationalize.**

Reference Books

- Data Science & Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data. Wiley., Dietrich, D., Heller, B., & Yang, B, Wiley, First Edition, 2015. (Chapters 1.0, 1.1, 1.2, 2.0, 2.1 - 2.7)
- Big Data: A Beginner's Guide to Using Data Science for Business, Eliot P. Reznor, CreateSpace Independent Publishing Platform, 2017.
- Data Analytics: A Practical Guide to Data Analytics for Business, Beginner to Expert, Fahl, J, CreateSpace Independent Publishing Platform, 2017.

Course Contents and Lecture Schedule

Module No.	Topic	Lecture Hours
1	**Taxonomy of Data**	
1.1	Basics of Data Structures	1
1.2	Overview of Big Data	1
1.3	Introduction to analytics	1
1.4	Data Repositories	1
2	**Data Analytics**	
2.1	Overview	1
2.2	Analytics in a Data Science Project	1
2.3	Key roles for a successful analytics project	1
3	**Data Analytics Life Cycle (DALC)**	
3.1	Overview	1
3.2	Different phases in a DALC	1
4	**Phase I Discovery**	1
4.1	Resources, Framing the Problem	1
4.2	Identifying key stakeholders	1
4.3	Interviewing the Analytics Sponsor	1
4.4	Developing initial hypotheses	1
4.5	Identifying potential data Sources	1
5	**Phase II-Data Preparation**	
5.1	Preparing the analytic Sandbox	1
5.2	Performing ETLT	1
5.3	Learning about the data, Data conditioning	1
5.4	Survey and Visualize data using common tools for the Data Visualization Phase.	1
6	**Phase III-Model Planning**	
6.1	Data exploration and variable selection	1
6.2	Model selection	1
6.3	Common tools for the model planning phase	1
7	**Phase IV-Model Building**	1
8	**Phase V-Communicate Results**	1
9	**Phase VI-Operationalize**	1
	Total	**25**

Course Designers:

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22CHAB0	CONSTITUTION OF INDIA

Category	L	T	P	Credit
AC	2	0	0	0

Preamble

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 but also strengthened the same through progressive interpretations of the text 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

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	L	-	-	-	M	-	M	-	L	-	-
CO2	M	L	-	-	-	M	-	M	-	L	-	-
CO3	M	L	-	-	-	M	-	M	-	L	-	-
CO4	M	L	-	-	-	M	-	M	-	L	-	-
CO5	M	L	-	-	-	M	-	M	-	L	-	-
CO6	M	L	-	-	-	M	-	M	-	L	-	-

S- Strong; M-Medium; L-Low

Syllabus

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

Assessment Pattern

Bloom's category	Continuous Assessment Tests		Seminar
	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/my-government/constitution-india

Course Designers:

1. Adapted from AICTE Model Curriculum for Undergraduate Degree Courses in Engineering & Technology, Volume-II, January 2018.

CURRICULUM AND DETAILED SYLLABI

FOR

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

FIFTH SEMESTER

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution Affiliated to Anna University)
MADURAI – 625 015, TAMILNADU

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22EC510	DATA COMMUNICATION NETWORKS

Category	L	T	P	Credit
ESC	3	0	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, 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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Build a reliable data networks using LAN technologies such as ETHERNET, WLAN and WPAN	TPS 3	70	70
CO2	Apply the distributed and centralized routing protocols for the networks	TPS 3	70	70
CO3	Apply internetworking techniques to configure subnetting.	TPS 3	70	70
CO4	Analyze the concepts of reliable data transfer and congestion control of TCP and Application layer	TPS 4	70	65
CO5	Analyze the performance parameters such as delay, throughput of a network and QoS parameters.	TPS 4	70	65
CO6	Apply cryptographic algorithms and security mechanisms for secured networks.	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L
CO2	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L
CO3	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L
CO4	S	S	M	L	-	-	-	L	M	M	-	L	S	L	L
CO5	S	S	M	L	-	-	-	L	M	M	-	L	S	L	L
CO6	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I							Assessment - II							Terminal Exam(%)		
	CAT – I(%)			**Assg. I ***(%)				**CAT – II**(%)			**Assg. II ***(%)						
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**1**	**2**	**3**	**4**	**1**	**2**	**3**
CO1	-	10	20					-							-	4	10
CO2	-	10	20	100				-							-	4	15
CO3	-	10	30					-							-	4	15
CO4	-							-	10	20					-	-	15
CO5	-							-	10	30	100				-	4	15
CO6	-							-	10	20					-	4	10
Total	**-**	**30**	**70**	**100**				**-**	**30**	**70**	**100**				**-**	**20**	**80**

Syllabus

Fundamentals & Link Layer: Network requirements, OSI and Internet reference models, Packet and Circuit Switching, Data Link layer Services – Framing - Error Detection – Parity check, CRC, Reliable Flow control – Stop and wait ARQ and Sliding window ARQ. **Media Access & Inter Networking**: Media access control - CSMA/CD-802.3 Ethernet Physical Properties, Encoding - Wireless LANs – CSMA/CA-802.11, Spread Spectrum techniques and Distribution systems, WPAN – Bluetooth, Zigbee, Internetworking – Ipv4, Datagram Fragmentation, IPv6, sub-netting - Classfull, CIDR, other network layer protocols – ARP, ICMP, DHCP. **Routing**: Interior Routing protocols – RIP (Bellman-Ford), OSPF (Dijkstra's), routing metrics, Exterior routing protocols - BGP, Generalized forwarding and SDN-OpenFlow protocol. **Transport Layer &**: **Application Layer** Overview of Transport layer – UDP, Reliable byte stream (TCP) - Connection management - TCP State transition diagram, Congestion control techniques. Application layer protocols - SMTP, FTP, DNS and HTTP. **Network Performance**: Delay, Packet Loss and Throughput, Bandwidth and two-way Latency (RTT), High speed networks, Application performance needs. **Quality Of Service**: Application Requirements – Differentiated services and Integrated Services – Resource Reservation Protocol (RSVP), Expedited Forwarding- per Hop Behaviour (EF-PHB) **Network Security**: Security services and mechanisms, Cryptography Techniques– DES and RSA.

Text Book

- Larry L. Peterson, Bruce S. Davie, “Computer Networks: A Systems Approach”, Sixth Edition, Morgan Kaufmann Publishers, 2021.

Reference Books

- James F. Kurose, Keith W. Ross, “Computer Networking – A Top-Down Approach Featuring the Internet”, Fifth Edition, Pearson Education, 2009.
- Nader. F. Mir, “Computer and Communication Networks”, Prentice Hall Publishers, 2010.
- Web Page http://www.cse.iitd.ernet.in/~vinay/courses/CSL858.html
- NPTEL Video Lecture on “Computer Networks”, weblink: https://onlinecourses.nptel.ac.in/noc19_ee11/course

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**Introduction to the Course, COs POs**	1
	Fundamentals & Link Layer	
2	Network requirements, OSI and Internet reference models	1
3	Packet and Circuit Switching	1
4	Data Link layer Services - Framing	1
5	Error Detection – Parity check, CRC	1
6	Reliable Flow controls - Stop and wait ARQ	1
7	Sliding window ARQ	1

	Media access & inter networking	
8	Media access control, CSMA/CD-802.3 Ethernet Physical Properties, Encoding	2
9	Wireless LANs - CSMA/CA-802.11, Spread Spectrum techniques and Distribution systems	2
10	WPAN – Bluetooth, Zigbee,	1
11	Internetworking – Ipv4, Datagram Fragmentation	1
12	IPv6, subnetting	1
13	Classfull, CIDR, other network layer protocols – ARP, ICMP, DHCP.	2
	Routing	
14	Interior Routing protocols – RIP (Bellman-Ford),	1
15	OSPF(Dijkstra's), routing metrics	1
16	Exterior routing protocols - BGP, Generalized forwarding	1
17	SDN- OpenFlow	1
	Transport Layer & Application Layer	
18	Overview of Transport layer	1
19	UDP, Reliable byte stream (TCP) - Connection management	1
20	TCP State transition diagram, Congestion control techniques	2
21	SMTP,FTP,DNS and HTTP	2
	Network Performance	
22	Throughput, Bandwidth and Latency	1
23	High speed networks, Application performance needs	2
	Quality of Service	
24	Application Requirements – Differentiated services and Integrated Services	1
25	Resource Reservation Protocol (RSVP), Expedited Forwarding- per Hop Behaviour (EF-PHB	2
	Network Security	
26	Security services and mechanisms	1
27	Cryptography Techniques– DES	2
28	RSA	1
	TOTAL	**36**

Course Designers:

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22EC520	VLSI CIRCUITS AND SYSTEMS

Category	L	T	P	Credit
PCC	3	0	0	3

Preamble

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

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Construct CMOS logic circuits and Layouts	TPS3	70	60
CO2	Understand VLSI design flow and fabrication of CMOS Integrated circuits	TPS2	70	60
CO3	Examine the electrical characteristics of CMOS logic circuits.	TPS3	70	60
CO4	Examine the electronic aspects of CMOS logic circuits.	TPS4	70	60
CO5	Combinational Circuit Design using Advanced CMOS logic design techniques	TPS3	70	60
CO6	Construct CMOS VLSI system components	TPS3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	M	L	L	-	-	-	-	-	-	-	M	-	-
CO2	M	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	M	L	L	-	-	-	-	-	-	-	M	-	-
CO4	S	S	M	L	L	-	-	-	-	-	-	-	S	-	-
CO5	S	M	M	M	L	-	-	-	-	-	-	-	M	-	-
CO6	S	M	M	M	L	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**						**Terminal Exam** (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)					
CO / **TPS Scale**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	30				-						-	4	10
CO2	-	20			100		-						-	8	-
CO3	-	10	30				-						-	4	20
CO4	-						-	10	20				-	2	20
CO5	-						-	10	30		100		-	2	15
CO6	-						-	10	20				-	-	15
Total	**-**	**40**	**60**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

CMOS Logic and Layout Design: CMOS Logic and Layout Design: MOSFETs as Switches, Logic Gates and their static CMOS implementation, Transmission Gate Circuits, FET sizing, Stick Diagram and Layout Design Rules.

Fabrication of CMOS Integrated Circuits: VLSI Design Flow, Integrated Circuit Fabrication Process: Oxidation, Diffusion, Ion Implantation, Photolithography and Twin-tub CMOS Process, Trends in CMOS Technology.

Electrical Characteristics of CMOS Logic: MOS Threshold Voltage Equation, nFET Current-Voltage Equations, The FET RC Model.

Electronics Analysis of CMOS Logic: Switching Characteristics, DC Characteristics of CMOS Inverter Logical Effort, Analysis of Complex Logic Gates, Power Dissipation, Interconnect Delay Model, Crosstalk and Interconnect Scaling.

Advanced CMOS Logic Circuits: Mirror Circuits, Pseudo- nMOS, Tri-state Circuits, locked CMOS, Dynamic CMOS and Dual Rail Logic Networks.

CMOS VLSI System Components: Multiplexors, Binary Decoders, Priority Encoders, Latches, D-Flip Flop, Registers, Full Adder, Binary Multiplier, SRAM, DRAM and Logic Arrays, Switch level Modelling (Verilog HDL)

Text Book

- Uyemura, John P," Introduction to VLSI Circuits and Systems". Wiley & Sons, 8th Reprint 2015.

Reference book & web resources

- N. Weste and David Harris," CMOS VLSI Design: A circuits and systems perspective" 4th Edition, Pearson, 2022.
- N. Weste and K. Eshraghian, "Principles of CMOS VLSI Design", Second Edition, Addison-Wesley, 1993.
- Jan M. Rabaey, "Digital Integrated Circuits: A Design Perspective", Prentice Hall, Second Edition, 2006.
- R. Jacob Baker, "CMOS: Circuit Design, Layout, and Simulation", Wiley-IEEE, Revised Second Edition, 2008.
- Wayne Wolf, "Modern VLSI Design: System on Chip", Pearson Education, 2002.
- MIT Open courseware: http://ocw.mit.edu/courses/electrical-engineering-andcomputer-science/6-374-analysis-and-design-of-digital-integrated-circuits/.
- By Prof. Sudeb Dasgupta, IIT Roorkee, CMOS Digital VLSI Design https://onlinecourses.nptel.ac.in/noc22_ee08/
- Dr.Nandita Dasgupta, VLSI Design, NPTEL Video Lectures: http://www.nptelvideos.in/2012/12/vlsi-design.html

Course Contents and Lecture Schedule

No.	Topic	Lecture Hours	COs
1	**CMOS Logic and Layout Design**		
1	Introduction	1	
1.1	MOSFETs as Switches	1	CO1
1.2	Logic Gates and their static CMOS implementation	1	CO1
1.3	Transmission Gate Circuits	2	CO1
1.4	FET sizing	1	CO1
1.5	Stick Diagram and Layout Design Rules	2	CO1
2	**Fabrication of CMOS Integrated Circuits:**		
2.1	VLSI Design Flow	1	CO2
2.2	Integrated Circuit Fabrication Process	0.5	CO2
2.3	Oxidation	0.5	CO2
2.4	Diffusion	0.5	CO2

2.5	Ion Implantation	0.5	CO2
2.6	Photolithography and Twin-tub CMOS Process	0.5	CO2
2.7	Trends in CMOS Technology	0.5	CO2
3	**Electrical Characteristics of CMOS Logic**.		
3.1	MOS Threshold Voltage Equation	2	CO3
3.2	nFET Current-Voltage Equations	2	CO3
3.3	The FET RC Model	2	CO3
4	**Electronic Analysis of CMOS Logic**		
4.1	Switching Characteristics	2	CO4
4.2	DC Characteristics of CMOS Inverter	1	CO4
4.3	Logical Effort	1	CO4
4.4	Analysis of Complex Logic Gates	1	CO4
4.5	Power Dissipation	1	CO4
4.6	Interconnect Delay Model	1	CO4
4.7	Crosstalk and Interconnect Scaling	1	CO4
5	**Advanced CMOS Logic Circuits**		
5.1	Mirror Circuits, Pseudo- nMOS,	2	CO5
5.2	Tri-state Circuits, locked CMOS	1	CO5
5.3	Dynamic CMOS	1	CO5
5.4	Dual Rail Logic Networks	1	CO5
6	**CMOS VLSI System Components:**		
6.1	Multiplexors, Binary Decoders, Priority Encoders,	1	CO6
6.2	Latches, D-Flip Flop, Registers	1	CO6
6.3	Full Adder, Binary Multiplier,	1	CO6
6.4	SRAM, DRAM and Logic Arrays,	1	CO6
6.5	Switch level Modelling (Verilog HDL)	1	CO6

Course Designers:

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22EC530	ANTENNAS AND WAVE PROPAGATION	Category	L	T	P	Credit	TE
		PCC	2	0	2	3	Theory

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. The objective of this course is to provide an in-depth understanding of modern antenna concepts, and practical antenna design for various applications. The course also focuses practical approach to simulate, prototype antennas for a given wireless specification and measure various antenna parameters.

Prerequisite

NIL

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the role of antenna in real world applications and study the antenna parameters.	TPS2	70	70
CO2	Understand the concepts of wire, loop, aperture antennas.	TPS2	70	70
CO3	Understand array concept and design antenna arrays for wireless applications	TPS3	70	70
CO4	Understand the radiation mechanism and design Horn, reflector, Helical antennas	TPS3	70	70
CO5	Design and develop Microstrip, Planar inverted F antenna and multiband antennas for cellular applications	TPS3	70	70
CO6	Measure the antenna parameters and Explain the process of radio wave propagation in the atmosphere	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO2
CO1	M	L	L	-	-	-	-	-	M	-	-	M	L	-	M
CO2	M	M	L	-	-	-	-	-	M	-	-	M	L	-	M
CO3	S	M	M	L	S	M	M	L	M	M	M	M	M	M	M
CO4	S	M	M	L	S	M	M	L	M	M	M	M	M	M	M
CO5	S	M	M	L	S	L	L	L	M	M	M	M	M	M	M
CO6	M	L	L	-	-	L	L	L	M	-	-	M	L	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I			Assessment - II			Terminal Exam (%) (Theory)		
	CAT – I (%)			CAT – II (%)					
TPS / CO	1	2	3	1	2	3	1	2	3
CO1	-	20	-	-	-	-	-	15	-
CO2	-	20	20	-	-	-	-	15	-
CO3	-	20	20	-	-	-	-	15	-
CO4	-	-	-	-	20	20	-	-	20
CO5	-	-	-	-	20	20	-	-	20
CO6	-	-	-	-	20	-	-	15	-
Total	-	**60**	**40**	**-**	**60**	**40**	**-**	**60**	**40**

Syllabus

Theory:

Fundamental Concepts of Antenna: Antenna in real world applications-Cellular, Satellite, and RADAR. Radiation mechanism, Antenna parameters- Radiated power, radiation pattern, Beamwidth, Power intensity, Directivity, Gain, Effective aperture, Impedance bandwidth, VSWR polarization- Field regions. Friss transmission equation.

Radiation from Wires, Loops and aperture: Infinitesimal dipole-small dipole, finite length dipole, Half wavelength dipole, Wire antennas: Folded dipole, loop antenna, Aperture antennas, Huygens principle.

Antenna Arrays: Isotropic Broadside and End fire array, Pattern multiplication, N element array, Phased array, Cellular applications, Yagi-Uda, Log periodic array, FSS, IRS.

Horn, Reflector and Circularly polarized Antennas: Radiation from Horn, Reflector antennas, Principle of circular polarization, Helical, Spiral antennas.

Planar Antennas: Microstrip patch- Basic characteristics, design, feeding methods, MPA tuning for bandwidth and polarization, Planar Inverted F antenna -Principle, design, Multiband antennas for typical wireless applications.

Antenna Measurements and Wave propagation: Radiation pattern and Gain measurements, Radomes, Anechoic chamber, Mode of propagation in different environment (Ground wave, sky wave and tropospheric wave propagation, Characteristics and Parameters, Cellular link calculations.

Practical:

1. Design and testing of wire antennas (monopole, dipole and loop)- FM reception
2. EM Field strength measurement in college campus - WiFi, Cellular band.
3. Radiation pattern testing of Wire, printed Yagi-Uda antenna–VHF/UHF, ISM reception
4. Design and simulation Patch antenna and array - ISM, X band application
5. Design and simulation of PIFA for cellular application
6. Design and simulation antennas for GPS application
7. Antenna Gain measurement- X band Horn and S band printed antennas
8. Antenna measurements with Spectrum and Network analysers

Text Book

- C. A. Balanis, "Antenna Theory and Design", 4th Ed., John Wiley & Sons., 2016.
- F.E.Terman, “Electronic and Radio Engineering”, Mc Graw Hill, 1985.

Reference Books& web resources

- W. L. Stutzman, and G. A. Thiele, "Antenna Theory and Design", 2nd Ed., John Wiley & Sons., 1998.
- John D.Kraus, ”Antennas for all Applications”, Tata McGraw Hill ,2002

- NPTEL Course Antenna and wave propagation: https://nptel.ac.in/courses/ 108101092/
- WWW.amanogawa.con
- www, orbanmicrowave.com
- Course handouts prepared by RF Special interest Group, TCE

Course Contents and Lecture Schedule

Module No.	Topic	Lecture Hours
1	**Fundamental Concepts of Antenna**	
1.1	Antenna in real world applications-Cellular, Satellite, and RADAR.	1
1.2	Radiation mechanism ,Antenna parameters- Radiated power, radiation pattern, Beamwidth, Power intensity, Directivity, Gain	2
1.3	Effective aperture, Impedance bandwidth, VSWR polarization-Field regions. Friss transmission equation.	2
2	**Radiation from Wires, Loops and aperture:**	
2.1	Infinitesimal dipole-small dipole, finite length dipole, Half wavelength dipole	2
2.2	Wire antennas: Folded dipole, loop antenna, Aperture antennas, Huygens principle.	2
3	**Antenna Arrays:**	
3.1	Isotropic Broadside and End fire array, Pattern multiplication, N element array	2
3.2	Phased array, Cellular applications, Yagi-Uda, Log periodic array, FSS, IRS.	2
4	**Horn, Reflector and Circularly polarized Antennas:**	
4.1	Radiation from Horn, Reflector antennas	2
4.2	Principle of circular polarization, Helical, Spiral antennas.	2
5	**Planar Antennas:**	
5.1	Microstrip patch- Basic characteristics, design, feeding methods, MPA tuning for bandwidth and polarization	2
5.2	Planar Inverted F antenna -Principle, design, Multiband antennas for typical wireless applications.	2
6	**Antenna Measurements and Wave propagation**:	
6.1	Radiation pattern and Gain measurements, Radomes, Anechoic chamber	1
6.2	Mode of propagation in different environment (Ground wave, sky wave and tropospheric wave propagation, Characteristics and Parameters, Cellular link calculations.	2
	Theory	**24**
	Practical	**24**
	Total	**48**

Course Designers:

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- Dr.K.Vasudevan, kvasudevan@tce.edu

22EC540	SENSORS AND INSTRUMENTATION

Category	L	T	P	Credit
BSC	2	0	0	2

Preamble

This syllabus offers a concise yet comprehensive exploration of sensors and instrumentation, essential for understanding and utilizing measurement technologies. Students will delve into sensor principles, classification, and characteristics, including calibration standards. The diverse array of sensor types, interface circuits, and shielding techniques will be covered, preparing students to design and implement precise measurement systems. Through practical applications and theoretical understanding, students will gain the knowledge and skills to innovate in fields ranging from industrial automation to biomedical engineering.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand sensors and transducers, including classification, measurement units, calibration, and standards.	TPS 2	70	60
CO2	Identify and describe various sensor types, from position to specialized sensors for environmental and physiological signals.	TPS 2	70	60
CO3	Design interface circuits like amplifiers and converters to ensure accurate signal processing from sensors.	TPS 3	70	60
CO4	Apply techniques to reduce electromagnetic interference and ensure signal integrity in sensor applications.	TPS 3	70	60
CO5	Understand how to effectively use data acquisition systems and virtual instruments in practical situations to achieve specific objectives.	TPS 2	70	60
CO6	Apply the integration of sensors and electronic circuits to design accurate measurement systems suitable for various applications.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	L	L	L	-	-	L	M	M	-	-	L	L	L
CO2	M	M	L	L	L	-	-	L	M	M	-	-	L	L	L
CO3	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	-	-	-	L	M	M	-	L	M	-	L
CO5	M	M	L	L	-	-	-	L	M	M	-	L	L	-	L
CO6	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)					
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	35	-				-						-	15	
CO2	-	35	-		100		-						-	15	
CO3	-	-	30				-						-		15
CO4	-						-	15	20				-	5	15
CO5	-						-	30			100		-	15	
CO6	-						-	15	20				-	5	15
Total	-	**70**	**30**		**100**		**-**	**60**	**40**		**100**		**-**	**55**	**45**

Syllabus

Sensor and Transducer: Introduction, Sensor Classification, Units of Measurements. Sensor Characteristics: Transfer Function, specifications. Transducer Classification and Characteristics. Calibration and Standards.

Sensor Types: Position, Displacement, Level, Velocity and Acceleration, Force, Strain, Tactile Sensors, Humidity and Moisture Sensors, Temperature Sensors, Pressure Sensors, and Sensors for EEG and ECG signals.

Interface Electronic Circuits: Input Characteristics, Amplifiers: Instrumentation Amplifier, Charge Amplifiers, Light-to-Voltage Converters, V/F Converters, and Capacitance-to-Voltage Converters. Bridge Circuits, Kelvin Four-Wire and Six-wire Sensing.

Electromagnetic Interference and Shielding: Inherent Noise, Mechanical Noise, See beck Noise, Electric Shielding, Magnetic Shielding, Bypass Capacitors, Ground Planes, Ground Loops, and Ground Isolation.

Instruments: Data Acquisition System, Virtual Instruments, Bio-Medical, and Smart Sensors.

Text Book

- Jacob Fraden, "Handbook of Modern Sensors Physics, Designs, and Applications" Fourth Edition, Springer, 2010, Reprint 2014.
- D. V. S. MURTY, "Transducers and Instrumentation", Prentice Hall India Pvt., Limited, 2004, Reprint 2010.
- R.S. Khandpur, Handbook of Biomedical Instrumentation, 3rd Edition, Mc Graw Hill, 2014.

Reference Books

- Albert D. Helfrick and William D. Cooper "Modern Electronic Instrumentation and Measurement Techniques" Pearson, 2016.
- 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.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Sensor and Transducer	
1	Introduction, Sensor Classification, Units of Measurements.	1
2	Sensor Characteristics: Transfer Function, specifications.	1
3	Transducer Classification and Characteristics. Calibration and Standards.	1
	Sensor Types	
4	Position, Displacement, Level, Velocity and Acceleration	2
5	Force, Strain, Tactile Sensors,	1
6	Humidity and Moisture Sensors,	1
7	Temperature Sensors, Pressure Sensors,	1
8	Sensors for EEG and ECG signals.	1
	Interface Electronic Circuits	
9	Input Characteristics, Amplifiers: Instrumentation Amplifier, Charge Amplifiers	1
10	Light-to-Voltage Converters, V/F Converters,	1
11	Capacitance-to-Voltage Converters.	1
12	Bridge Circuits, Kelvin Four-Wire and Six-wire Sensing.	2
	Electromagnetic Interference and Shielding	
13	Inherent Noise, Mechanical Noise, See beck Noise,	2
14	Electric Shielding, Magnetic Shielding,	2
15	Bypass Capacitors, Ground Planes, Ground Loops, and Ground Isolation.	2
	Instruments	
16	Data Acquisition System, Virtual Instruments,	2
17	Bio-Medical, and Smart Sensors.	2
	TOTAL	**24**

Course Designers:

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22EC550	ANALOG AND DIGITAL COMMUNICATION

Category	L	T	P	Credit
PCC	2	1	0	3

Preamble

The course “22EC550: 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

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Examine the analog modulation methods in time and frequency domains to understand their characteristics and performance attributes.	TPS 3	70	70
CO2	Analyze the performance of analog modulation schemes in the presence of additive white Gaussian noise.	TPS 4	70	70
CO3	Describe the principle of pulse modulation techniques namely PAM, PPM PCM, DPCM and DM	TPS 3	70	70
CO4	Apply estimation and detection theory for the development of digital communication transmitters and receivers for various digital modulation schemes and analyze their BER performances	TPS 3	70	70
CO5	Apply synchronization techniques to mitigate issues such as timing offset and frequency offset.	TPS 3	70	70
CO6	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	TPS 3	70	70
CO7	Detect and correct the errors introduced in the channel using error control coding schemes	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	L	L	L	-	L	M	L	L
CO2	S	S	M	L	-	-	-	L	L	L	-	L	S	L	L
CO3	S	M	L	-	-	-	-	L	L	L	-	L	M	L	L
CO4	S	M	L	-	-	-	-	L	L	L	-	L	M	L	L
CO5	S	M	L	-	-	-	-	L	L	L	-	L	M	L	L
CO6	S	M	L	-	-	-	-	L	L	L	-	L	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)					
CO \ **TPS Scale**	**2**	**3**	**4**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**2**	**3**	**4**
CO1	10	20			100		-	-	-		-		4	10	
CO2	10	10	20				-	-	-		-		4	-	15
CO3	10	20					-	-	-		-		2	10	
CO4	-	-			-		-	05	20		100		2	15	
CO5	-	-			-		-	05	20				2	10	
CO6	-	-			-		-	05	20				2	10	
CO7	-	-			-			05	20				4	10	
Total	**30**	**50**	**20**		**100**		**-**	**20**	**80**		**100**		**20**	**65**	**15**

Syllabus

Analog Communication Systems: Amplitude Modulation, Double Side Band Suppressed Carrier Modulation, Single side band Modulation, Vestigial Side band Modulation, Angle Modulation Systems: Narrow band and wideband FM, Generation and demodulation of FM waves, Phase Modulation systems, Noise Analysis on analog communication systems.

Analog to Digital Transition Systems: Pulse Amplitude Modulation, Pulse Position Modulation, Pulse Code Modulation, DPCM, Delta Modulation. **Digital Modulation:** Complex baseband representation, Spectral description of random processes: Pulse Shaping, Modulation degrees of freedom, Linear modulation, Orthogonal & biorthogonal modulation, Differential modulation. **Digital Demodulation:** Hypothesis testing, Signal space concepts, Optimal reception in AWGN, Performance analysis of ML reception. **Synchronization and non-coherent communication:** Receiver design requirements, Parameter estimation for synchronization, Non-coherent communication, Performance of non-coherent communication. **Information Theory:** Entropy, Mutual Information, Capacity of AWGN channel, Shannon theory basics, Capacity for standard constellations. **Channel Coding:** Binary convolutional codes, Turbo Codes, Low density parity check codes.

Text Book

- Simon Haykin, "Communication Systems", Wiley Student Edition, 4 Edition - 2006
- Upamanyu Madhow, "Fundamentals of Digital Communication", Cambridge University Press 2008, First Edition – 2008
- Bernard Sklar, "Digital Communications: Fundamentals and Applications", Prentice Hall; 2nd edition – 2017.

Reference Books

- John G. Proakis, Masoud Salehi, "Communication System Engineering", Prentice Hall, 2nd Edition, - 2002.
- Simon Haykin, "Digital Communications", Wiley India, - 2017 4th Edition.
- https://nptel.ac.in/courses/117105144.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Analog Communication Systems:	
1	Amplitude Modulation, Double Side Band Suppressed Carrier Modulation,	1
2	Vestigial Side band Modulation, Single side band Modulation	1
3	Angle Modulation Systems: Narrow band and wideband FM,	2
4	Generation and demodulation of FM waves	1
5	Phase Modulation systems	1
6	Noise Analysis on analog communication systems	2
	Analog to Digital Transition Systems	

7	Pulse Amplitude Modulation, Pulse Position Modulation,	1
8	Pulse Code Modulation, DPCM	2
9	Delta Modulation	1
	Digital Modulation	
10	Complex baseband representation, Spectral description of random processes	1
11	Pulse Shaping, Modulation degrees of freedom	2
12	Linear modulation, Orthogonal & biorthogonal modulation	1
13	Differential modulation	1
	Digital Demodulation	
14	Hypothesis testing	1
15	Signal space concepts	1
16	Optimal reception in AWGN	2
17	Performance analysis of ML reception	1
	Synchronization and non-coherent communication	
18	Receiver design requirements	1
19	Parameter estimation for synchronization	1
20	Non-coherent communication	2
21	Performance of non-coherent communication	2
	Information Theory	
22	Entropy, Mutual Information	1
23	Capacity of AWGN channel	1
24	Shannon theory basics	1
25	Capacity for standard constellations	1
	Channel Coding	
26	Binary convolutional codes	1
27	Turbo Codes	1
28	Low density parity check codes	2
	TOTAL	**36**

Course Designers:

- Dr.S.J.Thiruvengadam sjtece@tce.edu
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- Dr.P.G.S.Velmurugan pgsvels@tce.edu

22EC570	DATA COMMUNICATION NETWORKING LABORATORY

Category	L	T	P	Credit
ESC	0	0	2	1

Preamble

The goal of this course is to supplement the theory course '22EC510 Data Communication Networks' by giving hands on practice on structured network cabling, router configuration, socket programming and the implementation of communication protocols.

Prerequisite

Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficien -cy Scale	Expecte d Proficien -cy in %	Expected Attainmen -t Level %
CO1	Use network utility commands to explore the communication network	TPS3	80	80
CO2	Demonstrate structured cabling concepts using Straight through, Cross over and Rollover cables	TPS3	80	80
CO3	Use the routing algorithms and configure routers using Packet Tracer/e-Sim CISCO simulator	TPS3	80	80
CO4	Analyze the network performance using packet sniffer tools – NETMON /Wireshark	TPS4	80	75
CO5	Apply Socket Programming to build/configure network applications	TPS3	80	80
CO6	Analyze the performance of MAC and routing protocols using network simulator	TPS4	80	75

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O2
CO1	S	M	L	-	S	-	-	M	M	M	-	M	M	M	L
CO2	S	M	L	-	S	-	-	M	M	M	-	M	M	M	L
CO3	S	M	L	-	S	-	-	M	M	M	-	M	M	M	L
CO4	S	S	M	L	S	-	-	M	M	M	-	M	S	M	L
CO5	S	M	L	-	S	-	-	M	M	M	-	M	M	M	L
CO6	S	S	M	L	S	-	-	M	M	M	-	M	S	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Model Exam (%)			**Terminal Exam (%)**		
TPS / CO	**2**	**3**	**4**	**2**	**3**	**4**
CO1	-	10	-	-	10	-
CO2	-	10	-	-	10	-
CO3	-	10	-	-	10	-
CO4	-	10	20	-	10	20
CO5	-	10	-	-	10	-
CO6	-	10	20	-	10	20
Total	**-**	**60**	**40**	**-**	**60**	**40**

Experiment List

1. Explore the network utility commands such as IPCONFIG, NSLOOKUP, PING, TRACERT, NETSTAT, and ARP.
2. Implement Structured cabling concepts for TIA/EIA-358B standard to connect different network components using the following types:
   a. Straight through cable
   b. Cross over cable
   c. Roll over cable
3. Develop program to find the following:
   a. IP address and host name of local host
   b. IP address of the given host
   c. compare the given IP address and host name
4. Implement port scanning program
   a. Ito find the open ports of local host
   b. Scan the range of server ports at the client
5. Implement routing concepts
   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-connected subnets using IOS modes and commands
   c. to find routing table, trace path between devices and verify the connectivity
6. Use Protocol Analyzer/ Sniffing Tools - Wireshark/ NETMON to capturing network data traffic
   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 protocols
   a. Time Server
   b. Chat Server
   c. File Server
8. Analyze the network performance of the given network using network simulator package - NetSim
   a. to find the latency and throughput of MAC protocols
   b. to find the packet delivery ratio and throughput of routing protocols
9. Develop IoT based mini projects / prototype development for remote process control applications.

Text Book

- Larry L. Peterson, Bruce S. Davie, “Computer Networks: A Systems Approach”, Sixth Edition, Morgan Kaufmann Publishers, 2021.
- James F. Kurose, Keith W. Ross, “Computer Networking – A Top-Down Approach Featuring the Internet”, Fifth Edition, Pearson Education, 2009.
- Virtual Lab of IIT Kharagpur, Weblink: http://vlabs.iitkgp.ernet.in/ant/
- Lab Manual in LMS, Weblink https://murugavalli.gnomio.com/

Course Designers:

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22EC580	ANALOG AND DIGITAL COMMUNICATION LABORATORY

Category	L	T	P	Credit
PCC	0	0	2	1

Preamble

This course is offered in the fifth semester in concurrent with the theory course 22EC550 - 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. Students can easily design, simulate, and analyze models of analog and digital communication systems using the open-source GNU Radio software.

Prerequisite

NIL

Course Outcomes

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

CO	Course Outcome	TCE Proficien-cy Scale	Expected Proficien-cy in %	Expected Attainmen-t Level %
CO1	Design and implement up and down conversion techniques using GNU Radio for analog communication systems namely AM, DSB-SC, SSB, and narrowband and wideband FM signals.	TPS4	80	75
CO2	Design and implement various modulation techniques including ASK, PSK, FSK, and QAM using GNU Radio, demonstrating proficiency in signal generation, modulation, and spectral analysis for digital communication systems.	TPS4	80	75
CO3	Apply pulse shaping techniques to shape a digital modulated waveform using GNU Radio, demonstrating proficiency in designing and implementing pulse shaping filters to control the spectral properties of the transmitted signal.	TPS3	80	75
CO4	Construct and visualize signal constellations digital modulation schemes using GNU Radio and Python	TPS3	80	75
CO5	Design and implement matched filters using GNU Radio to achieve optimal signal detection and symbol recovery in communication system.	TPS4	80	75
CO6	Develop and simulate end-to-end digital communication systems using GNU Radio, demonstrating proficiency in designing and integrating signal processing blocks such as modulation, coding, filtering, and demodulation to emulate real-world communication scenarios.	TPS4	80	75

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO2
CO1	S	S	M	L	S	-	-	M	M	M	-	M	S	M	L
CO2	S	S	M	L	S	-	-	M	M	M	-	M	S	M	L
CO3	S	M	L	-	S	-	-	M	M	M	-	M	M	M	L
CO4	S	M	L	-	S	-	-	M	M	M	-	M	M	M	L
CO5	S	S	M	L	S	-	-	M	M	M	-	M	S	M	L
CO6	S	S	M	L	S	-	-	M	M	M	-	M	S	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Model Exam (%)			**Terminal Exam (%)**		
TPS / CO	**2**	**3**	**4**	**2**	**3**	**4**
CO1	-	10	10	-	10	10
CO2	-	10	10	-	10	10
CO3	-	10	-	-	10	-
CO4	-	10	-	-	10	-
CO5	-	10	10	-	10	10
CO6	-	10	10	-	10	10
Total	**-**	**60**	**40**	**-**	**60**	**40**

Experiment List

1. Generation of complex baseband signal using GNU radio.
2. Up and down conversion for a pair of real baseband signal using GNU radio.
3. AM, DSB-SC and SSB modulation using GNU radio.
4. Narrowband and Wideband FM generation using GNU radio.
5. Linear modulation methods (ASK, PSK, FSK and QAM) in GNU radio.
6. ASK using Pulse Shaping filters.
7. Constructing and visualizing constellations using GNU radio using Python.
8. Matching filtering in GNU radio.
9. Bit error rates for various constellations using GNU radio.
10. End-to-end digital communication system simulation in GNU radio.

Text Book

- Alexander M. Wyglinski and Di Pu Digital Communication Systems Engineering with Software-defined Radio, Artech House Publishers, First edition, 2013.
- Travis F. Collins, Robin Getz, Di Pu, and Alexander M. Wyglinsk, Software-Defined Radio for Engineers, 2018, ISBN-13: 978-1-63081-457-1.
- Cory Clark, Software Defined Radio: with GNU Radio and USRP, McGraw-Hill Professional, First edition, 2009.

Course Designers:

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22CHAC0	ESSENCE OF INDIAN KNOWLEDGE

Category	L	T	P	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 systematization and canonization 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 knowledge of India.	Understand
CO2	Explain the need and importance of protecting Traditional Knowledge, Knowledge sharing, and Intellectual property rights over Traditional Knowledge.	Understand
CO3	Explain about the use of Traditional Knowledge to meet the basic needs of human being.	Understand
CO4	Explain the rich biodiversity materials and knowledge preserved for practicing traditional lifestyle.	Understand
CO5	Explain the use of Traditional Knowledge in Manufacturing and Industry.	Understand
CO6	Explain about the cultural expression and modern applications of Traditional Knowledge	Understand

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO2	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO3	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO4	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO5	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO6	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M

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 Organization (ILO), UN Working Group on Indigenous Populations, Evolution of Other 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 Assessment Tests		Seminar (Internal Exam)
	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

This course assessment is fully internal. There is no terminal examination.

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:

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CURRICULUM AND DETAILED SYLLABI

FOR

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

SIXTH SEMESTER

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution Affiliated to Anna University)
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22EC610	ACCOUNTING AND FINANCE

Category	L	T	P	Credit
HSMC	4	0	0	4

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. Integrating investment planning into the curriculum can empower students with the knowledge and skills they need to achieve financial independence and thrive in an ever-changing world.

Prerequisite

Nil

Course Outcomes

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

CO Number	Course Outcome Statement	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Prepare financial statements of accounting such as trial balance, trading and profit loss account.	TPS 3	70	60
CO2	Prepare cost sheet and depreciation values of fixed asset for business.	TPS 3	70	60
CO3	Estimate budgets for an organization based on function, time and flexibility.	TPS 3	70	60
CO4	Compute breakeven point and activity-based costing for business applications.	TPS 3	70	60
CO5	Compute working capital requirements and return on investment for long-term capital budget decisions.	TPS 3	70	60
CO6	Calculate the investment proportion for business and individual.	TPS 3	70	60

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	M	L	-	-	M	S	M	S	S	S	S	M	-	
CO2	S	M	L	-	-	-	M	M	S	S	S	M	M	-	
CO3	S	M	L	-	-	-	-	S	S	S	S	S	M	-	
CO4	S	M	L	-	M	M	L	S	S	S	S	M	M	-	
CO5	S	M	L	-	S	M	M	S	S	S	M	M	M	-	
CO6	S	M	L	-	-	M	M	S	S	M	M	S	M	-	

S- Strong; M-Medium; L-Low

Assessment Pattern:

TPS Scale / CO	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II * (%)					
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20	100			-						-	2	10
CO2	-	10	20				-						-	2	10
CO3	-		40				-						-	4	15
CO4	-						-	8	30	100			-	4	20
CO5	-						-	4	20				-	4	15
CO6	-						-	8	30				-	4	10
Total	-	**20**	**80**	**100**			**-**	**20**	**80**	**100**			**-**	**20**	**80**

Syllabus

Accounting- Introduction, definition, accounting principles-functions of accounting-Preparation of Financial statements and their analysis with the common size and comparative statements-Case studies.
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-Case studies.
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-Case studies.
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-Case studies. **Investment Management:** Nature and Scope, Investment Avenues, Types of Financial Assets and Real Assets, Return and Risk- Systematic and Unsystematic Risk, Measurement of Risk, Measurement of Return, Capital Asset Pricing Model (CAPM).
Personal Investment: Investors life cycle, Personal Finance and Investment, Internal and International Diversification.

Text Books

1. M.C.Shukla,T.S.Grewal,—Advanced Accounts-Volume-I, 2010 Reprint, S. Chand & company Ltd.,2010.
2. Michael C. Ehrhardt and Eugene F. Brigham, —Financial Management: Theory and Practice -thirteenth edition‖ South-Western cengage learning, 2011
3. Preeti Singh, Investment Management, Himalay Publishing House, First Edition, 2016

Reference Books

1. P.S.Boopathi Manickam —Financial and Management Accounting‖ PSG publications 2009.
2. Prasanna Chandra, —Financial Management-Theory and practice‖ seventh Reprint,Tata McGraw-Hill publishing company Limited,2010.
3. Don R. Hansen and Maryanne M. Mowen —Cost Management: Accounting and Control, Fifth Edition‖ Thomson, 2006.
4. R.P.Rustagi, Investment Management-Theory and Practice, Sultan Chand & Sons, Eleventh Edition, 2021
5. https://nptel.ac.in/courses/110101003/
6. https://swayam.gov.in/nd1_noc19_mg38/preview

7. Website: https://www.youtube.com/watch?v=P9JIBbZas3w

Course Contents and Lecture Schedule

Module No	Topic	No. of Lectures
1	**Accounting**	
1.1	Introduction, Definition, Functions of accounting	1
1.2	Accounting principles	1
1.3	Preparation of Financial statements	3
1.4	Common size statement analysis	1
1.5	Comparative statement analysis	1
1.6	Case studies	1
2	**Cost Accounting**	
2.1	Meaning, importance and Elements of cost	1
2.2	classification of cost and meaning of Cost centre,	1
2.3	Preparation of Cost sheet and its applications	3
2.4	Depreciation – meaning and causes of depreciation	1
2.5	Methods to find out the depreciation	2
2.6	Case studies	1
3	**Budget and Budgetary control**	
3.1	Introduction- Meaning -objectives of budgetary control –	2
3.2	Budget- Types of budgets and their preparation	4
3.3	Case studies	2
4	**Marginal costing**	
4.1	Introduction, Break even analysis	2
4.2	Managerial uses of breakeven analysis.	1
4.3	Activity Based Costing	2
4.4	Case studies	2
5	**Capital budgeting**	
5.1	Meaning and features, capital budgeting decisions	1
5.2	Methods of evaluating capital budgeting decisions by traditional and modern methods	4
5.3	Working capital management – concept, classification,	1
5.4	Estimation of working capital requirements.	1
5.5	Case studies	1
6	**Investment Management**	
6.1	Nature and Scope of Investment Management, Investment Avenues	1
6.2	Types of Financial Assets and Real Assets	1
6.3	Return and Risk- Systematic and Unsystematic Risk	2
6.4	Measurement of Risk, Measurement of Return, Capital Asset Pricing Model (CAPM)	2
7	**Personal Investment**	
7.1	Investors life cycle, Personal Finance and Investment	1
7.2	Internal and International Diversification	1
	Total	**48 hrs**

Course Designers:

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22EC620	IMAGE PROCESSING

Category	L	T	P	Credit	TE
PCC	2	0	2	3	Theory

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 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	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Demonstrate the digital image acquisition, digitization, formation, storage, and the relationship between pixels.	TPS2	70	75
CO2	Enhance the visual perception of the digital imagery from contrast/brightness degradation and by removing noise in spatial domain.	TPS3	70	70
CO3	Apply image transformations such as Fourier and DCT for image enhancement and coding.	TPS3	70	70
CO4	Extract regions of interest from an image using region-based segmentation by region splitting, merging and watershed segmentation	TPS3	70	70
CO5	Represent the segmented boundary by chain code and shape numbers and describe it using shape number, Fourier, and Euler number with structural and geometric operations.	TPS3	70	70
CO6	Apply image processing algorithms to solve real-world image 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.	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO2
CO1	M	L	-	-	M	-	-	L	L	L	-	-	L	-	L
CO2	S	S	M	L	M	M	-	L	M	M	-	L	M	S	L
CO3	S	S	M	L	M	L	L	L	M	M	-	L	M	S	L
CO4	S	S	M	L	M	L	-	L	M	M	-	L	M	M	L
CO5	S	S	M	L	M	M	L	L	M	M	-	L	M	S	L
CO6	S	S	M	L	S	M	M	L	M	M	-	L	S	S	M

Assessment Pattern

	Assessment - I			**Assessment - II**			**Terminal Exam** (%) (Theory)		
	CAT – I (%)			**CAT – II** (%)					
TPS / **CO**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	20	-	-	-	-	-	10	-
CO2	-		40	-	-	-	-	-	20
CO3	-		40	-	-	-	-	-	15
CO4	-	-	-	-	10	20	-	-	15
CO5	-	-	-	-		30	-	-	20
CO6	-	-	-	-		40	-	-	20
Total	-	**20**	**80**	**-**	**10**	**90**	**-**	**10**	**90**

Syllabus

Theory:

Image acquisition and Fundamentals: Elements of Human Visual Perception-Image acquisition- Sensors-CCD, CMOS, Imaging modalities. Digital Image model**,** Image formats, Image Sampling and Quantization, Connectivity and Distance measures- Euclidean, city-block, chessboard, Color models and Color space conversion. **[5 hours**]

Image Enhancement: Point transformations, Image Negative, Contrast stretching, Log transformation- Gamma Correction, Histogram processing **[2 hours]**

Spatial Filtering- Noise models, Noise Removal, Smoothing- mean, median filters, Order statistics filter- Gray level thresholding- Binary image, Sharpening- sharpening**-** Point, line detection, Laplacian filter, unsharp masking, high-boost filter, and Sobel and Prewitt operators. **[4 hours]**

Spectral representation for enhancement and coding: Fourier, Discrete cosine Transform, Frequency domain filtering, JPEG compression. **[4 hours]**

Segmentation: Region based segmentation, Region growing, Region splitting and merging, Gray-scale Morphological operations. **[3 hours]**

Representation and Description: Boundary Representation, Chain codes, Signatures, Boundary descriptors, Regional Descriptors, Topological descriptors. **[2 hours]**

Real world Applications: Number plate detection, detecting cyst/tumour in MRI images, Non-destructive testing with Thermal images, Change detection between two satellite images. **[4 hours]**

Practical:

1. Image enhancement: Apply gray scale transformation to a poor contrast image.
2. Image enhancement: Apply spatial filters for different noisy images.
3. Image enhancement: Apply spatial filters to enhance the edges.
4. Perform DFT and DCT on images for noise removal and image compression.
5. Perform segmentation to obtain meaningful segments in images
6. Mini projects:

Text Book

- Rafael.C.Gonzalez, Richard.E. Woods and Steven L. Eddins, "Digital Image Processing using Matlab", 4th Edition, Gatesmark Publishing, 2018, ISBN 10: 1-292-22304-9.

Reference Books& web resources

- William K. Pratt, "Introduction to Digital Image Processing", CRC Press, 2013.
- Oge Marques, "Practical Image and Video Processing using MATLAB", Wiley-IEEE Press, 2011, ISBN: 978-0-470-04815-3.
- Al.Bovik, "The Essential Guide to Image Processing", Academic Press, 2009.
- Anil K.Jain, "Fundamentals of Digital Image Processing", Pearson Education 2003.
- 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.	Topic	No. of Lectures	CO
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 test pattern image	2	1
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, Color space conversion-RGB to HSV and YCbCr	1	1
2.4	**Practical:** HVS and color space: (RGB to HSV, YCbCr color space)	2	1
3.	**Image Enhancement:** Point transformations- gray level Transformations	1	2
3.1	Image Negative, Contrast stretching, Log transformation-Gamma correction	1	2
3.2	Histogram processing	1	2
3.3	**Practical:** Image enhancement: Point transformations: Image negative, log-transformation, contrast-stretching, histogram equalization	2	2
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-Laplacian filter, unsharp masking, high-boost filter, and Sobel and Roberts operators	1	2
3.7	Dithering**:** Gray-level thresholding- Binary image	1	2
3.8	**Practical: Dithering**: Threshold a gray-scale image to get binary, add noise to the original image and threshold, Compare and comment	2	2

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 coding - DFT, DCT of simple images containing an edge or a box.	2	3
4.4	Spectrum-Frequency domain filtering –Periodic noise removal-	1	3
4.5	JPEG compression	2	3
4.6	**Practical:** Image enhancement: Filtering in the frequency domain: Perform LP of different size (spatial). Add periodic noise and remove using frequency filtering methods	2	3
5	**Segmentation:** Region based segmentation	1	4
5.1	Region growing– Region splitting and merging	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 Rotation by Interpolations	2	4
5.7	**Practical: Morphological operations:** Erosion, Dilation, Opening, closing Selection of the structuring element, Increase the size of structuring element – Locating an object	2	4
6.	**Representation and Description:** Boundary representation	1	5
6.1	Chain codes–Signatures		
6.2	Boundary descriptors–Shape numbers-Fourier descriptors	1	5
6.3	Regional Descriptors-Topological descriptors-Euler number		
6.4	**Practical:** Geometric operations: Shrinking, Zooming and Rotation by Interpolations Comment on the quality of a thumbnail-size using different interpolation methods	2	4
7.	**Real world Applications:** Number plate detection	2	6
7.2	Detecting cyst/tumour in MRI sound images	1	6
7.3	Non-destructive testing with Thermal images	1	6
7.4	Change detection between two satellite images		
	Mini project:		6
	Theory	24	
	Practical	24	
	Total	48	

Course Designers:

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23EC630	WIRELESS COMMUNICATIONS

Category	L	T	P	Credit	TE
PCC	3	0	2	4	Theory

Preamble

Wireless communication has revolutionized the way we connect, interact, and exchange information, becoming a cornerstone of modern technology. This course is meticulously designed to provide a comprehensive understanding of the fundamental principles and advanced concepts that drive the design, development, and optimization of wireless communication systems. This theory cum practical course bridges the gap between foundational knowledge and cutting-edge innovations. Through hands-on experiments, case studies, and exposure to current research trends, students will gain a holistic understanding, empowering them to innovate and excel in the dynamic field of wireless communication.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Model the wireless channel in terms of small scale and large-scale fading parameters.	TPS3	70	70
CO2	Determine the BER performance of wireless communication systems in fading environments.	TPS3	70	70
CO3	Determine the impact of power and bandwidth on the channel capacity of SIMO, MISO, and MIMO systems using fundamental concepts of MIMO communication systems.	TPS3	70	70
CO4	Determine the capacity of LoS SIMO, MISO, and MIMO channels in wireless communication systems using the principles of antenna array properties and three-dimensional far-field channel modeling.	TPS3	70	70
CO5	Determine the capacity of non-LoS MIMO channels under slow and fast fading conditions using the concepts of multipath propagation and Rayleigh fading.	TPS3	70	70
CO6	Determine the performance of wideband wireless communication systems in fading environment	TPS3	70	70
CO7	Analyze the bit error rate (BER) and outage performance of Reconfigurable Intelligent (RIS) assisted narrowband wireless communication systems.	TSP4	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	S	M	L	-	S	-	-	M	M	-	-	S	L	M
CO2	S	M	L	-	S	-	-	M	M	-	-	S	L	M
CO3	S	M	L	-	S	-	-	M	M	-	-	S	L	M
CO4	S	M	L	-	S	-	--	M	M	-	-	S	L	M
CO5	S	M	L	-	S	-	-	M	M	-	-	S	L	M
CO6	S	M	L	-	S	-	-	M	M	-	-	S	L	M
CO7	S	S	M	L	S	-	-	M	M	-	-	S	L	M
Overall	S	M	L	-	S	-	-	M	M	-	-	S	L	M

Assessment Pattern:

	Assessment – I						Assessment - II						Terminal Exam (Theory) (%)		
	CAT – I (%)			Assignment I (%)			CAT – II (%)			Assignment II (%)					
TPS / CO	2	3	4	2	3	4	2	3	4	2	3	4	2	3	4
CO1	4	20		100									4	10	
CO2	8	30											4	10	
CO3	8	30											4	10	
CO4							6	20		100			2	10	
CO5							6	20					2	10	
CO6							4	20					2	15	
CO7							4	-	20				2	-	15
Total	20	80					20	60	20				20	65	15

Syllabus

Statistical Channel Models: Radio wave propagation, Ray tracing, two ray ground reflection model, signal modelling: discrete memoryless channel model, statistical multipath channel model: time varying channel impulse response, narrowband fading models, wideband fading models, space time channel model for Single Input Single Output (SISO), Single Input Multiple Output (SIMO), Multiple Input Single Output (MISO), and Multiple Input Multiple Output (MIMO) factors influencing small scale fading.

Point to point Wireless Communication: Diversity gain, Coding gain, receive antenna diversity, transmit antenna diversity, Diversity order and channel variability.

Capacity of point-to-point MIMO Channels: Impact of power and bandwidth on the capacity, Capacity of SIMO channels, Capacity of MISO channels, capacity of MIMO channels. **Line of Sight:** Basic properties of antenna arrays, modeling of LoS SIMO, MISO and MIMO channels. Three-dimensional far field channel modeling. **Non-Line of Sight:** Basics of multipath propagation and Rayleigh fading, slow and fast fading versus the channel coherence time, capacity concept with slow fading, capacity with fast fading.

Space Time OFDM: SISO Orthogonal Frequency Division Multiplexing (OFDM), MIMO OFDM

Reconfigurable Intelligent Surface (RIS) assisted Wireless Communication Systems: Basic physics of reflecting surface, BER and Outage analysis performance of RIS assisted narrow band system.

Practical

Experimental List:

1. Simulation on received power using Friis transmission model.
2. Simulation comparison of received power for large scale model and log normal shadowing.
3. Simulation of power delay profile and Doppler power spectrum.
4. Simulation of BER performance in fading environment.
5. Simulation of Capacity and Outage analysis of SISO, SIMO, MISO and MIMO channels.
6. Simulation of Transmit beamforming and receive beamforming
7. Simulation of Channel Estimation in SISO, SIMO and MIMO flat fading channels.
8. End to End packet transmission and reception.
9. Simulation of BER of OFDM scheme.
10. Simulation of BER and Outage in RIS assisted wireless communication.

Text Books

- Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2005.
- Paulraj, R. Nabar and D Gore, “Introduction to Space-Time Wireless Communications”, Cambridge University Press, 2003.
- Emil Bjornson and Ozlem Tugfe Demir, “Introduction to Multiple Antenna Communications and Reconfigurable Surfaces” now Publisher Inc, 2024.

Reference materials

- Theodore S.Rappaport, “Wireless Communications Principles and Practice”, Pearson Education, Second Edition, 2001.
- David Tse and Pramod Viswanath, “Fundamentals of Wireless Communications”, Cambridge University Press, First Asian Edition, 2006.
- Aditya. K. Jegannatham, “Principles of Modern Wireless Communication Systems”,Tata McGraw Hill, 2016.
- https://nptel.ac.in/courses/117104115
- https://archive.nptel.ac.in/courses/108/106/106106167/

Course Contents and Lecture Schedule

No.	Topic	Lecture Hours
1	**Statistical Channel Models**	
1.1	Radio wave propagation, Ray tracing	1
1.2	Two ray ground reflection model	1
1.3	Signal modelling:Discrete memoryless channel model	1
1.4	Statistical multipath channel model: time varying channel impulse response	1
1.5	Narrowband fading models	1
1.6	Wideband fading models	1
1.7	Space time channel model for Single Input Single Output (SISO), Single Input Multiple Output (SIMO)	1
1.8	Space time channel model for Multiple Input Single Output (MISO)	1
1.9	Multiple Input Multiple Output (MIMO) factors influencing small scale fading	1
2	**Point to Point Wireless Communication**	
2.1	Diversity gain	2
2.2	Coding gain	1
2.3	Receive antenna diversity	1
2.4	Transmit antenna diversity	1
2.5	Diversity order and channel variability	1
3	**Capacity of point-to-point MIMO Channels**	
3.1	Impact of power and bandwidth on the capacity	1
3.2	Capacity of SIMO channels	1
3.3	Capacity of MISO channels	1
3.4	Capacity of MIMO channels.	2
4	**Line of Sight (LoS) point to point MIMO channels**	
4.1	Basic properties of antenna arrays	2
4.2	Modeling of LoS SIMO, MISO and MIMO channels	1
4.3	Three dimensional far field channel modeling.	2
5	**Non LoS point to point MIMO channels**	
5.1	Basics of multipath propagation and Rayleigh fading	1
5.2	Slow and fast fading versus the channel coherence time	1
5.3	Capacity concept with slow fading	1
5.4	Capacity with fast fading	1

6	**Space Time OFDM**	
6.1	SISO Orthogonal Frequency Division Multiplexing (OFDM)	2
6.2	MIMO OFDM	2
7	**Reconfigurable Intelligent Surface (RIS) assisted Wireless Communication Systems**	
7.1	Basic physics of reflecting surface	1
7.2	BER and Outage analysis performance of RIS assisted narrow band system	2
Total		**36**

Course Designers:

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CURRICULUM AND DETAILED SYLLABI

FOR

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

SEVENTH SEMESTER

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution Affiliated to Anna University)
MADURAI – 625 015, TAMILNADU

Phone : 0452 – 2482240, 41
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22EC710	OPTICAL FIBER COMMUNICATION SYSTEM

Category	L	T	P	Credit
ESC	2	0	0	2

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, integrated optics and photonics, future optical systems and Networks.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Determine the transmission characteristics of optical fiber	TPS 2	70	60
CO2	Demonstrate the characteristics of optical sources and modulation techniques.	TPS 3	70	60
CO3	Demonstrate the characteristics of optical detectors and demodulation techniques	TPS 3	70	60
CO4	Demonstrate the characteristics of SONET/SDH, WDM network and network components. (Couplers, isolators, multiplexers, switches, filters, etc.)	TPS 3	70	60
CO5	Design and analyze the performance of optical communication links.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	L	L	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	L	L	-	-	-	-	-	-	M	-	-
CO3	S	M	L	L	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	L	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	L	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
CO \ TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	30				-						-	4	20
CO2	-	10	20		100		-						-	4	15
CO3	-	10	20				-						-	4	10
CO4	-	-	-				-	10	35		100		-	4	10
CO5	-	-	-				-	20	35				-	4	25
Total	-	30	70		100		-	30	70		100		-	20	80

Syllabus

Optical fiber Communication: Key elements of optical fiber system, Optical Fibers: Structures, optical fiber modes and configurations, Modal analysis, Step-index and graded index optical fibers, advanced optical fibers (Photonic crystal fiber, multi core fiber), fiber fabrications.

Transmission characteristics of optical fiber: Attenuation, Material absorption losses, Linear scattering losses, Nonlinear scattering losses, Fiber bend loss, Dispersion, Chromatic dispersion, Intermodal dispersion, polarization mode dispersion and Dispersion modified single mode fibers.

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, Optical OFDM.

Optical Receivers: PIN photo detector, characteristics; Avalanche photodiode, characteristics, Noise in Photo detector. Demodulation: Direct detection, coherent detection.

Optical Networks and Components: System design consideration point –to –point links, Link power budget, rise time budget. Optical network: Optical layer, SONET/SDH, high speed light wave link. WDM concepts and Components: Coupler, Isolator, Multiplexers, switches, cross connects. Optical amplifiers: EDFA.

Text Book

- Gerd Kaiser, “Optical fiber communications”, McGraw Hill Int., 5th edition, 2017.
- John Senior, “Optica fiber communication-principles and practices”, Prentice Hall of India, 3rd edition, 2013.

Reference Books

- Rajiv Ramaswami, Kumar Sivarajan, Galen Sasaki, “Optical Networks: a practical perspective” Morgan Kaufmann publishers, 3rd edition, 2009.
- G.P. Agarwal, “Fiber optic communication system”, Wiley, 4th edition, 2010.
- J. Gower, “Optical communication system”, Prentice Hall of India, 2nd edition, 2001.
- Joseph C. Palais, “Fiber Optic Communication”, Pearson Education, 5th edition, 2011.
- Biswanath Mukherjee, “Optical WDM Network”, Springer, 1st edition.
- H Nishihara, M Haruna and T Suhara, Optical Integrated Circuits; McGraw-Hill Book Company, New York, 1989.
- C. R. Pollock and M Lipson, Integrated photonics, Kluwer Pub, 2003.
- NPTEL course on “Fiber Optic Communication Technology” by Prof. Deepa Venkatesh. Link: https://www.youtube.com/watch?v=ougKUUM3hJA

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**Introduction to the Course, COs POs**	1
1.1	**Overview of Optical Fiber Communication**	
1.2	Key elements of optical fiber system, Fiber Types: Step index, Graded index, Single mode, multimode,	1
1.3	Optical fiber modes and configurations	2
1.4	Photonic crystal fiber, Fiber fabrication.	1
2	**Transmission characteristics of optical fiber**	
2.1	Attenuation, Material absorption losses, Linear scattering losses, Nonlinear scattering losses, Fiber bend loss	2
2.2	Dispersion, Chromatic dispersion, Intermodal dispersion, polarization mode dispersion and Dispersion modified single mode fibers	2
3	**Optical Transmitters**	
3.1	Light Emitting Diode: structure, Characteristics: Quantum efficiency,	2

	output power, modulation bandwidth	
3.2	Laser: Structure, laser diode mode and threshold condition, rate equation, quantum efficiency and resonant frequency	2
3.3	Direct modulation, sub carrier modulation/multiplexing OTDM, Optical OFDM	1
4	**Optical Receivers**	
4.1	PIN photo detector and Avalanche photodiode: characteristics	1
4.2	Noise in Photo detector.	1
4.3	Demodulation: Direct detection, coherent detection	2
5	**Optical Networks and Components**	
5.1	System design consideration point –to –point links, Link power budget, rise time budget.	2
5.2	Optical network: Optical layer, SONET/SDH, high speed light wave link.	2
5.3	WDM concepts and Components: Coupler, Isolator, Multiplexers, switches, cross connects. Optical amplifiers: EDFA	2
	TOTAL	**24**

Course Designers:

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DETAILED SYLLABI

FOR

ELECTIVE COURSES
(for the students admitted from the academic year 2022-23)

B. E. DEGREE PROGRAMME
(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

Passed in BoS meeting 18.11.2023 Approved in 67th Academic Council Meeting 16.12.2023

LIST OF ELECTIVE COURSES

Sl. No.	Course Code	Course Tile	Category
1.	22ECRA0	SIGNAL INTEGRITY FOR HIGH-SPEED SYSTEM DESIGN	PEES
2.	22ECPA0	ARTIFICIAL NEURAL NETWORKS FOR RF APPLICATIONS	PSE
3.	22ECPB0	MICRO STRUCTURES	PSE
4.	22ECPC0	ADVANCED ANTENNA TECHNOLOGY	PSE
5.	22ECPD0	COMPUTER VISION AND APPLICATIONS	PSE
6.	22ECRB0	MULTIMEDIA COMPRESSION TECHNIQUES	PEES
7.	22ECPE0	SATELLITE REMOTE SENSING	PSE
8.	22ECPF0	SATELLITE DATA ANALYSIS	PSE
9.	22ECRC0	ARRAY SIGNAL PROCESSING	PEES
10.	22ECRD0	STATISTICAL SIGNAL PROCESSING	PEES
11.	22ECPG0	SIGNAL PROCESSING WITH SMARTPHONE	PSE
12.	22ECPH0	SIGNAL PROCESSING AND MACHINE LEARNING FOR AUDIO AND SPEECH	PSE
13.	22ECPJ0	DIGITAL SYSTEM DESIGN USING FPGA	PSE
14.	22ECPK0	LOW POWER VLSI DESIGN	PSE
15.	22ECRE0	CAD FOR VLSI CIRCUITS	PEES
16.	22ECRF0	ASIC DESIGN	PEES
17.	22ECRG0	REAL TIME SYSTEMS	PEES
18.	22ECPL0	IOT SYSTEM AND APPLICATIONS	PSE
19.	22ECRH0	PARALLEL PROGRAMMING	PEES
20.	22ECPM0	ELECTRONIC MEASUREMENT AND INSTRUMENTS	PSE
21.	22ECPN0	FIBER OPTIC COMMUNICATION	PSE
22.	22ECPP0	5G WIRELESS NETWORKS	PSE
23.	22ECRJ0	AD-HOC NETWORKS AND APPLICATIONS	PEES
24.	22ECRK0	BLOCKCHAIN AND APPLICATIONS	PEES
25.	22ECPQ0	CRYPTOGRAPHY AND CYBERSECURITY	PSE
26.	22ECPR0	CONTROL SYSTEMS	PSE
27.	22ECPS0	VLSI DEVICE MODELING	PSE

PSE - Programme Specific Elective

PEES - Programme Elective for Expanded Scope

22ECRA0	SIGNAL INTEGRITY FOR HIGH-SPEED SYSTEM DESIGN

Category	L	T	P	Credit
PEES	2	1	0	3

Preamble

Signal integrity refers to the quality of electrical signals as they travel through electronic systems, ensuring minimal distortion, noise, or loss, crucial for reliable communication and functionality in high-speed system design. The fundamentals of ideal transmission line structures, properties, parameters, reflection analysis at the source/load-end, performance metrics to ensure signal integrity is covered in module-1. The crosstalk, one of the major sources of noise coupling phenomenon in high density PCB systems and the different techniques to minimize the crosstalk noise is given in module-2. One of the signaling techniques that is commonly employed at higher data-rates, called Differential signaling, the source of common-mode noise generation and strategies to minimize the noise are covered in module-3. In module-4, the non-ideal return paths, the sources of switching noise generation and the methodologies to suppress the noise were presented. Finally, the high-speed measurement techniques to measure TDR, impedance, crosstalk noise and the usage of VNA for one-port and two-port measurements were discussed in module-5. A tutorial is given at the end of each module to gain insight in to the theoretical concepts.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Design and analyze transmission lines, ensuring efficient signal propagation and minimal signal degradation	TPS 3	70	60
CO2	Apply techniques to suppress crosstalk issues in electronic circuits, ensuring reliable device operation and signal integrity	TPS 3	70	60
CO3	Design and implement effective techniques to minimize common-mode noise and ensure robust data transmission	TPS 3	70	60
CO4	Apply practical strategies to mitigate switching noise and PDN noise impact on signal integrity and circuit performance	TPS 3	70	60
CO5	Use advanced tools and methods for accurate analysis and troubleshooting of high-speed electronic systems	TPS 3	70	60
CO6	Analyze the coupled noise in multiconductor transmission lines through PCB prototype fabrication and measurements using VNA	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	L	L	L	-	-	M	L	L
CO2	S	M	L	-	L	-	-	L	M	M	-	-	M	L	L
CO3	S	M	L	-	L	-	-	L	M	M	-	-	M	L	L

CO4	S	M	L	-	L	-	-	L	M	M	-	-	M	L	L
CO5	S	M	L	-	L	-	-	L	M	M	-	-	M	L	L
CO6	S	M	L	-	L	-	-	L	M	M	-	-	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**						**Terminal Exam** (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)					
CO \ **TPS Scale**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	20		100		-						-	-	10
CO2	-	10	20				-						-	4	10
CO3	-	10	30				-						-	4	15
CO4	-						-	10	20		100		-	4	15
CO5	-						-	10	30				-	4	15
CO6							-	10	20					4	15
Total	-	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Introduction: Ideal Transmission Line Fundamentals, Transmission Line Structures, Transmission-Line Properties, Transmission Line Parameters, RLGC extraction, Transmission Line Reflections, Time-Domain Reflectometry (TDR), Eye-diagram, Jitter. ***Tutorial - 1:*** Transient simulation of interconnects and analyze response using TDR, EYE, Jitter, and RLGC extraction. **Crosstalk:** Mutual Inductance and Capacitance, Coupled Wave Equations, Coupled Line Analysis, Near-end crosstalk, Far-end crosstalk, Crosstalk Minimization: 3W rule, Dielectric overlay, Guard Trace – open-ended, terminated and vias stitched, Serpentine trace. ***Tutorial - 2:*** Coupled line simulation with guard trace – open-ended, short, termination and analyze NEXT, FEXT. **Differential Signaling:** Removal of Common-Mode Noise, Differential Crosstalk, Virtual Reference Plane, Propagation of Modal Voltages, Drawbacks of Differential Signaling - Mode Conversion, Fiber-Weave Effect. Common-mode suppression – Common-mode filters. ***Tutorial - 3:*** DGS based common mode filter design and analyze response using Differential and common-mode insertion loss, EYE and Jitter. **Channel Effects:** Nonideal Return Paths, Vias, Physics based Via modeling, Simultaneous Switching Noise, Power Delivery Network. Switching noise suppression: Split powerplane, Decoupling capacitors, High-impedance powerplane. High Speed Digital Interface - USB, PCIE, DDR, SDIO, eMMC. ***Tutorial - 4:*** Parallel plate resonance and suppression using high-impedance power plane. **High-Speed Measurement Techniques:** Time-Domain Reflectometry, Impedance Measurement, Crosstalk Noise, Propagation Velocity, Vector Network Analyzer, S-Parameters, One-Port Measurements (Z_O,L,C), Two-Port Measurements (Td, Attenuation, Crosstalk). ***Tutorial – 5:*** Coupled line fabrication and analyze NEXT, FEXT in frequency domain using VNA.

Text Book

- Stephen H. Hall, Howard L. Heck, "Advanced Signal Integrity for High-Speed Digital Designs", John Wiley & Sons, 2009.
- Stephen H. Hall, Garrett W. Hall, James A. McCall, "High-Speed Digital System Design: A Handbook of Interconnect Theory and Design Practices", Wiley-IEEE Press, 2000.

Reference Books

- Peter J. Pupalaikis, "S-Parameters for Signal Integrity", Cambridge University Press, 2020.
- Eric Bogatin, "Signal and Power Integrity – Simplified", Pearson, Third Edition, 2018.
- Fabien Ndagijimana, "Signal Integrity: From High-Speed to Radiofrequency Applications", Wiley-ISTE, 2014.
- Stephen C. Thierauf, "Understanding Signal Integrity", Artech House, 2010.
- Huray, Paul G., "The Foundations of Signal Integrity", John Wiley & Sons, 2009.
- Howard W. Johnson, Martin Graham, "High-speed Digital Design: A Handbook of Black

Magic", Prentice Hall, 1993.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction: (7)	
1	Ideal Transmission Line Fundamentals, Transmission Line Structures,	2
2	Transmission-Line Properties, Transmission Line Parameters, RLGC extraction,	2
3	Transmission Line Reflections, Time-Domain Reflectometry (TDR), Eye-diagram, Jitter.	2
4	***Tutorial - 1:*** Transient simulation of interconnects and analyze response using TDR, EYE, Jitter, and RLGC extraction.	1
	Crosstalk: (7)	
5	Mutual Inductance and Capacitance, Coupled Wave Equations, Coupled Line Analysis,	2
6	Near-end crosstalk, Far-end crosstalk, Crosstalk Minimization: 3W rule, Dielectric overlay,	2
7	Guard Trace – open-ended, terminated and vias stitched, Serpentine trace.	2
8	***Tutorial - 2:*** Coupled line simulation with guard trace – open-ended, short, termination and analyze NEXT, FEXT.	1
	Differential Signaling: (7)	
9	Removal of Common-Mode Noise, Differential Crosstalk, Virtual Reference Plane,	2
10	Propagation of Modal Voltages, Drawbacks of Differential Signaling - Mode Conversion,	2
11	Fiber-Weave Effect. Common-mode suppression – Common-mode filters.	2
12	***Tutorial - 3:*** DGS based common mode filter design and analyze response using Differential and common-mode insertion loss, EYE and Jitter	1
	Channel Effects: (7)	
13	Nonideal Return Paths, Vias, Physics based Via modeling, Simultaneous Switching Noise,	2
14	Power Delivery Network. Switching noise suppression: Split powerplane, Decoupling capacitors, High-impedance powerplane.	2
15	High Speed Digital Interface - USB, PCIE, DDR, SDIO, eMMC.	2
16	***Tutorial - 4:*** Parallel plate resonance and suppression using high-impedance power plane.	1
	High-Speed Measurement Techniques: (8)	
17	Time-Domain Reflectometry, Impedance Measurement, Crosstalk Noise,	2
18	Propagation Velocity, Vector Network Analyzer, S-Parameters,	2
19	One-Port Measurements (Z_O,L,C), Two-Port Measurements (Td, Attenuation, Crosstalk).	1
20	***Tutorial – 5:*** Coupled line fabrication and analyze NEXT, FEXT in frequency domain using VNA.	3
	TOTAL	**36**

Course Designers:

- Dr.K.Vasudevan, kvasudevan@tce.edu
- Dr B.Manimegalai, naveenmegaa@tce.edu
- Dr.S.Kanthamani, skmece@tce.edu

22ECPA0	ARTIFICIAL NEURAL NETWORKS FOR RF APPLICATIONS

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

This course provides an in-depth exploration using Artificial Neural Network techniques for the design and modelling of RF and microwave components. It covers fundamental concepts of neural networks, data pre-processing, model evaluation and techniques. It also provides an insight to the implementation of neural network models for RF circuit design and optimization.

Prerequisite

Nil

Course Outcomes

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

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the design and optimization process of RF and Microwave Components	TPS2	70	70
CO2	Discuss the basic concepts of neural networks	TPS3	70	70
CO3	Explore the different neural network training techniques	TPS3	70	70
CO4	Discuss the procedure for modeling RF and Microwave Components using neural networks	TPS3	70	70
CO5	Discuss the process for optimization of various RF Components	TPS3	70	70
CO6	Apply ANN technique in the design of RF and microwave circuits	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	L	-	-	-	-	-	-	-	-	L	L	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	L	M	-	-
CO3	S	M	L	-	M	-	-	-	-	-	-	L	M	-	-
CO4	S	M	L	-	M	-	-	-	-	-	-	L	M	-	-
CO5	S	M	L	-	M	-	-	-	-	-	-	L	M	-	-
CO6	S	M	L	-	M	-	-	-	-	-	-	L	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam(%)		
	CAT – I(%)			**Assg. I ***(%)			**CAT – II**(%)			**Assg. II ***(%)					
CO / **TPS Scale**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	20	-				-	-	-				-	10	-
CO2	-	20	-		100		-	-	-				-	10	-
CO3	-	20	40				-	-	-				-	10	-
CO4	-	-	-				-	20	10				-	10	10
CO5	-	-	-				-	10	20		100		-	-	20
CO6	-	-	-				-	10	30				-	-	30
Total	**-**	**60**	**40**		**100**		**-**	**40**	**60**		**100**		**-**	**40**	**60**

Syllabus

Introduction – RF and Microwave Design, Anatomy of Design Process, Conventional design procedures, CAD Approach and Optimization of RF circuits.

Introduction to Artificial Neural Networks: Highlights of neural network modelling approach –Multilayer perceptron (MLP) - Back Propagation – Radial Basis function networks (RBF), Clustering algorithms, Recurrent neural networks

Training of neural networks: Microwave neural modelling- Key issues in neural modelling- Neural network training- Back propagation algorithm and its variants- Training algorithms using Gradient Descent Techniques- Genetic algorithms- Comparison of different training Techniques**-** feed forward neural network training

Models for RF and Microwave Components – Modelling procedure, Selection of Model Input and Output parameters, Training Data Generation, Error Measures, Integration of EM-ML Models with circuit and network simulators, Passive component modelling using Neural Networks-Models for vias and multilayer interconnects-CPW transmission line, Bends, opens, short, spiral inductors, Patch antenna, high speed interconnects, active component modelling: Direct and Indirect Modelling Approach – Transistor DC model-Small and Large Signal Models

Design, Analysis and Optimization: Optimization of component structure- Circuit optimization using ANN models- Multilayer circuit design and optimization using ANNs-yield optimization of amplifiers, ANN models linked to design software, efficient use of EM simulators, Trends and challenges

Case Studies - Design and Optimization-Antenna, RF MEMS and Nano structures, FSS

Text Book

- K. C. Gupta, Q. J. Zhang. "Neural Networks for RF and Microwave Design"ArtechHouse, 2000.

Reference Books& web resources

- Zlatica Marinkovicet et al., "Artificial Neural Network based Design of RF MEMS Capacitive Shunt Switches", The Applied Computational Electromagnetics Society Journal,31(7):756-764,2021.
- Percy, J.J., Kanthamani, S., Sethuraman, S. et al. Artificial Neural Network Approach to Model Sidewall Metallization of Silicon-based Bistable Lateral RF MEMS Switch for Redundancy Applications. Silicon 14, 9175–9185 (2022). https://doi.org/10.1007/s12633-022-02070-2
- El Misilmani, HM, Naous, T, Al Khatib, SK. A review on the design and optimization of antennas using machine learning algorithms and techniques. *Int J RF MicrowComput Aided Eng*. 30:e22356, 2020.
- https://nptel.ac.in/courses/106105152/- Introduction to machine learning by Prof. Sudeshna Sarkar, IIT Kharagpur

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
1	**Introduction** – RF and Microwave Design **(2)**	
2	Anatomy of Design Process and Conventional design procedures	1
3	CAD Approach and Optimization of RF circuits	1
	Introduction to Artificial Neural Networks: **(5)**	
4	Highlights of neural network modelling approach	1
5	Multilayer perceptron (MLP)	1
6	Back Propagation	1
7	Radial Basis function networks (RBF)	1
8	Clustering algorithms, Recurrent neural networks	1
	Training of neural networks (6)	
9	Microwave neural modelling- Key issues in neural modelling	1
10	Neural network training- Back propagation algorithm and its variants	1
11	Training algorithms using Gradient Descent Techniques	1
12	Genetic algorithms, Comparison of different training Techniques	2
13	Feed forward neural network training	1
	Models for RF and Microwave Components (10)	
14	Modelling procedure, Selection of Model Input and Output parameters, Training Data Generation, Error Measures	1
15	Integration of EM-ML Models with circuit and network simulators, Passive component modelling using Neural Networks-Models for vias and multilayer interconnects-CPW transmission line, Bends, opens, short, spiral inductors, Patch antenna, high speed interconnects	3
16	Active component modelling: Direct and Indirect Modelling Approach – Transistor DC model-Small and Large Signal Models Design	2
17	Analysis and Optimization: Optimization of component structure	1
18	Circuit optimization using ANN models- Multilayer circuit design and optimization using ANNs	1
19	Yield optimization of amplifiers, ANN models linked to design software, efficient use of EM simulators, Trends and challenges	2
	Case Studies - Design and Optimization (12)	
20	Antenna	4
21	RF MEMS and Nano structures	4
22	FSS	4
	TOTAL	**36**

Course Designers:

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22ECPB0	MICRO STRUCTURES

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

Miniaturization of RF Transceiver have 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 transmitter-receiver architecture and need for miniaturization followed by 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, modeling various RF MEMS components such as switches, capacitors, phase shifters, 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

NIL

Course Outcomes

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

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understanding of transmitter-receiver architecture, including its blocks, functionalities and the advantages of miniaturization and scaling	TPS2	70	70
CO2	Discuss the basic concepts of actuation mechanisms, packaging and micro-fabrication techniques to RF applications	TPS3	70	70
CO3	Design RF MEMS Switch Networks	TPS3	70	70
CO4	Design RF MEMS capacitors and inductors	TPS3	70	70
CO5	Design RF MEMS phase shifters for phased array antennas	TPS3	70	70
CO6	Apply the concept of micromachining to various micro structures	TPS3	70	70
CO7	Acquire skills in computer-aided design tools for modeling and simulating RF MEMS devices	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	L	-	-	L	-	L	-	L	M	-	-
CO4	S	M	L	-	L	-	-	L	-	L	-	L	M	-	-
CO5	S	M	L	-	L	-	-	L	-	-	-	L	M	-	-
CO6	S	M	L	-	L	-	-	L	-	-	-	L	M	-	-
CO7	S	M	L	-	L	-	-	L	-	-	-	L	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)					
CO \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	-				-	-	-				-	10	-
CO2	-	20	-		100		-	-	-				-	20	-
CO3	-	5	30				-	-	-				-	-	15
CO4	-	5	30				-	-	-				-	-	15
CO5	-	-	-				-	20	30		100		-	-	15
CO6	-	-	-				-	5	20				-	-	10
CO7	-	-	-					10	15				-	5	10
Total	**-**	**40**	**60**		**100**		**-**	**35**	**65**		**100**		**-**	**35**	**65**

Syllabus

Introduction: Transmitter Receiver Architecture– Blocks and Functionalities, Benefits of Miniaturization and Scaling
Overview of MEMS: Driving force for MEMS development, Applications in wireless communication, space and defence, RF MEMS in industry and academia, Commercial packages.
Actuation Mechanisms in MEMS: Electrostatic, Thermal and Magnetic
Micro fabrication Techniques: MEMS Materials, Material Properties, Bulk micromachining, surface micromachining, Wet etching 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 in Switching Networks: Series switches, Capacitive shunt switches, Electromagnetic modeling and Current research. Examples of switches for various applications
Case Study 2: Tunable Capacitors and Inductors: 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: RF MEMS in Phased Arrays: Types of phase shifters and their limitations, Switched delay line phase shifters, Distributed phase shifters, Micromachined antennas, Micromachining techniques to improve antenna performance, Reconfigurable antennas.
Case Study 4: Fabrication flow of cantilever and bridge type structures.
Computer-aided design of MEMS: Usage of Intellisuite, Coventorware, and Comsol CAD tools.

Text Book

- Jacopo Iannacci. "RF-MEMS Technology for High-Performance Passives (2nd Edition): 5G applications and prospects for 6G", IOP Publishing Ltd 2022

Reference Books & web resources

- Vijay K Varadhan, K.J.Vinoy, "RF MEMS and their Applications", John Wiley & Sons,1998
- G.K. Ananthasuresh, K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre. "Micro and Smart Systems",Wiley India Pvt. Limited, 2010
- 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 Microsystems'
- http://www.mecheng.iisc.ernet.in/~suresh/memscourse/pcontent.html

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
1	**Introduction:** transmitter receiver architecture **(2)**	
2	Blocks and Functionalities	1
3	Benefits of Miniaturization and Scaling	1
	Overview of MEMS (2)	
4	Driving force for MEMS development, Application in wireless communications, space and defence applications	1
5	RF MEMS in industry and academia, Introduction to Commercial packages	1
	Actuation Mechanisms in MEMS (2)	
6	Electrostatic Thermal and Magnetic	2
	Micro Fabrication Techniques (3)	
7	MEMS Materials, Material Properties	1
8	Bulk and surface micromachining	0.5
9	Wet and dry etching	0.5
10	Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating), Conventional IC fabrication Processes	1
	Packaging of RF MEMS (1)	
11	Role of MEMS packaging ,Types of MEMS Packages	0.5
12	Reliability issues of MEMS packaging.	0.5
	RF MEMS Components: Case study 1: RF MEMS Switch (3)	
13	RF MEMS in Switching network : Series , Capacitive shunt switches	1
14	Electromagnetic modelling	1
15	Current research, Examples of switches for various applications	1
	Case Study 2:Tunable Capacitors And Inductors (2)	
16	Example of tunable capacitors and inductors and their applications in circuits, Effect of inductor layout	0.5
17	Reduction of stray capacitance of planar inductor	0.5
18	Approaches for improving quality factor	0.5
19	MEMS gap tuning, Area tuning and dielectric tuning capacitors	0.5
	Case Study 3: RF MEMS In Phased Array (6)	
20	Types of phase shifters and their limitations	1
21	MEMS phase shifters: Switched delay line phase shifters, Distributed phase shifters	2
22	Micromachined antennas, Microstrip antennas	1
23	Micromachining techniques to improve antenna performance	1
24	Reconfigurable antennas	1
25	**Case study 4: Fabrication flow of cantilever and bridge type structures**	2
	Computer aided design of MEMS (12)	
26	Overview of Commercial packages	2
27	Usage of Intellisuite, Coventorware and Comsol CAD tools	9
28	Future trends in MEMS device design	1
	TOTAL	**36**

Course Designers:

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22ECPC0	ADVANCED ANTENNA TECHNOLOGY

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

Advanced antenna technology revolutionizes telecommunications, offering transformative improvements in wireless communication. Innovations like smart antennas and Massive MIMO enhance signal strength, reduce interference, and boost coverage. These technologies, coupled with advanced materials, result in compact, high-performance antennas resilient to environmental factors. As the demand for faster and more reliable communication grows, advanced antenna technology plays a crucial role in shaping the future of connectivity. 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

NIL

Course Outcomes

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	To understand the principle of various antenna technology suitable for advanced wireless communication	TPS3	70	60
CO2	To design miniaturized antennas such as metamaterials and EBG based structures and techniques for enabling advanced control of electromagnetic properties	TPS3	70	60
CO3	To design and develop antennas for navigation system covering GPS, GNSS and IRNSS	TPS3	70	60
CO4	To design and analyse antenna arrays and algorithms for smart antenna system	TPS3	70	60
CO5	To design and analyze antennas for 5G and future wireless communication systems.	TPS3	70	60
CO6	To study and investigate various applications of millimeter wave antennas and Radar for applications	TPS3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	L	M	M	-	-	L	L	L
CO2	S	M	L	-	L	-	-	L	M	M	-	-	L	L	L
CO3	S	M	L	-	L	-	-	L	M	M	-	-	L	L	L
CO4	S	M	L	-	L	-	-	L	M	M	-	-	L	L	L
CO5	S	M	L	-	L	-	-	L	M	M	-	-	L	L	L
CO6	S	M	L	-	-	-	-	L	M	M	-	-	L	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)					
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	20				-						-	4	10
CO2	-	10	30		100		-						-	4	10
CO3	-	10	20				-						-	4	15
CO4	-						-	10	20				-	-	15
CO5	-						-	10	30		100		-	4	15
CO6	-						-	10	20				-	4	15
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Introduction: Review of antenna arrays and planar antenna design. Trends in recent wireless applications and antenna technology such as Smart antenna, Miniaturized antennas, Navigation system, Millimeterwave Radars, 5G and beyond, Design requirements and specifications [6 hours]

Miniaturized antennas - Metamaterial, EBG structures: Concept of Metamaterials, Classification, Principle of EBG structure and Compact EBG designs, Antenna Miniaturization, Multi-band applications. [6 hours]

Antennas for Navigation system: Circularly polarized antennas for GPS, Single-and dual feed Microstrip, Spiral and Helix antennas for GNSS, Low profile antenans for IRNSS application [6 hours]

Smart Antenna: Antenna arrays, Types of arrays, Buttler matrices, Active and passive arrays. Beamforming, Concept of angle of arrival estimation, Fixed weight beamforming and adaptive beamforming. [6 hours]

Antenna for 5G & Beyond: 5G Massive MIMO Systems, Microstrip antennas for future 5G mobile handsets, Substrate Integrated waveguide antennas, Reconfigurable and metasurface antenna [6 hours]

Millimeter wave antennas for Automotive Radar: Millimeter wave technology, characteristics and applications, Transceiver architecture, frequency allocation and FMCW technique, mm wave Radar integrated sensor antenna, and Radome. Radar Equation and Link Budget. [6 hours]

Reference Books & web resources

- Amit K. Singh, Mahesh P. Abegaonkar, Shiban Kishen Koul, "Metamaterials for Antenna Applications", CRC Press, 2021.
- Fan Yang, Yahya Rahmat Samii, “Electromagnetic Band Gap Structures in Antenna Engineering”, Cambridge University Press, 2009.
- Xiaodong Chen, Clive G. Parini, Brian Collins, Yuan Yao, Masood Ur Rehman, "Antennas for Global Navigation Satellite Systems", John Wiley & Sons Ltd., 2012.
- Frank Gross, “Smart antennas for wireless communications”, McGraw-Hill, 2006.
- S. Chandran, “Adaptive antenna arrays, trends and applications”, Springer, 2009.
- Xiang, W.Zheng, K. Shen, X.S, “5G Mobile Communications”, Springer, 2016.
- Ericsson Handbook on “ Massive MIMO” 2023, Edition 2
- Robert W. Heath, Robert C. Daniel, James N. T.S. Rappaport, Murdock, “Millimeter Wave Wireless Communications”, PH, 2014.
- Wonbin Hong, Chow-Yen Desmond Sim, "Microwave and Millimeter-wave Antenna Design for 5G Smartphone Applications", Wiley-IEEE Press, 2022.

Course Contents and Lecture Schedule		
#	Topic	Lecture Hours
	Introduction (6)	1
1	Review of antenna arrays and planar antenna design.	2
2	Trends in recent wireless applications and antenna technology	2
5	Design requirements and specifications	1
	Miniaturized antennas - Metamaterial, EBG structures (6)	
6	Concept of Metamaterials, Classification,	2
7	Principle of EBG structure and Compact EBG designs,	2
8	Antenna Miniaturization,	1
9	Multi-band applications.	1
	Antennas for Navigation system (6)	
11	Circularly polarized antennas for GPS,	2
12	Single-and dual feed Microstrip	1
13	Spiral and Helix antennas for GNSS	2
14	Low profile antenans for IRNSS application	1
	Smart Antenna (6)	
16	Antenna arrays, Types of arrays,	1
17	Buttler matrices, Active and passive arrays	1
18	Beamforming, Concept of angle of arrival estimation	2
	Fixed weight beamforming and adaptive beamforming	2
	Antenna for 5G & Beyond (6)	
19	5G Massive MIMO Systems	2
20	Microstrip antennas for future 5G mobile handsets,	2
21	Substrate Integrated waveguide antennas,	1
	Reconfigurable and metasurface antenna	1
	Millimeter wave antennas for Automotive Radar (6)	
22	Millimeter wave technology, characteristics and applications,	2
23	Transceiver architecture, frequency allocation and FMCW technique	1
24	mm wave Radar integrated sensor antenna, and Radome.	2
	Radar Equation and Link Budget.	1
	TOTAL	**36**

Course Designers:

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22ECPD0	COMPUTER VISION AND APPLICATIONS

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

This course focuses on how computers treat vision to understand the 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 valuable 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 are required for the low-level vision process. In mid-level, it describes how the feature points such as interest points corner points are detected, matched and the alignment of matched feature points. The higher-level vision encompasses object recognition and categorization, which includes various classifiers. Recent developments in deep learning have revolutionized the field of computer vision, bringing new innovations closer to deployment that benefit end users. The course will cover traditional computer vision topics before introducing deep learning methods. In this course, students will learn both basic concepts as well as the latest advances in these fields, so the students can apply these methods in real-world applications after learning the basics.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the concepts of image formation, camera parameters, 3D-2D transformations, and perspective projection to solve computer vision problems.	TPS 2	70	60
CO2	Extract meaningful information from images, including the identification of key interest points, gradients, corners, and textures for computer vision applications.	TPS 3	70	60
CO3	Demonstrate supervised and unsupervised classifiers and the architecture of a multilayer perceptron by employing the backpropagation algorithm to train the neural network.	TPS 3	70	60
CO4	Illustrate the concept of convolution, pooling, activation functions, batch normalization, data augmentation and hyperparameters tuning to train CNN architectures for specific computer vision tasks.	TPS 3	70	60
CO5	Illustrate the concept of transfer learning, and pre-trained models such as AlexNet, VGGNet, and ResNet to train and develop network models for specific computer vision tasks.	TPS 3	70	60
CO6	Develop deep learning algorithms for image stitching, object detection using single-stage and two-stage detectors, MRI reconstruction and anomaly detection.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	L	-	-	M	L	L	L
CO2	S	M	L	-	M	-	-	-	M	-	-	M	M	M	M
CO3	S	M	L	-	M	-	-	-	M	-	-	M	M	M	M
CO4	S	M	L	-	L	-	-	-	M	L	-	M	M	L	L
CO5	S	M	L	-	M	-	-	-	M	-	-	M	M	L	M
CO6	S	M	L	-	M	M	-	M	M	M	-	M	M	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	30	0				-						-	10	
CO2	-	5	30		100		-						-		15
CO3	-	5	30				-						-	10	15
CO4	-						-	10	20				-	-	15
CO5	-						-	5	30		100		-	-	15
CO6	-						-	5	30				-	-	20
Total	-	**40**	**60**		**100**		**-**	**20**	**80**		**100**		**-**	**20**	**80**

Syllabus

Low Level Vision: Introduction to computer vision and its applications – Image formation – camera intrinsic and extrinsic parameters – 3D-2D Transformations – Euler Angle – Rotation matrices – Translation – Perspective Projection [4 hours]

Middle Level Vision: Feature detectors and descriptors – Interest points, Harris corner detection – Scale Invariant Feature Transform (SIFT), Histogram of Oriented Gradients (HOG) – Local Binary Pattern (LBP) – Feature matching algorithms – RANSAC Euclidean distance metric – Performance measures – Error rates [8 hours]

High Level Vision: Classifiers**:** Supervised, K-nearest neighbour, SVM, Unsupervised – Deep learning – Multilayer perceptron – Back propagation – Higher-level representations, image features – Convolution and pooling– CNN Architecture-Batch Normalization –Transfer Learning – Alexnet – VGGnet – Resnet [8 hours]

Training Neural Networks: Activation functions – Data processing – Weight Initialization – Hyperparameter tuning – Data augmentation. [6 hours]

Computer vision applications: Image stitching using feature alignment – Object detection – Two stage detectors – RCNN – Faster RCNN - Single stage detector YOLO–– Semantic Segmentation – Deep Generative model – GAN – MRI reconstruction – Anomaly Detection [10 hours]

Text Book

- Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016.

Reference Books

- 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://nptel.ac.in/courses/106106224/Course on Deep learning for Computer Vision by Vineet N Balasubramanian
- https://www.coursera.org/courses?query=computer%20vision.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1.	Introduction to the Course and course outcomes **Computer Vision and Applications**	1
2.	**Image formation:** camera intrinsic and extrinsic parameters	1
3.	3D-2D Transformations	1
4.	Euler Angle, Rotation matrices	1
5.	Translation	1
6.	Perspective Projection, Pinhole cameras	1
7.	**Middle Level Vision:** Feature detectors and descriptors	1
8.	Interest points, Harris corner detection	1
9.	Scale Invariant Feature Transform (SIFT)	1
10.	Histogram of Oriented Gradients (HOG)	1
11.	Local Binary Pattern (LBP)	1
12.	Feature matching algorithms, RANSAC Euclidean distance metric	1
13.	Performance measures, Error rates	1
14.	**High Level Vision:** Classifiers**:** Supervised, K-nearest neighbour	1
15.	SVM	1
16.	Unsupervised, Deep learning: Multilayer perceptron, Back propagation	2
17.	Higher-level representations, image features, Convolution and pooling, CNN Architecture, Batch Normalization	2
18.	Transfer Learning	1
19.	Alexnet–	2
20.	VGGnet–Resnet	2
21.	**Training Neural Networks:** Activation functions	1
22.	Data processing – Weight Initialization –Hyperparameter tuning	2
23.	Data augmentation	1
24.	**Computer vision applications:** Image stitching using feature alignment	1
25.	Object detection: Two stage detectors: RCNN, Faster RCNN	2
26.	Single stage detector: YOLO, Semantic Segmentation,	2
27.	Deep Generative model, GAN – MRI Reconstruction	2
28.	Anomaly Detection	1
	TOTAL	**36**

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22ECRB0	MULTIMEDIA COMPRESSION TECHNIQUES

Category	L	T	P	Credit
PEES	3	0	0	3

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	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Characterize Multimedia data and its Compression with performance measures	TPS3	70	60
CO2	Determine the performance of lossless compression techniques such as variable-length coding, Arithmetic and Dictionary-based coding	TPS3	70	60
CO3	Determine the performance of lossy compression techniques such as scalar and vector quantization and transform coding	TPS3	70	60
CO4	Illustrate the performance of Image compression standards such as JPEG 2000 and JBIG	TPS3	70	60
CO5	Illustrate the performance of video compression schemes such as H.261 and MPEG	TPS3	70	60
CO6	Illustrate the performance of Audio compression techniques such as G.726, Vocoder, MPEG Audio , Surround sound and Silence Compression	TPS3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)					
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	10				-						-	6	-
CO2	-	10	30		100		-						-	4	16
CO3	-	10	30				-						-	4	16
CO4	-						-	5	20				-	2	16
CO5	-						-	5	30		100		-	2	16
CO6	-						-	10	30				-	2	16
Total	**-**	**30**	**70**		**100**		**-**	**20**	**80**		**100**		**-**	**20**	**80**

Syllabus

Multimedia Data Representation: Special features of Multimedia – Graphics and Image Data Representations –Fundamental Concepts in Video and Digital Audio – Storage requirements for multimedia applications -Need for Compression. (4 hours)

Multimedia Data Compression: Lossless Compression Techniques: Run length coding- Variable Length Coding: Huffman Coding- Non binary Huffman coding- Extended Huffman- Adaptive Huffman, Arithmetic Coding, Dictionary Based Coding- LZ7 Algorithms (6 hours)

Lossy Compression Techniques: Distortion Measures-The Rate-Distortion Theory- Quantization- Scalar and Vector Quantization, Differential Encoding- 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; (8 Hours)

Image Compression Standards: JPEG 2000, JBIG, HEIF (High Efficiency Image File Format); (5 hours)

Video Compression Standards: Video Compression Based on Motion Compensation- MPEG-4, H.264, H.265 (HEVC (High Efficiency Video Coding)), MP4-Container, MOV. (6 Hours)

Audio Compression Standards: Speech compression techniques – LPC and CELP- Application to speech coding – G.722 - Application to audio coding – MPEG audio (MP3)- **AAC**–M4A Surround sound - Dolby Digital- Silence Compression. (7 Hours)

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. Mark Nelson, Jean Louf Goilly, “The Data Compression Book”, BPB Publications, 1995.
4. Yun-Qing Shi, Huifang Sun, “Image and Video Compression for Multimedia Engineering - Fundamentals, Algorithms, and Standards, Second Edition”, CRC Press, 2017.
5. https://archive.nptel.ac.in/course.html: Multimedia processing, Prof. Somnath Sengupta, IIT Kharagpur
6. https://nptel.ac.in/courses/117101053: Information Theory and Coding, IIT Bombay, Prof. S.N. Merchant

Course Contents and Lecture Schedule

Module No.	Topic	Lecture Hour
1.	**Multimedia- Data Representation**	
1.1	What is Multimedia- Special features of Multimedia	1
1.2	Graphics and Image Data Representations –Fundamental Concepts in Video and Digital Audio	1
1.3	Storage requirements for multimedia applications	1
1.4	Need for Compression, Measures of Performance	1
2.	**Multimedia Data Compression**	
2.1	**Lossless Compression Techniques**	
2.1.1	Lossless Compression overview - Coding Redundancy-Run length Coding	1
2.1.2	Variable Length Coding: Huffman Coding and its variations-Baseline, Non-Binary, Extended	1
2.1.3	Adaptive Huffman	2
2.1.4	Arithmetic coding	1
2.1.5	Dictionary Based Coding –Diagrams, LZ77, LZ78, LZW	1
2.2	**Lossy Compression Techniques**	
2.2.1	Distortion Measures, Rate Distortion Theory, differential encoding	1
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	1
2.2.4.2	Embedded Zero tree of Wavelet coding	1
2.2.4.3	Set Partitioning in Hierarchical Trees (SPIHT)	1
3	**Image Compression Standards**	
3.1	JPEG 2000	2
3.2	Bi-level Image Compression Standards: JBIG	1
3.3	HEIF (High Efficiency Image File Format)	2
4	**Video Compression Standards**	
4.1	Video Compression Based on Motion Compensation	1
4.2	MPEG-4	1
4.3	H.264,H.265	2
4.4	MP4-Container, MOV	2
5.	**Audio Compression Standards**	
5.1	Speech compression: Vocoder	1
5.2	LPC, CELP, G.722	1
5.3	Application to audio coding – MPEG audio (MP3)	1
5.4	MPEG (AAC), M4A	2
5.5	Surround Sound- Dolby Digital and DTS X	1
5.6	Silence Compression	1

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22ECPE0	SATELLITE REMOTE SENSING

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

In this course the students will learn about the concepts and principles of various processes of remote sensing, data acquisition systems and sensors, different types of remote sensing satellites, data and their characteristics and satellite image processing operations using open source software. They will also apply the satellite data for various societal developments applications.

Prerequisite

NIL

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the concepts of Electromagnetic energy, spectrum and spectral signature curves, Satellite orbits and platforms	TPS2	70	70
CO2	Interpret Multispectral, Thermal and Hyperspectral Images	TPS3	70	70
CO3	Interpret SAR (Microwave) and LIDAR Images	TPS3	70	70
CO4	Interpret the concepts of satellite and sensor parameters and characteristics of different platforms	TPS3	70	70
CO5	Apply open source Image processing packages to process satellite images	TPS3	70	70
CO6	Choose appropriate satellite data and apply the concepts for different applications	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO1 1	PO1 2	PSO 1	PS O 2	PS O 3
CO1	M	L	-	-	-	-	-	M	M	L	-	-	L	L	L
CO2	S	M	L	-	M	M	-	M	M	L	-	-	M	L	L
CO3	S	M	L	L	M	M	-	M	M	L	-	-	M	-	L
CO4	S	M	L	L	-	-	-	M	M	L	-	-	M	-	L
CO5	S	M	L	-	-	-	-	M	M	L	-	-	M	-	L
CO6	S	M	L	L	L	M	-	M	M	L	-	M	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

<table>
<tr><td rowspan="2"></td><td colspan="6">Assessment - I</td><td colspan="6">Assessment - II</td><td rowspan="2" colspan="3">Terminal Exam(%)</td></tr>
<tr><td colspan="3">CAT – I(%)</td><td colspan="3">Assg. I *(%)</td><td colspan="3">CAT – II(%)</td><td colspan="3">Assg. II *(%)</td></tr>
<tr><td>TPS Scale
CO</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>CO1</td><td>-</td><td>10</td><td>20</td><td rowspan="3" colspan="3">100</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>5</td><td>10</td></tr>
<tr><td>CO2</td><td>-</td><td>15</td><td>20</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>5</td><td>10</td></tr>
<tr><td>CO3</td><td>-</td><td>15</td><td>20</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>5</td><td>10</td></tr>
<tr><td>CO4</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>10</td><td>10</td><td rowspan="3" colspan="3">100</td><td>-</td><td>5</td><td>10</td></tr>
<tr><td>CO5</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>15</td><td>25</td><td>-</td><td>5</td><td>15</td></tr>
<tr><td>CO6</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>15</td><td>25</td><td>-</td><td>5</td><td>15</td></tr>
<tr><td>Total</td><td>-</td><td>40</td><td>60</td><td colspan="3">100</td><td>-</td><td>40</td><td>60</td><td colspan="3">100</td><td>-</td><td>30</td><td>70</td></tr>
</table>

Syllabus

Fundamentals: Remote Sensing Process- Satellite orbits and platforms -Image Resolution Types-Image Resolution Types-False Color Images and Band Combinations-Radiometric and Geometric Errors **[5 Hours]**

Types: Multi Spectral Sensing –Along Track & Across Track scanning-Thermal Remote Sensing – Radiation Principles, Interpretations- Hyperspectral Sensing– Dimensionality Reduction, Analysis Techniques- Microwave Sensing–Side looking Radar Systems, Synthetic Aperture Radar (SAR), Radar Image Characteristics, Radar Image Interprétation- LIDAR Remote Sensing– Data Characteristics, Point Cloud Processing. **[8 Hours]**

Sensors &Platforms: Multi Spectral: Landsat, SPOT, and IRS Programmes- Thermal: AVHRR, ASTER, ATLAS, MODIS- Hyper Spectral: Hyperion, HySIS, Enmap, PROBA, Microwave: RISAT, RADARSAT, TerraSAR, TanDEM- LIDAR: ICESat2, CALIPSO- High Resolution Satellites: GeoEye, IKONOS, QuickBird- Remote Sensing Data Providers. **[7 Hours]**

Processing using Open Source Packages: Interpretation of MSS and Thermal Data- Statistics Computation and Band math operations on MSS Data- Preprocessing- Destriping, Masking, Georeferencing of MSS Data- Supervised & Unsupervised Classification of MSS Data- Adaptive & Texture Filters for Speckle Removal from Radar Data- Visualization and Analysis of various bands of Hyperspectral Data **[7 Hours]**

Applications: Land Use Land Cover Change Detection and Urban Sprawl Monitoring (MSS)- Mineral exploration & Agricultural Crop Detection (HS)- Temperature Mapping, Forest Fire Detection (TRS)- Snow Cover Studies (SAR)- 3D Reconstruction (LIDAR) **[9 Hours]**

Text Book

- T.M. Lillesand and R.W. Kiefer “Remote Sensing and Image Interpretation (7th Edition)”, John Wiley,2015.

Reference Books

- R.A. Schowengerdt “Remote Sensing – Models and Methods for Image Processing”, Academic Press, 2006
- John R. Jensen, “Introductory Digital Image Processing | A Remote Sensing Perspective”, 4th Edition, Pearson Education, 2017.
- J.R. Jensen “Remote Sensing of the Environment – An Earth Resources Perspective”, 2nd Edition, Pearson Education, 2013

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Fundamentals**	
1.1	Remote Sensing Process	1
1.2	Satellite orbits and platforms	1
1.3	Spectral Reflectance Curve, Image Resolution Types	1
1.4	False Color Images and Band Combinations	1
1.5	Radiometric and Geometric Errors	1
2	**Types**	
2.1	Multi Spectral Sensing – Along Track &Across Track scanning	1
2.2	Thermal Remote Sensing – Radiation Principles, Interpretations	2
2.3	Hyperspectral Sensing– Dimensionality Reduction, Analysis Techniques	2
2.4	Microwave Sensing–Side looking Radar Systems, Synthetic Aperture Radar (SAR), Radar Image Characteristics, Radar Image Interpretation,	2
2.5	LIDAR Remote Sensing– Data Characteristics, Point Cloud Processing	1
3	**Sensors &Platforms**	
3.1	Multi Spectral: Landsat, SPOT, and IRS Programmes	1
3.2	Thermal: AVHRR, ASTER, ATLAS, MODIS	1
3.3	Hyper Spectral: Hyperion, HySIS, Enmap, PROBA,	1
3.4	Microwave: RISAT, RADARSAT, TerraSAR, TanDEM	1
3.5	LIDAR: ICESat2, CALIPSO	1
3.6	High Resolution Satellites: GeoEye, IKONOS, QuickBird	1
3.7	Remote Sensing Data Providers	1
4	**Processing using Open Source Packages**	
4.1	Interpretation of MSS and Thermal Data	
4.2	Statistics Computation and Band math operations on MSS Data	1
4.3	Preprocessing- Destriping, Masking, Georeferencing of MSS Data	1
4.4	Supervised & Unsupervised Classification of MSS Data	2
4.5	Adaptive & Texture Filters for Speckle Removal from Radar Data	2
4.6	Visualization and Analysis of various bands of Hyperspectral Data	1
5	**Applications**	
5.1	Land Use Land Cover Change Detection and Urban Sprawl Monitoring (MSS)	2
5.2	Mineral exploration & Agricultural Crop Detection (HS)	2
5.3	Temperature Mapping, Forest Fire Detection (TRS)	2
5.4	Snow Cover Studies (SAR)	2
5.5	3D Reconstruction (LIDAR)	1
	Total Periods	**36**

Course Designer(s):

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22ECPF0	SATELLITE DATA ANALYSIS

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

This course deals with the qualitative and quantitative techniques applied on analyzing satellite data and related applications. The students will learn the computation of different parameters from satellite data, data transformation techniques, advanced feature extraction algorithms, popular machine learning classifiers and finally data fusion algorithms.

Prerequisite

NIL

Course Outcomes

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

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the Satellite data characteristics and their resolutions	TPS2	70	60
CO2	Compute different statistics and quality parameters of satellite data for analysis	TPS3	70	60
CO3	Apply various data transformation techniques on satellite images for different perspective of analysis	TPS3	70	60
CO4	Apply advanced feature extraction algorithms on satellite data for texture feature extraction and analysis	TPS3	70	60
CO5	Learn the types of supervised and unsupervised machine learning classifiers for satellite data analysis	TPS3	70	60
CO6	Perform data fusion algorithms on satellite images	TPS3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	M	M	L	-	-	L	L	L
CO2	S	M	-	-	M	-	-	M	M	L	-	-	M	L	L
CO3	S	M	L	L	M	M	-	M	M	L	-	-	M	-	L
CO4	S	M	L	L	-	-	-	M	M	L	-	-	M	-	L
CO5	S	M	L	-	-	-	-	M	M	L	-	-	M	-	L
CO6	S	M	L	L	L	M	-	M	M	L	-	M	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

TPS / CO	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	-	100			-						-	5	-
CO2	-	10	35				-						-	5	10
CO3	-	10	35				-						-	5	10
CO4	-						-	10	25	100			-	5	15
CO5	-						-	10	25				-	5	20
CO6	-						-	10	20				-	5	15
Total	-	**30**	**70**	**100**			**-**	**30**	**70**	**100**			**-**	**30**	**70**

Syllabus

Satellite Data: Satellite Image Characteristics- Spatial, Spectral, Radiometric and Multi-Temporal Resolutions- Geometric and Radiometric Correction- Image Rectification. [5 Hrs]

Image Statistics: Univariate Statistics- Multivariate Statistics - Image quality statistics. [5 Hrs]

Data Transformation: Multispectral Ratios -Vegetation indices, Water related indices- Principal Components, Tasseled-Cap Components- Wavelet Transform. [6 Hrs]

Feature Extraction: Gray Level Co-occurrence Matrix (GLCM)- Local Binary Pattern (LBP)- Scale Invariant Feature Transform (SIFT)- Histogram Oriented Gradient (HoG)- Wavelet Features- Morphological Features. [8 Hrs]

Learning Methods: Unsupervised learning: Clustering, EM Algorithm- Supervised learning: SVM Classifier- Decision tree learning- Random Forest Classier- Ada Boost Classifier- Texture Based Classification- Accuracy Assessment. [9 Hrs]

Data Fusion: Brovey Method- IHS Fusion- Wavelet Fusion. [3 Hrs]

Learning Resources

- Robert A. Schowengerdt, Remote Sensing Models & Methods for Image Processing, 3rd Edition, 2007.
- Shunlin Liang, Advanced Remote Sensing: Terrestrial Information Extraction and Applications, First edition, 2019
- John R. Jensen, — Introductory Digital Image Processing, A Remote Sensing Perspective, Pearson Education Series, Fourth Edition, 2021.
- Shai Shalev-Shwartz, Shai Ben-David, Understanding Machine Learning From Theory to Algorithms ,Cambridge University press, 2014.
- Ethem Alpaydin —Introduction to Machine Learning, second edition, The MIT Press, 2010.

Course Contents and Lecture Schedule

Module No.	Topic	Lecture Hours
1	**Satellite Data**	
1.1	Satellite Image Characteristics- Spatial, Spectral, Radiometric and Multi-Temporal Resolutions	3
1.2	Geometric and Radiometric Correction	1
1.3	Image Rectification	1
2	**Image Statistics**	
2.1	Univariate Statistics	2
2.2	Multivariate Statistics	2
2.3	Image quality statistics	1

Module No.	Topic	Lecture Hours
3	**Data Transformation**	
3.1	Multispectral Ratios	1
3.2	Vegetation indices	1
3.3	Water related indices	1
3.4	Principal Components	1
3.5	Tasseled-Cap Components	1
3.6	Wavelet Transform	1
4	**Feature Extraction**	
4.1	Gray Level Co-occurrence Matrix (GLCM)	1
4.2	Local Binary Pattern (LBP)	1
4.3	Scale Invariant Feature Transform (SIFT)	1
4.4	Histogram Oriented Gradient (HoG)	2
4.5	Wavelet Features	2
4.6	Morphological Features	1
5	**Learning Methods** - - -	
5.1	Unsupervised learning : Clustering , EM Algorithm	2
5.2	Supervised learning : SVM Classifier- Decision tree learning- Random Forest Classier- Ada Boost Classifier	4
5.3	Texture Based Classification	2
5.4	Accuracy Assessment	1
6	**Data Fusion**	
6.1	Brovey Method	1
6.2	IHS Fusion	1
6.3	Wavelet Fusion	1
	Total Periods	**36**

Course Designers:

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22ECRC0	ARRAY SIGNAL PROCESSING

Category	L	T	P	Credit
PEES	2	1	0	3

Preamble

The objective of this course is to assemble in a coherent way a variety of theoretical and practical approaches to sensor array processing problems.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the properties of spatiotemporal propagating signals and noise.	TPS 3	70	60
CO2	Represent signal modeling and apply optimal filters, spectral estimation techniques for the specific problem.	TPS 3	70	60
CO3	Apply spatiotemporal filtering to separate signals according to their directions of propagation and their frequency content.	TPS 3	70	60
CO4	Determine the characteristics of apertures and find the array geometry that determines the performance characteristics of arrays.	TPS 3	70	60
CO5	Apply Optimum beamforming techniques adjust the array pattern to optimize the characteristics of received signal.	TPS 3	70	60
CO6	Apply Array geometries in higher dimensions based on characteristics of the observations.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO2	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO3	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO4	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO5	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO6	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
CO \ TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	5	15	15				-						-	4	10
CO2	5	15	15		100		-						-	4	10
CO3	5	15	10				-						-	4	15
CO4	-	-	-	-			5	10	15		100		-	-	15

CO5	-	-	-	-	5	15	15		-	4	15
CO6	-	-	-	-	5	15	15		-	4	15
Total	**15**	**45**	**40**	**100**	**15**	**40**	**45**	**100**	**-**	**20**	**80**

Syllabus

Representation of space - time signals: Coordinate systems; propagating waves; wave number-frequency space; arrays and apertures; space-time random processes and their characterization; noise assumptions. **[5 Hours]**

Signal modeling and optimal filters: Auto-regressive (AR), Moving average (MA), ARMA models; Autocorrelation and power spectral density of random processes; linear minimum mean square and linear least squares error estimator; solution of normal equations; optimum filters; matched filters. Power spectrum estimation: Nonparametric methods: Estimation of autocorrelation function and PSD using periodogram; BlackmanTukey and Welch-Bartlett methods; Parametric methods: Model and model order selection; PSD estimation using rational spectral models; MUSIC; ESPRIT. **[12 Hours]**

Arrays and spatial filters: Frequency-wavenumber response and beam patterns, uniform linear arrays, uniform weighted linear arrays, array steering, array performance measures: directivity, array gain, linear apertures. **[5 Hours]**

Synthesis of linear arrays and apertures: Spectral weighting, array polynomials, pattern sampling in wavenumber space, minimum beamwidth for specified sidelobe levels, broadband arrays. **[5 Hours]**

Optimum beamforming: MVDR beamformers, MMSE beamformers, Eigenvector beamformers. Adaptive beamforming: Least mean squares algorithms, Recursive least squares; Generalized sidelobe canceler. **[5 Hours]**

Array geometries in higher dimensions: Rectangular arrays; Circular arrays; Spherical arrays; Cylindrical arrays **[4 Hours]**

Text Book

- Harry L Van Trees, “Optimum Array Processing”,John Wiley & Sons,2004.

Reference Books

- S. Theodoridis and R. Chellapa, Academic Press Library in Signal Processing, Vol. 3: Statistical and Array Signal Processing, Academic Press, 2013.
- S. Haykin and K. J. Ray Liu, Handbook on Array Processing and Sensor Networks, WileyIEEE Press, 2010.
- Don H.Johnson, Dan E.Judgeon, “Array signal processing:concepts and techniques”,First edition, Prentice hall signal processing series,1993.
- Prabhakar S. Naidu, Sensor Array Signal Processing,CRC Press,2000.
- Pillai, S. Unnikrishna, Array Signal Processing, Springer,1989.
- Vijay K. Madisetti, The Digital Signal Processing Handbook: Wireless, Networking, Radar, Sensor Array Processing, and Nonlinear Signal Processing, CRC Press, 2nd Edn., 2010.
- P. Stoica and R. L. Moses, “Spectral Analysis of Signals,” Prentice Hall, 2005.
- Sophocles J. Orfanidis, “Optimum Signal Processing An Introduction,” McGraw-Hill Publishing Company,2007.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	
1	**Representation of space - time signals (5)**	
2	Coordinate systems; propagating waves;	1
3	wave number-frequency space;	1
4	arrays and apertures;	1

5	space-time random processes and their characterization; noise assumptions.	2
	Signal modeling and optimal filters (12)	
6	Auto-regressive (AR), Moving average (MA)	1
7	ARMA models	1
8	Autocorrelation and power spectral density of random processes	1
9	linear minimum mean square and linear least squares error estimator; solution of normal equations	1
10	optimum filters; matched filters	1
11	Nonparametric methods: Estimation of autocorrelation function and PSD using periodogram	2
12	Power spectrum estimation: BlackmanTukey and Welch-Bartlett methods	2
13	Parametric methods: Model and model order selection	1
14	PSD estimation using rational spectral models; MUSIC; ESPRIT	2
	Arrays and spatial filters (5)	
15	Frequency-wavenumber response and beam patterns,	2
16	uniform linear arrays, uniform weighted linear arrays,	1
17	array steering	1
18	array performance measures: directivity, array gain, linear apertures.	1
	Synthesis of linear arrays and apertures (5)	
19	Spectral weighting	2
20	array polynomials, pattern sampling in wavenumber space	1
21	minimum beamwidth for specified sidelobe levels	1
22	broadband arrays	1
	Optimum beamforming (5)	
23	MVDR beamformers	1
24	MMSE beamformers	1
25	Eigenvector beamformers	1
26	Adaptive beamforming: Least mean squares algorithms, Recursive least squares;	1
27	Generalized sidelobe canceler.	1
	Array geometries in higher dimensions (4)	
28	Rectangular arrays	1
29	Circular arrays	1
30	Spherical arrays	1
31	Cylindrical arrays	1
	TOTAL	**36**

Course Designers:

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22ECRD0	STATISTICAL SIGNAL PROCESSING

Category	L	T	P	Credit
PEES	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 statistical estimation theory and detection theory are discussed in detail. The topics have been chosen based on the grounds of theoretical value and practical importance.

Prerequisite

NIL

Course Outcomes

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

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the properties of commonly used probability density functions.	TPS2	70	60
CO2	Design an unbiased and consistent estimator that meets the CRLB	TPS3	70	60
CO3	Design Least square and Maximum likelihood estimators for parameter estimation for the given problem	TPS3	70	60
CO4	Design Bayesian estimator both for scalar and linear vector parameters estimation	TPS3	70	60
CO5	Design an optimal detector that detects the signals in noise through hypothesis testing	TPS3	70	60
CO6	Design an optimal detector to determine unknown parameters in deterministic signals	TPS3	70	60
CO7	Design an optimal detector to determine unknown parameters of random signals	TPS3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	M	-	-	L	M	-
CO2	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO3	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO4	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO5	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO6	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-
CO7	S	M	L	-	-	-	-	-	-	M	-	-	M	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	05	05	-				-						2	-	-
CO2	05	05	30		100		-						2	-	10
CO3	05	05	40				-						2	2	10
CO4	-	-	-	-			05	-	15				2	2	15
CO5	-	-	-	-			-	05	15		100		2	2	15
CO6	-	-	-	-			05	05	20				-	2	15
CO7	-	-	-	-			05	05	20				-	2	15
Total	**15**	**15**	**70**		**100**		**15**	**15**	**70**		**100**		**10**	**10**	**80**

Syllabus

Basics: Estimation in Signal Processing, The mathematical estimation problem. Detection theory in signal processing, The mathematical detection problem, Hierarchy of detection problem, Role of asymptotics, Fundamental probability density functions [3 Hours]

Minimum variance unbiased estimator and CRLB: Unbiased estimators, Minimum variance criterion, Cramer-Rao Lower Bound (CLRB) for signals in White Gaussian noise, Vector parameter CRLB for Transformations. Signal Processing example. [5 Hours]

Least Square (LS) and Maximum Likelihood Estimators (MLE): Linear least square, Geometrical interpretation, Finding MLE, Properties of MLE, MLE for Transformed parameters, extension to a vector parameter, Signal Processing example. [5 Hours]

Linear Bayesian Estimators: Linear Minimum Mean Square Error (MMSE) Estimator, Vector LMMSE estimator, sequential LMMSE estimator, Signal Processing Example.
[5 Hours]

Hypothesis Testing: Binary hypothesis testing, Bayes risk, multiple hypothesis testing, minimum bayes risk detector, Composite hypothesis testing. [8 Hours]

Detection of Deterministic signals: Detection of deterministic signals with unknown parameters-amplitude, arrival time, Sinusoidal detection, Generalized Likelihood Ratio Test (GLRT) for linear model, Energy Detector [5 Hours]

Detection of Random signals: Detection of Random signals with unknown covariance, Detection for large data records, Weak signal detection, Detection of periodic random signals [5 Hours]

Text Books

- Steven M. Kay, "Fundamentals of Statistical Signal Processing, Vol I - Estimation Theory", Prentice Hall, 1993.
- Steven M. Kay, "Fundamentals of Statistical Signal Processing, Vol II - Detection Theory", Prentice Hall, 1998.

Reference Books

- Umberto Spagnolini, Politecnico di Milano, "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.
- 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/

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	
	Basics (3)	
1.	Estimation in Signal Processing, The mathematical estimation problem, Detection theory in signal processing, The mathematical detection problem	1
2.	Hierarchy of detection problem, Role of asymptotics	1
3.	Fundamental probability density functions	1
	Minimum variance unbiased estimator and CRLB (5)	
4.	Unbiased estimators, Minimum variance criterion	1
5.	Cramer-Rao Lower Bound (CLRB) for signals in White Gaussian noise	1
6.	Vector parameter CRLB for Transformations	2
7.	Signal Processing example.	1
	Least Square (LS) and Maximum Likelihood Estimators (MLE) (5)	
8.	Linear least square estimator, Geometrical interpretation	1
9.	Finding MLE, Properties of MLE	1
10.	MLE for Transformed parameters	1
11.	Extension to a vector parameter,	1
12.	Signal Processing example	1
	Linear Bayesian Estimators (5)	
13.	Linear Minimum Mean Square Error (MMSE) Estimator	1
14.	Vector LMMSE estimator	1
15.	Sequential LMMSE estimator	2
16.	Signal Processing Example	1
	Hypothesis Testing (8)	
17.	Binary hypothesis testing, Bayes risk	2
18.	Multiple hypothesis testing	2
19.	Minimum bayes risk detector	1
20.	Composite hypothesis testing	3
	Detection of Deterministic signals (5)	
21.	Detection of deterministic signals with unknown amplitude	1
22.	Detection of deterministic signals with unknown arrival time	1
23.	Sinusoidal detection	1
24.	Generalized Likelihood Ratio Test (GLRT) for linear model	1
25.	Energy Detector	1
	Detection of Random signals (5)	
26.	Detection of Random signals with unknown covariance	2
27.	Detection for large data records	1
28.	Weak signal detection	1
29.	Detection of periodic random signals	1
	TOTAL	**36**

Course Designers:

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22ECPG0	**SIGNAL PROCESSING WITH SMARTPHONE**	Category	L	T	P	Credit	TE
		PSE	2	0	2	3	Practical

Preamble

This course is offered as a follow-up to the courses “Signals and Systems” and “Discrete Time Signal Processing". The purpose of this courses is to enable students to bridge the gap between signal processing theory and implementation aspects. Smartphones have become powerful processing platforms led to the development of this course toward enabling students to use their own smartphones as implementation platforms for running signal processing algorithms.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the smartphone implementation tools for Android operating system	TPS 2	70	70
CO2	Perform signal sampling and frame based processing in smartphone	TPS 3	70	70
CO3	Determine the effects of quantization of fixed point and floating point arithmetic for implementing FIR and IIR filter in smartphone	TPS 3	70	70
CO4	Perform adaptive filtering and frequency domain filtering in smartphone	TPS 3	70	70
CO5	Perform code optimization by exploiting hardware features	TPS 3	70	70
CO6	Transform MATLAB code for signal processing algorithm to smartphone	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	L	-	-	-	L	L	-	L	L	-	-
CO2	S	M	L	-	L	-	-		L	L	-	L	M	-	-
CO3	S	M	L	-	S	-	-		S	M	-	L	M	L	M
CO4	S	M	L	-	S	-	-		S	M	-	L	M	L	M
CO5	S	M	L	-	S	-	-		S	M	-	L	M	L	M
CO6	S	M	L	-	S	-	-		S	M	-	L	M	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO \ TPS	Assessment - I CAT – I (%)			Assessment - II CAT – II (%)			Terminal Exam (%)		
	1	2	3	1	2	3	1	2	3
CO1	-	10	-	-	-	-	Practical Exam		
CO2	-	10	30	-	-	-			
CO3	-	10	40	-	-	-			
CO4	-			-	20	30			
CO5	-			-	10	30			
CO6	-			-	-	10			
Total	**-**	**30**	**70**	**-**	**30**	**70**	**100**		

Syllabus

Basics: Smartphone implementation tools, smartphone implementation shells, Overview of ARM processor architecture, Android/iOS Software development tools. [2 Hours]

Sampling and Frame based processing: Sampling and Quantization, Android /iPhone audio signal sampling [4 Hours]

Fixed-Point and Floating Point representation for real time filtering: Q-format number representation, floating point number representation, overflow and scaling, Functional approximation [6 Hours]

Real Time Filtering: FIR/IIR filter implementation, circular buffering, frame processing, finite word length effect. [6 Hours]

Adaptive Signal Processing: Implementation of frequency domain adaptive filtering algorithm. [6 Hours]

Theory: 24 Hours

Practical:

1. Getting familiar with Android Software tools
2. Android Audio Signal Sampling
3. Fixed Point operations
4. Floating Point operations
5. Real time FIR filtering, Quantization effects and overflow
6. IIR filtering and Adaptive filtering
7. Frequency domain transforms – DFT and FFT
8. Code Optimization
9. MATLAB coder implementation

Practical:24 Hours
Total: 48 Hours

Text Book

- Nasser Kehtarnavaz, Abhishek Sehgal, Shane Parris, and Arian Azaran, "Smartphone-Based Real-Time Digital Signal Processing", 3rd Edition, A Publication in the Morgan & Claypool Publishers series Synthesis Lectures on Signal Processing, 2020.

Reference Books& web resources

- Nasser Kehtarnavaz, Fatemeh Saki, Adrian Druan and Arian Azarang, "Anywhere-Anytime Signals and Systems Laboratory: From MATLAB to Smartphones", 3rd Edition, A Publication in the Morgan & Claypool Publishers series Synthesis Lectures on Signal Processing, 2020.
- Sen M.Kuo, Bob H.Lee and Wenshun Tian, "Real-Time Digital Signal Processing, Fundamentals, Implementations and Applications", 3rd Edition, Wiley.
  https://onlinecourses.nptel.ac.in/noc22_ee99/preview

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	
1	**Basics:** Smartphone implementation tools, smartphone implementation shells	1
2	Overview of ARM processor architecture, Android/iOS Software development tools.	1
	Sampling and Frame based processing	
3	Sampling and Quantization	2
4	Android /iPhone audio signal sampling	2
	Fixed-Point and Floating Point representation for real time filtering	
5	Q-format number representation	2
6	Floating point number representation	2
7	overflow and scaling	1
8	Functional approximation	1
	Real Time Filtering	
10	FIR/IIR filter implementation	2
11	Circular buffering	1
12	Frame processing	1
13	Finite word length effect	2
	Adaptive Signal Processing	
14	Implementation of frequency domain adaptive filtering algorithm	6
	TOTAL	**24**

Course Designers:

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3. Dr.P.G.S.Velmurugan - pgsvels@tce.edu

22ECPH0	SIGNAL PROCESSING AND MACHINE LEARNING FOR AUDIO AND SPEECH	Category	L	T	P	Credit
		PSE	3	0	0	3

Preamble

This course aims to provide students with a foundational understanding of signal processing concepts and tools essential for the application of machine learning to discrete signals. Students will gain insights into techniques for capturing, processing, manipulating, learning, and classifying signals. The course will delve into diverse mathematical methods integral to machine learning, empowering students to craft and optimize their own models effectively. Emphasizing mathematical principles, the course includes coding-based assignments tailored for applications in audio and speech processing.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Apply mathematical tools and techniques on discrete signals for machine learning applications	TPS 3	70	70
CO2	Apply signal processing tools on speech and audio data	TPS3	70	70
CO3	Apply the theory of machine learning relevant to Signal Processing applications	TPS 3	70	70
CO4	Apply multi-class discriminant and support vector machine for Multi-class classification, Multi-label classification and regression analysis.	TPS 3	70	70
CO5	Apply probability models and Expectation Maximization algorithm for processing, manipulating, learning and classifying signals.	TPS 3	70	70
CO6	Apply Neural Networks and Deep Learning algorithms for audio classification	TPS 3	70	70
CO7	Apply Neural Networks and Deep Learning algorithms for speech recognition	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO2	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO3	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO4	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO5	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO6	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO7	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
TPS Scale / CO	2	3	4	2	3	4	2	3	4	2	3	4	2	3	4
CO1	-	10	30				-						-	4	15
CO2	-	10	20		100		-						-	4	10
CO3	-	10	20				-						-	4	15
CO4	-	-	-	-			-	10	20				-	2	10
CO5	-	-	-	-			-	10	20		100		-	2	10
CO6	-	-	-	-			-	5	20				-	2	10
CO7								5	10					2	10
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Basics for Signal Processing and Machine Learning (ML) Systems: Mathematical foundations for ML: Linear Algebra and convex optimization, Linear Gaussian systems and signal processing, Human speech production, perception mechanism, Cepstrum, Mel-Frequency Cepstral Coefficients (MFCCs), Wavelets, Short Time Fourier Transform, Time Series Analysis, [12 Hours]

Classification Problem: Statistical decision theory – Bayes Classifiers, detecting a constant signal in Gaussian noise, detecting change in variance, detecting known signal and detecting correlated signal. Linear and quadratic discriminant analysis. Multi-class discriminant analysis, Support Vector Machine in classification and regression. [6 Hours]

Probability Models and Expectation Maximization algorithm: Expectation Maximization (EM) algorithm, Gaussian Mixture Models [6 Hours]

ML for Audio Classification: Long Short Term Memory (LSTMs) and Convolutional Neural Networks (CNNs) [6 Hours]

ML for Speech Recognition: Hidden Markov Models, Finite State Transducers and Dynamic Programming [6 Hours]

Total: 36 Hours

Text Book

- C.M. Bishop, Pattern Recognition and Machine Learning, 2nd Edition, Springer, 2011.
- I. Goodfellow, Y, Bengio, A. Courville, Deep Learning, MIT Press, 2016.
- D. Yu and L. Deng, Automatic Speech Recognition: A Deep Learning Approach, Springer, 2016.
- Paolo Prandoni and MartinVetterli, Signal Processing for Communications, CRC-Taylor and Francis Group, 2008.
- Mohammed J.Zaki and Wagner Meira. J.R, Data Mining and Machine learning, fundamental concepts and algorithm, 2nd Edition, Cambridge University Press, 2020.
- Max A. Little, Machine Learning for Signal Processing: Data Science, Algorithms, and Computational Statistics, 1st Edition, Oxford University Press, 2019.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	
	Basics for Signal Processing and Machine Learning (ML) Systems	
1	Mathematical foundations for ML: Linear Algebra	1
2	Linear Algebra and convex optimization,	2

3	Linear Gaussian systems and signal processing	2
4	Human speech production	1
5	perception mechanism	1
6	Cepstrum	1
7	Mel-Frequency Cepstral Coefficients (MFCCs)	1
8	Wavelets	1
9	Short Time Fourier Transform	1
10	Time Series Analysis	1
	Classification Problem	
11	Statistical decision theory	1
12	detecting a constant signal in Gaussian noise	1
13	Bayes Classifiers	1
14	detecting change in variance, detecting known signal and detecting correlated signal	1
15	Linear and quadratic discriminant analysis. Multi-class discriminant analysis	1
16	Support Vector Machine in classification and regression	1
	Probability Models and Expectation Maximization algorithm	
17	Expectation Maximization algorithm	3
18	Gaussian Mixture Model	3
	ML for Audio Classification	
19	Long Short Term Memory (LSTMs)	3
20	Convolutional Neural Networks (CNNs)	3
	ML for Speech Recognition	
21	Hidden Markov Models	3
22	Finite State Transducers and Dynamic Programming	3
	TOTAL	**36**

Course Designers:

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22ECPJ0	DIGITAL SYSTEM DESIGN USING FPGA

Category	L	T	P	Credit	TE
PSE	2	0	2	3	Theory

Preamble

Digital System Design using FPGA aims to analyze the different architecture and organization of Field Programmable Gate Arrays. Initially the different elements like Programmable logic cell, interconnect and Input/Output cells of the FPGA are explored and analyzed. The subject focuses on the procedure for the design and implementation of sequential digital circuits and their mapping with the fixed platform of FPGA. It also deals with the implementation of algorithms that is used to interface the FPGA with the external world for applications. Finally, the learner is exposed with some reference case studies for FPGA implementation of combinational, sequential digital circuits and interfaces for practical applications.

Prerequisite

NIL

Course Outcomes

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

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the architecture, programming technologies of standard logic families and Programmable Logic Devices.	TPS3	70	70
CO2	Use the logic and dedicated blocks to implement combinational and sequential logics.	TPS3	70	70
CO3	Examine the Input / Output cells of FPGA for interfacing with external peripherals.	TPS3	70	70
CO4	Illustrate the routing process in interconnect architectures of different vendors of FPGA	TPS3	70	70
CO5	Verify the functionality of the digital logic functions using the IDE tool.	TPS3	70	70
CO6	Demonstrate the functioning of a digital system in a FPGA hardware platform	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	S	-	-	-	L	L	-	-	M	L	L
CO2	S	M	L	L	S	-	-	-	L	L	-	-	M	L	L
CO3	S	M	L	L	S	-	-	-	L	L	-	-	M	L	L
CO4	S	M	L	L	S	-	-	-	L	L	-	L	M	L	L
CO5	S	M	L	L	S	-	-	-	L	L	-	L	M	L	L
CO6	S	M	L	L	S	-	-	-	L	L	-	-	M	L	L

S-Strong; M-Medium; L-Low

Assessment Pattern

	Assessment-I CAT–I(%)			Assessment-II CAT–II(%)			Terminal Exam (Theory) (%)		
TPS / CO	1	2	3	1	2	3	1	2	3
CO1	-	10	20	-			-	04	20
CO2	-	10	30	-			-	04	20
CO3	-	20	10	-			-	04	10
CO4	-			-	05	30	-	04	10
CO5	-			-	10	20	-	02	10
CO6	-			-	05	30	-	02	10
Total	**-**	**40**	**60**	**-**	**20**	**80**	**-**	**20**	**80**

Psychomotor Skill	**Practical**
Perception	-
Set	-
Guided Response	-
Mechanism	100
Complex Overt Responses	-
Adaptation	-
Origination	-

Syllabus

Digital Design process: Standard IC: Logic families (TTL, ECL, CMOS), Design flow:PLD, CPLD, FPGA and ASIC, Architectures: Programmable Logic Devices, FPGA, Programming technologies: SRAM, DRAM, EPROM, EEPROM FLASH and Anti-fuses. **[8]**

Programmable Logic cells: Xilinx and Altera logic blocks, Dedicated blocks, Logic synthesis for combinational circuits, sequential circuits - Synchronous and Asynchronous Sequential Circuit -Finite State Machine design, Design examples. **[8]**

Programmable I/O cells: AC, DC inputs and outputs, Clock inputs and power inputs Xilinx I/O cells and Altera I/O cells. **[4]**

Programmable interconnects: Switch matrix, Xilinx and Altera interconnect architectures.**[4]**

Practical: **[24 hours]**

1. Simulation and Implementation of Basic gates and flip flops using Altera platform.
2. Simulation and implementation of Arithmetic circuits using Altera platform.
3. Simulation and Implementation of BCD to Seven segment display
4. Design and Implementation of Synchronous Mod counters
5. Design and Simulation of Sequence Detectors using FSM Approaches.
6. Interfacing LCD and PS2 keyboard with cyclone II FPGA using Altera DE1 board.
7. Interfacing matrix, PS2 keyboard with cyclone II FPGA using Altera DE1 board.
8. Controlling the speed of DC motor using Altera DE1 board.
9. Stepper motor angle control using Altera DE1 board.

Text Book

- M. Morris Mano and Michael D. Ciletti, "Digital Design: with an Introduction to the Verilog HDL", 5th Edition, Prentice Hall 2012.
- M.J.S.Smith, "Application Specific Integrated Circuits", Pearson, 2003.
- Samir Palnitkar, "Verilog HDL: A guide to digital design and synthesis" Pearson Education India, 2010.

Reference Books

- Jan M. Rabey, Anantha Chandrakasan and Borivoje Nikolic " Digital integrated circuits: A Design Perspective (2nd Edition) ", Pearson 2009.
- Stephen D. Brown, and Zvonko Vranesic, "Fundamentals of Digital Logic with Verilog Design, 2nd Edition," McGraw Hill, June, 2007.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1.	**Digital Design process**	
2.	Standard IC: Logic families (TTL, ECL, CMOS IC datasheets)	3
3.	Design flow: PLD, CPLD, FPGA and ASIC	1
4.	Architectures: Programmable Logic Devices, FPGA	2
5.	Programming technologies: SRAM, DRAM, EPROM, EEPROM FLASH and Anti-fuses	2
6.	**Programmable Logic cells**	
7.	Xilinx and Altera logic blocks (with reference datasheet)	2
8.	Dedicated blocks	1
9.	Logic synthesis for combinational circuits	1
10.	sequential circuits - Synchronous and Asynchronous Sequential Circuit	2
11.	Finite State Machine design	2
12.	Design examples	
13.	**Programmable I/O cells**	
14.	AC, DC inputs and outputs	1
15.	Clock inputs and power inputs	1
16.	Xilinx I/O cells and Altera I/O cells (from datasheet)	2
17.	**Programmable interconnects**	
18.	Switch matrix	2
19.	Xilinx and Altera interconnect architectures	2

Course Designers:

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22ECPK0	LOW POWER VLSI DESIGN

Category	L	T	P	Credit
PSE	3	0	0	3

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 optimization of power at various levels of design abstraction for designing energy-efficient digital systems used in battery operated devices

Prerequisite

NIL

Course Outcomes

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Demonstrate various sources of power dissipation in CMOS Digital logic Circuits.	TPS3	70	70
CO2	Use techniques to design circuits for leakage power reduction.	TPS3	70	70
CO3	Estimate the switching power in CMOS digital circuits using probabilistic and statistical techniques.	TPS3	70	70
CO4	Optimize the given Digital logic and arithmetic circuits for reduced power consumption.	TPS3	70	70
CO5	Apply circuit design techniques to the different elements of Memory to reduce power consumption.	TPS3	70	70
CO6	Modify the conventional digital logic circuits into adiabatic logic circuits using the energy recovery techniques.	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO2	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO3	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO4	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO5	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO6	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II** ***(%)					
TPS / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	10				-						-	4	15
CO2	-	10	20		100		-						-	4	15
CO3	-	10	40				-						-	4	15
CO4	-						-	5	20				-	2	15
CO5	-						-	5	30		100		-	2	10
CO6	-						-	10	30				-	4	10
Total	**-**	**30**	**70**		**100**		**-**	**20**	**80**		**100**		**-**	**20**	**80**

Syllabus

Power Dissipation in CMOS: Sources of power dissipation, Hierarchy of limits of power, Physics of power dissipation in MOSFET devices, leakage mechanism, leakage current in deep submicrometer transistors, low power VLSI design limits and issues, Circuit techniques for leakage power reduction. [10 hours]

Power Estimation: Signal Probability calculation, Probabilistic Techniques for signal activity estimation, Statistical Techniques, Estimation of Glitching power, Circuit level power estimation. [7 hours]

Power Optimization: Algorithm level, Logical level and Circuit level power optimization techniques, Techniques for reducing power consumption in digital circuits: supply voltage scaling, multiple supply voltages and minimizing switched capacitance. [7 hours]

Low Power Static RAM Architectures: Organization of a static RAM, MOS Static RAM Memory cell, Banked organization of SRAMs, Reducing voltage swings on bit lines, Reducing power in write driver circuits, Reducing power in sense amplifier circuits, method for achieving low core voltages from a single supply. [6 hours]

Adiabatic Logic Circuits: Energy recovery circuit design, Adiabatic charging, Adiabatic amplification, Adiabatic logic circuits, Pulsed power supply, Stepwise charging circuits, Partially adiabatic circuits – 2N-2N2P logic, Efficient charge recovery logic, Positive feedback logic. [6 hours]

Text Book

- Kaushik Roy and Sharat Prasad, “Low Power CMOS VLSI Circuit Design”, Wiley India, Reprint 2009.
- A.P. Chandrakasan and R.W. Broadersen, “Low Power Digital CMOS Design”, Kluwer,2012.

Reference Books& web resources

- P. Rashinkar, Paterson and L. Singh, “Low Power Design Methodologies”, Kluwer Academic, 2002
- Gary Yeap, “Practical Low Power Digital VLSI Design”, Kluwer, 1998.Abdellatif Bellaouar, Mohamed. I. Elmasry, “Low Power Digital VLSI designs” Kluwer, 1995.
- Jan Rabaey, “Low Power Design Essentials”, Springer Publications, 2009.
- 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 No.	Topic	No. of Lectures
1	**Power Dissipation in CMOS**	
1.1	Sources of power dissipation	1
1.2	Hierarchy of limits of power	1
1.3	Physics of power dissipation in MOSFET devices	2
1.4	Leakage mechanism, leakage current in deep submicrometer transistors	2
1.5	Low power VLSI design limits and issues	1
1.6	Circuit techniques for leakage power reduction	3
2	**Power Estimation**	
2.1	Signal Probability calculation	2
2.2	Probabilistic Techniques for signal activity estimation	2
2.3	Statistical Techniques	1
2.4	Estimation of Glitching power	1
2.5	Circuit level power estimation.	1
3.	**Power Optimization**	
3.1	Algorithm level	1
3.2	Logical level and Circuit level power optimization techniques	2
3.3	Techniques for reducing power consumption in digital circuits: supply voltage scaling	2
3.4	multiple supply voltages and minimizing switched capacitance	2
4	**Low Power Static Ram Architecture**	
4.1	Organization of a static RAM	1
4.2	MOS Static RAM Memory cell	1
4.3	Banked organization of SRAMs	1
4.4	Reducing voltage swings on bit lines	1
4.5	Reducing power in write driver circuits	1
4.6	Reducing power in sense amplifier circuits, method for achieving low core voltages from a single supply.	1
5	**Adiabatic Logic Circuits**	
5.1	Energy recovery circuit design	1
5.2	Adiabatic charging	1
5.3	Adiabatic amplification, Adiabatic logic circuits	1
5.4	Pulsed power supply, Stepwise charging circuits	1
5.5	Partially adiabatic circuits – 2N-2N2P logic	1
5.6	Efficient charge recovery logic, Positive feedback logic	1
	Total Number of Hours	**36**

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22ECRE0	CAD VLSI

Category	L	T	P	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. 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

NIL

Course Outcomes

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

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Demonstrate the knowledge of computational and optimization algorithms and tools applicable to solving CAD related problems	TPS3	70	70
CO2	Represent mechanism for Boolean functions that has application in logic synthesis and Verification	TPS3	70	70
CO3	Partition or divide the system into smaller portions based on the performance such as area, wire length and cost matrices.	TPS3	70	70
CO4	Determine the approximate location of each module in a chip area.	TPS3	70	70
CO5	Use Optimization algorithms in placement to determine the best position for each module on the chip.	TPS3	70	70
CO6	Analyse the Optimizations algorithms in VLSI Global and Detailed Routing process based on their wire length and area constraints.	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO2	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO5	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO6	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II *** (%)					
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	10				-						-	4	10
CO2	-	10	20		100		-						-	4	10
CO3	-	10	40				-						-	4	15
CO4	-						-	5	20				-	2	15
CO5	-						-	5	30		100		-	2	15
CO6	-						-	10	30				-	4	15
Total	-	**30**	**70**		**100**		**-**	**20**	**80**		**100**		**-**	**20**	**80**

Syllabus

VLSI Design Automation: VLSI Design Cycle, New trends in VLSI Design cycle, Physical Design cycle, Design styles, Different Packaging Styles, Design Abstraction Levels, Evolution of CAD Tools, Importance of Design Automation.

Data Structures and Basic Algorithms: Terminology, Complexity Issues and NP-hardness, Data Structures for the representation of Graphs, Graph algorithms for Physical design, Integer Linear Programming

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, Ratio Cut Algorithm, Fiduccia Mattheyess Algorithm, Clustering.

Chip Planning: Terminology, Optimization Goals in Floorplanning, Floorplan Representations: Floorplan to a Constraint-Graph Pair, Floorplan Sizing, Cluster Growth, Simulated Annealing, Integrated Floorplanning Algorithms**.**

Placement: Circuit Representation: bipatite Model Clique Model, Wire length Estimation; Global Placement Algorithms: Min-cut Placement, Analytic Placement, and Simulated Annealing Algorithms.

Routing: Fundamentals: Maze Running, Line Searching, Steiner Trees, and Global Routing: Sequential Approaches, Hierarchical approaches, Integer Linear Programming, 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: H-tree Based Algorithm, Power and Ground Routing.

Learning Resources

- Andrew B. Kahng, Jens Lienig, Igor L. Markov, Jin Hu, VLSI Physical Design: From Graph Partitioning to Timing Closure, Springer Dordrecht, 2011.
- 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

#	Topic	Lecture Hours
1.	**Introduction to the Course, COs POs**	1
2.	**VLSI Design Automation:** VLSI Design Cycle, New trends in VLSI Design cycle,	1
3.	Design styles, Different Packaging Styles	1
4.	Design Abstraction Levels,	1
5.	Physical Design cycle Evolution of CAD Tools, Importance of Design Automation.	1
6.	**Data Structures and Basic Algorithms:** Terminology	1
7.	Complexity Issues and NP-hardness	1
8.	Data Structures for the representation of Graphs,	1
9.	Graph algorithms for Physical design, Integer Linear Programming	1
10	**Logic Synthesis:** Combinational Logic Synthesis	1
11	Binary Decision Diagrams,	1
12	Reduced Ordered BDD principles, ROBDD Manipulation,	2
13	Variable Ordering, Two Level Logic Synthesis.	1
14	**System Partitioning:** Terminology, Optimization Goals	1
15	Kernighan-Lin Algorithm, Ratio Cut Algorithm	2
16	Fiduccia Mattheyess Algorithm	1
17	Clustering.	1
18	**Chip Planning**: Terminology, Optimization Goals in Floorplanning,	0.5
19	Floorplan Representations: Floorplan to a Constraint-Graph Pair	0.5
20	Floorplanning Algorithms: Floorplan Sizing, Cluster Growth,	2
21	Simulated Annealing, Integrated Floorplanning Algorithms.	2
22	**Placement:** Circuit Representation: bipatite Model Clique Model	0.5
23	Wire length Estimation	0.5
24	Global Placement Algorithms: Min-cut Placement,	2
25	Analytic Placement, and Simulated Annealing Algorithms	2
26	**Routing:** Fundamentals: Maze Running	1
27	Line Searching, Steiner Trees	1
28	Sequential Approaches, Hierarchical approaches	1
29	Integer Linear Programming,	1
30	Detailed routing: Channel Routing, switchbox Routing,	1
31	**Clock and Power Routing:** Clock Routing, Clocking Schemes	1
32	Design Considerations for the Clocking System, Problem Formulation,	1
33	Clock Routing Algorithms: H-tree Based Algorithm, Power and Ground Routing	1
		36

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22ECRF0	ASIC DESIGN

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

The course aims at ASIC physical design flow, including partitioning, floor-planning, placement, routing and testing.

Prerequisite

Nil

Course Outcomes

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

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the ASIC Design flow, Programmable ASICs, ASIC types and Library design	TPS2	70	70
CO2	Use algorithms to partition the ASIC to meet the given objectives	TPS3	70	70
CO3	Use floorplanning algorithms to place the logic cells inside the flexible blocks of an ASIC	TPS3	70	70
CO4	Use placement algorithms - Min-cut Placement, Eigen value Placement, Iterative Placement Improvement, Timing Driven Placement algorithms	TPS3	70	70
CO5	Use global and detailed routing algorithms to route the channels in ASIC and apply techniques for circuit extraction	TPS3	70	70
CO6	Use techniques to test ASIC- Boundary Scan Test, BIST.	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	5	15				-	-	-	-			-	4	10
CO2	-	10	30	50			-	-	-	-			-	4	10
CO3	-	10	30	50			-	-	-	-			-	2	15
CO4	-	-	-	-			-	10	20	100			-	2	15
CO5	-	-	-	-			-	10	25				-	4	15
CO6	-	-	-	-			-	10	25				-	4	15
Total	-	**25**	**75**	**100**			**-**	**30**	**70**	**100**			**-**	**20**	**80**

Syllabus

ASIC Types and Library Design: ASIC Design Flow, Types of ASIC - Full Custom, Semi Custom – Standard Cell Based ASIC and Gate Array ASIC - Programmable ASICs-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:** The importance of Testing-Boundary Scan Test- Faults-Faults Models- Physical and Logical Faults- IDDQ Test - Fault Simulation - Automatic Test-Pattern Generation, Design for Testability- Built-in-Self-Test.

Text Book

- Michael John Sebastian Smith, - Applications Specific Integrated Circuits, Pearson Education, 2013.

Reference Books& web resources

- 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 Techniquesfor 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.	Topic	No. of Hours
1	**ASIC Types and Library Design**	
1.1	ASIC Design Flow	1
1.2	Types of ASIC - Full Custom, Semi Custom	1
1.3	Standard Cell Based ASIC and Gate Array ASIC	2
1.4	Programmable ASICs, Library cell design	1
1.5	Library architecture	1
2	**System Partitioning**	
2.1	Measurement of Partitioning	1
2.2	Partitioning Algorithms - Constructive Partitioning	1
2.3	Iterative Partitioning Improvement Algorithms- Kernighan-Lin algorithm	2
2.4	Ratio-Cut Algorithm	1
2.5	FPGA Partitioning	1
3	**Floorplanning and Placement**	
3.1	Floor Planning Measurement and tools	2
3.2	I/O, Power and clock planning	1
3.3	Measurement of Placement	1
3.4	Placement Algorithms – Min-cut Placement	2
3.5	Eigen value Placement, Iterative Placement Improvement	1
3.6	Timing Driven Placement algorithms	1
4	**Routing and Circuit Extraction**	
5	**ASIC TESTING**	
5.1	The importance of Testing, Boundary Scan Test	1
5.2	Faults, Faults Models	1
5.3	Physical and Logical Faults	1
5.4	IDDQTest, Fault Simulation,	2
5.6	Automatic Test-Pattern Generation	2
5.7	Design for Testability, Built-in-Self-Test.	2
	Total	36

Course Designers:

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22ECRG0	REAL TIME SYSTEMS

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

The course on Real Time Systems is designed as a theory that aims to provide students with an understanding of operating system and real time systems principles. This subject dives into the core principles and practical applications of the embedded systems in real-time environments. The course covers Hard and Soft Real-Time systems, task scheduling, inter process communication and other resources managements. The final stretch of the course is covered with practical examples that showcase Free RTOS in action, and its API use cases.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the real time systems parameters	TPS 3	70	60
CO2	Distinguish between conventional operating system and a real time operating system	TPS 3	70	60
CO3	Describe and exemplify the RTOS kernel functions	TPS 3	70	60
CO4	Develop pseudo codes for multitasking scheduler	TPS 3	70	60
CO5	Develop a model for a real time embedded system methods and protocol for validation and testing	TPS 3	70	60
CO6	Develop the codes using free RTOS APIs	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	L	-	-	L	M	M	-	-	M	L	L
CO2	S	M	L	L	L	-	-	L	M	M	-	-	M	L	L
CO3	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	-	-	-	L	M	M	-	L	M	-	L
CO5	S	M	L	L	-	-	-	L	M	M	-	L	M	-	L
CO6	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**						**Terminal Exam**(%)		
	CAT – I(%)			**Assg. I** *(%)			**CAT – II**(%)			**Assg. II** *(%)					
TPS / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	20				-						-	4	10
CO2	-	10	20		100		-						-	4	10
CO3	-	10	30				-						-	4	15
CO4	-						-	10	20				-	-	15
CO5	-						-	10	30		100		-	4	15
CO6	-						-	10	20				-	4	15
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Real-Time Systems: Embedded Systems and Real-Time System characteristics, Structure, Response, Concurrency, Predictability, Safety and Reliability, Hard and Soft Real-Time Embedded Systems.

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, RTOS principles for System Bus Sharing and RTOS Examples POSIX.

Task Management: Tasks and Specification, Task control Block, Task Assignment and Scheduling, Clock-Driven Scheduling, Round-Robin Approach, Scheduling Algorithms: Rate monotonic, Priority-Driven, Bin-Packing, First-Fit, First-Fit Decreasing, Rate-Monotonic First-Fit (RMFF) and EDF

System modeling and Testing: Introduction to FSM, UML and Petri Nets.

Validation and testing: Program Validation and Testing

FreeRTOS: Datatypes and coding formats, task management APIs, IPC-Queue management, Timer management, Interrupts management and resource sharing APIs

Text Book

- Jiacun Wang, Real-Time Embedded Systems, "Wiley publication 1st edition 2017
- Richard Barry "Mastering the FreeRTOS Real Time Kernel A Hands-On Tutorial Guide

Reference Books

- Philip A.Laplante, "Real time systems analysis and Design-IEEE Computer Society Press PHI-2000
- Allan.V.Shaw, Real Time systems and software", John Wiley & Sons 2000.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
1	**Real-Time Systems (2)**	
2	Embedded Systems and Real-Time Embedded System characteristics,.	1
3	structure, response, concurrency, predictability, safety and reliability	1
	Functions of Operating Systems (6)	
4	Process Management, and Memory Management,	1
5	Interrupts Management,	1
6	Multitasking, File System Management, I/O Management	1
	Real-Time Operating Systems (10)	
7	Characteristics of RTOS Kernels, Scheduling	2
8	Priority Types Scheduling	2
9	Inter Task/Process Communication and Resource Sharing,	2
10	Real-Time Signals, Semaphores, Message Passing, Shared Memory, Memory Locking	2
11	RTOS principles for System Bus Sharing and RTOS Examples POSIX	2
	Task Management: **(10)**	
12	Tasks and its Specification, TCB	2
13	Task Assignment and Scheduling,	2
14	Clock-Driven Scheduling, Round-Robin Approach, S	2
15	cheduling Algorithms : Priority-Driven,	2

16	Bin-Packing, First-Fit, First-Fit Decreasing, Rate-Monotonic First-Fit (RMFF) and EDF	2
17	**System modeling and Testing (2)**	
18	Introduction to FSM, UML and Petri Nets	1
19	**Validation and testing:** Program Validation and Testing	1
	FreeRTOS (6)	
20	Datatypes and coding formats	1
21	Task management APIs	1
22	IPC and program	1
23	Timer management	1
24	Interrupts management	1
25	resource sharing APIs	1
	TOTAL	**36**

Course Designers:

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22ECPL0	IOT SYSTEM AND APPLICATIONS

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

This course is designed to provide a comprehensive understanding and practical mastery of Internet of Things (IoT) systems and their diverse applications. Through a structured curriculum, students will delve into the intricacies of IoT, ranging from its foundational characteristics, physical design, and protocols to the logical design and enabling technologies. The course aims to empower students with the necessary skills to design, implement, and optimize IoT systems.

Prerequisite

NIL

Course Outcomes

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the characteristics, physical design, protocols, logical design, and enabling technologies of IoT systems	TPS2	70	60
CO2	Use IoT design methodology - NETCONF-YANG, enabling the development of specifications, models, and integration strategies for devices and applications.	TPS3	70	60
CO3	Demonstrate proficiency in using Python packages, cloud platforms, web application frameworks, and working with basic building blocks of IoT devices and open-source hardware.	TPS3	70	60
CO4	Apply IoT Edge fundamentals, sensor integration with open-source hardware, and wireless protocol implementation for effective IoT communication.	TPS3	70	60
CO5	Apply the knowledge of cloud storage models, communication APIs, and key IoT platforms, including WAMP, Xively, Django, and AWS, for practical integration in IoT scenarios.	TPS3	70	60
CO6	Understand the Internet of Medical Things (IoMT) and apply Internet of Everything (IoE) concepts through case studies, gaining the ability to implement real-time applications in diverse contexts.	TPS3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	L	L	-	-	-	L	M	M	M	-	L	L	L
CO2	S	M	L	L	-	-	-	L	M	M	M	-	M	L	L
CO3	S	M	L	L	-	-	-	L	M	M	M	L	M	-	L
CO4	S	M	L	L	L	-	-	L	M	M	M	L	M	-	L
CO5	S	M	L	L	L	-	L	L	M	M	M	L	M	-	L
CO6	S	M	L	L	L	-	L	L	M	M	M	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**						**Terminal Exam**(%)		
	CAT – I(%)			**Assg. I** *(%)			**CAT – II**(%)			**Assg. II** *(%)					
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	25					-						-	15	
CO2	-		25	100			-						-		15
CO3	-		50				-						-		20
CO4	-						-	10	20				-		10
CO5	-						-	10	30	100			-		20
CO6	-						-	10	20				-	5	15
Total	**-**	**25**	**75**	**100**			**-**	**30**	**70**	**100**			**-**	**20**	**80**

Syllabus

Foundations of IoT Systems: Characteristics of IoT systems, Physical design and protocols Logical design, enabling technologies, and IoT levels, Domain-specific IoT: Medical IoT vs M2M. [4]

IoT Design Methodology and Specifications: Design methodology with NETCONF-YANG IoT design specifications, models, and level specifications, Device and component integration, and application development. [4]

Logical Design and Physical Devices in IoT: Python packages for IoT**,** Cloud platforms for IoT (AWS, Google Cloud, IBM Cloud)**,** Python web application frameworks**,** Basic building blocks of IoT devices, open source hardware (NodeMCU, Raspberry Pi-4, Intel Galileo Gen -2). [10]

IoT Edge: Introduction, sensor interface with Open Source Hardware, Wireless protocols for Internet of Things. [4]

IoT Physical Servers & Cloud Offerings: Introduction to cloud storage models and communication APIs,WAMP - AutoBahn for IoT, Xively Cloud for IoT, Python web application framework- Django, Designing a RESTful Web API, Amazon web services for IoT. [8]

IoECase Studies: smart lighting, home security, weather reporting BOT, smart irrigation**,** IoE in Retail Environments, Industry 4.0 Implementation. [4]

Internet of Medical Things (IoMT): Overview, Emerging Technologies, Benefits, Challenges and Case Studies. [2]

Text Book

- ArshdeepBahga, Vijay Madisetti, ―Internet of Things – A hands-on approach, Universities Press, 2015.

Reference Books& web resources

- Adrian McEwen, Hakim Cassimally ―Designing the Internet of Things, Wiley Publishing,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.
- SahshanuRazdan&Sachin Sharma (2022) Internet of Medical Things (IoMT): Overview, Emerging Technologies, and Case Studies, IETE Technical Review, 39:4, 775-788, DOI: 10.1080/02564602.2021.1927863
- https://www.cse.wustl.edu/~jain/cse574-16/
- https://www.techtarget.com/iotagenda/definition/IoMT-Internet-of-Medical-Things

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Foundations of IoT Systems	
1	Characteristics of IoT systems, Physical design and protocols	1
2	Logical design, enabling technologies	1
3	IoT levels	1
4	Domain-specific IoT: Medical IoT vs M2M	1
	IoT Design Methodology and Specifications	
5	Design methodology with NETCONF-YANG	1
6	IoT design specifications, models, and level specifications,	1
7	Device and component integration	1
8	Application development.	1
	Logical Design and Physical Devices in IoT	
9	Python packages for IoT	2
10	Cloud platforms for IoT (AWS, Google Cloud, IBM Cloud)	2
11	Python web application frameworks	2
12	Basic building blocks of IoT devices	2
13	Open-source hardware (NodeMCU, Raspberry Pi-4, Intel Galileo Gen -2).	2
	IoT Edge	
16	Introduction, sensor interface with Open Source Hardware	2
17	Wireless protocols for Internet of Things.	2
	IoT Physical Servers & Cloud Offerings	
18	Introduction to cloud storage models and communication APIs	2
19	WAMP - AutoBahn for IoT	1
20	Xively Cloud for IoT	1
21	Python web application framework- Django	2
22	Designing a RESTful Web API	1
23	Amazon web services for IoT	1
	IoECase Studies	
24	Smart lighting, home security, weather reporting BOT,	2
25	Smart irrigation, IoE in Retail Environments, Industry 4.0 Implementation.	2
	Internet of Medical Things (IoMT)	
26	Overview, Emerging Technologies, Benefits, Challenges	1
27	Case Studies	1
	TOTAL	**36**

Course Designers:

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22ECRH0	PARALLEL PROGRAMMING

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

The goal of this course is to make the students understand the need for multi-core processors, their architecture and various parallel programming paradigms.

Prerequisite

NIL

Course Outcomes

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the need for multicore architecture	TPS2	70	70
CO2	Use the concepts of Parallel program design	TPS3	70	70
CO3	Apply parallel programming concepts in Distributed Memory and shared Memory	TPS3	70	70
CO4	Develop parallel programs for distributed address space	TPS3	70	70
CO5	Develop parallel programs using shared memory paradigms	TPS3	70	70
CO6	Implement parallel programs for Tree Search	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	L	L		-	-	L	M	M	-	-	L	L	L
CO2	S	M	L	L	L	-	-	L	M	M	-	-	M	L	L
CO3	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	-	-	-	L	M	M	-	L	M	-	L
CO5	S	M	L	L	-	-	-	L	M	M	-	L	M	-	L
CO6	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**						**Terminal Exam** (%)		
	CAT – I(%)			**Assg. I** *(%)			**CAT – II**(%)			**Assg. II** *(%)					
TPS Scale / CO	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**
CO1	-	10	20		100		-	-	-	-	-	-	-	10	-
CO2	-	10	20				-	-	-	-	-	-	-	6	12
CO3	-	10	30				-	-	-	-	-	-	-	6	12
CO4	-	-	-	-	-	-	-	10	20		100		-	4	14
CO5	-	-	-	-	-	-	-	10	30				-	4	14
CO6	-	-	-	-	-	-	-	10	20				-	4	14
Total	-	**30**	**70**		100		**-**	**30**	**70**		**100**		**-**	**34**	**66**

Syllabus

Parallel Hardware: Need for high speed computing device, solving problems in parallel, Von Neumann architecture, Modifications to the von Neumann Model Parallel Hardware – SIMD and MIMD systems – Interconnection networks - Cache coherence - Shared Memory versus Distributed Memory Architectures, ARM-Neon-SIMD Architecture, Nividia GPU Architecture..

[8 hours]

Parallel Software: Caveats, Coordinating the processes/threads, Shared-memory, Distributed-memory, Programming hybrid systems, Input and Output, Performance, Parallel Program Design

[8 hours]

Distributed Memory Programming With MPI: MPI program execution – MPI constructs – libraries – MPI send and receive – Point-to-point and Collective communication – MPI derived datatypes – Performance evaluation

[7 hours]

Shared Memory Programming With OpenMP: OpenMP Execution Model – Memory Model – OpenMP Directives – Work-sharing Constructs - Library functions – Handling Data and Functional Parallelism – Handling Loops - Performance Considerations.

[8 hours]

Parallel Program Development: Case studies - n-Body solvers – Tree Search – OpenMP and MPI implementations and comparison.

[5 hours]

Text Book

- Peter S. Pacheco, —An Introduction to Parallel Programming, Morgan-Kauffman/Elsevier, 2011.

Reference Books& web resources

- Darryl Gove, —Multicore Application Programming for Windows, Linux, and Oracle Solaris, Pearson, 2011
- Michael J Quinn, —Parallel programming in C with MPI and OpenMP, Tata McGraw Hill,2003.
- V. Rajaraman, C. Siva Ram Murthy M., Parallel Computers - Architecture and Programming, PHI, 2016.
- Victor Alessandrini, Shared Memory Application Programming, 1st Edition, Concepts and Strategies in Multicore Application Programming, Morgan Kaufmann, 2015.
- Yan Solihin, Fundamentals of Parallel Multicore Architecture, CRC Press, 2015.
- https://nptel.ac.in/courses/106102163 by Dr. Yogish Sabharwal, IIT Delhi

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1.	**Introduction**	1
2.	**Parallel Hardware:** Need for high speed computing device, solving problems in parallel	
3.	Von Neumann architecture, Modifications to the von Neumann Model	1
4.	Parallel Hardware – SIMD	1
5.	MIMD systems	1
6.	Interconnection networks	1
7.	Cache coherence	
8.	Shared Memory versus Distributed Memory Architectures	1

9.	ARM-Neon-SIMD Architecture	1
10.	Nividia GPU Architecture	1
	Parallel Software	
11.	Caveats	1
12.	Coordinating the processes/threads	1
13.	Shared-memory	1
14.	Distributed-memory	1
15.	Programming hybrid systems	1
16.	Input and Output	1
17.	Performance	1
18.	Parallel Program Design	1
	Distributed Memory Programming With MPI	
19.	MPI program execution	1
20.	MPI constructs	1
21.	Libraries	1
22.	MPI send and receive	1
23.	Point-to-point and Collective communication	1
24.	MPI derived datatypes	1
25.	Performance evaluation	1
	Shared Memory Programming With OpenMP	
26.	OpenMP Execution Model	2
27.	Memory Model	1
28.	OpenMP Directives-Work-sharing Constructs	1
29.	Library functions	1
30.	Handling Data and Functional Parallelism	1
31.	Handling Loops	1
32.	Performance Considerations	1
	Parallel Program Development	
33.	Case studies: n-Body solvers, Tree Search	2
34.	OpenMP and MPI implementations and comparison	3
	Total	**36**

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22ECPM0	ELECTRONIC MEASUREMENT AND INSTRUMENTS

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

This course deals with the computation of errors in different types of electrical measurements, analog measurement concepts, DC bridges, AC bridges, Digital measurement concepts and the functionality of signal generators and oscilloscope.

Prerequisite

NIL

Course Outcomes

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Compute errors in different types of electrical measurements	TPS3	70	70
CO2	Use analog measurement concepts	TPS3	70	70
CO3	Determine resistance using DC bridges.	TPS3	70	70
CO4	Determine capacitance and inductance using AC bridges.	TPS3	70	70
CO5	Use Digital Measurement Concepts	TPS3	70	70
CO6	Understand the functionality of Signal generators and oscilloscope	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO2	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO3	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO4	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO5	S	M	L	-	L	-	-	-	M	-	-	L	M	L	L
CO6	M	L	-	-	L	-	-	-	M	-	-	L	L	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**						**Terminal Exam** (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)					
CO / **TPS**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	10				-						-	4	14
CO2	-	10	20		100		-						-	4	14
CO3	-	10	40				-						-	4	14
CO4	-						-	10	20				-	4	14
CO5	-						-	10	30		100		-	4	14
CO6	-						-	30	-				-	10	-
Total	-	**30**	**70**		**100**		**-**	**50**	**50**		**100**		**-**	**30**	**70**

Syllabus

Measurements and Measurement Error: Significance of measurements, methods of measurements, instruments and measurement systems, Functions of instruments and measurement systems, Calibration, Gross errors and systematic errors, Absolute and relative errors, basic concepts of accuracy, Precision, Repeatability, Tolerance, range/Span, Linearity, Sensitivity, threshold, Resolution and Significant figures. [8 Hours]

Analog Meters: PMMC Meter, Characteristics of Moving Coil Meter Movement, Moving Coil Galvanometer, Torque Equation of Galvanometer, D.C. Ammeter, Properties of shunt resistor, Multi-range Ammeter, DC Voltmeter, Multi-range Voltmeter, Sensitivity, Loading Effect, Ohmmeter, Series Ohmmeter, Shunt Type Ohmmeter. [8 Hours]

Bridges: Measurement of Resistance, Ammeter-Voltmeter Method, Kelvin Bridge, Double Kelvin Bridge, Substitution Method, Wheatstone Bridge, Measurement Errors in Wheatstone Bridge, A.C. Bridges, Condition for Bridge Balance, Maxwell Inductance Bridge, Maxwell Inductance Capacitance Bridge, Hay Bridge, Anderson Bridge, Owen Bridge, De Sauty Bridge, Schering Bridge, Wien Bridge. [8 Hours]

Digital Meters: Digital Voltmeter Systems, Types of Digital Voltmeter, Ramp-Type DVM, Dual-Slope Integrating Type DVM, Successive-approximation DVM, Digital Multimeter, Specification of Digital Multimeter, Digital frequency meter System, High Frequency Measurement. [6 Hours]

Signal generators and oscilloscope: Signal Generators, Audio Generators, Function Generators, Pulse Generators, Spectrum Analyser, Logic Analyser, Frequency Synthesizer, Oscilloscopes: Analog, Digital CRO and DSO. [6 Hours]

Text Book

- Reza Langari Alan S. Morris, ‘Measurement and Instrumentation Theory and Application’ Elsevier, 3rd Edition, 2020.

Reference book & web resources

- *Albert D.Helfrick and William D.Cooper* ““Modern Electronic Instrumentation and Measurement Techniques” Pearson, 2016.
- Ernest O. Doebelin, Measurement Systems-Application and Design, TMH,2007.
- R.S. Sedha, "Electronic Measurements and Instrumentation" S. Chand & Company, 2013.
- H. S. Kalsi, “Electronic Instrumentation”, Tata McGraw Hills, 2004
- Sawhney A K, 'A course in Electrical and Electronic Measurements and Instrumentation' Dhanpat Rai & Co, 2021.
- David A Bell “Electronic Instrumentation and Measurements”, Pearson Education, 2013.
- NPTEL course on Electrical Measurement and Electronic Instruments, Prof. Avishek chatterjee, IIT Kharagpur.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Measurements and Measurement Error**	
1.1	Significance of measurements, methods of measurements	1
1.2	instruments and measurement systems, Functions of instruments and measurement systems	1
1.3	Calibration, Gross errors and systematic errors	1
1.4	Absolute and relative errors, basic concepts of accuracy	1
1.5	Precision, Repeatability	1
1.6	Tolerance, range/Span	1
1.7	Linearity, Sensitivity	1

1.8	Threshold, Resolution and Significant figures	1
2	**Analog Meters**	
2.1	PMMC Meter, Characteristics of Moving Coil Meter Movement	1
2.2	Moving Coil Galvanometer, Torque Equation of Galvanometer	1
2.3	D.C. Ammeter, Properties of shunt resistor	1
2.4	Multi-range Ammeter, DC Voltmeter	1
2.5	Multi-range Voltmeter, Sensitivity	1
2.6	Loading Effect, Ohmmeter	1
2.7	Series Ohmmeter, Shunt Type Ohmmeter.	2
3.	**Bridges**	
3.1	Measurement of Resistance, Ammeter-Voltmeter Method	1
3.2	Kelvin Bridge, Double Kelvin Bridge	1
3.3	Substitution Method, Wheatstone Bridge	1
3.4	Measurement Errors in Wheatstone Bridge, A.C. Bridges	1
3.5	Condition for Bridge Balance, Maxwell Inductance Bridge	1
3.6	Maxwell Inductance Capacitance Bridge, Hay Bridge	1
3.7	Anderson Bridge, Owen Bridge	1
3.8	De Sauty Bridge, Schering Bridge, Wien Bridge	1
4	**Digital Meters**	
4.1	Digital Voltmeter Systems, Types of Digital Voltmeter	1
4.2	Ramp-Type DVM	1
4.3	Dual-Slope Integrating Type DVM	1
4.4	Successive-approximation DVM	1
4.5	Digital Multimeter, Specification of Digital Multimeter	1
4.6	Digital frequency meter System, High Frequency Measurement.	1
5	**Signal generators and oscilloscope**	
5.1	Signal Generators, Audio Generators	1
5.2	Function Generators, Pulse Generators	1
5.3	Spectrum Analyser	1
5.4	Logic Analyser, Frequency Synthesizer	1
5.5	Oscilloscopes: Analog	1
5.6	Digital CRO and DSO	1
	Total Number of Hours	**36**

Course Designers:

- Dr.K.Hariharan khh@tce.edu
- Dr.V.R.Venkatasubramani venthiru@tce.edu

22ECPN0	FIBER OPTIC COMMUNICATION

Category	L	T	P	Credit
PSE	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, integrated optics and photonics, future optical systems and Networks

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Determine the transmission characteristics of optical fiber and their measurement procedures.	TPS 3	70	60
CO2	Demonstrate the characteristics of optical sources and modulation techniques.	TPS 3	70	60
CO3	Analyze various coupling losses.	TPS 4	70	60
CO4	Demonstrate the characteristics of optical detectors and demodulation techniques	TPS 3	70	60
CO5	Demonstrate the characteristics of SONET/SDH, WDM network and network components.	TPS 3	70	60
CO6	Design and analyze the performance of optical communication links.	TPS 3	70	60

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	L	-	-	L	M	M	-	-	M	L	L
CO2	S	M	L	L	L	-	-	L	M	M	-	-	M	L	L
CO3	S	S	M	L	-	-	-	L	M	M	-	-	S	-	L
CO4	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L
CO5	S	M	L	L	-	L	-	L	M	M	-	L	M	-	L
CO6	S	M	L	L	-	L	-	L	M	M	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II											
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II** *(%)			**Terminal Exam** (%)		
TPS / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	30				-						-	4	20
CO2	-	10	20		100		-						-	4	10
CO3	-	10	20				-						-	4	10
CO4	-						-	10	20				-	4	15
CO5	-						-	10	20		100		-	4	10
CO6	-						-	10	30				-	-	15
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Introduction: Motivation and evolution of fiber optic system, Role of fiber optics in telecom, Key elements of optical fiber system: **Optical Fibers:** Structures, optical fiber modes and configurations, Modal analysis, Step-index and graded index optical fibers, Multi-core fibers, Ring core fiber, photonic crystal fiber, Fiber fabrication. Transmission characteristics of optical fiber: Attenuation, Dispersion. Test and Measurements: Basic test equipment, Optical power measurement and Optical time domain reflectometer. **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: Direct modulation, sub carrier modulation; Multiplexing strategies: Optical TDM, subcarrier multiplexing, OFDM, SDM. **Optical Power Launching and Coupling:** Lensing schemes for coupling improvement, Fiber-to-fiber joints, Splicing techniques, Fiber connectors. **Optical Receivers:** PIN photo detector, characteristics; Avalanche photodiode, characteristics, Noise in Photo detector. Demodulation: Direct detection, coherent detection. **Optical communication system and Networks:** System design consideration point –to –point links, Link power budget, Rise time budget. Optical network: Optical layer, SONET/SDH, high speed light wave link. WDM concepts and Components: Coupler, Isolator, Multiplexers, switches, cross connects. Optical amplifiers: EDFA. **Integrated optics and photonics:** Technologies, integrated optical devices: Beam splitters, directional couplers, Modulators, Polarization converters and photonic integrated circuits.

Text Book

- Gerd Kaiser, "Optical fiber communications", MCGraw Hill Int., 5th edition, 2017.
- John Senior, "Optica fiber communication-principles and practices", Prentice Hall of India, 3rd edition, 2013.

Reference Books

- Rajiv Ramaswami, Kumar Sivarajan, Galen Sasaki, "Optical Networks: a practical perspective" Morgan Kaufmann Publishers, 3rd edition, 2009.
- G.P. Agarwal, "Fiber optic communication system", Wiley, 4th edition, 2010.
- J.Gower, "Optical communication system", Prentice Hall of India, 2nd edition, 2001.
- Joseph C. Palais, "Fiber Optic Communication", Pearson Education, 5th edition, 2011.
- Biswanath Mukherjee, "Optical WDM Network", Springer, 1st edition.
- H Nishihara, M Haruna and T Suhara, Optical Integrated Circuits; McGraw-Hill Book Company, New York, 1989.
- C. R. Pollock and M Lipson, Integrated photonics, Kluwer Pub, 2003.
- José Capmany and Daniel Pérez, Photonic Integrated Circuits, Oxford University Press, 2020.
- NPTEL course on "Introduction to photonics" by Dr. Balaji Srinivasan.Link: https://nptel.ac.in/courses/108106135/
- NPTEL course on "Fiber Optic Communication Technology" by Prof. Deepa Venkitesh.

Link: https://www.youtube.com/watch?v=ougKUUM3hJA

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
1	**Overview of Optical Fiber Communication (9)**	
2	Motivation and evolution of fiber optic system, Elements of optical fiber transmission link, optics in telecom	1
3	Fiber Types: Step index, Graded index, Single mode, multimode,	1
4	optical fiber modes and configurations	2
5	Multi-core fibers, Ring core fiber, photonic crystal fiber, Fiber fabrication.	1
6	Transmission characteristics of optical fiber: Attenuation, Dispersion.	2
7	Test and Measurements: Basic test equipment, Optical power measurement and Optical time domain reflectometer.	1
	Optical Transmitters (6)	
8	Light Emitting Diode: structure, Characteristics: Quantum efficiency, output power, modulation bandwidth	2
9	Laser: Structure, laser diode mode and threshold condition, rate equation, quantum efficiency and resonant frequency	2
10	Direct modulation, sub carrier modulation/multiplexing OTDM, Optical OFDM, SDM	2
	Optical Power Launching and Coupling (5)	
11	Lensing schemes for coupling improvement,	2
12	Fiber-to-fiber joints, Splicing techniques	2
13	Fiber connectors	1
	Optical Receivers (6)	
14	PIN photo detector and Avalanche photodiode: characteristics	2
15	Noise in Photo detector.	2
16	Demodulation: Direct detection, coherent detection	2
	Optical communication system and Networks (10)	
17	System design consideration point –to –point links, Link power budget, rise time budget.	2
18	Optical network: Optical layer, SONET/SDH, high speed light wave link.	2
19	WDM concepts and Components: Coupler, Isolator, Multiplexers, switches, cross connects. Optical amplifiers: EDFA	3
20	Integrated optics and photonics: Technologies, integrated optical devices: Beam splitters, directional couplers, Modulators, Polarization converters and photonic integrated circuits.	3
	TOTAL	**36**

Course Designers:

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- Dr.K. Hariharan khh@tce.edu
- Dr. M. S. K. Manikandan manimsk@tce.edu
- Dr. E. Murugavalli murugavalli@tce.edu
- Dr.G. Prabhakar gpece@tce.edu

22ECPP0	5G WIRELESS NETWORKS

Category	L	T	P	Credit
PSE	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 Thing. This course also includes cloud network and security challenges in 5G network

Prerequisite

Nil

Course Outcomes

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

Course Outcomes

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Apply the access technologies for realizing the capabilities of TDMA, CDMA, GSM and LTE architecture of cellular networks	TPS 3	70	70
CO2	Illustrate the role of 5G and service-based architecture in the core and radio networks	TPS 2	70	75
CO3	Use the distributed mobility management functions for the next generation mobile networks	TPS 3	70	70
CO4	Describe the next generation application protocols such as 5GNAS, NGAP, PFCP, EAP and SCTP	TPS 3	70	70
CO5	use Cloud, Fog and Edge computing techniques for 5G enabled IoT	TPS 3	70	70
CO6	Use the privacy-preserving techniques and Blockchain technology for the IoT systems	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L
CO2	M	L	-	-	-	-	-	L	M	M	-	-	L	-	L
CO3	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L
CO5	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L
CO6	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

TPS / CO	Assessment - I						Assessment - II						Terminal Exam(%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)					
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	30	100			-						-	5	15
CO2	-	20	-				-						-	5	-
CO3	-	10	30				-						-	5	15
CO4	-						-	10	20	100			-	5	15
CO5	-						-	10	30				-	5	15
CO6	-						-	10	20				-	5	10
Total	-	**40**	**60**	**100**			**-**	**30**	**70**	**100**			**-**	**30**	**70**

Syllabus

Generation of Cellular Network: Principles of Cellular Networks, First- Generation Analog, Second- Generation TDMA Second- Generation CDMA Third- Generation Systems Fourth Generation Systems and LTE- LTE Architecture, Evolved Packet Core LTE Resource Management, LTE Channel Structure and Protocols **5G Architecture overview:** Overview, 5G—A new era of connectivity, The road to 5G network deployments, Core requirements, New use cases, New technologies, Two perspectives on 5G Core, Service-based architecture (SBA), The core of the core, Connecting the core network to mobile devices and radio networks, Mobility and data connectivity, 5GC interworking with EPC, Voice services, Messaging services **Management of 5G Networks:** PDU Session concepts, Session types, User plane handling, Mechanisms to provide efficient user plane connectivity, Edge computing, Session authentication and authorization, Local Area Data Network. **5G Protocols:** Protocols, 5G non-access stratum (5G NAS), NG application protocol (NGAP), Hypertext transfer protocol (HTTP), Transport layer security (TLS), Packet forwarding control protocol (PFCP), GPRS tunneling protocol for the User Plane (GTP-U), Extensible Authentication Protocol (EAP), IP security (IPSec), Stream Control Transmission Protocol (SCTP), Generic routing encapsulation. **5G Enabled Internet of Things:** 5G cloud, Mobile and Edge computing for IoT, Emerging challenges and requirements for IoT in 5G, Network function virtualization based IoT in 5G network, 5G small cells. **Privacy and Security Issues:** Privacy and security issues in 5G Enabled IoT, Privacy-preserving Techniques for the 5G Enabled Location Based Services, Block chain Technology for the 5G Enabled IoT Systems-Principles, Applications and Challenges.

Text Book

- Stefan Rommer, Peter Hedman, Magnus Olsson, Lars Frid, Shabnam Sultana, Catherine Mulligan, "5G Core Networks", Academic Press, 2020

Reference Books

- Cory Beard, William Stallings, "Wireless Communication Networks and Systems", Pearson, 2014.
- Stefan Rommer, Peter Hedman, Magnus Olsson, Lars Frid, Shabnam Sultana, Catherine Mulligan, "5G Core Networks", Academic Press, 2020
- Yulei Wu, Haojun Huang, Cheng-Xiang Wang, Yi Pan(edited),"5G Enabled Internet of Things", CRC Press, 2019.
- Saad Z. Asif, "5G Mobile Communications Concepts and Technologies", CRC Press, 2019.
- Jonathan Rodriguez, Fundamental of 5G Mobile Network, Wiley, 2015.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
	Generation of Cellular Network: (6)	
1	Principles of Cellular Networks, First- Generation Analog, Second-Generation TDMA and CDMA	1
2	Third- Generation Systems Fourth Generation Systems and LTE	1
3	LTE Architecture	1
4	Evolved Packet Core LTE	1
5	Resource Management	1
6	LTE Channel Structure and Protocols	1
	5G Architecture overview: (7)	
7	Overview, 5G—A new era of connectivity, The road to 5G network deployments	1
8	Core requirements, new use cases, new technologies, Two perspectives on 5G Core	1
9	Service-based architecture (SBA), The core of the core,	1
10	Connecting the core network to mobile devices and radio networks, Mobility and data connectivity	2
11	5GC interworking with EPC	1
12	Voice services, Messaging services	1
	Management of 5G Networks: (6)	
13	PDU Session concepts, Session types, User plane handling	2
14	Mechanisms to provide efficient user plane connectivity	2
15	Edge computing, Session authentication and authorization, Local Area Data Network	2
	5G Protocols: (6)	
16	5G non-access stratum (5G NAS), NG application protocol (NGAP), Hypertext transfer protocol (HTTP)	2
17	Transport layer security (TLS), Packet forwarding control protocol (PFCP), GPRS tunneling protocol for the User Plane (GTP-U)	2
18	Extensible Authentication Protocol (EAP), IP security (IPSec)	1
19	Stream Control Transmission Protocol (SCTP), Generic routing encapsulation	1
	5G Enabled Internet of Things: (6)	
20	5G cloud, Mobile and Edge computing for IoT	2
21	Emerging challenges and requirements for IoT in 5G	2
22	Network function virtualization based IoT in 5G network, 5G small cells	2
23	**Privacy and Security Issues: (5)**	
24	Privacy and security issues in 5G Enabled IoT	1
25	Privacy-preserving Techniques for the 5G Enabled Location Based Services	2
26	Block chain Technology for the 5G Enabled IoT Systems-Principles, Applications and Challenges	2
	TOTAL	**36**

Course Designers:

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22ECRJ0	AD-HOC NETWORKS AND APPLICATIONS

Category	L	T	P	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. This course also includes VANET enabled safety applications and Intelligent Transport Systems.

Prerequisite

Nil

Course Outcomes

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

Course Outcomes

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Identify the necessity of Ad Hoc and Sensor networks	TPS 2	70	75
CO2	Use various MAC protocols for Adhoc Network	TPS 3	70	70
CO3	Use various routing protocols for Adhoc Network	TPS 3	70	70
CO4	Use appropriate network protocol to provide solutions for transport layer issues	TPS 3	70	70
CO5	Apply appropriate protocols for sensor network based applications	TPS 3	70	70
CO6	Use VANET to disseminate information for intelligent transport systems	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	L	L	-	-	-	L	M	M	-	-	L	-	L
CO2	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L
CO3	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	L	-	-	L	M	M	-	-	M	L	L
CO5	S	M	L	L	L	-	-	L	M	M	-	-	M	L	L
CO6	S	M	L	L	L	-	-	L	M	M	-	-	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**						**Terminal Exam**(%)		
	CAT – I(%)			**Assg. I** *(%)			**CAT – II**(%)			**Assg. II** *(%)					
TPS / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	20				-						-	5	-
CO2	-	10	20	100			-						-	5	15
CO3	-	10	30				-						-	5	15
CO4	-						-	10	20				-	5	15
CO5	-						-	10	30	100			-	5	15
CO6	-						-	10	20				-	5	10
Total	-	**30**	**70**	**100**			**-**	**30**	**70**	**100**			**-**	**30**	**70**

Syllabus

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 and Transport layer protocols:** 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.

Wireless Sensor Networks: Introduction **–** Design Issues and challenges – Energy consumption – Clustering of sensors, MAC and Routing mechanisms of WSN **Applications and Case studies in WSN:** Target detection – Habitat Monitoring – Environment disaster Monitoring. **VANET**- Introduction to VANET and its Applications-VANET enabled Active Safety Applications -Infrastructure-to-vehicle applications Vehicle-to-vehicle applications, Pedestrian-to-vehicle applications **Information Dissemination in VANETs –**Intelligent Transport Systems (ITS) Introduction Obtaining Local Measurements Information Transport Protocols for information transport Improving network connectivity Geographical Data Aggregation

Text Book

- C.Siva Ram Murthy and B.S. Manoj, “Ad Hoc Wireless Networks – Architectures and Protocols”, Pearson Education, 2008.

Reference Books

- Feng Zhao and Leonidas Guibas, “Wireless Sensor Networks”, Morgan Kaufman Publishers, 2010.
- Hannes Hartenstein Kenneth P Laberteaux, “VANET: Vehicular Applications and Inter-Networking Technologies”, Wiley 2010.
- Jun Zheng and Abbas Jamalipour,“Wireless Sensor Network A Networking Perspective”, A John Wiley & Sons, Inc., Publication,2009.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
1	**Ad-hoc Mac: (9)**	
2	Design Issues in Ad-Hoc Networks - MAC Protocols – Issues	1
3	Classifications of MAC protocols: Contention Based Protocols, Contention Based Protocols with reservation mechanisms	3
4	Contention Based Protocols with Scheduling Mechanism	2
5	MAC protocol with Directional Antenna - Multi channel MAC & Power control MAC protocol	3
	Ad-Hoc Routing and Transport layer protocols: (9)	
6	Issues – Classifications of routing protocols:	1
7	Table Driven Protocols, On-Demand Routing Protocols	2
8	Hybrid Routing Protocols – Hierarchical and Power aware Routing Protocols	2
9	Ad Hoc Transport Layer Issues, TCP Over Ad Hoc, Feedback based,	2
10	TCP with explicit link, TCP-Bus, Ad Hoc TCP, and Split TCP	2
	Wireless Sensor Networks: (8)	
11	Design Issues and challenges	1
12	Energy consumption	1
13	Clustering of sensors,	1
14	MAC and Routing mechanisms of WSN	2
15	Applications and Case studies in WSN: Target detection – Habitat Monitoring – Environment disaster Monitoring.	3

	VANET: (5)	
16	Introduction to VANET and its Applications	1
17	VANET enabled Active Safety Applications	1
18	Infrastructure-to-vehicle applications Vehicle-to-vehicle applications, Pedestrian-to-vehicle applications	3
	Information Dissemination in VANETs: (5)	
19	Intelligent Transport Systems (ITS) Introduction, Obtaining Local Measurements	2
20	Information Transport Protocols for information transport	1
21	Improving network connectivity Geographical Data Aggregation	2
	TOTAL	**36**

Course Designers:

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22ECRK0	BLOCKCHAIN AND APPLICATIONS

Category	L	T	P	Credit
PEES	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 along with consensus mechanisms, crypto currencies, and smart contracts. The applications of Blockchain have now spread from crypto-currencies to various other domains, including business process management, IoT, trustworthy e-governance and so on.

Prerequisite

Nil

Course Outcomes

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

Course Outcomes

G30 CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Determine the role of Hash functions and digital signature as blockchain primitives	TPS 3	70	70
CO2	Describe the operations of Bitcoin and Ethereum	TPS 2	70	75
CO3	Apply the distributed consensus mechanisms of proof of work and proof of stake	TPS 3	70	70
CO4	Use the scripting language to write smart contracts and blockchain platforms to develop hyperledgers	TPS 3	70	70
CO5	Use Geth - Mist/ Metamask and hyper Ledger to develop the blockchain framework	TPS 3	70	70
CO6	Build the Blockchain use cases in finance, industry, IoT and e-governance.	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L
CO2	M	L	-	-	-	-	-	L	M	M	-	-	L	-	L
CO3	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L
CO5	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L
CO6	S	M	L	-	-	-	-	L	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam(%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)					
TPS / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	30				-						-	5	15
CO2	-	20	-		100		-						-	5	-
CO3	-	10	30				-						-	5	15
CO4	-						-	10	20				-	5	15
CO5	-						-	10	30		100		-	5	15
CO6	-						-	10	20				-	5	10
Total	-	**40**	**60**		**100**		**-**	**30**	**70**		**100**		**-**	**30**	**70**

Syllabus

Cryptography and Blockchain: Blockchain Mechanism – Centralization Vs Decentralization – P2P Systems - Transactions and Blocks - Consensus - Cryptographic Hash functions - SHA 256 - Proof of membership - Digital Signatures - Public Key Cryptosystems - encryption schemes and elliptic curve cryptography, Types of Blockchains.**Bitcoin:** Bitcoin transactions - Bitcoin script - Wallet - Ledger - Bitcoin Blocks - Bitcoin Network - Mining - Proof -of- Work Consensus - Cryptocurrency. **Ethereum**: The Ethereum Network – Components of Ethereum Ecosystem – Ethereum Programming Languages: Runtime Byte Code, Blocks and Blockchain- EVM - Smart Contract -Solidity. **Blockchain Development Frameworks:** Ethereum Development framework - Geth - Mist/Metamask-Web3 -HyperLedger as a Protocol - Reference Architecture - Hyperledger Fabric. **Applications and Emerging Trends:** Distributed applications - Blockchain interoperability - Non-Fungible Tokens (NFTs)- Scalability -Alt coins- Case studies - Finance, Industry – supply chain management, e-governance, Land Registration, Internet of Things, Medical Record Management System, and Domain Name Service.

Text Book

- Imran Bashir, “Mastering Blockchain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained”, Second Edition, Packt Publishing, 2018

Reference Books

- S.Shukla, M.Dhawan, S.Sharma, S. Venkatesan, “Blockchain Technology: Cryptocurrency and Applications”, Oxford University Press, 2019.
- M.Antonopoulos, “Mastering Bitcoin”, Second Edition, O’Reilly Publishers .2017.
- Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction. Princeton University Press ,2016.
- D. Drescher, ‘Blockchain Basics’ First Edition, Apress, 2017.
- Ambadas Tulajadas Choudhari, “Blockchain for Enterprise Application Developers”, Wiley Publication, 2016
- Anshul Kaushik, “Block Chain & Crypto Currencies”, Khanna Publication, 2018
- 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/

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
	Cryptography and Blockchain: (8)	
1	Blockchain Mechanism	1
2	Centralization Vs Decentralization, P2P Systems	1
3	Transactions and Blocks - Consensus	2
4	Cryptographic Hash functions - SHA 256 - Proof of membership - Digital Signatures	2
5	Public Key Cryptosystems - encryption schemes	1
6	Elliptic curve cryptography, Types of Blockchains	1
	Bitcoin: (7)	
7	Bitcoin transactions	1
8	Bitcoin script - Wallet - Ledger	2
9	Bitcoin Blocks - Bitcoin Network - Mining	2
10	Proof -of- Work Consensus - Cryptocurrency	2
	Ethereum: (7)	
11	The Ethereum Network – Components of Ethereum Ecosystem	1
12	Ethereum Programming Languages: Runtime Byte Code	2
13	Blocks and Blockchain- EVM	2
14	Smart Contract -Solidity	2
	Blockchain Development Frameworks: **(7)**	
15	Ethereum Development framework	1
16	Geth - Mist/Metamask	2
17	Web3 -HyperLedger as a Protocol - Reference Architecture -	2
18	Hyperledger Fabric	2
	Applications and Emerging Trends: **(7)**	
19	Distributed applications - Blockchain interoperability	2
20	Non-Fungible Tokens (NFTs)- Scalability Alt coins	1
21	Case studies - Finance, Industry – supply chain management, e-governance, Land Registration	2
22	Internet of Things, Medical Record Management System, and Domain Name Service	2
	TOTAL	**36**

Course Designers:

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22ECPQ0	CRYPTOGRAPHY AND CYBERSECURITY

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

The objectives of this course are to provide in-depth understanding of the underlying concepts of cryptographic techniques along with their network security applications. This course also includes various cybersecurity attacks and countermeasures.

Prerequisite

Nil

Course Outcomes

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

Course Outcomes

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Identify the threats and security attacks in the networks and corresponding services and mechanism	TPS 2	70	75
CO2	Use conventional encryption technique, classical encryption technique and modern encryption technique	TPS 3	70	70
CO3	Use Asymmetric encryption algorithm and Diffie-Hellman algorithm, Elliptic Curve Cryptography	TPS 3	70	70
CO4	Identify threats and services of cyber security	TPS 3	70	70
CO5	Use security tools and counter measures to overcome the cyber attacks	TPS 3	70	70
CO6	Relate various system security attacks along with their countermeasures	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	L	-	-	-	-	L	M	M	-	-	L	-	L
CO2	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L
CO3	S	M	L	L	-	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	-	-	-	L	M	M	-	-	M	L	L
CO5	S	M	L	L	-	-	-	L	M	M	-	-	M	L	L
CO6	S	M	L	L	-	-	-	L	M	M	-	-	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam(%)		
	CAT – I(%)			**Assg. I** *(%)			**CAT – II**(%)			**Assg. II** *(%)					
CO \ **TPS**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	20	-				-						-	5	-
CO2	-	10	30		100		-						-	5	15
CO3	-	10	30				-						-	5	15
CO4	-						-	10	20				-	5	15
CO5	-						-	10	30		100		-	5	15
CO6	-						-	10	20				-	5	10
Total	-	**40**	**60**		**100**		**-**	**30**	**70**		**100**		**-**	**30**	**70**

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-discrete Logarithms RSA algorithm Diffie-Hellman Key Exchange, Elliptic curve cryptography Message authentication and Hash function Hash MAC algorithms Digital signatures. **System Security**: Intruders Intrusion detection-password management -Viruses and related threats-Worms Firewall design Trusted systems Antivirus techniques digital immune systems. Case study-Secure Electronic Transaction **Cyber Security** – History of Internet – Impact of Internet – CIA Triad; Reason for Cyber Crime – Need for Cyber Security – History of Cyber Crime; Cybercriminals – Classification of Cybercrimes – A Global Perspective on Cyber Crimes; Cyber Laws – The Indian IT Act – Cybercrime and Punishment. **Attacks and Countermeasures** OSWAP; Malicious Attack Threats and Vulnerabilities: Scope of Cyber-Attacks – Security Breach – Types of Malicious Attacks – Malicious Software – Common Attack Vectors – Social engineering Attack – Wireless Network Attack – Web Application Attack – Attack Tools – Countermeasures

Text Book

- William Stallings, “Cryptography and network security”, 4th Edition, PHI, 2012

Reference Books

- W.R. Cheswick, S.M. Bellovin and A.D. Rubin, “Firewalls and Internet Security”, Addison Welseyy, 2003.
- Anand Shinde, “Introduction to Cyber Security Guide to the World of Cyber Security”, Notion Press, 2021.
- Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives by Sumit Belapure and Nina Godbole, Wiley India Pvt. Ltd., 2011
- R. C. Mishra, “Cyber Crime Impact in the New Millennium”, Author Press. 2010
- NPTEL course on Cryptography and network security: https://nptel.ac.in/courses/106105031/

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
1	**Conventional Encryption**: **(6)**	
2	Introduction Conventional Encryption model	1
3	Data Encryption Standard	2
4	block cipher Encryption algorithms and confidentiality	2
5	Key distribution	1
	Encryption and Hashing: (10)	
6	Principles of Public key cryptosystems Number Theory-discrete	1

	Logarithms	
7	RSA algorithm	2
8	Diffie-Hellman Key Exchange,	2
9	Elliptic curve cryptography	2
10	Message authentication and Hash function and Hash MAC algorithms	2
11	Digital signatures	1
	System Security: (7)	
12	Intruders Intrusion detection-password management	1
13	Viruses related threats and Worms	1
14	Firewall design	2
15	Trusted systems Antivirus techniques digital immune systems.	2
16	Case study-Secure Electronic Transaction	1
	Cyber Security: (6)	
17	History of Internet – Impact of Internet – CIA Triad; Reason for Cyber Crime – Need for Cyber Security – History of Cyber Crime;.	2
18	Cybercriminals – Classification of Cybercrimes – A Global Perspective on Cyber Crimes;	2
19	Cyber Laws – The Indian IT Act – Cybercrime and Punishment	2
	Attacks and Countermeasures: **(7)**	
20	OSWAP; Malicious Attack Threats and Vulnerabilities: Scope of Cyber-Attacks – Security Breach	2
21	Types of Malicious Attacks – Malicious Software – Common Attack Vectors	1
22	Social engineering Attack – Wireless Network Attack – Web Application Attack	2
23	Attack Tools – Countermeasures	
	TOTAL	**36**

Course Designers:

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22ECPR0	CONTROL SYSTEMS

Category	L	T	P	Credit
PSE	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

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Compute transfer function of multiple subsystems modelled as state space representation.	TPS 3	70	60
CO2	Compute transfer function of multiple subsystems modelled as block diagram and signal flow graph.	TPS 3	70	60
CO3	Compute and describe the output response and steady state error of first, second and higher order systems for standard input signals	TPS 3	70	60
CO4	Determine the stability of a system using Routh Hurwitz criterion.	TPS 3	70	60
CO5	Determine the stability of a system using Root locus and Nyquist criterion.	TPS 3	70	60
CO6	Find the closed loop frequency response and time response parameter given the open loop frequency response.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO2	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO3	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO4	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO5	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO6	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
TPS / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20				-						-	4	10
CO2	-	10	20		100		-						-	4	10
CO3	-	10	30				-						-	4	15
CO4	-						-	10	20				-	-	15
CO5	-						-	10	30		100		-	4	15
CO6	-						-	10	20				-	4	15
Total	-	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Modeling of Control Systems: Basic control system components: Open loop LTI systems, closed loop LTI systems, transfer function, electrical network transfer function, Electric circuits, general state-space representation, converting a transfer function to state space, converting from state space to a transfer function. **Reduction of multiple subsystems:** Block diagram representation, Analysis and Design of Feedback Systems Signal flow graph, Mason's Rule, Signal flow graphs of state equation. **Transient and steady-state analysis of LTI systems:** 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, Steady state error analysis. **Stability:** Routh Hurwitz criterion, Root locus techniques: Lag, lead and lag-lead compensation, 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

Text Book

- Norman S. Nise, 'Control Systems Engineering, Wiley India Edition, 2019
- G. Franklin, J. Powell, A.Emami-Naemi, 'Feedback Control of Dynamical Systems', Pearson, 8th Edition, 2019.
- R. C. Dorf, R. H. Bishop, 'Modern Control Systems', Pearson; 13th edition, 2016.
- K. Ogata, 'Modern Control Engineering', Pearson Education India; 5th edition, 2015

Reference Books

- M. Gopal, Control Systems: Principles and Design, 2nd Ed., Tata McGraw-Hill, 2012
- P. Belanger, Control Engineering: A modern approach, Saunders College Publishing, s1995.
- https://onlinecourses.nptel.ac.in/noc20_ee90/preview , C.S.Shankar Ram, IIT Madras

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
1	**Modeling of Control Systems**, ,	
2	Basic control system components: Open loop LTI systems, closed loop LTI systems,	1
3	transfer function, electrical network transfer function ,Electric circuits,	1
4	general state-space representation,	1
5	converting a transfer function to state space	1
6	converting from state space to a transfer function	1
	Reduction of multiple subsystems,	
6	Block diagram representation	1
7	Analysis and Design of Feedback Systems	1
8	Signal flow graph	1
9	Mason's Rule	1
10	Signal flow graphs of state equation	2
	Transient and steady-state analysis of LTI systems	
11	Poles, zeros and system response	1
12	first order systems	1
13	second order Systems	1
14	General second order systems	1
15	underdamped second order systems	1
16	Higher order systems	1
17	System response with additional poles	1
18	system response with zeros, Steady state error analysis	1

	Stability	
19	Routh Hurwitz criterion	2
20	Root locus techniques	2
21	Lag, lead and lag-lead compensation,	2
22	Nyquist stability	2
	Frequency response techniques:	
23	Bode plot,	2
24	Nyquist diagram, Gain margin, phase margin	2
25	transient response via gain adjustment	2
24	Lag compensation, Lead compensation, Lag-Lead compensation	2
	TOTAL	**36**

Course Designers:

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22ECPS0	VLSI DEVICE MODELING

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

In the ever-evolving landscape of VLSI systems, MOSFETs have emerged as the cornerstone of present and future generations. The VLSI industry has strategically transitioned towards the exclusive utilization of MOSFETs across all functionalities. This course serves as an introduction to the fundamental principles of device modeling, a discipline that amalgamates device physics with experimentally derived characteristics. Through this synthesis, participants will gain insights into formulating predictive equations and expressions that delineate device performance across various excitation scenarios

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the fundamentals of VLSI device physics.	TPS 3	70	60
CO2	Analyze the I-V characteristics of MOSFET in a Long channel MOSFET.	TPS 3	70	60
CO3	Grasp the CMOS scaling theory, understand the threshold voltage requirements, and the effects of short-channel MOSFET	TPS 3	70	60
CO4	Explore advanced CMOS engineering techniques including quantum confinement.	TPS 3	70	60
CO5	Understand the operation principles and characteristics of non-classical transistors including SOI MOSFETs.	TPS 3	70	60
CO6	Learn the TCAD simulation flow for IC process and device simulation, including numerical solution methods.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	-	L	L	-	-	M	-	L
CO2	S	M	L	-	-	-	-	-	L	L	-	-	M	-	L
CO3	S	M	L	-	-	-	-	-	L	L	-	-	M	-	L
CO4	S	M	L	-	-	-	-	-	L	L	L	-	M	-	L
CO5	S	M	L	-	-	-	-	-	L	L	L	-	M	-	L
CO6	S	M	L	-	M	-	-	-	L	L	L	-	M	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO \ TPS Scale	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	5	10	10				-						-	4	10
CO2	5	10	10		100		-						-	4	10
CO3	10	10	30				-						-	4	15
CO4	-						5	10	10				-	2	15
CO5	-						5	10	30		100		-	2	15
CO6	-						10	10	10				-	4	15
Total	**20**	**30**	**50**		**100**		**20**	**30**	**50**		**100**		**-**	**20**	**80**

Syllabus

Introduction to VLSI Device Modeling: Overview of VLSI technology and its importance**,** Semiconductor materials and their properties**,** Crystal structure and lattice constants**,** Energy band theory and charge carriers**,** Carrier transport mechanisms, MOSFET structure and operation**,** Threshold voltage and its dependence on device parameters.

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 Frequency-dependent 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.

MOSFET Scaling and Short Channel Effects: CMOS Scaling theory– 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 – Junction less 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.

Text Book

- Das Gupta, Nandita, and Amitava Das Gupta. Semiconductor devices: Modelling and Technology. PHI Learning Pvt. Ltd., 2004.

Reference Books

- N. B. Balamurugan - “Analog Electronic circuits: Theory and Practicals”, AICTE, New Delhi, 2024, https://ekumbh.aicte-india.org/book.php#.
- 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, 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
- J.P.Colinge ―FinFETs and other Multigate Transistors‖, Springer, Germany, 2010.
- Visvendra Singh Poonia, IIT Roorkee, Physics of Nano Scale Devices, NPTEL video Lectures: https://onlinecourses.nptel.ac.in/noc24_ee70.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to VLSI Device Modeling:	
1	Overview of VLSI technology and its importance.	2
2	Semiconductor materials and their properties, Crystal structure and lattice constants	2
3	Energy band theory and charge carriers.	1
4	Carrier transport mechanisms	2
5	MOSFET structure and operation, Threshold voltage and its dependence on device parameters.	1
	Long Channel Effects:	
6	Ideal MOS C-V Characteristics, Effect of non-idealities on C-V.	1
7	MOS Parameter extraction from C-V characteristics and I-V characteristics.	1
8	MOSFET Channel Mobility.	1
9	MOSFET capacitances, Inversion-Layer Capacitance effect and frequency dependent capacitance.	1
	MOSFET Scaling and Short Channel Effects:	
10	CMOS Scaling theory	1
11	Threshold-Voltage Requirement	1
12	MOSFET Channel Length	1
13	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.	1
	MOSFET Scaling and Short Channel Effects:	
14	Quantum effects, Volume inversion	1
15	Channel and Source / Drain engineering.	2
16	High-k dielectric, Strain engineering	1
17	Multigate technology mobility	1
18	Gate stack Engineering, Halo implants.	1
	Non – Classical Transistors:	
19	SOI MOSFET structures.	1
20	Partially Depleted (PD) and Fully Depleted SOI MOSFETs.	1
21	Double Gate.	1
22	Surrounding Gate, Multigate MOSFETs.	1
23	FINFETs - TFETs – HEMTs.	1
24	Silicon Nanowires – Junctionless FETs.	1
	TCAD Simulation:	
25	TCAD Flow for IC Process and Device Simulation, Numerical Solution Methods.	1
26	Drift Diffusion Calculations, Energy Balance Calculation.	1
27	Classical Models - Thermodynamic and Schrodinger Model.	1
28	Random Dopant Fluctuations, Ballistic Transport.	1
	TOTAL	**36**

Course Designers:

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- Dr.V.R.Venkatasubramani venthiru@tce.edu
- Dr.J.Shanthi jsiece@tce.edu

22ECPTO	DATA STRUCTURES IN C

Category	L	T	P	Credit	TE
PSE	2	0	2	3	Practical

Preamble

Data structures and algorithms serve as the bedrock upon which all software systems are built, enabling efficient manipulation and organization of data, and facilitating the creation of powerful and scalable applications. This course offers formal introduction the fundamental principles behind various data structures and algorithms, understanding their strengths, weaknesses, and applications. From linear abstract data types stack, queue and linked lists to advanced topics such as trees, graphs, hashing and dynamic programming,

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Implement linear data structures such as stack, queue, linked lists	TPS 3	70	60
CO2	Implement non-linear data structures such as binary trees and priority queues.	TPS 3	70	60
CO3	Analyze the time complexity of sorting and hashing algorithms.	TPS 4	70	60
CO4	Apply graph algorithms in solving real time problem.	TPS 3	70	60
CO5	Apply dynamic programming in solving real time problem.	TPS 3	70	60
CO6	Choose appropriate data structure and algorithms to solve a real time problem efficiently	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	M	L	L	-	-	L	M	M	-	-	-	M	L
CO2	S	M	M	L	L	-	-	L	M	M	-	-	-	M	L
CO3	S	M	M	L	L	-	-	L	M	M	-	L	-	M	L
CO4	S	M	M	L	L	-	-	L	M	M	-	L	L	M	L
CO5	S	M	M	M	L	-	-	L	M	M	-	L	-	M	L
CO6	S	M	M	M	L	-	-	L	M	M	-	L	L	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Practical Exam (%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)					
TPS / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20	-			-	-	-	-			-	-	20
CO2	-	10	30	-			-	-	-	-			-	-	30
CO3	-	10	20	-			-	-	-	-			-	-	10
CO4	-	-	-	-			-	10	30	-			-	-	10
CO5	-	-	-	-			-	10	20	-			-	-	10
CO6	-	-	-	-			-	10	20	-			-	-	20
Total	-	**30**	**70**	**-**			**-**	**30**	**70**	**-**			**-**	**-**	**100**

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 (only Logical level)

Linear Data Structures: Implementation of Stacks, Queues, Linked Lists – Singly Linked List, Doubly Linked List, Circular Linked List

Nonlinear Data Structures: Implementation of Binary tree, Tree traversal, Binary Search tree (BST), AVL tree, and Priority Queues: Binary Heaps (only Logical level)

Hashing and Sorting Algorithms: Hash tables, Hash functions, Collision Resolution, Rehashing, Quick Sort

Graph Algorithms: Graph Terminologies, DFS, BFS, Topological Sorting, Minimum Spanning Tree algorithms, Shortest Path Algorithms – Dijkstra Algorithm

Dynamic Programming: Elements of dynamic programming, 0/1 knapsack problem, Longest Common subsequence

PRACTICAL

List of Experiments:

1. Implement the basic operation of Stack and Queue using arrays - CO1
2. Implement insertion, deletion and searching operations in Linked list- CO2
3. Implement insertion, deletion and searching in BST- CO3
4. Implement Hash table with linear/quadratic probing collision resolution techniques- CO4
5. Implement Dijkstras' Algorithm to find the shortest path in a graph - CO4
6. Implement Dynamic Programming to find the longest common subsequence - CO5
   Mini Project – CO6

Text Book

- Seymour Lipschutz — Data Structures with C, Tata McGraw-Hill, 2017.
- Mark Allen Weiss, —Data Structures and Algorithm Analysis in C —, 2nd edition, PearsonEducation, 2013.

Reference Books

- Sartaj Sahni, —Data Structures, Algorithms and applications in C++, 2nd edition, Silicon Press, 2017.
- Michael T., Goodrich, —Data Structures and Algorithms in C++, 2nd edition, John Wiley, 2016.
- Adam Drozdek, Data Structures and Algorithms in C++, 4th edition, Cengage, 2013.
- Michael T., Goodrich, —Data Structures and Algorithms in Python, 2nd edition, Wiley, 2016.
- Mark Allen Weiss, —Data Structures and Algorithm Analysis in java —, 6th edition, Pearson Education, 2014.
- Nell Dale, —C++ Data structures, 6th edition, Jones and Bartlett Publishers, 2016.
- Cormen, Thomas, Charles Leiserson, et al. Introduction to Algorithms. 3rd edition, MIT Press, 2009.
- Coursera course on data structures and algorithms https://www.coursera.org/specializations/data-structures-algorithms
- NPTEL course on Programming, Data Structures And Algorithms using python by Prof. Madhavan Mukund, Chennai Mathematical Institute https://onlinecourses.nptel.ac.in/noc22_cs26/preview
- NPTEL course on Programming, Data structures and Algorithms by Prof. Hema A Murthy, Dr. N S. Narayanaswamy, Prof. Shankar Balachandran, IIT Madras - https://nptel.ac.in/courses/106106133

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction	
1	Role of data structures and algorithms in data organization Data Abstraction and Abstract Data Types	2
2	Algorithms: complexity, time space tradeoff	
3	Asymptotic measures – Big O, theta and omega	2
4	Types of Algorithms - Divide and Conquer, greedy, back tracking, dynamic programming (only Logical level)	
	Linear Data structures	
5	Basic operations of Stack – Push, Pop	2
6	Basic operations of Linear Queue – Enqueue, dequeue	
7	Linked Lists: Single Linked List – Doubly Linked List – Circular Linked	2
	Non-linear Data structures	
8	Implementation of Binary tree, Tree traversal – preorder, in order, post order, level order	2
9	Basic operations of Binary Search Tree – Insert, delete, search	
10	Basic operations of AVL Tree – Insert, delete, search	2
11	Priority Queues: Binary Heap	2
	Hashing and Sorting	
12	Hash tables, Hash functions	2
13	Collision Resolution: Separate Chaining, Linear probing, Quadratic probing	
14	Rehashing	2
15	Sorting Algorithms – Quick Sort	
	Graph Algorithms	
16	Basic Terminologies	2
17	Depth First Search(DFS)/ Breadth First Search(BFS) – **only Logical level**	
18	Topological Sorting **- only Logical level**	
19	Minimum Spanning Tree Algorithms – Prim’s Algorithm	2
20	Shortest Path Algorithm – Dijkstra’s Algorithm	
	Dynamic Programming	
21	Elements of dynamic programming, knapsack problem	2
22	Longest Common subsequence	
	PRACTICAL	**24**
	TOTAL	**48**

Course Designers:

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22ECRW0	ANTENNAS FOR 5G/6G COMMUNICATION SYSTEMS

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

This course focuses on antenna design for 5G and future 6G mobile communication systems. Students will learn about the frequency spectrum, 5G antenna requirements, and antenna types like Sub-6GHz, mm-wave, and multiband antennas. The course also covers mobile terminal antenna challenges, including form factor, wideband operation, and SAR compliance, with designs like patch and slot antennas. For 5G base stations, students will study high-efficiency antennas, diversity antennas, and mm-wave tapered slot antennas. Finally, the course explores advanced antenna technologies for 6G, such as terahertz antennas, massive MIMO, meta-surfaces, and holographic beamforming antennas.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Identify the design requirements for 5G and 6G communication systems, including various types of antennas.	TPS 3	70	70
CO2	Apply antenna design principles for mobile terminals, addressing challenges using patch, slot, and Vivaldi antennas.	TPS 3	70	70
CO3	Apply design principles for mm-wave slot antennas, diversity antennas, and shared aperture antennas for base stations	TPS 3	70	70
CO4	Apply techniques for phased arrays, beam steering, beamforming, polarization, and isolation using advanced materials	TPS 3	70	70
CO5	Apply design principles for advanced antennas like terahertz, MIMO, meta-surface, holographic, lens, and integrated sensing antennas.	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	M	M	-	L	M	-	L
CO2	S	M	L	-	M	-	-	M	M	-	L	M	-	L
CO3	S	M	L	-	M	-	-	M	M	-	L	M	-	L
CO4	S	M	L	-	M	-	-	M	M	-	L	M	-	L
CO5	S	M	L	-	M	-	-	M	M	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
CO \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20				-						-	4	16
CO2	-	10	20		100		-						-	4	16
CO3	-	10	30				-						-	4	16
CO4	-						-	15	35		100		-	4	16
CO5	-						-	15	35				-	4	16
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Introduction: 5G Mobile Communication Systems, frequency spectrum, 5G antenna design requirements, Antenna parameters. Sub-6GHz antennas, mm-wave and reconfigurable multiband antennas. Spectrum and Requirements for 6G Communication, Millimeter-Wave and Terahertz Antennas, Lens Antennas.

5G Mobile terminal antennas: Challenges in mobile terminal antennas - form factor, wideband and multi-band operation, SAR compliance. Wide band compact antenna designs, high gain antennas, Flexible antennas, Patch antenna, slot antenna and Vivaldi antenna.

5G Base station antennas: mm-wave tapered slot antenna, dielectric and metamaterial loaded, diversity antenna with radome, high aperture, efficiency antenna, shared aperture antenna for base station, pattern diversity.

Antenna arrays for 5G: phased arrays, beam steering, digital and hybrid beamforming techniques. linear and circularly polarized differential antennas, conformal transmit arrays, multi beam transmit array. UWB dual polarized array, Isolation techniques - Electromagnetic Band Gap, Defected Ground Surface, Metamaterials.

Advanced antennas for future 6G: Terahertz antennas, Massive MIMO Antennas, Reconfigurable Intelligent Surface antennas, Metasurface antennas, Holographic Beamforming antennas, Lens antennas, Integrated Sensing and Communication antennas.

Text Book

- Qingqing Wu, Trung Q. Duong, Derrick Wing Kwan Ng, Robert Schober, Rui Zhang, Intelligent Surfaces Empowered 6G Wireless Network, John Wiley & Sons, 2023.
- Wonbin Hong, Chow-Yen-Desmond Sim, Microwave and Millimeter-Wave Antenna Design for 5G Smartphone Applications, IEEE Press, 2022.
- Y. Jay Guo, Richard W. Ziolkowski, Antenna and Array Technologies for Future Wireless Ecosystems, IEEE Press, 2022.
- Y. Jay Guo, Richard W. Ziolkowski, Advanced Antenna Array Engineering for 6G and Beyond Wireless Communications, IEEE Press, 2021.
- Prashant Ranjan, Dharmendra Kumar Jhariya, Manoj Gupta, Krishna Kumar, Pradeep Kumar, Next-Generation Antennas: Advances and Challenges, Scrivener Publishing LLC, 2021.
- Trevor Bird, Mutual Coupling Between Antennas, John Wiley & Sons, 2021
- Satish K. Sharma, Jia-Chi S. Chieh, Multifunctional Antennas and Arrays for Wireless Communication Systems, John Wiley & Sons, 2021
- Debatosh Guha, Chandrakanta Kumar, Sujoy Biswas, Defected Ground Structure (DGS) Based Antennas: Design Physics, Engineering, and Applications, John Wiley & Sons, 2020.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction	
1	5G Mobile Communication Systems, frequency spectrum, 5G antenna design requirements, Antenna parameters	2
2	Sub-6GHz antennas, mm-wave and reconfigurable multiband antennas. Spectrum and Requirements for 6G Communication	2
3	Millimeter-Wave and Terahertz Antennas, Lens Antennas	1
	5G Mobile terminal antennas	
4	Challenges in mobile terminal antennas - form factor, wideband and multi-band operation, SAR compliance	2
5	Wide band compact antenna designs	2
6	high gain antennas, Flexible antennas, Patch antenna	2
7	slot antenna and Vivaldi antenna.	1
	5G Base station antennas	
8	mm-wave tapered slot antenna, dielectric and metamaterial loaded	3

9	diversity antenna with radome, high aperture, efficiency antenna	3
10	shared aperture antenna for base station, pattern diversity	2
	Antenna arrays for 5G	
11	phased arrays, beam steering, digital and hybrid beamforming techniques	3
12	linear and circularly polarized differential antennas, conformal transmit arrays, multi beam transmit array	3
13	UWB dual polarized array, Isolation techniques - Electromagnetic Band Gap, Defected Ground Surface, Metamaterials	2
	Advanced antennas for future 6G	
14	Terahertz antennas, Massive MIMO Antennas, Reconfigurable Intelligent Surface antennas	3
15	Metasurface antennas, Holographic Beamforming antennas	3
16	Lens antennas, Integrated Sensing and Communication antennas	2
	TOTAL	**36**

Course Designers:

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22ECRX0	5G NR PHYSICAL LAYER WIRELESS STANDARDS

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

The objective of the course on "5G NR Physical Layer Wireless Standards" 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

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Demonstrate their understanding of the 5G frame structure and spectrum utilization in proposing solutions for real-world 5G use cases.	TPS 3	80	70
CO2	Explain and compare the principles and applications of duplex schemes such as TDD and FDD in the context of 5G networks.	TPS 3	80	70
CO3	Implement and utilize the 5G Physical Downlink Shared Channel (PDSCH) transmit and receive chain processes.	TPS 3	80	70
CO4	Develop and optimize the 5G Physical Downlink Control Channel (PDCCH) functionalities in 5G networks.	TPS 3	80	70
CO5	Develop and implement 5G MIMO systems by designing transceiver chains, creating codebooks, and applying downlink and uplink multi-antenna precoding techniques to enhance communication performance in practical 5G scenarios.	TPS 3	80	70
CO6	Design and utilize channel sounding mechanisms such as CSI-RS,DM-RS, and SRS with synchronization signals.	TPS 3	80	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	M	M	-	L	M	-	L
CO2	S	M	L	-	-	-	-	M	M	-	L	M	-	L
CO3	S	M	L	-	-	-	-	M	M	-	L	M	-	L
CO4	S	M	L	-	M	-	-	M	M	-	L	M	-	L
CO5	S	M	L	-	M	-	-	M	M	-	L	M	-	L
CO6	S	M	L	-	M	-	-	M	M	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**						**Terminal Exam** (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)					
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	20				-						-	2	10
CO2	-	10	20		100		-						-	4	10
CO3	-	10	30				-						-	4	15
CO4	-						-	10	20				-	4	15
CO5	-						-	10	30		100		-	4	15
CO6	-						-	10	20				-	2	15
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

5G Overview:
5G and IMT 2020, Use cases, Spectrum for 5G - Spectrum for Mobile Systems, Spectrum Defined for IMT Systems by the ITU-R, Global Spectrum Situation for 5G, Frequency Bands for NR, Adaptive Modulation and Coding, Hybrid automatic repeat request (HARQ), OFDM, 5G Numerology, 5G frame structure.

Time-Frequency transmission resource of NR:
Transmission Scheme, Time-Domain Structure, Frequency-Domain Structure, Frequency-Domain Location of NR Carriers, Carrier Aggregation, Control Signaling, Duplex Schemes, TDD—Time-Division Duplex, FDD—Frequency-Division Duplex.

5G physical downlink shared channel (PDSCH):
Transmit chain, CRC generation, code block segmentation, LDPC coding, code block segmentation, rate matching, interleaving and concatenation, scrambling and modulation, receive chain and receiver design.

5G physical downlink control channel (PDCCH): transmit chain, CRC and segmentation, Polar encoding, CRC interleaver, rate matching, control resource set (CORESET) design.

5G MIMO: Transceiver chain, codebook design, Downlink Multi-antenna precoding, NR Uplink Multi-antenna precoding.

Synchronization: SS block, initial access.

Channel Sounding: Downlink Channel Sounding—CSI-RS, Basic CSI-RS Structure, Frequency-Domain Structure of CSI-RS Configurations, Time-Domain Property of CSI-RS Configurations, CSI-IM—Resources for Interference Measurements, demodulation reference signal (DM-RS) design, sounding reference signal (SRS) design.

Text Book

- Erik Dahlman, Stefan Parkvall, Johan Skold, “5G NR, The Next Generation Wireless Access Technology”, Academic Press,2018.
- Sassan Ahmadi, “5G NR Architecture, Technology, Implementation, and operation of 3GPP New Radio Standards”, Academic Press, 2019.

Reference Books

- 3GPP TS 38.523-3 version 15.1.0 Release 15, 2018.
- 3GPP TS 38.211 version 15.2.0 Release 15, 2018.
- 3GPP TS 38.214 version 15.3.0 Release 15, 2018
- 3GPP TS 38.211 version 16.2.0 Release 16, 2020.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
1	**5G Overview** 5G and IMT 2020, Use cases, Spectrum for 5G - Spectrum for Mobile Systems, Spectrum Defined for IMT Systems by the ITU-R, Global	
2	Spectrum Situation for 5G, Frequency Bands for NR, Adaptive Modulation and Coding,	1
3	Hybrid automatic repeat request (HARQ),	1
4	OFDM	1
5	5G Numerology, 5G frame structure.	1
	Time-Frequency transmission resource of NR	
6	Transmission Scheme, Time-Domain Structure, Frequency-Domain Structure,	2
7	Frequency-Domain Location of NR Carriers	1
8	Carrier Aggregation, Control Signalling	1
9	Duplex Schemes, TDD—Time-Division Duplex, FDD—Frequency-Division Duplex.	1
	5G physical downlink shared channel (PDSCH)	
10	Transmit chain	1
11	CRC generation, code block segmentation	1
12	LDPC coding, code block segmentation	1
13	rate matching	1
14	interleaving and concatenation	1
15	scrambling and modulation, receive chain and receiver design	1
	5G physical downlink control channel (PDCCH)	
16	Transmit chain	1
17	CRC and segmentation	1
18	Polar encoding	1
19	CRC interleaver	1
20	rate matching	1
21	control resource set (CORESET) design	1
	5G MIMO	
22	Transceiver chain	1
23	codebook design	1
24	Downlink multi-antenna precoding,	2
25	NR Uplink Multi-antenna precoding	2
	Channel Sounding:	
26	Downlink Channel Sounding—CSI-RS, Basic CSI-RS Structure	1
27	Frequency-Domain Structure of CSI-RS Configurations	1
28	Time-Domain Property of CSI-RS Configurations	1
29	CSI-IM—Resources for Interference Measurements	1
30	demodulation reference signal (DM-RS) design	1
31	sounding reference signal (SRS) design	1
	TOTAL	**36**

Course Designers:

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SYLLABI

FOR

INDUSTRY SUPPORTED COURSES

B.E. DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
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22EC1A0	FIELD TESTS FOR 5G COMMUNICATION	Category	L	T	P	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 main 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#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Interpret RF test instruments, passive & active component test and characterization	TPS 2	70	60
CO2	Illustrate the base station test, EVM measurement, Interference troubleshooting with real time spectrum analysis	TPS 3	70	60
CO3	Illustrate the EM field measurement test, OTA, Coverage test with phased array antenna, Inter-RAT	TPS 3	70	60

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	M	L	-	-	-	-	-	-	-	-	-	-	M	-	L
CO2	S	M	L	-	S	-	-	-	M	M	-	-	M	M	L
CO3	S	M	L	-	S	-	-	-	M	M	-	-	M	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

TPS Scale / CO	Continuous Assessment Test-I (%)			Terminal Exam (%)		
	1	**2**	**3**	**1**	**2**	**3**
CO1	-	10	20	-	10	20
CO2	-	5	30	-	5	30
CO3	-	5	30	-	5	30
Total	**-**	**20**	**80**	**-**	**20**	**80**

Syllabus

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.	Topic	Lecture Hours
1.	**RF concepts and basic understanding of RF Test & RF Instruments** -Frequency vs Time domain, spectrum analysis	2
2.	Testing active and passive devices, time domain analysis.	2
3.	**Base station RF Parametric Test** - Performance verification of gNB such as cable and antenna conditions, transmit power, RF spurious responses.	2
4.	**Interference troubleshooting with Real time Spectrum Analysis** - Detect 5G synchronization signals and interference with RTSA, EVM measurement, detection of SSB offset, subcarrier spacing	2
5.	**Electromagnetic Field Measurement for total human RF exposure** - Measurement of total field strength, Pass/fail limit testing.	1
6.	**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.	2
7.	**Coverage test with phased array antenna** - Coverage testing of 5G base stations, collecting signal power data across azimuth and elevation	2
8.	**Inter-RAT (Radio access technology) optimization** - RAT handovers between 4G and 5G networks in non-standalone (NSA) mode.	1
	Total Hours	**14**

Course Designers:

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22EC1B0	DEEP LEARNING WITH TENSOR FLOW

Category	L	T	P	Credit
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 Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Illustrate the design of deep neural network architecture.	TPS 3	70	70
CO2	Explore an entire TensorFlow deep learning pipeline.	TPS 3	70	70
CO3	Construct the design of convolutional neural network architecture.	TPS 3	70	70
CO4	Make use of the Alexnet deep convolutional model for imageclassification.	TPS 3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

	CAT – I (%)			**Terminal Exam** (%)		
TPS / CO	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	5	20	-	5	20
CO2	-	5	20	-	5	20
CO3	-	5	20	-	5	20
CO4	-	5	20	-	5	20
Total	-	**20**	**80**	-	**20**	**80**

Syllabus

Learning Paradigms: AI, Machine learning, Deep learning, ANN, Designing a Deep Neural Network**. Tensor flow and its elements:** TensorFlow's core API, tensors, operations, graphs, and sessions. Running a simple TensorFlow net and establishing a baseline, Dropout, testing different optimizers in TensorFlow, Increasing the number of epochs, Controlling the optimizer learning rate**. Convolutional Neural Network:** CNN Architecture, CNN for classification: Training, vanishing gradients,Testing, Validation**. Deep Convolutional Model:**

Alexnet Architecture, Anchor boxes**,** Loss functions. **Case Study:** Alexnet based Image classification by Transfer learning with TensorFlow. Auto Encoders.

Learning Resources

- GGiancarlo Zaccone, Md. Rezaul Karim, “Deep Learning with TensorFlow: Explore neural networks with Python”, 2018.
- Kapoor, Amita, Gulli, Antonio, Pal, Sujit, Chollet, Francois, “Deep learning with Tensor Flow and Keras 3/e, ISBN: 9781803232911, 2017.
- Ian Goodfellow, Yoshuva Benjio, Aaron Courville, “Deep Learning”, MIT Press, 2016.
- Richard O Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, Wiley, 2/e, 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

#	Topic	Lecture Hours
	Learning Paradigms:	
1.	AI, Deep learning, ANN, Designing a Deep Neural Network: Neural Networks, Architecture with one hidden layer	1
2.	Activation function, Derivatives, Gradient Descent, Batch size, Scaling features, number of epochs, Optimization, Hyperparameterstuning	1
3.	Batch Normalization, drop out, learning rate, Loss function, choosing the loss function: Regression loss (MSE), Binary classification loss and multi-classification loss	2
	Simple neural network using TensorFlow:	
4.	Running a simple TensorFlow net and establishing a baseline	1
5.	Improving the simple net in TensorFlow with hidden layers and Dropout	1
6.	Testing different optimizers in TensorFlow	1
7.	Increasing the number of epochs, Controlling the optimizer learningrate	1
	Convolutional Network	
8.	CNN Architecture:Convolution	1
9.	Stride and padding in convolutional layers, activation function, Pooling layers, Normalization, FCN	1
10.	CNN for classification: Training, Testing, Validation	1
	Deep Convolutional Model Alexnet	
11.	Anchor boxes, Ground Truth Anchor boxes, Loss functions	1
12.	Alexnet Model Architecture	1
13.	**Case Study:** Alexnet based image classification	1
		14

Course Designers:

- Dr. D.Antony Louis Piriyakumar, antony@piriyakumar.co.in. Indian patent agent, Founder director, BudhiAI (GoI recognized Startup)
- Dr.S.Md.Mansoor Roomi, smmroomi@tce.edu
- Dr.B.Yogameena, ymece@tce.edu
- Dr.B. Sathyabama, sbece@tce.edu

22EC1C0	EMBEDDED FIRMWARE

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

Embedded systems have seamlessly integrated into the fabric of contemporary society, permeating sectors ranging from domestic appliances and transportation networks to cutting-edge healthcare devices and industrial machinery. Proficiency in understanding embedded systems serves as a cornerstone for a prosperous career in Embedded Engineering. This course explores the pivotal role of the C and RUST programming languages in the realm of embedded systems, along with practical applications of data structures. Participants will delve into the intricacies of the power-on-reset sequence of an MCU, bootloader functionality, and the memory organization of C programs. Through meticulously crafted practical demonstrations, participants will glean a comprehensive understanding of these concepts, ensuring a robust grasp of embedded systems principles.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Compile and build a C program using cross-compiler for MCU by developing linker and make files and understand the various memory sections of the program's executable	TPS 3	70	60
CO2	Develop startup code for an MCU	TPS 3	70	60
CO3	Design and develop bootloader	TPS 3	70	60
CO4	Implement embedded C, RUST and Data structure concepts	TPS 3	70	60

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	M	M	-	S	-	-	-	M	L	-	L	M	M	L
CO2	S	M	L	-	S	-	-	-	M	L	-	L	M	M	L
CO3	S	M	L	-	S	-	-	-	M	L	-	L	M	M	M
CO4	S	M	L	-	S	-	-	-	M	L	-	L	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

	CAT – I (%)			Terminal Exam (%)		
CO \ TPS Scale	1	2	3	1	2	3
CO1	-	6	20	-	6	20
CO2	-	4	20	-	4	20
CO3	-	6	20	-	6	20
CO4	-	4	20	-	4	20
Total	-	**20**	**80**	-	**20**	**80**

Syllabus

Language Processing System: Cross-compilation Toolchain, Preprocessing, Compiling, Assembling, Linking and Debugging. **Memory Organization in C:** Memory layout of a C program, Storage Classes. **Boot Sequence:** How a MCU is booted upon Power-on-Reset, Vector Table, Reset Handler, Introduction and development of Startup Code. **Bootloader:** Introduction to Bootloader & Memory Design considerations for bootloader and bootable application, Development of a simple bootloader and bootable application. **Embedded C Programming**: Data types, Variables, Keywords and Constants, Preprocessors, Macros and Board Support Package (BSP). **Implementation of Data Structure:** Queue, Singly Linked List, Double Linked List. **RUST Programming:** Variables and Data types, Ownership, Structs, Enums, Generics and Traits, Smart Pointers and Memory management. **Version Control System:** Importance of version control system with Git.

Learning Resources

- Using the GNU Compiler Collection, https://gcc.gnu.org/onlinedocs/gcc-8.1.0/gcc/ARM-Options.html
- David E Simon, An Embedded Software Primer, First Edition, 2002
- https://www.beningo.com/wp-content/uploads/images/Papers/bootloader_design_for_microcontrollers_in_embedded_systems%20.pdf
- https://doc.rust-lang.org/book/

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1.	**Language Processing System:** Cross-compilation Toolchain, Preprocessing, Compiling, Assembling, Linking and Debugging.	1.5
2.	**Memory Organization in C:** Memory layout of a C program, Storage Classes.	1
3.	**Boot Sequence:** How a MCU is booted upon Power-on-Reset, Vector Table, Reset Handler, Introduction and development of Startup Code.	2
4.	**Bootloader:** Introduction to Bootloader & Memory Design considerations for bootloader and bootable application, Development of a simple bootloader and bootable application.	2.5
5.	**Embedded C Programming**: Data types, Variables, Keywords and Constants, Preprocessors, Macros and Board Support Package (BSP).	2
6.	**Implementation of Data Structure:** Queue, Singly Linked List, Double Linked List.	2
7.	**RUST Programming:** Variables and Data types, Ownership, Structs, Enums, Generics and Traits, Smart Pointers and Memory management.	2
8.	**Version Control System:** Importance of version control system, Hands-on demo using Git.	1
	Total Hours	14

Course Designers:

- Ms.A.Ishwarya, Senior Firmware Engineer, Analog Devices, ishwarya.ashokkumar@analog.com
- Dr.K.Hariharan, khh@tce.edu
- Dr.K.Rajeswari, rajeswari@tce.edu
- Dr.G.Prabhakar, gpece@tce.edu

22EC1D0	AUTOMOTIVE RADAR SYSTEMS

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

Radio Detection and Ranging (Radar) is at the forefront of modern technology, playing crucial roles in various fields like aviation, meteorology, defence, and even automotive safety. Understanding RADAR systems can give insights into the latest technological advancements. In this course, comprehensive insights are offered on Radar terminologies, typical system configurations, and advanced signal processing techniques essential for Radar operations. Moreover, applications in in-cabin radar are highlighted to ensure a thorough understanding of its current practical significance.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Design radar parameters by understanding the terminologies and components of different types Radar.	TPS 3	70	60
CO2	Measure range, doppler shift, angle of arrival and radar cross-section (RCS) using RADAR equations.	TPS 3	70	60
CO3	Detect targets using frequency representation of the received RADAR signal	TPS 3	70	60
CO4	Design automotive in-cabin radar system to monitor the interior of the vehicle to enhance the passenger safety and comfort.	TPS 3	70	60

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

	CAT – I (%)			**Terminal Exam** (%)		
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	5	20	-	5	20
CO2	-	5	20	-	5	20
CO3	-	5	20	-	5	20
CO4	-	5	20	-	5	20
Total	-	**20**	**80**	-	**20**	**80**

Syllabus

Introduction: Automotive Radar, Types of Automotive Radars, Frequency and Band of Operation, How Radar Sensor Look, Radar sensors on Vehicle, Different types of Radar, FMCW. **Radar Terminologies:** Frequency, Wavelength, Bandwidth, ADC bits, Signal to Noise Ratio (SNR), Noise, Radar Cross Section (RCS), Channel behaviour – properties, Attenuation, Absorption, Multipath. **Typical Radar System:** Components of Radar System, Radar System Design, Design Limitations. **Radar Signal Processing:** Components of Radar Signal processing, Range Equation, Measurement of Range (Distance) & Doppler (Velocity), Measurement of Angle/Angle of Arrival, Measurement of RCS. **Radar Signal Processing using FFT:** Range FFT and Doppler FFT, Angle FFT and RD Map, Clutter Removal and CFAR, Final Detection List. **Automotive in-Cabin Radar:** Near Range Applications - Occupant Detection, Classification, Gesture Recognition, Automotive Radar Trends.

Learning Resources

- Simon Kingsley & Shaun Quegan, Understanding RADAR Systems, McGraw Hill Books Co., 2001.
- Merrill Skolnik, Introduction to RADAR Systems, McGraw Hill Education, 2nd Edition, 2017.
- NPTEL Course, Principles and Techniques of Modern RADAR Systems, https://archive.nptel.ac.in/courses/108/105/108105154/

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1.	**Introduction**: Automotive Radar, Types of Automotive Radars, Frequency and Band of Operation, How Radar Sensor Looks, Radar sensors on Vehicle, Different types of Radar, FMCW.	1
2.	**Radar Terminologies:** Frequency, Wavelength, Bandwidth, ADC bits, Signal to Noise Ratio (SNR), Noise, Radar Cross Section (RCS), Channel behaviour – properties, Attenuation, Absorption, Multipath.	2
3.	**Typical Radar System:** Components of Radar System, Radar System Design, Design Limitations.	2
4.	**Radar Signal Processing:** Components of Radar Signal processing, Range Equation, Measurement of Range (Distance) & Doppler (Velocity), Measurement of Angle/Angle of Arrival, Measurement of RCS.	2
5.	**Radar Signal Processing using FFT:** Range FFT and Doppler FFT, Angle FFT and RD Map,	2
6.	Clutter Removal and Constant False Alarm Rate (CFAR) Detection, Final Detection List.	2
7.	**Automotive in-Cabin Radar:** Near Range Applications - Occupant Detection, Classification, Gesture Recognition, Automotive Radar Trends	4
	Total Hours	15

Course Designers:

- Dr.A.R.Karthikeyan, Sr.Principal Engineer, Harman International India Pvt. Ltd., Karthikeyan.Rajarathinam@harman.com
- Mr.B.Srinivasan, Senior Software Engineer II, Harman International India Pvt. Ltd., Srinivasan.Bhuramoorthy@harman.com
- Dr.S.J.Thiruvengadam, sjtece@tce.edu
- Dr.K.Rajeswari, rajeswari@tce.edu

22EC1E0	VLSI IMPLEMENTATION OF COMMUNICATION TRANSCEIVERS

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

In the ever-evolving world of telecommunications, this course delves into communication transceivers and digital signal processing (DSP). Students explore FM transceivers and DSP techniques, laying a robust foundation. Through lectures and labs, they learn digital filter design principles, emphasizing FPGA implementation. The course elucidates PLLs in communication systems, differentiating between analog and digital variants. Practical sessions provide hands-on experience, preparing students to tackle real-world challenges in telecommunications.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understanding of communication transceivers, including both receivers and transmitters, with a focus on Frequency Modulation (FM) transceivers	TPS 3	70	60
CO2	Acquire knowledge and skills in Digital Signal Processing (DSP) techniques applicable to communication systems, particularly in the context of FM transceivers.	TPS 3	70	60
CO3	Demonstrate proficiency in designing and implementing digital filters using Real-Time Logic (RTL) coding techniques, with a specific emphasis on Finite Impulse Response (FIR) filters	TPS 3	70	60
CO4	Understand the principles and applications of Phase-Locked Loops (PLLs) in communication systems, distinguishing between different types including Integer PLLs and Fractional PLLs	TPS 3	70	60

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	M	L	-	-	-	-	-	-	-	-	L	M	-	L
CO2	S	M	L	-	S	-	-	-	M	M	-	L	M	M	L
CO3	S	M	L	-	S	-	-	-	M	M	-	L	M	M	M
CO4	S	M	L	-	S	-	-	-	M	M	-	L	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

TPS Scale / CO	CAT – I (%)			Terminal Exam (%)		
	1	2	3	1	2	3
CO1	-	5	20	-	5	20
CO2	-	5	20	-	5	20
CO3	-	5	20	-	5	20
CO4	-	5	20	-	5	20
Total	-	**20**	**80**	-	**20**	**80**

Syllabus

Introduction to Communication Transceivers: Communication receivers and transmitters**,** Frequency Modulation (FM) transceivers**,** Digital signal processing in communication systems**,** Digital Filters and Phase-Locked Loops (PLLs). **Digital Signal Processing in Communication Transceivers:** FM Transceiver with a focus on digital signal processing techniques, Digital filter design principles and techniques, Real-time logic (RTL) coding for digital synthesis. **Design and Implementation of Digital Filters:** RTL coding and synthesis for digital FIR filters**,** FPGA implementation of digital FIR filters**,** Architectures for digital filters: Pipelining, Parallel architecture, CSD implementation**,** Low power implementation of multi-rate filters. **Phase-Locked Loops (PLLs) in Communication Systems:** Types of PLLs: Integer PLLs, Fractional PLLs**,** Analog vs. digital PLLs: Tradeoffs and applications**,** Analysis of PLL metrics: Response time, Noise bandwidth, Performance evaluation. **Building Blocks of PLLs:** Components of a PLL: Voltage Controlled Oscillator (VCO), Phase Frequency Detector (PFD), Time-to-Digital Converter (TDC) **Laboratory practices:** Emulation of basic digital FIR filters and PLLs on FPGA **I**mplementation of ALU-RAM based multi-rate digital filters

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 Contents and Lecture Schedule

#	Topic	Lecture Hours
1.	**Introduction to Communication Transceivers:** Communication receivers and transmitters**,** Frequency Modulation (FM) transceivers**,** Digital signal processing in communication systems**,** Digital Filters and Phase-Locked Loops (PLLs).	2
2.	**Digital Signal Processing in Communication Transceivers:** FM Transceiver with a focus on digital signal processing techniques, Digital filter design principles and techniques, Real-time logic (RTL) coding for digital synthesis.	2
3.	**Design and Implementation of Digital Filters:** RTL coding and synthesis for digital FIR filters**,** FPGA implementation of digital FIR filters**,** Architectures for digital filters: Pipelining, Parallel architecture, CSD implementation**,** Low power implementation of multi-rate filters.	2
4.	**Phase-Locked Loops (PLLs) in Communication Systems:** Types	2

	of PLLs: Integer PLLs, Fractional PLLs**,** Analog vs. digital PLLs: Tradeoffs and applications**,** Analysis of PLL metrics: Response time, Noise bandwidth, Performance evaluation.	
5.	**Building Blocks of PLLs:** Components of a PLL: Voltage Controlled Oscillator (VCO), Phase Frequency Detector (PFD), Time-to-Digital Converter (TDC)	2
6.	**Laboratory practices:** Emulation of basic digital FIR filters and PLLs on FPGA **I**mplementation of ALU-RAM based multi-rate digital filters	2
Total Hours		**12**

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
- Dr.J.Shanthi, jsiece@tce.edu

22EC1F0	EMBEDDED SYSTEM HARDWARE

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 microcontroller-based 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 Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the architecture of PIC devices, AVR devices and the working of essential peripherals	TPS 2	70	60
CO2	Develop embedded-c code for various peripherals	TPS 3	70	60
CO3	Use low power techniques, linking, compilation and start-up process	TPS 3	70	60
CO4	Implement a complete system by interfacing various peripherals, using latest development tools	TPS 3	70	60

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

	CAT – I (%)			**Terminal Exam** (%)		
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	25	-	-	25	-
CO2	-	5	20	-	5	20
CO3	-	5	20	-	5	20
CO4	-	5	20	-	5	20
Total	-	**40**	**60**	-	**40**	**60**

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-twi-module-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 Contents and Lecture Schedule

#	Topic	Lecture Hours
1.	**Introduction:** Architecture Overview: AVR and PIC, 8-bit and 32-bit MCUs	2
2.	**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	4
3.	**Low power design techniques:** Sleep modes, Event System, Factors affecting low power, Lab-3**,** Hardware design considerations	3
4.	**Moving the design from concept to reality:** Ecosystem (Development Tools), From Embedded-C to Microcontroller, Home Automation – Putting together a real-world application	3
Total Hours		**12**

Course Designers:

- Mr. Enoch Richbert, Application Engineer, Microchip Technology, enochrichbert.jebakumar@micorchip.com
- Dr.K.Hariharan, khh@tce.edu
- Dr M S K Manikandan, manimsk@tce.edu
- Dr.V.R. Venkatasubramani, venthiru@tce.edu
- Dr. G. Prabhakar, gpece@tce.edu

22EC1G0	GREEN NETWORKS

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

Green networking is the practice of selecting energy-efficient networking technologies and products and minimizing resource use whenever possible. The goal of the course is to understand and apply the concepts of Energy Consumption Models, Battery Life Estimations and Enhancements

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand Digital Networking Fundamentals and Energy Consumption Models	TPS 2	70	60
CO2	Apply Modulation Costs Energy Efficiency & Entropy	TPS 3	70	60
CO3	Apply QoS Approximations and Workload Characterizations	TPS 3	70	60
CO4	Understand Battery Life Estimations and Enhancements and AI Techniques in Symbol Recovery	TPS 2	70	60

Mapping with Programme Outcomes and Programme Specific Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

	CAT – I (%)			**Terminal Exam** (%)		
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	15	-	10	15
CO2	-	10	15	-	10	15
CO3	-	10	15	-	10	15
CO4	-	10	15	-	10	15
Total	-	**40**	**60**	-	**40**	**60**

Syllabus

Digital Networking Fundamentals: Introduction to All-IP Networks, IP protocol overview**,** Reduced Header Compression Cross Layer Optimizations. **Energy Consumption Models:** Joules / Bit. **Modulation Costs Energy Efficiency & Entropy:** Error Correction Codes, Error Correction Costs. **QoS Approximations and Workload Characterization:** Energy Aware Computing & Communications, Computing Energy Costs**,** Connection Overhead Costs **Battery Life Estimations and Enhancements:** Energy Harvesting Technique, Advancements in Energy Harvesting, Introduction to TSN. **AI Techniques in Symbol Recover:** 6G Advancements.

Learning Resources

- Konstantinos Samdanis, Peter Rost, Andreas Maeder, Michela Meo, and Christos Verikoukis, “Green Communications: Principles, Concepts and Practice”, Wiley, 2017.
- Brendan Gregg, “Systems Performance”, Addison Wesley, 2021.
- Anne Currie, Sarah Hsu, and Sara Bergman, “Building Green Software”, O'Reilly Media, Inc.,2024

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1.	**Digital Networking Fundamentals-** • Introduction to All-IP Networks • IP protocol overview • Reduced Header Compression • Cross Layer Optimizations	3
2.	**Energy Consumption Models** • Joules / Bit	2
3.	**Modulation Costs Energy Efficiency & Entropy** • Error Correction Codes • Error Correction Costs	3
4.	**QoS Approximations and Workload Characterizations** • Energy Aware Computing & Communications • Computing Energy Costs • Connection Overhead Costs	3
5.	**Battery Life Estimations and Enhancements** • Energy Harvesting Techniques • Advancements in Energy Harvesting • Introduction to TSN	1
6.	**AI Techniques in Symbol Recovery** • 6G Advancements	2
	Total Hours	14

Course Designers:

- Dr S B Anand, Senior Architech, Qualcomm, Bengaluru
- Dr MSK Manikandan, manimsk@tce.edu
- Dr E Murugavalli, murugavalli@tce.edu

22EC1H0	COMMUNICATION LINK ANALYSIS	Category	L	T	P	credit
		PEES	1	0	0	1

Preamble

The objectives of the course include (1) providing an understanding concept and features of digital mission engineering and System Tool Kit, (2) interpret the STK models of wireless transmitter and receiver, (3) apply the STK to analyze the RF environment models, and (4) uutilize the STK to wireless link analysis and power budget calculations.

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 concept and features of digital mission engineering and System Tool Kit	10
CO2	Interpret the STK models of wireless transmitter and receiver	30
CO3	Apply the STK to analyze the RF environment models	30
CO4	Utilize the STK to wireless link analysis and power budget calculations	30

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	S	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	S	-	L
CO3	S	M	L	-		-	-	-	M	M	-	S	L	L
CO4	S	M	L	-	M	-	-	-	M	M	-	S	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

	CAT – I (%)			**Terminal Exam** (%)		
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	5	10	-	5	10
CO2	-	5	20	-	5	20
CO3	-	5	20	-	5	20
CO4	-	5	30	-	5	30
Total	-	**20**	**80**	-	**20**	**80**

Syllabus

Digital Mission engineering – applications: Satellite communication - Radar cross section Analysis, EOIR (Electro Optical, Infra-red Sensor modeling, **Introduction to AGI STK**-Features, **System modeling** : ***STK receiver types***: Simple, Cable, Medium, Complex, Multibeam, Laser, RF plugin, and Laser plugin , **Transmitter types**: Simple, Cable, Medium, Complex, Multibeam, Plugin, Laser, and GPS Satellite, **Re-transmitter models**: Simple, Medium, and Complex, Antenna types- multi-beam and phased array, Wideband and narrowband jammer modulators, third-party modulators.

Modeling the RF environment: Empirical rain models, Atmospheric absorption models, Urban and terrestrial models, Clouds and fog models, Troposphere scintillation model, Ionosphere fading loss, Custom loss plug-in models, Terrain Integrated Rough Earth Model (TIREM)

Analyzing Communication systems: Link margin specification and calculations-Link Information report for a Receiver - Link Margin Type (BER, RIP, C/N, etc.), Link Margin threshold, Interference analysis-network and target interference analysis, impact of the interference network into communication links - probability density functions (PDFs) and cumulative density functions (CDFs) - investigate the C/(N+I), C/I, DT/T and power flux density, RADAR Simulations – Monostatic, bistatic and multi-function.

Learning Resources

- STK Level 1 and Level 2 Training Manual STK VERSION 12.9.1, October 2024 © Ansys, Inc and / or Its Affiliated Companies.
- Lecture slides and class notes

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Digital Mission Engineering**		
1.1	Applications: Satellite communication - Radar cross section Analysis, EOIR (Electro Optical, Infra red Sensor modelling	1	CO1
2	**Introduction to AGI STK**		
2.1	Features	0.5	CO1
3	**System modelling**		
3.1	STK receiver types		
3.1.1	Simple, Cable, Medium	0.5	CO2
3.1.2	Multibeam, Laser, RF plugin, and Laser plugin	0.5	CO2
3.2	Transmitter types		
3.2.1	Simple, Cable, Medium	0.5	CO2
3.2.2	Multibeam, Plugin, Laser, and GPS Satellite	0.5	CO2
3.3	Re-transmitter models		
3.3.1	Simple, Medium, and Complex	0.5	CO2
3.4	Multi-beam and phased array	0.5	CO2
3.5	Wideband and narrowband jammer modulators	0.5	CO2
3.6	Third-party modulators	0.5	CO2
4	**Modelling the RF environment**		
4.1	Empirical rain models, Atmospheric absorption models, Urban and terrestrial models, Clouds and fog models	1	CO3

4.2	Troposphere scintillation model, Ionosphere fading loss, Custom loss plug-in models, Terrain Integrated Rough Earth Model (TIREM)	1	CO3
5	**Analyzing Communication systems**		
5.1	Link margin specification and calculations-Link Information report for a Receiver - Link Margin Type (BER, RIP, C/N, etc.)	2	CO4
5.2	Link Margin threshold, Interference analysis-network and target interference analysis	2	CO4
5.3	impact of the interference network into communication links probability density functions (PDFs) and cumulative density functions (CDFs) – investigate the C/(N+I), C/I, DT/T and power flux density	2	CO4
5.4	RADAR Simulations		
5.4.1	Monostatic, bistatic and multi-function	0.5	CO4
	TOTAL	**14 hours**	

Course Designers:

- Mr Renganath Kumar, Regional Manager, Aerospace and Defence
- Ms. Aishwarya, Academic Consultant Manager (Technical) - Digital Mission Engineering, CADFEM India Pvt. Ltd.
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22EC1J0	AUTONOMOUS DRIVING: PRINCIPLES AND ALGORITHMS

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

The objectives of the course include (1) providing an understanding on various sensors being used for autonomous driver assistance, (2) providing mathematical foundations for target detection and parameters estimation, (3) discussion on technologies and algorithms used for autonomous driving cars, and (4) Hands-on experiments using COTS radar evaluation board.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Comprehend the working of an ADAS.	20
CO2	Understand the target parameters that need to be estimated using different types of sensors.	30
CO3	Understand the fusion of information from various sensors and tracking of objects.	30
CO4	Understand and solve the difficulties faced in practical application of self-driving car systems.	20

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	S	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	S	-	L
CO3	S	M	L	-	S	-	-	-	S	S	-	S	L	L
CO4	S	M	L	-	S	-	-	-	S	S	-	S	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

	CAT – 1 (%)			**Terminal Exam** (%)		
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	5	20	-	5	20
CO2	-	5	20	-	5	20
CO3	-	5	20	-	5	20
CO4	-	5	20	-	5	20
Total	-	**20**	**80**	-	**20**	**80**

Syllabus

Introduction to Self-Driving Cars: Various levels of self-driving cars, Components of ADAS, Basics of target detection, parameter estimation and tracking. **Mathematical Foundations:** Maximum likelihood detection, ML estimation, Uniform Linear Array and Angle estimation using FFT. **ADAS Sensors and Algorithms:** LIDAR, RADAR, Camera based sensing, ToF based Range estimation, Velocity estimation and Fusion of sensor outputs. Alpha-Beta based Tracking filters. **TI AWR2944:** Radar Application case study: Handson experiments using the COTS Radar board. Machine learning-based algorithms.

Learning Resources

- Lecture slides and class notes

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Introduction to Self-Driving Cars**		
1.1	Various levels of self-driving cars	1	CO1
1.2	Components of ADAS	1	CO1
1.3	Basics of target detection	1	CO1,CO2
1.4	Parameter estimation and tracking	1	CO1,CO2
2	**Mathematical Foundation**		
2.1	Maximum likelihood detection	0.5	CO2
2.2	ML estimation	0.5	CO2
2.3	Uniform linear array	0.5	CO2
2.4	Angle estimation using FFT	0.5	CO2
3	**ADAS Sensors and Algorithms**		
3.1	LIDAR systems	1	CO1,CO2
3.2	RADAR systems	1	CO1,CO3
3.3	Camera based sensing	1	CO2,CO3
3.4	Inertial measurement units	1	CO2,CO3
3.5	Fusion, filters and tracking	1	CO1,CO3
4	**TI AWR2944: Radar Application Case Study**		
4.1	Handson experiments using the COTS radar board	1	CO4
4.2	Experiments using TI tools for range and velocity estimation	1	CO4
4.3	Machine learning based algorithms	1	CO4
Total		14	

Course Designers:

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22EC1K0	INTEGRATED SENSING AND COMMUNICATIONS

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

The objectives of the course include (1) providing an understanding on multi-antenna wireless communications for ISAC, (2) providing an understanding on radar signal processing for ISAC, (3) discussion on fundamentals of ISAC and communication-sensing performance trade-off, and (4) discussion on specific case studies for ISAC.

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 fundamentals required for ISAC	20
CO2	Understand and use the importance performance metrics for communication part design in ISAC	30
CO3	Understand and use the importance performance metrics for radar part design in ISAC	30
CO4	Comprehend the fundamental working principle of ISAC with performance trade-off and have a specific relevant case study	20

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	S	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	S	-	L
CO3	S	M	L	-	S	-	-	-	S	S	-	S	L	L
CO4	S	M	L	-	S	-	-	-	S	S	-	S	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

	CAT – I (%)			Terminal Exam (%)		
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	5	20	-	5	20
CO2	-	5	20	-	5	20
CO3	-	5	20	-	5	20
CO4	-	5	20	-	5	20
Total	-	**20**	**80**	-	**20**	**80**

Syllabus

Pre-requisites and Review: Digital communication system, FFT and probability models, basics of signal detection, Basics of point estimation, array signal processing and angle estimation, **Multi-Antenna Communications**: Wireless channel models, MIMO communications, Channel capacity, beamforming, precoders, combiners and decoders, **Radars and Sensing**: Radar equation and MIMO radars, FMCW radars, localization techniques, **Integration and Applications**: History, the ISAC problem, performance trade-off, case study with IEEE 802.11ad, waveform design and applications.

Learning Resources

- Lecture slides and class notes

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Pre-requisites and Review**		
1.1	Digital communication system, FFT and probability models	1	CO1
1.2	Basics of signal detection and maximum likelihood detection	1	CO1
1.3	Basics of point estimation and maximum likelihood estimation	1	CO1
1.4	Introduction to array signal processing and angle estimation	1	CO1
2	**Multi-Antenna Communications**		
2.1	Wireless channel models: Rayleigh, Rician, Jakes' and extensions	1	CO2
2.2	Motivation and introduction to MIMO communications	1	CO2
2.3	Channel capacity, beamforming and precoders	1	CO2
2.4	Combiners, decoders and numericals	1	CO2
3	**Radars and Sensing**		
3.1	Radar equation and MIMO radars	1	CO3
3.2	FMCW radars and signal processing	1	CO3
3.3	Localization: Introduction, ToF-based technique	1	CO3
3.4	Localization: Triangulation using RSSI and ToA	1	CO3
4	**Integration and Applications**		
4.1	History, the ISAC problem and performance trade-off	0.5	CO4
4.2	Case study: ISAC with IEEE 802.11ad	0.5	CO4
4.3	Waveform design	0.5	CO4
4.4	Applications of ISAC	0.5	CO4
Total		14	

Course Designers:

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SYLLABI

FOR

INTERDISCIPLINARY ELECTIVE COURSES

B.E. / B.Tech. DEGREE PROGRAMME

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
THIAGARAJAR COLLEGE OF ENGINEERING
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22ECGA0	CONSUMER ELECTRONICS

Category	L	T	P	Credit
IE	3	0	0	3

Preamble

This course offers a comprehensive overview of consumer electronics. It provides a better understanding to students about the construction and working principles of audio systems, display technologies, automotive electronics, and a wide array of consumer devices and home appliances.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the characteristics and working principle of microphones and loud speakers	TPS 2	70	60
CO2	Describe the key features of digital audio system.	TPS 2	70	60
CO3	Construct digital television system with essential features and functionalities.	TPS 3	70	60
CO4	Utilize the characteristics of display technologies to build an output devices.	TPS 3	70	60
CO5	Identify the components present in the infotainment of automotives	TPS 3	70	60
CO6	Idetify the features and functionalities of various electronic components and circuitry present in consumer devices and domestic appliances.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	L	L	-	-	-	L	L	M	-	L	L	-	L
CO2	M	L	L	L	-	-	-	L	L	M	-	L	L	-	L
CO3	S	M	L	L	-	-	-	L	L	M	-	L	M	-	L
CO4	S	M	L	L	-	-	-	L	L	M	-	L	M	-	L
CO5	S	M	L	L	-	-	-	L	L	M	-	L	M	-	L
CO6	S	M	L	L	-	-	-	L	L	M	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam(%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)					
CO \ TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	30				-						-	4	20
CO2	-	10	20		100		-						-	4	10
CO3	-	10	20				-						-	4	10
CO4	-						-	10	20				-	-	10
CO5	-						-	10	20		100		-	4	10
CO6	-						-	10	30				-	4	20
Total	-	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Introduction: Overview, Era of consumer devices, Components of a typical consumer device.
Analog Audio System: Microphones and its types- Carbon, Velocity, Crystal, Condenser, Cordless; Loud Speaker**:** Direct radiating, horn loaded woofer, tweeter, mid-range, multi-speaker system, baffles and enclosures, Hi-Fi system, pre-amplifier, amplifier, Equalizer system, stereo amplifiers, Sound bars.
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, Audio over IP – Dante, AES67.
Digital Television System: Digital TV System and Standards, HDTV, Hardware Architecture of a Digital Set-top Box, Home Theatre, DTH. Cable TV and Cable TV in internet and Digital Video Recorder, Audio Video Receiver.
Digital Display System: Organic LEDs, LCD, Plasma, Plasma Addressed LCD, and Quantum LED.
Automotive Electronics: Standards for In-vehicle Multimedia Electronics, Vehicle Area Network Bus, Controller Area Networks, Media-oriented Systems Transfer Technologies, Components of a Telematics System and Automotive Software Technologies.
Consumer Devices/Domestic appliances: Smart Phones, Smart TV, Digital Still Cameras, Refrigeration cycle, Types of compressors, Refrigerator, Air Conditioner, Induction cook top, Washing machines, Microwave oven, Dish washer, Vacuum cleaner, GPS Tracker.

Text Book

- Bali S.P, “Consumer Electronics”, Pearson Education, 2022.
- Amit Dhir, “The Digital Consumer Technology Handbook: A Comprehensive Guide to Devices, Standards, Future Directions, and Programmable Logic Solutions”, Elsevier 2004

Reference Books

- Jordan Frith, "Smartphones as Locative Media ", Wiley. 2014.
- R.S. Khandpur, “Troubleshooting Electronic Equipment: Includes Repair and Maintenance”, Second Edition, McGraw Hill Education (India) Private Limited., 2003.
- Philp Hoff "Consumer Electronics for Engineers" - Cambridge University Press.1998.
- Lal A. K, “Trouble Shooting and Maintenance of Electronics Equipments”, McGraw Hill Education, 2020.
- Thomas M. Coughlin, "Digital Storage in Consumer Electronics", Elsevier and Newness 2012.
- Nick vandome, Smart homes in easy steps, - Master smart technology for your home 2018.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction	
1	Overview of consumer electronics, Era of consumer devices	2
2	Components of a typical consumer device	
3	**Analog Audio System**	
4	Microphones and its types- Carbon, Velocity, Crystal, Condenser, Cordless	2
5	Loud Speaker**:** Direct radiating, horn loaded woofer, tweeter	2
6	Mid-range, multi-speaker system	1
7	baffles and enclosures	
8	Hi-Fi system	
9	Pre-amplifier/amplifier	
10	Equalizer system	1
11	Stereo amplifiers	
12	Sound bars	
	Digital Audio System	

13	Digital Audio player	1
14	Storage audio formats	
15	Internet Audio Formats	
16	MP3 Portable Players	1
17	Internet Radio	1
18	Digital Audio Radio	
19	Online Music Distribution	1
20	Digital Physical Media Formats	
21	Audio over IP – Dante, AES67	1
	Digital Television System	
22	Digital TV System and Standards	1
23	HDTV	
24	Hardware Architecture of a Digital Set-top Box	1
25	Home Theatre	
26	DTH	1
27	Cable TV	1
28	Cable TV in internet	
29	Digital Video Recorder	1
30	Audio Video Receiver	1
	Digital Display System	
31	Organic LEDs	1
32	LCD	1
33	Plasma	1
34	Plasma Addressed LCD	
35	Quantum LED	1
	Automotive Electronics	
36	Standards for In-vehicle Multimedia Electronics	1
37	Vehicle Area Network Bus	
38	Controller Area Networks	1
39	Media-oriented Systems Transfer Technologies	
40	Components of a Telematics System	1
41	Automotive Software Technologies	1
	Consumer Devices/Domestic appliances	
42	Smart Phones, Smart TV	2
43	Digital Still Cameras	1
44	Refrigeration cycle, Types of compressors, Refrigerator	2
45	Air Conditioner	1
46	Induction cook top, Microwave oven	1
47	Washing machines, Dish washer	1
48	Vacuum cleaner, GPS Tracker	1
	TOTAL	**36**

Course Designers:

- Dr.S.Mohamed Mansoor Roomi smmroomi@tce.edu
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22ECGB0	MULTIMEDIA SYSTEMS

Category	L	T	P	Credit
IE	3	0	0	3

Preamble

Multimedia Systems are becoming an integral part of our heterogeneous computing and communication environment. There is an explosive growth of multimedia computing, communication, and applications over the last decade. The World Wide Web, conferencing, digital entertainment, and other widely used applications are using not only text and images but also video, audio, and other continuous media. In the future, all computers and networks will include multimedia devices. They will also require corresponding processing and communication support to provide appropriate services for multimedia applications in a seamless and often also ubiquitous way.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the fundamentals of multimedia and networks to support media and data streams, sound/audio, image, graphics, and video.	TPS 2	70	75
CO2	Use the digitization mechanisms to encode multimedia information.	TPS 3	70	70
CO3	Use the compression principles including coding requirements, entropy and hybrid coding, encoders and decoders to multimedia.	TPS 3	70	70
CO4	Apply the compression techniques to text, image, audio and video.	TPS 3	70	70
CO5	Relate the communication network standards and protocols to multimedia information.	TPS 2	70	70
CO6	Analyze the multimedia networking and steaming protocols.	TPS 4	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	L	-	-	-	-	L	-	M	-	-	L	L	L
CO2	S	M	L	-	-	-	-	L	-	M	-	-	M	L	L
CO3	S	M	L	-	L	-	-	L	-	M	-	-	M	-	L
CO4	S	M	L	L	L	-	-	L	M	M	-	L	M	-	L
CO5	M	L	L	-	-	-	-	L	-	M	-	-	L	-	L
CO6	S	S	M	L	L	-	-	L	M	M	-	L	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam(%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)					
CO \ TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-				-						-	6	-
CO2	-	10	30		100		-						-	4	10
CO3	-	10	30				-						-	4	15
CO4	-						-	10	40				-	5	30
CO5	-						-	15	-		100		-	6	-
CO6	-						-	10	35				-	5	15
Total	**-**	**40**	**60**		**100**		**-**	**35**	**65**		**100**		**-**	**30**	**70**

Syllabus

Multimedia communications: Introduction to Multimedia information, 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, and entertainment applications. Networking terminology- media types, communication modes, network types, network QoS, application QoS.periodic. **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 standard, High Efficiency Image File Format (HEIF). **Audio and video compression:** Audio compression-differential pulse code modulation, adaptive differential PCM, adaptive predictive coding, linear predictive coding, MPEG audio coders, Surround sound - Dolby Digital Video compression - Principles, H.261, H.263, H.264, MPEG standards, High Efficiency Video Coding (HEVC) **Standards for multimedia communications:** Reference models- TCP/IP reference model, protocol basics, Real time streaming transport protocols –, RTP and RTCP, Session Initiation Protocol (SIP)Real Time Streaming Protocol (RTSP),P2P Video Streaming, Standards relating to interpersonal communications-circuit mode networks, packet switched networks

Text Book

- Fred Halsall, “Multimedia Communications: Applications, Networks, Protocols and Standards”, Addison-Wesley, 2012.

Reference Books

- Larry L. Peterson, Bruce S. Davie, “Computer Networks: A Systems Approach”, Sixth Edition, Morgan Kaufmann Publishers, 2021
- K. Rammohan Rao, Z. S. Bolzkovic and D. A. Milanovic, “Multimedia Communication: Techniques, Standards, and Networks”, Prentice Hall, 2002.
- 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.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
1	**Multimedia communications:**	
2	Introduction to Multimedia information, Multimedia networks	1
3	telephone networks, data networks, broadcast television networks	1
4	integrated services digital networks, broadcast multiservice networks.	1
5	Multimedia applications - interpersonal communications, interactive applications over the internet, and entertainment applications	1
6	Networking terminology- media types, communication modes, network types, network QoS, application QoS.periodic	1
	Multimedia information representation:	
7	Digitization principles- analog signals	1
8	encoder design, decoder design.	1
9	Text - unformatted text, formatted text, hypertext	1
10	Images- graphics, digitized documents, digitized pictures.	2
11	Audio-PCM speech, CD quality audio, Video- Broadcast television.	2
	Text and image compression:	
12	Compression principles-source encoders and destination decoders	1
13	lossless and lossy compression, entropy encoding	1
14	Text compression- Huffman coding	1
15	Image compression – JPEG standard	2
	High Efficiency Image File Format (HEIF).	1
	Audio and video compression:.	
16	Audio compression-differential pulse code modulation, adaptive differential	2
17	PCM, adaptive predictive coding, linear predictive coding,	3
18	MPEG audio coders, Surround sound - Dolby Digital	2
19	Video compression - Principles, H.261, H.263, H.264,	1
20	MPEG standards, High Efficiency Video Coding (HEVC)	3
	Standards for multimedia communications:	
21	Reference models- TCP/IP reference model, protocol basics	1
22	Real time streaming transport protocols –, RTP and RTCP,	2
23	Session Initiation Protocol (SIP)	1
24	Standards relating to interpersonal communications-circuit mode networks, packet switched networks	2
	TOTAL	**36**

Course Designers:

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22ECGC0	TELECOMMUNICATION SYSTEMS

Category	L	T	P	Credit
IE	3	0	0	3

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 Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the functionality of digital communication system and determine the signal to noise ratio (SNR) at the input of a digitalcommunication receiver and at the output of the detector.	TPS 3	70	70
CO2	Describe the functionality of Radar system and determine the link analysis using Friss formula	TPS 3	70	70
CO3	Describe the optical fiber communication link and the physical structure and guiding properties of optical fibers.	TPS 3	70	70
CO4	Describe the functionality of Satellite communication system and determine the SNR for both the uplink and downlink	TPS 3	70	70
CO5	Describe the functionality of a data communication network	TPS 2	70	75
CO6	Describe the cellular concept of Wireless Communication Systems, 2G, 3G and 4G wireless standards for mobile communication, IEEE 802.11b, g Wireless Local area network (WLAN) standards.	TPS 2	70	75

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	M	M	-	-	-	M	L	-
CO2	S	M	L	-	-	-	-	M	M	-	-	-	M	L	-
CO3	S	M	L	-	-	-	-	M	M	-	-	-	M	L	-
CO4	S	M	L	-	-	-	-	M	M	-	-	-	M	L	-
CO5	M	L	-	-	-	-	-	M	M	-	-	-	M	L	-
CO6	M	L	-	-	-	-	-	M	M	-	-	-	M	L	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20		100		-						-	4	15
CO2	-	20	20				-						-	4	15
CO3	-	10	20				-						-	4	15
CO4	-						-	20	40		100		-	4	15
CO5	-						-	20	-				-	12	-
CO6	-						-	20	-				-	12	-
Total	-	**40**	**60**		**100**		-	**60**	**40**		**100**		-	**40**	**60**

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 **Transmission Media** : Twisted-Pair, Coaxial Cable, Microwave, Satellite, Fiber Optics **Propagation mechanism:** Friis Link Equation, Decibel forms for the oneway link equations, Line of Sight Propagation Reflection and refraction, Ground wave propagation, Sky wave propagation ,Satellite link. **Digital Communication System:** Pulse code modulation(PCM)-encoding and quantization, baseband encoding forms, Time Division Multiplexing, Binary digital modulation schemes (ASK, PSK, FSK), Bit Error Rate Analysis. **Radar system:** Radar link equation, pulse radar. **Fiber Optic Communication System:** Optical Spectral bands, WDM Concepts, Key Elements of Optical Fiber Systems, Optical Fiber Modes and Configurations. **Satellite Communication Systems:** Orbital Mechanics, Satellite Alignment, Space craft communication Systems, Antennas Aboard Satellites and Earth Station, Satellite Link Analysis. **Data communication networks:** Networking Modes and Switching Modes-The PSTN Versus the Internet- The Evolution of Data Communications, Data Flow, The OSI Reference Model and the TCP/IP Reference Model. **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

Text Book

- Goleniewski," Telecommunications essentials the Complete Global Source", 2nd edition, Addison Vesley,2006.
- William D.Stanley amd John.M. Jeffords, “ Electronic Communications Principles and Systems”, Cengage Learning, 2009 ,India Editi, 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, Tata McGraw – 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).

- Satellite Communication Systems Coursein 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

Reference Books

- 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.

Course Contents and Lecture Schedule

No.	Topic	Lecture Hours	COs
1	**Introduction**		
1.1	Communication system model	1	CO1
1.2	Bandwidth and spectrum, modulation and demodulation	1	CO1
1.3	decibel gain and loss ratios	1	CO1
1.4	Signal to noise ratio and system level decibel Analysis	1	CO1
2	**Transmission Media**		
2.1	Twisted-Pair, Coaxial Cable, Microwave,	1	CO1
2.2	Satellite, Fiber Optics	1	CO1
3	**Propagation mechanism**		
3.1	Friis Link Equation	1	CO1
3.2	Decibel forms for the oneway link equations	1	CO1
3.3	Line of Sight Propagation Reflection and refraction	1	CO1
3.4	Ground wave propagation, Sky wave propagation	1	CO1
3.5	Satellite link	1	CO1
4	**Digital Communication System**		
4.1	Pulse code modulation (PCM)- encoding and quantization	1	CO1
4.2	baseband encoding forms	1	CO1
4.3	Time Division Multiplexing	1	CO1
4.4	Binary digital modulation schemes (ASK, PSK, FSK)	1	CO1
4.5	Bit Error Rate Analysis	1	CO1
5	**Radar system**		
5.1	Radar link equation	2	CO2
5.2	pulse radar	1	CO2
6	**Fiber Optic Communication System**		
6.1	Optical Spectral bands, WDM Concepts	1	CO3
6.2	Key Elements of Optical Fiber Systems	1	CO3
6.3	Optical Fiber Modes and Configurations	1	CO3
7	**Satellite Communication Systems**		
7.1	Orbital Mechanics, Satellite Alignment, Space craft communication Systems	1	CO4

7.2	Antennas Aboard Satellites and Earth Station, Satellite Link Analysis	1	CO4
8	**Data communication networks**		
8.1	Networking Modes and Switching Modes-The PSTN Versus the Internet	1	CO5
8.2	The Evolution of Data Communications, Data Flow	1	CO5
8.3	The OSI Reference Model and the TCP/IP Reference Model	2	CO5
9	**Wireless Communication Systems**		
9.1	Cellular Concept	1	CO6
9.2	Frequency Reuse, Channel Assignment Strategies, Handoff Strategies	2	CO6
9.3	Interference, System Capacity,	1	CO6
9.4	Wireless Standards: 2G, 3G, 4G and 5G Mobile Standards,	2	CO6
9.5	IEEE 802.11b,g Wireless Local Area Network (WLAN) standards	2	CO6
	Total Hours	**36**	

Course Designers:

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22ECGD0	APPLIED IMAGE PROCESSING

Category	L	T	P	Credit
IE	3	0	0	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 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 Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Demonstrate the human visual perception, digital image acquisition and relationship between pixels for grayscale and color images.	TPS 2	70	75
CO2	Enhance the visual perception of digital imagery from poor contrast and noise degradation in spatial domain.	TPS 3	70	70
CO3	Enhance the given image in frequency domain by applying image transforms such as Fourier and DCT.	TPS 3	70	70
CO4	Extract regions of interest from an image using thresholding, edge and region-based segmentation algorithms.	TPS 3	70	70
CO5	Describe the segmented region using boundary as well as region representors and descriptors with the combination of morphological operations.	TPS 3	70	70
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.	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	L	-	L	-	-		-	L	-	-
CO2	S	M	L	-	L	L	-	L	-	L	-	-	M	-	L
CO3	S	M	L	-	L	L	-	L	L	L	-	-	M	-	L
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	L	L	-	L	-	L	-	L	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**						**Terminal Exam** (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)					
TPS / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	20					-						-	15	-
CO2	-		40	100			-						-	-	20
CO3	-		40				-						-	-	15
CO4	-						-	10	20				-	-	15
CO5	-						-		30	100			-	-	15
CO6	-						-		40				-	-	20
Total	**-**	**20**	**80**	**100**			**-**	**10**	**90**	**100**			**-**	**15**	**85**

Syllabus

Image acquisition and Fundamentals: Elements of visual perception, light and the Electromagnetic spectrum, Imaging modalities, 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 Color models and Conversion **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, Principal Component Analysis Transform (PCA) **Image Compression:** JPEG compression. **Segmentation:** Thresholding: Local and global, Edge based: Point, Line and Edge detection, Prewitt, Sobel, Canny and Robert's operators. Region based segmentation: Region growing, Region splitting and merging. Gray-scale Morphological operations. **Feature Extraction:** Boundary feature descriptors, Region feature Descriptors, Topological descriptors: Texture feature descriptors. **Real world Applications:** Vehicle license plate detection, PCA-based face recognition, 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. Vehicle number plate detection for traffic surveillance applications
2. Detecting cyst/tumour or muscle disorders in US/CT/MRI/XRay images.
3. Industry inspection in IR/Thermal images (Non-Destructive Testing).
4. Change detection between two remotely sensed satellite images, land cover usage.
5. Fault diagnosis/analysis in power systems.

Text Book

- Rafael.C.Gonzalez, Richard.E. Woods and Steven L. Eddins, "Digital Image Processing using Matlab", 4th Edition, Gatesmark Publishing, 2018, ISBN 10: 1-292-22304-9.

Reference Books

- William K. Pratt, "Introduction to Digital Image Processing", CRC Press, 2013.
- Oge Marques, "Practical Image and Video Processing using MATLAB", Wiley-IEEE Press, 2011, ISBN: 978-0-470-04815-3.
- Al.Bovik, "The Essential Guide to Image Processing", Academic Press, 2009.
- Anil K.Jain, "Fundamentals of Digital Image Processing", Pearson Education 2003.
- 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

#	Topic	Lecture Hours
1	**Introduction to the Course and course outcomes**	1
	Introduction to Image processing, Need and applications	
2	Elements of visual perception	1
3	Light and the Electromagnetic spectrum	1
4	Imaging modalities- X-Ray, CT, Ultrasound,	1
5	Visible, Infrared, Thermal	1
6	Digital image Model, Image file formats, Color space conversion	1
7	Image Sampling and Quantization	1
8	Basic relationship between pixels, Adjacency, Connectivity- 4, 8 and m connectivity, region, boundary	1
9	Distance measures- Euclidean, city-block, chessboard	1
	Full color image processing, Color model-RGB, CMY, HSI	1
10	Color models-RGB, CMY, HSI	1
11	HVS and color space: (RGB to HSI, YCbCr color space), Extendible of grayscale methods into color	1
12	**Image Enhancement:** Intensity Transformations, Image Negative, Contrast stretching	1
13	Log transformation- Gamma correction	1
14	Histogram equalization, color histogram processing	1
15	Assignment 1: Image contrast Enhancement	
16	**Noise Removal-Spatial Filtering**- **Smoothing**-Noise models – Salt and Pepper, Uniform, Gaussian	1
17	Mean- Order statistics filter-median filters Min, Max and Mid-point	1
18	**Spatial filtering – Sharpening**- Laplacian filter, unsharp masking	1
	Spectral representation for enhancement and coding:	
19	Fourier, Discrete cosine Transform	2
20	Principal Component Analysis Transform	2
21	Low pass and high pass filters in frequency domain	1
22	JPEG compression	1
23	Assignment II: Noise removal in spatial/frequency domain	
24	**Segmentation:** Thresholding – Local and global	1
25	**Edges-** Point, line detection, Edge detection, Prewitt, Sobel and Roberts operators	1
26	Region based segmentation- Region growing, Region splitting and merging	1
27	Gray-scale Morphological operations: dilation and erosion – opening and closing	1
	Representation and Description:	
28	Boundary representation- Chain codes–Signatures	1
29	Boundary descriptors–Shape numbers-Fourier descriptors	1
30	Regional Descriptors-Topological Descriptors-Texture	1
	Real world Applications:	
31	Vehicle number plate detection	1
32	Digital image watermarking, Missing component detection for automatic industry inspection	1
33	Detecting cyst/tumour in Ultrasound/CT images	1
34	Fault analysis in power system	1
	TOTAL	**36**

Course Designers:

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22ECGE0	COMPUTER VISION FOR ENGINEERING APPLICATIONS

Category	L	T	P	Credit
IE	3	0	0	3

Preamble

This course focuses on how computers treat vision to understand the 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 on the theoretical and algorithmic basis by which valuable 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 and photometric geometries are required for the low-level vision process. In mid-level, it describes how the feature points such as interest points corner points are detected, matched and the alignment of matched feature points. Subsequently, it deals with 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

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Illustrate image formation using projective and photometric geometry with the relationship between world coordinates and image coordinates.	TPS 2	70	75
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.	TPS 3	70	70
CO3	Obtain meaningful segments using similarity-based K Means clustering segmentation algorithm and discontinuity based active contour segmentation algorithm.	TPS 3	70	70
CO4	Recognize the detected objects by applying supervised algorithms like K-nearest neighbour and SVM.	TPS 3	70	70
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.	TPS 3	70	70
CO6	Make use of algorithms for computer vision applications such as face detection and recognition, visual authentication, Optical Character Recognition (OCR) for automatic number plate recognition, Case study on implementing a vision system for robotic picking, medical image segmentation and Augmented Reality.	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	L	-	-	M	L	L	L
CO2	S	M	L	-	M	-	-	-	M	-	-	M	M	M	M
CO3	S	M	L	-	M	-	-	-	M	-	-	M	M	M	M
CO4	S	M	L	-	L	-	-	-	M	L	-	M	M	L	L
CO5	S	M	L	-	M	-	-	-	M	-	-	M	M	L	M
CO6	S	M	L	-	M	M	-	M	M	M	-	M	M	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**						**Terminal Exam** (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)					
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	20					-						-	15	-
CO2	-		40		100		-						-	-	20
CO3	-		40				-						-	-	15
CO4	-						-	10	20				-	-	15
CO5	-						-		30		100		-	-	15
CO6	-						-		40				-	-	20
Total	**-**	**20**	**80**		**100**		**-**	**10**	**90**		**100**		**-**	**15**	**85**

Syllabus

Computer Vision: Low Level Vision: History and Evolution of Computer Vision, Applications, Geometric image formation, projection, Pinholes, Lenses, perspective, orthographic projections, 2D Transformations, 3D Transformations, camera intrinsic and extrinsic parameters, Photometric image formation, Image scaling, rotation, and translation.

Middle Level Vision: Feature detectors and descriptors, Interest points, Harris corner detection, Scale Invariant Feature Transform (SIFT), blob detection, feature matching algorithms, Euclidean distance metric, Error rates, K-Means Clustering, Active Contour Model

High Level Vision: Classifiers-Machine Learning**:** Supervised vs Unsupervised, K-nearest neighbour, SVM, PCA, Deep Learning: Neural networks, Convolutional Neural Networks (CNN), Region-based CNN (R-CNN).

Applications: Face detection using R-CNN and face recognition using PCA, Optical Character Recognition (OCR) for automatic number plate recognition, Case study on implementing a vision system for robotic picking, Medical Image Segmentation, and augmented reality.

Text Book

- R Szeliski, “Computer vision: algorithms and applications”, Springer Science & Business Media, 2021.

Reference Books

- David A. Forsyth, Jean Ponce, “Computer Vision – A Modern Approach”, Prentice Hall, 2015, ISBN: 9781292014081.
- Prince, S.J.D, “Computer Vision: Models, Learning, and Inference”, Cambridge University Press, 2012
- 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.
- 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.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course and course outcomes	1
1	**Low Level Vision –** Introduction -Pinholes	1
2	**Image formation**-Geometric image formation-projection	1
3	Lenses-perspective-orthographic	1
4	Camera intrinsic and extrinsic parameters	1
5	2D Transformations	1
6	3D Transformations	1
7	Photometric image formation	1
8	Image scaling	1
9	Rotation and Translation	1
	Middle Level Vision- Feature detection, matching and alignment	1
10	Feature detectors and descriptors-Interest points-Harris corner detection	1
11	Scale Invariant Feature Transform (SIFT)	1
12	Histogram of Oriented Gradients (HOG)	1
13	Feature matching algorithms	1
14	Euclidean distance metric	1
15	Feature alignment algorithms	1
16	Error rates	1
17	Clustering and Segmentation- K-Means Clustering	2
18	Active Contour Model	1
	Assignment 1: Feature Extraction and Segmentation	
19	**High Level Vision-Classifiers**	1
20	-**Machine Learning: Supervised**	1
21	K-nearest neighbour	1
22	SVM	2
23	**Unsupervised**- PCA	1
24	Deep Learning	1
25	Neural networks	1
26	Convolutional Neural Networks (CNN)	1
27	Region-based CNN	1
	Assignment II: PCA/ RCNN classifiers	
	Applications: Face detection using RCNN	1
28	Face recognition using PCA for visual authentication	1
29	Face recognition using RCNN for visual authentication	
30	Optical Character Recognition (OCR) for automatic number plate recognition	1
31	Case study: Implementing a vision system for robotic picking	1
32	Medical Image Segmentation	1
33	Augmented reality	1
	Assignment III: Mini Project on CV Applications	
	TOTAL	**36**

Course Designers:

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22ECGG0	NON-INVASIVE TESTING AND EVALUATION

Category	L	T	P	Credit
IE	3	0	0	3

Preamble

Non-Destructive Testing (NDT) plays a pivotal role in ensuring the safety, reliability, and quality of materials and components without causing damage. This course offers a comprehensive understanding of NDT methods, emphasizing their applications in detecting and analyzing discontinuities across various materials and structures.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the principles, history, and advantages of NDT compared to destructive testing.	TPS 2	70	60
CO2	Identify the origins and types of material discontinuities, including those arising from casting, welding, deformation, fatigue, creep, and operational stresses, and understand their impact on material integrity.	TPS 3	70	60
CO3	Perform visual examinations using direct and indirect methods, as well as penetrant testing, to detect surface-level defects and interpret results effectively.	TPS 3	70	60
CO4	Utilize radiographic techniques and ultrasonic inspection methods for internal defect detection, ensuring safety and accuracy.	TPS 3	70	60
CO5	Apply thermographic testing techniques, including active and passive methods, liquid crystal approaches, and infrared-based inspections, to detect defects in diverse applications	TPS 3	70	60
CO6	Apply the concept of Probability of Detection (POD) to assess the reliability and effectiveness of NDT methods in design and operational scenarios.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	L	L	-	-	-	L	M	M	-	L	-	L
CO2	S	M	L	L	-	-	-	L	M	M	-	M	-	L
CO3	S	M	L	L	-	-	-	L	M	M	-	M	-	L
CO4	S	M	L	L	-	-	-	L	M	M	-	M	-	L
CO5	S	M	L	L	-	-	-	L	M	M	-	M	-	L
CO6	S	M	L	L	-	-	-	L	M	M	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam(%)		
CO \ TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20				-						-	4	10
CO2	-	10	20		100		-						-	4	15
CO3	-	10	30				-						-	4	15
CO4	-						-	10	30				-	-	15
CO5	-						-	10	20		100		-	4	15
CO6	-						-	10	20				-	4	10
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

INTRODUCTION TO NON-DESTRUCTIVE TESTING
Non-Destructive Testing (NDT), History of NDT, Nondestructive testing versus destructive testing, conditions for effective NDT.

DISCONTINUITIES – ORIGINS AND CLASSIFICATION
Primary production of Metals, Castings, Cracks, Welding discontinuities, discontinuities from plastic deformation, operationally induced discontinuities, fatigue cracking, creep, brittle fracture, geometric discontinuities.

VISUAL TESTING
Fundamentals, vision, lighting, environmental factors, visual perception, visual examination methods-direct and indirect methods, visual examination aids-mirrors, magnifiers, boroscope and fiberscope, result interpretation, light sources and special lighting.

PENETRANT TESTING]
Basic principle, applications, advantage and limitations, types of dyes and methods of application, developers and cleaners, developer application, inspection procedure, methods and interpretation results.

RADIOGRAPHIC TESTING
Source – X-rays and Gamma rays, characterization of rays, absorption, scattering, types and use of filters and screens, Imaging modalities – film radiography and digital radiography, continuous inspection, problem in shadow formation, exposure factors, inverse square law, exposure charts, penetrometers, image interpretation, safety in radiography.

ULTRASONIC TESTING
Types of ultrasonic waves, principles of wave propagation, characteristics, attenuation, production of ultrasonic waves, couplands, probes, transducers, principle, inspection methods – pulse echo, transmission and resonance techniques, types of scanning, straight beam and angle beam inspection of welds, time of flight diffraction techniques, thickness measurement methods, Instrumentation, data representation, interpretation of results, advantages, limitations and applications.

THERMOGRAPHIC TESTING
Principle, Contact and Non-contact inspection method, active and passive methods, liquid crystal –concept, techniques for applying liquid crystals, advantages, limitations, application, Infrared - basics, infrared detectors, instrumentation and methods, interpretation results.

PROBABILITY OF DETECTION IN NDT
Probability of Detection (POD), typical methodology for establishing POD, Role of POD during design and operation.

Text Book

- J.Prasad and C.G.K. Nair, Non-destructive test and evaluation of materials, Tata Mc Graw Hill Education, 2nd edition, 2017.

- Baldev Raj, T.Jayakumar and M.Thavasimuthu, Practical Non-Destructive Testing, Narosa Publishing House, 2019.
- Chuck Hellier, “Handbook of Non-destructive testing”, McGraw Hill, 2012

Reference Books

- Paul E Mix, “Introduction to Non-Destructive testing: a training guide”, Wiley, 2nd edition, New Jersey 2005.
- ASM metals handbook, Volume-17, “Nondestructive Evaluation and Quality Control”, American society of metals, USA, 2018.
- https://archive.nptel.ac.in/courses/113/106/113106070/

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**INTRODUCTION TO NON-DESTRUCTIVE TESTING**	
1.1	Non-Destructive Testing (NDT)	1
1.2	History of NDT	
1.3	Nondestructive testing versus destructive testing	1
1.4	Conditions for effective NDT	
2	**DISCONTINUITIES – ORIGINS AND CLASSIFICATION**	
2.1	Primary production of Metals	1
2.2	Castings	
2.3	Cracks	1
2.4	Welding discontinuities	
2.5	Discontinuities from plastic deformation	
2.6	Operationally induced discontinuities - Fatigue cracking, creep, brittle fracture	1
2.7	Geometric discontinuities.	
3	**VISUAL TESTING**	
3.1	Fundamentals- Vision, Light sources, Lighting and special lighting.	1
3.2	Environmental factors	1
3.3	Visual perception	2
3.4	Visual examination methods-direct and indirect methods	
3.6	Visual examination aids-mirrors, magnifiers, boroscope and fiberscope,	2
3.7	Result interpretation,	
4	**PENETRANT TESTING**	
4.1	Basic principle of Penetrant testing	1
4.2	Applications, advantage and limitations	
4.3	Types of dyes and methods of application	1
4.4	Developers and cleaners	1
4.5	Developer application	1
4.6	Inspection procedure, methods and interpretation results	1
5	**RADIOGRAPHIC TESTING**	
5.1	Source – X-rays and Gamma rays	1
5.2	Characterization of rays- absorption, scattering	
5.3	Types and use of filters and screens	1
5.4	Imaging modalities – film radiography and digital radiography	1
5.5	Continuous inspection	1

5.6	Problem in shadow formation,	1
5.7	Exposure factors, inverse square law, exposure charts	
5.8	Penetrometers	1
5.9	Image interpretation and safety in radiography	1
6	**ULTRASONIC TESTING**	
6.1	Types of ultrasonic waves	1
6.2	Principles of wave propagation, characteristics, attenuation, production of ultrasonic waves	
6.3	Couplands, probes, transducers	1
6.4	Inspection methods – pulse echo, transmission and resonance techniques	1
6.5	Types of scanning, straight beam and angle beam inspection of welds, time of flight diffraction techniques	1
6.6	Thickness measurement methods	1
6.7	Instrumentation, data representation, interpretation of results, advantages, limitations and applications.	1
7	**THERMOGRAPHIC TESTING**	
7.1	Contact and Non-contact inspection method	1
7.2	Active and passive methods	1
7.3	Liquid crystal –concept, techniques for applying liquid crystals, advantages, limitations, application	2
7.4	Infrared - basics, infrared detectors, instrumentation and methods, interpretation results	2
8	**PROBABILITY OF DETECTION IN NDT**	
8.1	Probability of Detection (POD)	1
8.2	Typical methodology for establishing POD	
8.3	Role of POD during design and operation	1
	TOTAL	**36**

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DETAILED SYLLABI

FOR

PROGRAMME ELECTIVE COURSES FOR HONOURS
(for the students admitted from the academic year 2022-23)

B. E. DEGREE PROGRAMME
(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

HONOURS AND MINOR COURSES (For the students admitted in the Academic Year 2022-23 onwards)				
Honours				Minor
Electronic Products and Systems	Wireless and Optical Communications	Secure Communication / Cyber Physical System	AI in Communication, Vision and Health-care	Electronic Systems
22ECRH0 PARALLEL PROGRAMMING	22ECPC0 ADVANCED ANTENNA TECHNOLOGY	22ECPP0 5G WIRELESS NETWORKS	22ECPA0 ARTIFICIAL NEURAL NETWORKS FOR RF APPLICATIONS	22ECPL0 IOT SYSTEM AND APPLICATIONS
22ECPS0 VLSI DEVICE MODELING	22ECRC0 ARRAY SIGNAL PROCESSING	22ECRK0 BLOCKCHAIN AND APPLICATIONS	22ECPH0 SIGNAL PROCESSING AND MACHINE LEARNING FOR AUDIO AND SPEECH	22ECPM0 ELECTRONIC MEASUREMENT AND INSTRUMENTS
22ECRL0 VLSI TESTING AND VERIFICATION	22ECPN0 FIBER OPTIC COMMUNICATION	*22ECRR0 MULTIMEDIA SYSTEMS SECURITY*	22ECPF0 SATELLITE DATA ANALYSIS	*22ECQA0 CONSUMER ELECTRONICS AND SYSTEMS*
22ECRM0 ACTIVE CIRCUITS ANALYSIS AND SYNTHESIS	22ECRD0 STATISTICAL SIGNAL PROCESSING	*22ECRS0 IoT SECURITY*	*22ECRU0 BIOMEDICAL SIGNAL PROCESSING*	*22ECQB0 MULTIMEDIA SYSTEMS*
22ECRN0 DIGITAL SIGNAL PROCESSING WITH FPGA	*22ECRP0 RF FRONT-END SYSTEM*	*22ECRT0 CLOUD SECURITY*	*22ECRV0 DEEP LEARNING FOR VISION*	*22ECQC0 IMAGING SYSTEMS*
22ECPU0 ROBOTIC SYSTEMS AND CONTROL	*22ECRQ0 CONVEX OPTIMIZATION FOR WIRELESS COMMUNICATIONS*	*22ECPV0 WIRELESS AND MOBILE SECURITY*	*22ECPW0 SOFT COMPUTING*	*22ECQD0 BIOMEDICAL INSTRUMENTATION*
22ECPX0 SYSTEM DESIGN WITH ARM CORTEX	*22ECRY0 MIMO OFDM SYSTEMS*	*22ECRZ0 HARDWARE SECURITY*	*22ECPY0 INTRODUCTION TO ARTIFICIAL INTELLIGENCE*	*22ECQE0 CMOS VLSI SYSTEM AND CIRCUITS*
-	-	-	-	*22ECQF0 TELECOMMUNICATION SYSTEMS*

The students can also opt for maximum of two relevant NPTEL courses and two relevant TCE MOOCS courses in each vertical’

22ECRL0	VLSI TESTING AND VERIFICATION

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

This course explores various aspects of VLSI testing and formal design verification. It introduces design and manufacturing defect models, along with test generation and fault simulation algorithms tailored to different fault models. Topics include testing for both combinational and sequential logic, as well as synthesis-for-testability techniques such as Built-In Self-Test (BIST) and scan path design.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand VLSI Defects and its models at various levels of abstraction.	TPS2	70	60
CO2	Apply Fault Models and Simulation Techniques such as serial, parallel and Deductive	TPS3	70	60
CO3	To construct a Design for Testability (DFT) algorithm for VLSI Circuits.	TPS3	70	60
CO4	Develop efficient test generation strategies using ATPG algorithms, and design robust Built-In Self-Test (BIST) architectures.	TPS4	70	60
CO5	Describe the various levels of memory testing, including at-system, module, and chip levels, and explain their roles in ensuring reliable functionality.	TPS3	70	60
CO6	Apply hardware verification concepts, understand their significance, and utilize methodologies employed in modern hardware design.	TPS3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	L	L	L	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	L	L	-	-	-	-	-	-	M	-	-
CO4	S	S	M	L	L	-	-	-	-	-	-	S	-	-
CO5	S	M	L	L	L	-	-	-	-	-	-	M	-	-
CO6	S	M	L	L	L	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	30		100		-						-	8	-
CO2	-	20					-						-	4	10
CO3	-	10	30				-						-	4	20
CO4	-						-	10	20				-	2	20
CO5	-						-	10	30		100		-	2	15
CO6	-						-	10	20				-	-	15
Total	**-**	**40**	**60**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Introduction: Importance – Challenges - Levels of abstraction - Design and manufacturing defect models - Simulation based design verification.

Fault models: Stuck-at faults - Advanced Fault Models, Fault Simulation: Serial, Parallel, Deductive, Advanced issues.

Design for Testability: Testability Analysis, DFT Basics, Scan cell design, Scan Architecture: Scan design rules, Scan design flow

Test Generation: Exhaustive testing, Basic ATPG algorithms: Boolean difference, D Calculus and D algorithm, PODEM Algorithm, ATPG for non-stuck-at faults, other issues in test generation, Built-In-Self-Test: Introduction, BIST design rules, Test pattern generation, Output response analysis, Logic BIST Architectures

Memory Testing: Memory Density and Defect Trends, Memory Test Levels, March Test Notation, Memory Testing: Functional RAM Testing, Functional ROM Chip Testing, Electrical Parametric Testing

Verification Techniques: Introduction to Hardware Verification and methodologies Binary Decision Diagrams (BDDs) and algorithms over BDDs Combinational equivalence checking Temporal Logics modelling sequential systems and model checking Symbolic model checking
.

Text Book

- M. L. Bushnell and V.D. Agrawal, Essentials of Electronic Testing for Digital Memory and Mixed Signal VLSI Circuits, Springer, 2006

Reference book & web resources

- H. Fujiwara, Logic Testing and Design for Testability, MIT Press, 1985
- M. Abramovici, M. Breuer, and A. Friedman, Digital System Testing and Testable Design, IEEE Press, 1994
- M. Huth and M. Ryan, Logic in Computer Science, Cambridge Univ. Press, 2004
- T. Kropf, Introduction to Formal Hardware Verification, Springer Verlag, 2000
- Dr. Santosh Biswas Department of Computer Science and Engineering, IIT Guwahati Jatindra Kumar Deka, Department of Computer Science and Engineering, IIT Guwahati, Prof.Arnab sarkar, Department of Computer Science and Engineering, IIT Guwahati, VLSI Design Verification and Test : https://nptel.ac.in/courses/106103016.

Course Contents and Lecture Schedule

No.	Topic	No.of Hours	COs
1	**Introduction**		
1.1	Importance, Challenges	1	CO1
1.2	Levels of abstraction	1	CO1
1.3	Design and manufacturing defect models	2	CO1
1.4	Simulation based design verification	2	CO1

2	**Fault models**		
2.1	Stuck-at faults	1	CO2
2.2	Advanced Fault Models	1	CO2
2.3	Fault Simulation: Serial, Parallel,	1	CO2
2.4	Deductive, Advanced issues	1	CO2
3	**Design for Testability**		
3.1	Testability Analysis	2	CO3
3.2	DFT Basics	1	CO3
3.3	Scan cell design	1	CO3
3.4	Scan Architecture: Scan design rules	1	CO3
3.5	Scan Design flow	1	CO3
4	**Test Generation**		
4.1	Exhaustive testing	1	CO4
4.2	Basic ATPG algorithms: Boolean difference,	1	CO4
4.3	D Calculus and D algorithm, PODEM Algorithm	2	CO4
4.4	ATPG for non-stuck-at faults, Other issues in test generation	1	CO4
4.5	Built-In-Self-Test: Introduction, BIST design rules, Test pattern generation, Output response analysis,	2	CO4
4.6	Logic BIST Architecture	1	CO4
5	**Memory Testing**:, ,		
5.1	Memory Density and Defect Trends	0.5	CO5
5.2	Memory Test Levels, March Test Notation	1	CO5
5.3	Memory Testing: Functional RAM Testing,	1	CO5
5.4	Functional ROM Chip Testing	1	CO5
5.5	Electrical Parametric Testing	0.5	CO5
6	**Verification Techniques**: and and		
6.1	Introduction to Hardware Verification and methodologies	2	CO6
6.2	Binary Decision Diagrams (BDDs)	1	CO6
6.3	Algorithms over BDDs	1	CO6
6.4	Combinational equivalence checking	1.5	CO6
6.5	Temporal Logics modelling sequential systems	1.5	CO6
6.6	Model checking Symbolic model checking	1	CO6

Course Designers:

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22ECRM0	ACTIVE CIRCUITS ANALYSIS AND SYNTHESIS

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

This course is a study of Analog systems analysis and synthesis using active devices. The course aims at analysis and synthesis of active circuits, analysis of analog PLL, digital PLL and IC regulators.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the use of active devices as network elements and the method of analyzing the circuits containing active elements (Op-Amp)	TPS3	70	60
CO2	Analyze the active network containing multiple poles and operational amplifiers.	TPS3	70	60
CO3	Realization of active networks using driving point functions and transfer functions.	TPS3	70	60
CO4	Understand the characteristics of analog Phase Locked Loop	TPS2	70	60
CO5	Understand the characteristics of Digital Phase Locked Loop	TPS2	70	60
CO6	Analyze the characteristics of IC regulators, DC-DC converters and Low dropout regulators for voltage regulation applications.	TPS3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	L	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	L	-	-	-	-	-	-	M	-	-
CO4	M	L	L	-	L	-	-	-	-	-	-	L	-	-
CO5	M	L	L	-	L	-	-	-	-	-	-	L	-	-
CO6	S	M	L	-	L	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**								
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)			**Terminal Exam** (%)		
TPS / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	20				-						-	4	15
CO2	-	10	20		100		-						-	4	15
CO3	-	10	30				-						-	4	20
CO4	-						-	10	20		100		-	12	-
CO5	-						-	10	30				-	12	-
CO6	-						-	10	20				-	4	10
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**40**	**60**

Syllabus

Active devices as Network elements: Controlled Sources, Negative Resistance (NR) Inductance and Capacitance, Impedance Converter (IC) and Impedance Inverter (II). **Analysis of Active circuits:** Indefinite admittance matrix, Elementary operators, classification of multipoles and its network functions, equivalent circuits, analysis of networks containing ideal active elements and operational amplifiers. **Synthesis of Active circuits:** Realisation of networks containing active elements (NR, NIC, Controlled sources, Op-Amps and Gyrators), Practical considerations, synthesis of driving point functions and transfer functions, Sensitivity considerations, simulation of inductance. **Analog and Digital PLL:** Basic principles, phase detector, Voltage controlled oscillator (VCO), low pass filter, Frequency synthesizer, Introduction to Digital PLL, Design of Time-to-Digital Converter, Small Signal Analysis of Digital PLL, Noise Analysis in Digital PLL. **IC Regulators:** Basic principles and Characteristics, DC-DC converter, Low Drop out Regulator.

Text Book

- S. K. Mithra, Analysis And Synthesis of Linear Active Networks, John Wiley & Sons International, 1985.
- D.Roy Choudhury, and Shail B.Jain, Linear Integrated Circuits, ,New Age International Publishers, Fourth Edition, 2012.
- Woogeun Rhee, Zhiping Yu, ‘Phase-Locked Loops: System Perspectives and Circuit Design Aspects’ ,Wiley, 2024.

Reference Books

- Adel S.Sedra, Kenneth C.Smith, and adapted by Arun N.Chandorkar, Microelectronic Circuits Theory and Applications, Prentice-Hall, 5th Ed., 2009.
- Ramakant A. Gayakwad, “OP-AMP and Linear ICs”, 4th Ed., PHI, 2001.
- Sergio Franco, “Design with Operational Amplifiers and Analog Integrated Circuits”’ 3rd Edition, Tata McGraw-Hill, 2011.
- Robert F.Coughlin, Frederick F.Driscoll, “Operational Amplifiers and Linear Integrated Circuits”, Sixth Ed., PHI, 2001.
- G Daryanani, “Principles of Active Network Synthesis and Design”, John Wiley & Sons International, 1976.
- William D.Stanley, “Operational Amplifiers with Linear Integrated Circuits”, Pearson Education, 2004.
- K.R.K. Rao, C.P. Ravikmar,” Analog System Lab Manua”, 2nd Ed., Texas Instruments, Wiley, 2012.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1.	**Active devices as Network elements:**	
1.1	Controlled Sources	2
1.2	Negative Resistance (NR) Inductance and Capacitance	2
1.3	Impedance Converter (IC) and Impedance Inverter (II)	3
2.	**Analysis of Active circuits:**	
2.1	Indefinite admittance matrix	1
2.2	Elementary operators	1
2.3	Classification of multipoles and its network functions, equivalent circuits	2
2.4	analysis of networks containing ideal active elements and operational amplifiers	2
3.	**Synthesis of Active circuits:**	
3.1	Realisation of networks containing active elements (NR, NIC, Controlled sources, Op-Amps and Gyrators)	2
3.2	Practical considerations	1

Module No.	Topic	No. of Lectures
3.3	synthesis of driving point functions and transfer functions	2
3.4	Sensitivity considerations and simulation of inductance	2
4.	**Analog and Digital PLL**:	
4.1	Basic principles, Phase detector	2
4.2	Voltage controlled oscillator (VCO), Low pass filter	2
4.3	Introduction to Digital PLL, Design of Time-to-Digital Converter,.	2
4.4	Small Signal Analysis of Digital PLL	2
4.5	Noise Analysis in Digital PLL	2
5.	**IC Regulators**	
5.1	Basic principles and Characteristics of regulators	2
5.2	DC-DC converter	2
5.3	Low Drop out Regulator	2
	Total	36

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22ECRN0	DIGITAL SIGNAL PROCESSING WITH FPGA

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

The rapid advancements in computational power and hardware technologies have led to the integration of DSP algorithms in various platforms, with Field-Programmable Gate Arrays (FPGAs) emerging as a prominent solution for real-time DSP applications. The integration of DSP with FPGAs enables the design of highly efficient systems that meet the stringent performance requirements of modern applications. This course provides the students, the knowledge about implementation of signal processing blocks on FPGA. It provides both the fixed point and floating-point representation of data used for implementation. It considers algorithms and techniques for the optimal way of Implementing the communication system blocks efficiently on programmable device like FPGA.

Prerequisite

Digital Signal Processing
Digital System Design

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Compare the design flow of different ways of implementing the digital signal processing algorithms	TPS 3	80	70
CO2	Perform fixed- and floating-point arithmetic used in Digital signal processing.	TPS 3	80	70
CO3	Implement constant coefficient Finite Impulse Response (FIR) filter using programmable devices FPGA using HDL for given specification.	TPS 3	80	70
CO4	Implement Infinite Impulse Response (IIR) filter using Programmable devices FPGA using HDL for given specification.	TPS 3	80	70
CO5	Analyze the different algorithms used to Implement Fourier Transform in Programmable devices.	TPS 3	80	70
CO6	Implement the communication blocks in programmable device like FPGA using HDL.	TPS 3	80	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	M	M	-	L	M	-	L
CO2	S	M	L	-	-	-	-	M	M	-	L	M	-	L
CO3	S	M	L	-	-	-	-	M	M	-	L	M	-	L
CO4	S	M	L	-	M	-	-	M	M	-	L	M	-	L
CO5	S	M	L	-	M	-	-	M	M	-	L	M	-	L
CO6	S	M	L	-	M	-	-	M	M	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam(%)		
	CAT – I(%)			**Assg. I ***(%)			**CAT – II**(%)			**Assg. II ***(%)					
CO \ **TPS Scale**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	20				-						-	2	10
CO2	-	10	20		100		-						-	4	10
CO3	-	10	30				-						-	4	15
CO4	-						-	10	20				-	4	15
CO5	-						-	10	30		100		-	4	15
CO6	-						-	10	20				-	2	15
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Implementation Technology: Introduction to Signal Processing Hardware, Processor Architecture & Design flow, Programmable Devices architectures & Design flow, Programming languages, Programming technology

Basic Building Blocks: Number Representation, fixed point arithmetic, Binary adders, Binary dividers, Floating point arithmetic, MAC & SOP unit

Digital filter implementation: FIR filter, Theory and structure, Filter Design, Constant coefficient, FIR Design IIR filter, IIR theory, Coefficient computation, Implementation detail, Fast IIR filter

Fourier Transform: DFT algorithms, Goertzel algorithm, Hartley transform, Winograd DFT, Blustein chirp−z transform, Rader algorithm, FFT algorithms, Cooley-tukey, Good thomas, Winograd FFT

Communication blocks: Error control codes, Linear block code, Convolution codes, Modulation and Demodulation, Adaptive filters, LMS, RLS, Decimator and Interpolator, High Decimation Rate filters.

Text Book

- Uwe.Meyer-Baese, “Digital Signal Processing with Field Programmable Gate Arrays”, Springer, Third edition, May 2014

Reference Books

- Roger Woods, John McAllister, Gaye, Ying Yi, “FPGA-based Implementation of Signal Processing Systems”, John Wiley & Sons Inc., Second edition, 2017
- Keshab K. Parhi, “VLSI Digital Signal Processing systems, Design and implementation”, Wiley, Inter Science, 1999
- John G. Proakis, “Digital Communications,” Fourth Ed. McGraw Hill International Edition, 2000.
- Michael John Sebastian Smith, “Applications Specific Integrated Circuits”, Pearson Education, 2000
- Sophocles J. Orfanidis, “Introduction to Signal Processing”, Prentice Hall, 1996

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
1	**Implementation Technologies** Introduction to Signal Processing Hardware	
2	Processor Architecture & Design flow	2
3	Programmable Devices architectures & Design flow	2
4	Programming Languages	1

5	Programming technology	1
	Basic Building Blocks	
6	Number representations	2
7	Fixed point arithmetic	1
8	Binary adders Binary dividers	1
9	Floating point arithmetic	1
10	MAC & SOP unit	1
	Digital Filter Implementation	
11	FIR filter – Theory and structure	1
12	Filter Design flow: Constant coefficient FIR Design	1
13	IIR filter – Theory	1
14	Coefficient computation	1
15	Implementation: Fast IIR filter	1
	Fourier Transform	
16	DFT algorithms	1
17	Goertzel algorithm, Hartley transform	1
18	Winograd DFT, Bluestein Chirp-Z transform	2
19	Rader algorithm	1
20	FFT algorithms: cooley-tukey, Good Thomas	2
21	Winograd FFT	1
	Communication Blocks	
22	Error Control Codes	1
23	Linear block codes	1
24	Convolution Codes	1
25	Modulation and Demodulation	1
26	Adaptive filters : LMS	2
27	RLS	1
28	Decimator and Interpolator	2
29	High Decimation Rate filters	1
	TOTAL	**36**

Course Designers:

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22ECPU0	ROBOTIC SYSTEMS AND CONTROL

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

This course provides a foundation in designing, modeling, and controlling robotic systems, integrating concepts from mechanical, electrical, electronics and computer engineering. Students will explore robotic components, kinematics, dynamics, and advanced control techniques, using MATLAB for simulations. Practical case studies, including mobile and Segway robots, prepare learners for careers in automation, robotics, and research across diverse industries.

Prerequisite

Nil

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the classifications, components, and terminologies of robots and robotic systems.	TPS2	70	70
CO2	Apply matrix representation, DH modeling, and inverse kinematics solutions to describe and manipulate robotic movements accurately.	TPS3	70	70
CO3	Apply knowledge of differential motion and Jacobian matrices to create efficient path-planning algorithms.	TPS3	70	70
CO4	Apply the understanding of Lagrangian and Newton-Euler formulations for dynamic modeling to solve inverse dynamics problems and analyze manipulator behavior in real-world scenarios	TPS3	70	70
CO5	Apply a comprehensive understanding of different control schemes to control robotic systems effectively.	TPS3	70	70
CO6	Apply theoretical knowledge to practical situations by implementing control techniques for manipulators, modeling and controlling mobile robots, and analyzing case studies to solve real-world robotics challenges.	TPS3	70	70

Mapping with Programme Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PS O1	PS O2	PS O2
CO1	M	L	L	-	-	-	L	L	L	M	L	L	L	L
CO2	S	M	L	L	-	L	L	L	L	S	L	M	L	L
CO3	S	M	L	-	M	-	L	L	L	M	L	M	L	L
CO4	S	M	L	L	M	L	L	L	L	S	L	M	L	L
CO5	S	M	L	L	M	L	L	L	L	S	L	M	L	L
CO6	S	M	L	L	M	L	L	L	L	S	L	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Ass. I * (%)			CAT – II (%)			Ass. II * (%)					
TPS Scale CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	-	100			-	-	-	-			-	15	-
CO2	-	10	30				-	-	-	-			-		15
CO3	-	10	30				-	-	-	-			-	10	10
CO4	-	-	-	-			-	10	25	100			-	-	15
CO5	-	-	-	-			-	10	25				-	10	10
CO6	-	-	-	-			-	10	20						15
Total	-	**40**	**60**	**100**			**-**	**30**	**70**	**100**			**-**	**35**	**65**

Syllabus

INTRODUCTION AND TERMINOLOGIES: Definition, Classification, Robots components, Degrees of freedom, Robot joints, coordinates, Reference frames, workspace, Robot languages, actuators, sensors, Position-velocity and acceleration sensors, Torque sensors, tactile and touch sensors, proximity and range sensors, vision system.

KINEMATICS: Mechanism, matrix representation, homogenous transformation, Kinematic Modeling of the Manipulator, Denavit-Hartenberg (DH) representation, Inverse kinematics-solution, and programming, degeneracy and dexterity, MATLAB Simulations of Kinematic models.

DIFFERENTIAL MOTION AND PATH PLANNING: Jacobian, differential motion of frames, Interpretation, calculation of Jacobian, Inverse Jacobian, Robot Path planning, Simulation and modeling of a simple Path Planning application using MATLAB.

DYNAMIC MODELLING: Lagrangian mechanics, Two-DOF manipulator, Lagrange-Euler formulation, Newton-Euler formulation, Inverse dynamics, MATLAB Simulations of Dynamic models.

ROBOT CONTROL SYSTEM: Linear control schemes, joint actuators, decentralized PID control, computed torque control, force control, hybrid position force control, Impedance/ Torque control, Fuzzy Logic control, MATLAB Simulations of Control Schemes.

CASE STUDIES: PID control of robotic manipulators, modeling and control of mobile robots and Segway robots

Text Book

- R.K. Mittal and I J Nagrath, “Robotics and Control”, Tata McGraw Hill, 24th Reprint 2017.
- Corke, Peter, “Robotics and Control: Fundamental Algorithms in MATLAB(R)”. Springer Tracts in Advanced Robotics. Springer, Cham, Switzerland, 2022.

Reference Books& web resources

- Saeed B. Niku," Introduction to Robotics: Analysis, Control, Applications ", Wiley; 3rd edition (17 December 2019)
- Spong, Mark W., Seth Hutchinson, and Mathukumalli Vidyasagar. Robot Modelling and Control. Vol. 3. New York: Wiley, 2020.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**INTRODUCTION AND TERMINOLOGIES**	
1.1	Definition, Classification, Robots components,	1
1.2	Degrees of freedom, Robot joints, coordinates,	1
1.3	Reference frames, workspace, Robot languages,	1
1.4	actuators, sensors, Position-velocity and acceleration sensors,	1
1.5	Torque sensors, tactile and touch sensors,	1
1.6	proximity and range sensors, vision system.	1
2	**KINEMATICS**	
2.1	Mechanism, matrix representation, homogenous transformation	2
2.2	Kinematic Modeling of the Manipulator, Denavit-Hartenberg (DH) representation,	2
2.3	Inverse kinematics-solution, and programming,	2
2.4	degeneracy and dexterity, MATLAB Simulations of Kinematic models.	2
3	**DIFFERENTIAL MOTION AND PATH PLANNING**	
3.1	Jacobian, differential motion of frames, Interpretation,	2
3.2	calculation of Jacobian, Inverse Jacobian,	2
3.3	Robot Path planning,	1
3.4	Simulation and modeling of a simple Path Planning application using MATLAB.	1
4	**DYNAMIC MODELLING**	
4.1	Lagrangian mechanics, Two-DOF manipulator	1
4.2	Lagrange-Euler formulation, Newton-Euler formulation,	2
4.3	Inverse dynamics, MATLAB Simulations of Dynamic models.	1
5	**ROBOT CONTROL SYSTEM**	
5.1	Linear control schemes, joint actuators,	2
5.2	Decentralized PID control, computed torque control, .	1
5.3	force control, hybrid position force control, Impedance/ Torque control, Reinforcement Learning	3
5.4	Fuzzy Logic control, MATLAB Simulations of Control Schemes	2
6	**CASE STUDIES**	
6.1	PID control of robotic manipulators,	2
6.2	modeling and control of mobile robots and Segway robots	2
	Total	**36**

Course Designers:

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22ECRP0	RF FRONT-END SYSTEM

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

This course covers the key components and operation of RF front-end in a wireless communication system. Students will learn about RF system parameters, including interference, noise, and receiver performance, and how to optimize them. The course also explores different RF receiver architectures and their challenges. It includes the design and testing of RF front-end systems and their performance metrics. Finally, students will be able to analyze, design, and optimize RF front-end for emerging wireless communication systems.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the wireless communication system architecture, including their key components and functions	TPS 2	70	70
CO2	Optimize key RF system parameters, including interference, noise, leakage, and receiver performance	TPS 3	70	70
CO3	Explain and compare RF receiver architectures, their challenges, trade-offs and performance in different designs	TPS 3	70	70
CO4	Design RF front-end systems and evaluate key metrics like noise, linearity, and I/Q imbalance	TPS 3	70	70
CO5	Design and test antennas, and understand the concepts like path loss, fading	TPS 3	70	70
CO6	Analyze radar systems and GSM/CDMA architecture, and perform link budget and power calculations	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	M	L	L	-	-	-	-	M	M	-	L	L	-	L
CO2	S	M	L	-	-	-	-	M	M	-	L	M	-	L
CO3	S	M	L	-	-	-	-	M	M	-	L	M	-	L
CO4	S	M	L	-	L	-	-	M	M	-	L	M	-	L
CO5	S	M	L	-	L	-	-	M	M	-	L	M	-	L
CO6	S	M	L	-	L	-	-	M	M	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						**Assessment - II**						**Terminal Exam** (%)		
	CAT – I (%)			**Assg. I *** (%)			**CAT – II** (%)			**Assg. II ***(%)					
CO \ **TPS Scale**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	20				-						-	2	10
CO2	-	10	20		100		-						-	4	10
CO3	-	10	30				-						-	4	15
CO4	-						-	10	20				-	4	15
CO5	-						-	10	30		100		-	4	15
CO6	-						-	10	20				-	2	15
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Wireless System: General Architecture, RF front end, Up/Down Convertors, Working mechanism, RF subsystems and operation.

RF system level parameters: Frequency Planning: Blockers, Spurs and Desensing, Transmitter Leakage, LO Leakage and Interference, Image, Half IF, Linearity, Noise, Sources of noise, Signal-to-Noise Ratio, Receiver Gain.

RF Receiver Architectures: Heterodyne Receivers, Image Reject Receivers, Zero IF Receivers, Low IF Receivers, Issues in Direct Conversion Receivers, Noise, LO Leakage and Radiation, Phase and Amplitude Imbalance, DC Offset, Inter modulations, Architecture Comparison and Trade-off.

RF front end Design and Characterization: System Description and Calculations, Design and Integration of Building Blocks, DC Conditions Scattering Parameters, Small-Signal and Transient Performance, Noise Performance, Linearity, Front end Characterization: DC Test, Functionality Test, S-Parameter Test, Conversion Gain Test, Linearity Test, Noise Figure Test, I/Q Imbalance, DC Offset.

Antennas and Propagation Effects: Role of Antennas in RF front ends, Antenna parameters, Friss equation, Path Loss, Wireless link, Multipath and Fading, Equalization. Types of antennas: Monopole, Dipole, Patch, Aperture antenna, PIFA, Phased array antenna.

Applications: Radar range Equation, Radar system: block diagram, FMCW radar, GSM/CDMA System Architecture, Wireless link, Link budget and power Calculations.

Text Book

- Ibrahim A. Haroun, "Essentials of RF Front-end Design and Testing: A Practical Guide for Wireless Systems", Wiley-IEEE Press, 2023.
- 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.
- Constantine A. Balanis, Antenna Theory: Analysis and Design, 4th Edition, John Wiley and Sons, 2016
- Janine Love, "RF Front-End: World Class Designs", Newnes, 2009.
- Cotter W. Sayre, "Complete Wireless Design", Second Edition, McGraw-Hill, 2008.
- Joy Laskar, Babak Matinpour, Sudipto Chakraborty, "Modern Receiver Front-Ends: Systems, Circuits, and Integration, John Wiley & Sons, 2004.
- Les Besser, Rowan Gilmore, "Practical RF Circuit Design for Modern Wireless Systems, Volume I: Passive Circuits and Systems", Artech, 2003.
- David M Pozar, "Microwave and RF design of Wireless systems", John Wiley and Sons, 2001.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	3
1	**Wireless System:** General Architecture, RF front end, Up/Down Convertors, Working mechanism, RF subsystems and operation.	
	RF system level parameters	
2	Frequency Planning: Blockers, Spurs and Desensing, Transmitter Leakage, LO Leakage and Interference	2
3	Image, Half IF, Linearity, Noise, Sources of noise, Signal-to-Noise Ratio, Receiver Gain.	1
	RF Receiver Architectures	
4	Heterodyne Receivers, Image Reject Receivers, Zero IF Receivers, Low IF Receivers	3
5	Issues in Direct Conversion Receivers, Noise, LO Leakage and Radiation, Phase and Amplitude Imbalance	3
6	DC Offset, Inter modulations, Architecture Comparison and Trade-off	2
	RF front end Design and Characterization	
7	System Description and Calculations, Design and Integration of Building Blocks	2
8	DC Conditions Scattering Parameters, Small-Signal and Transient Performance	2
9	Noise Performance, Linearity, Front end Characterization: DC Test, Functionality Test, S-Parameter Test	2
10	Conversion Gain Test, Linearity Test, Noise Figure Test, I/Q Imbalance, DC Offset	2
	Antennas and Propagation Effects	
11	Role of Antennas in RF front ends, Antenna parameters	2
12	Friss equation, Path Loss, Wireless link, Multipath and Fading, Equalization.	3
13	Types of antennas: Monopole, Dipole, Patch, Aperture antenna, PIFA, Phased array antenna	3
	Applications	
14	Radar range Equation, Radar system: block diagram, FMCW radar,	3
15	GSM/CDMA System Architecture, Wireless link, Link budget and power Calculations	3
	TOTAL	**36**

Course Designers:

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22ECRQ0	OPTIMIZATION TECHNIQUES FOR WIRELESS COMMUNICATIONS

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

This course offers a foundational understanding of optimization, blending mathematical theory with practical applications in signal processing and wireless communications. Leveraging the robust principles and tools of convex optimization, it empowers learners with new perspectives and the ability to tackle complex scientific and engineering challenges encountered in real-world scenarios. This course lays the groundwork for mastering optimization techniques critical to advancing wireless communication systems.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Examine convex set representations and investigate their basic characteristics in a variety of settings.	TPS 3	70	70
CO2	Assess various conditions to identify whether a given function is convex or not	TPS 3	70	70
CO3	Formulate problems into standard convex optimization problems	TPS 3	70	70
CO4	Analyze wireless channel characteristics and distinguish between flat and frequency-selective fading.	TPS 3	70	70
CO5	Formulate and solve power optimization in wireless communications.	TPS 3	70	70
CO6	Formulate and solve beamforming optimization in wireless communications.	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	M	M	-	L	M	-	L
CO2	S	M	L	-	-	-	-	M	M	-	L	M	-	L
CO3	S	M	L	-	M	-	-	M	M	-	L	M	-	L
CO4	S	M	L	-	M	-	-	M	M	-	L	M	-	L
CO5	S	M	L	-	M	-	-	M	M	-	L	M	-	L
CO6	S	M	L	-	M	-	-	M	M	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II *(%)					
TPS / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20				-						-	2	10
CO2	-	10	20		100		-						-	4	15
CO3	-	10	30				-						-	4	15
CO4	-						-	10	20				-	4	15
CO5	-						-	10	30		100		-	4	10
CO6	-						-	10	20				-	2	15
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

Convex Sets:
Affine and convex sets, Examples of Convex sets, Operations that preserves convexity, generalized inequalities, dual cones and generalized inequalities.
Convex Functions:
Basic properties and examples of convex functions, convexity preserving operations, Quasi convex functions.
Convex Optimization Problems:
Optimization problems in a standard form, convex optimization problems, Equivalent representations and transforms, Geometric Programming, Linear programming and Quadratic Programming (QP), Second Order Cone Programming (SOCP), Semidefinite Programming (SDP). CVX tool in MATLAB, Disciplined Convex Programming.
Channel models in Wireless Communications: Static propagation condition, multi-path fading propagation conditions, MIMO Channel Correlation Matrices, Flat and Frequency channel models.
Case Studies:
Optimal power assignment problem, QP and Quadratically Constrained QP (QCQP) in beamformer design, Robust receive beamforming via SOCP, transmit downlink beamforming via SOCP, QCQP and SOCP as SDP via Schur complement, Maximum Likelihood (ML) detection in MIMO system and application in transmit beamforming.

Text Book

- Stephen Boyd, Lieven Vandenberghe, “Convex Optimization” Cambridge University Press, 2004. Pearson Education India, 2011.
- Chong-Yung Chi, Wei-Chiang Li and Chia-Hsiang Lin, “Convex Optimization for Signal Processing and Communications, From fundamentals to Applications” CRC Press, 2017.

Reference Books

- Daniel P.Palomar, Yonina C. Eldar “Convex Optimization in Signal Processing and Communications”, Cambridge University Press, 2010.
- 3GPP TS 38.101-4 version 16.3.0 Release 16
- Z. Q. Luo, “Applications of convex optimization in signal processing and digital communication,” Mathematical programming, 2003
- Zhi-Quan Luo and Wei Yu, “An Introduction to Convex Optimization for Communications and Signal Processing”, (Tutorial Paper), IEEE Journal on Selected Areas in Communications, 2006
- M Bengtsson, B Ottersten, Optimal downlink beamforming using Semidefinite optimization, Proc. Allerton Conference, 1999.
- ND Sidiropoulos, TN Davidson, ZQ Luo, Transmit Beamforming for Physical-Layer Multicasting, IEEE Transactions on Signal Processing, 2006
- M. Chiang, 'Geometric programming for communication systems', Short monograph in Foundations and Trends in Communications and Information Theory, vol. 2, no. 1-2, pp. 1-154, August 2005.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Convex Sets	
1	Affine and convex sets,	1
2	Examples of Convex sets	2
3	Operations that preserves convexity	1
4	generalized inequalities,	1
5	dual cones and generalized inequalities	1
	Convex Functions	
6	Basic properties and examples of convex functions	2
7	Convexity preserving operations	2

8	Quasi convex functions	2
	Convex Optimization Problems	
9	Optimization problems in a standard form	1
10	convex optimization problems	1
11	Equivalent representations and transforms	1
12	Geometric Programming	1
13	Linear programming and Quadratic Programming (QP)	1
14	Second Order Cone Programming (SOCP)	1
15	Semidefinite Programming (SDP)	1
16	CVX tool in MATLAB	1
17	Disciplined Convex Programming.	1
	Channel models in Wireless Communications	
18	Static propagation condition	1
19	Multi-path fading propagation conditions	1
20	MIMO Channel Correlation Matrices	2
21	Flat and Frequency channel models	1
	Case Studies	
22	Optimal power assignment problem	2
23	QP and Quadratically Constrained QP (QCQP) in beamformer design	2
24	Robust receive beamforming via SOCP	2
25	transmit downlink beamforming via SOCP	2
26	QCQP and SOCP as SDP via Schur complement	1
27	Maximum Likelihood (ML) detection in MIMO system and application in transmit beamforming	1
	TOTAL	**36**

Course Designers:

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22ECRR0	MULTIMEDIA SYSTEMS SECURITY

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

Multimedia systems, encompassing audio, video, images, and interactive content, have become integral to modern communication, entertainment, and information-sharing platforms. Securing these systems involves addressing threats to the confidentiality, integrity, and availability of multimedia data, which are frequently targeted for unauthorized access, piracy, and manipulation.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the concepts of Digital watermarking	TPS 2	70	75
CO2	Build water marking models	TPS 3	70	70
CO3	Use different water marking schemes for security	TPS 3	70	70
CO4	Apply media specific water marking techniques	TPS 3	70	70
CO5	Use modern steganography	TPS 3	70	70
CO6	Apply different multimedia techniques	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	M	M	-	-	L	-	L
CO2	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO3	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO4	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO5	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO6	S	M	L	-	-	-	-	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment – I						Assessment – II						Terminal Exam(%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)					
CO \ TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20				-						-	6	-
CO2	-	10	20	100			-						-	5	15
CO3	-	10	30				-						-	5	15
CO4	-						-	10	20				-	5	15
CO5	-						-	10	30	100			-	5	15
CO6	-						-	10	20				-	4	10
Total	**-**	**30**	**70**	**100**			**-**	**30**	**70**	**100**			**-**	**30**	**70**

Syllabus

Introduction to Digital Watermarking –Digital Watermarking Basics: Models of Watermarking, Basic Message Coding, Error Coding, Digital Watermarking Theoretic Aspects: Mutual information and Channel Capacity, Designing a good digital mark, Theoretical analysis of Digital watermarking **Watermarking Schemes**: Spread Spectrum Watermarking, Transform Domain Watermarking, Quantization Watermarking **Media - Specific Digital Watermarking** Video Watermarking, Audio Watermarking, Binary Image Watermarking, Robustness to Temporal and Geometric Distortions, Affine resistant transformations **Steganography**-Introduction- Digital Image formats- Modern Steganography, Steganography Channels Steganography Goals **Multimedia Encryption** - Introduction, Goals, Desired Characteristics, Performance metrics. **Multimedia Techniques** -Chaos based, Block based, and Transform based techniques

Text Book

- Singh, Amit Kumar, Mohan, Anand. Handbook of Multimedia Information Security: Techniques and Applications, Springer, Security and Cryptology, 2019

Reference Books& web resources

- Shih, F. Y. Digital watermarking and steganography: fundamentals and techniques. CRC press, 2017.
- Nematollahi, Mohammad Ali, Vorakulpipat, Chalee, Rosales, Hamurabi Gamboa . Digital Watermarking: Techniques and Trends, Springer, Signals and Communication, 2017
- Pande, Amit, Zambreno, Joseph. Embedded Multimedia Security Systems, Springer, Image Processing. 2013

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**Introduction to the Course, COs POs**	1
	Introduction to Digital Watermarking	
2	Digital Watermarking Basics: Models of Watermarking	2
3	Basic Message Coding, Error Coding	1
4	Digital Watermarking Theoretic Aspects: Mutual information and Channel Capacity	1
5	Designing a good digital mark	1
6	Theoretical analysis of Digital watermarking	1
	Watermarking Schemes	
7	Spread Spectrum Watermarking	2
8	Transform Domain Watermarking	1
9	Quantization Watermarking	1
	Media - Specific Digital Watermarking	
10	Video Watermarking	1
11	Audio Watermarking	1
12	Binary Image Watermarking	2
13	Robustness to Temporal and Geometric Distortions	2
14	Affine resistant transformations	1
	Steganography	
15	Introduction- Digital Image formats	1
16	Modern Steganography	2

17	Steganography Channels	2
18	Steganography Goals	2
	Multimedia Encryption	
19	Introduction, Goals, Desired Characteristics	2
20	Performance metrics	2
	Multimedia Techniques	
21	Chaos based	2
22	Block based	2
23	Transform based techniques	2
	TOTAL	**36**

Course Designers:

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22ECRS0	IoT SECURITY

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

The goal of this course is to ensure the protection of devices, data, and communication channels within an IoT ecosystem. It encompasses strategies to mitigate risks such as unauthorized access, data breaches, and cyber-attacks that can compromise sensitive information and disrupt essential services. Securing IoT involves implementing robust encryption, authentication, network segmentation, and real-time threat monitoring.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the IoT architecture and challenges	TPS 2	70	75
CO2	Develop IoT systems with the security features of public key crypto systems.	TPS 3	70	70
CO3	Implement Secure communication protocols for IoT	TPS 3	70	70
CO4	Asses the cyber physical systems and IoT Threats	TPS 4	70	65
CO5	Develop privacy preservation for IoT	TPS 3	70	70
CO6	Determine IoT Trust models	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	M	M	-	-	L	-	L
CO2	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO3	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO4	S	S	M	L	-	-	-	M	M	-	L	S	L	L
CO5	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO6	S	M	L	-	-	-	-	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment – I						Assessment – II							Terminal Exam(%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)						
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	4	1	2	3
CO1	-	20	-				-							-	6	-
CO2	-	10	30		100		-							-	5	15
CO3	-	10	30				-							-	5	15
CO4	-						-	10	20					-	5	15
CO5	-						-	10	30		100			-	5	15
CO6	-						-	10	20					-	4	10
Total	**-**	**40**	**60**		**100**		**-**	**30**	**70**		**100**			**-**	**30**	**70**

Syllabus

Introduction to IoT: IoT Ecosystem and Applications, Market Trends and Future of IoT. IoT Architecture: Perception, Network, and Application Layers, Protocol Stack and Standards. **Crypto Fundamentals:** Block ciphers, Message integrity, Authenticated encryption, Hash functions, public-key crypto (PKI), Signature algorithms **IoT Security Protocols: S**ecure MQTT, CoAP with DTLS, and LoRaWAN security, Zigbee Security and Lightweight Machine-to-Machine. **Physical Systems and Interconnection of Threat:** IoT and cyber-physical systems, IoT security vulnerabilities, attacks, and countermeasures, security engineering for IoT development, IoT security lifecycle. Network Robustness of Internet of Things Sybil Attack Detection in Vehicular Networks- Malware Propagation and Control in Internet of Things- Solution-Based Analysis of Attack Vectors on Smart **Privacy Preservation for IoT:** Privacy Preservation Data Dissemination- Privacy Preservation Data Dissemination- Social Features for Location Privacy Enhancement in Internet of Vehicles- Lightweight and Robust Schemes for Privacy Protection in Key Personal IoT Applications: Mobile WBSN and Participatory Sensing .**Trust Models for IoT:** Authentication in IoT- Computational Security for the IoT- Privacy-Preserving Time Series Data Aggregation- Secure Path Generation Scheme for Real-Time Green Internet of Things- Security Protocols for IoT Access Networks

Text Book

- Arshdeep Bahga, Vijay Madisetti, “Internet of Things: A Hands-On Approach", Universities Press, 2015.
- Hu, Fei. Security and privacy in Internet of things (IoTs): Models, Algorithms, and Implementations, 1stedition, CRC Press, 2020.

Reference Books& web resources

- Russell, Brian, and Drew Van Duren. Practical Internet of Things Security, 1st edition, Packet Publishing Ltd, 2016
- Whitehouse O. Security of things: An implementers’ guide to cyber-security for internet of things devices and beyond, 1 st edition, NCC Group, 2014

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**Introduction to the Course, COs POs**	1
	Introduction to IoT	
2	IoT Ecosystem and Applications	1
3	Market Trends and Future of IoT	1
4	IoT Architecture: Perception, Network, and Application Layers	1
5	Protocol Stack and Standards	1
	IoT Security Protocols:	
6	Secure MQTT, CoAP with DTLS	2
7	LoRaWAN security, Zigbee Security	2
8	Lightweight Machine-to-Machine.	1
	Crypto Fundamentals:	
9	Block ciphers, Message integrity	2
10	Authenticated encryption	1
11	Hash functions	1
12	public-key crypto (PKI), Signature algorithms	2
	Cyber physical systems and interconnection of threat	
13	IoT and cyber-physical systems, IoT security (vulnerabilities, attacks, and countermeasures)	2
14	security engineering for IoT development	1
15	IoT security lifecycle	1

16	Network Robustness of Internet of Things Sybil Attack Detection in Vehicular Networks	1
17	Malware Propagation and Control in Internet of Things-	1
18	Solution-Based Analysis of Attack Vectors on Smart	1
	Privacy preservation for IoT	
19	Privacy Preservation Data Dissemination	1
20	Social Features for Location Privacy Enhancement in Internet of Vehicles	2
21	Lightweight and Robust Schemes for Privacy Protection in Key Personal IoT Applications	2
22	Mobile WBSN and Participatory Sensing	1
	Trust Models for IoT	
21	Authentication in IoT, Computational Security for the IoT	2
22	Privacy-Preserving Time Series Data Aggregation	2
23	Secure Path Generation Scheme for Real-Time Green Internet of Things	2
24	Security Protocols for IoT Access Networks	2
	TOTAL	**36**

Course Designers:

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22ECRT0	CLOUD SECURITY

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

The goal of this course is to focus on safeguarding data, applications, and services in cloud environments. This includes implementing robust measures for identity and access management, encryption, network security, and threat detection across diverse cloud service models such as Infrastructure as a Service, Platform as a service and Software as a Service.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the fundamentals of cloud computing	TPS 2	70	75
CO2	Determine the assess security risks associated with various cloud service models	TPS 3	70	70
CO3	Use cloud data security audits and compliance monitoring	TPS 3	70	70
CO4	Develop secure cloud architecture	TPS 3	70	70
CO5	Implement secure identity management practices	TPS 3	70	70
CO6	Apply cloud security for different applications	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	M	M	-	-	L	-	L
CO2	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO3	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO4	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO5	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO6	S	M	L	-	-	-	-	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment – I						Assessment – II						Terminal Exam(%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	15	-				-						-	6	-
CO2	-	15	30	100			-						-	5	15
CO3	-	10	30				-						-	5	15
CO4	-						-	10	20				-	5	15
CO5	-						-	10	30	100			-	5	15
CO6	-						-	10	20				-	4	10
Total	**-**	**40**	**60**	**100**			**-**	**30**	**70**	**100**			**-**	**30**	**70**

Syllabus

Fundamentals: System Modeling, Clustering Virtualization: distributed system models and Enabling technologies. Computer clusters for scalable parallel computing, virtual machines and Virtualization of clusters and data centers. Introduction to cloud computing, migrating into cloud. Enriching the integration of service paradigm for cloud era, the enterprise cloud computing paradigm. **Infrastructure As Service (Iaas) & Platform and Software Service (Paas/Saas):** Virtual machine provisioning and migration services. on the management of virtual machines for cloud Infrastructure. Enhancing cloud computing environments using a cluster as service. Secure distributed data storage in cloud computing Aneka. Comet cloud T-systems, work flow engine for clouds. Understanding scientific applications for cloud environments. **Cloud Data Security:** Data Protection, Data Information lifecycle, cloud data Audit: AWS – EBS, S3 Azure – SAS, Demo - AWS CLI & power shell & Amazon, Azure portal, Key Management, Cloud management Audit: AWS – KMS, Azure – Azure Key Vauit. **Identity and Access Management:** Introduction to Identity and Access Management, Introduction to Federated Management, Case Study, Cloud IAM Audit: AWS CLI & Amazon portal. **Application Security:** Cloud Application Challenges, OWSAP Top 10, Secure SDLC, DevSecOps, Cloud Trail, Cloud watch, Lambda

Text Book

- Ronald L. Kurtz, Russell Dean Vines, Cloud Security: A Comprehensive Guide to Secure Cloud Computing, 30 July 2010
- J. R. Winkler, “Securing the cloud: Cloud Computer Security Techniques and Tactics”, Syngress, 2011

Reference Books& web resources

- Charlie Kaufman, Radia Perlman, Mike Speciner, “Network Security: Private Communication in a Public World”, Prentice Hall, 2010
- Atul Kahate, **“**Cryptography and Network Security”, 2nd edition, Tata Mc Graw hill, India., 2008.
- Robert Bragg, Mark Rhodes, “Network Security: The complete reference”, Tata Mc Graw hill, India, 2004.
- Chris Dotson "Practical Cloud Security", O'Reilly Media, 2019.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**Introduction to the Course, COs POs**	1
	Fundamentals	
2	System Modeling, Clustering Virtualization	1
3	Distributed system models and Enabling technologies. Computer clusters for scalable parallel computing	1
4	virtual machines and Virtualization of clusters and data centers.	1
5	Introduction to cloud computing, migrating into cloud. Enriching the integration of service paradigm for cloud era	2
6	the enterprise cloud computing paradigm	2
	Infrastructure As Service (Iaas) & Platform and Software Service (Paas/Saas)	
7	Virtual machine provisioning and migration services. on the management of virtual machines for cloud Infrastructure	2
8	Enhancing cloud computing environments using a cluster as service. Secure distributed data storage in cloud computing	2
9	Aneka. Comet cloud T-systems, work flow engine for clouds.	1

10	Understanding scientific applications for cloud environments.	1
	Cloud Data Security	
11	Data Information lifecycle, cloud data Audit:	2
12	AWS – EBS, S3 Azure – SAS,	2
13	Demo - AWS CLI & power shell & Amazon	1
14	Azure portal, Key Management	1
15	Cloud management Audit	1
16	Aws – KMS, Azure – Azure Key Vauit	2
	Identity and Access Management	
17	Introduction to Identity and Access Management	2
18	Introduction to Federated Management	2
19	Case Study - Cloud IAM Audit	2
20	AWS CLI & Amazon portal	2
	Cloud Application Security	
21	Cloud Application Challenges	1
22	OWSAP Top 10	1
23	Secure SDLC, DevSecOps	2
24	Cloud Trail, Cloud watch, Lambda	2
	TOTAL	**36**

Course Designers:

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22ECPV0	WIRELESS AND MOBILE SECURITY

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

The goal of this course is to explore the principles, protocols, and practices used to secure wireless and mobile networks. It addresses challenges in ensuring confidentiality, integrity, and availability in diverse wireless environments and also examines emerging security threats.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Identify the unique security challenges and vulnerabilities in wireless communication	TPS 2	70	75
CO2	Implement cryptographic protocols and mechanisms to secure wireless networks	TPS 3	70	70
CO3	Recognize wireless and mobile network attacks and countermeasures	TPS 3	70	70
CO4	Analyze the security features of mobile devices to protect against unauthorized access.	TPS 4	70	65
CO5	Analyze security risks in emerging wireless technologies, such as IoT and 5G	TPS 4	70	65
CO6	Develop security strategies and policies for managing risks in wireless network breaches	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	M	M	-	-	L	-	L
CO2	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO3	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO4	S	M	M	L	-	-	-	M	M	-	-	S	-	L
CO5	S	M	M	L	-	-	-	M	M	-	-	S	-	L
CO6	S	M	L	-	-	-	-	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment – I						Assessment – II							Terminal Exam (%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)						
CO \ TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	4	1	2	3
CO1	-	15	-		100		-							-	6	-
CO2	-	15	30				-							-	5	15
CO3	-	10	30				-							-	5	15
CO4	-						-	10	20					-	5	15
CO5	-						-	10	30		100			-	5	15
CO6	-						-	10	20					-	4	10
Total	-	**40**	**60**		**100**		**-**	**30**	**70**		**100**			**-**	**30**	**70**

Syllabus

Overview of Wireless Communication: Characteristics, architecture - Wi-Fi, Bluetooth, cellular networks Security Challenges - Open nature of wireless communication, resource constraints, mobility, and scalability. Threat Landscape - Eavesdropping, spoofing, denial of service, and unauthorized access Standards and Frameworks: IEEE 802.11 security standards, cellular network security standards - 3G, 4G, 5G. **Cryptography in Wireless Networks:** Role of Cryptography in Wireless Security: Ensuring confidentiality, integrity, and authentication. Key distribution for wireless networks. Cryptographic Protocols - WPA, WPA2, WPA3, and EAP. Emerging Encryption Techniques - Lightweight cryptography for resource-constrained devices. **Attacks and Countermeasures:** Wi-Fi Security Issues - WEP vulnerabilities, WPA/WPA2 flaws, KRACK attacks. Attack Vectors - Man-in-the-middle, replay attacks, session hijacking, and rogue access points. Intrusion Detection and Prevention - Wireless IDS/IPS tools and techniques. Case Studies: Real-world wireless network breaches and analysis of countermeasures. **Mobile Network Security:** Cellular Network Architectures - 3G/4G/5G security features and vulnerabilities. Mobile Device Security: Threats such as malware, phishing, and unauthorized applications. Authentication and Identity Management - SIM-based authentication, 2FA, and biometric authentication. **Emerging Wireless Technologies:** IoT Security Challenges - Device heterogeneity, resource constraints, and protocol vulnerabilities. Protocols and Standards - Zigbee, LoRaWAN, and BLE security mechanisms. Security in 5G Networks: Threats, use cases, and advanced encryption methods. Emerging Threats: AI-based attacks and drone security. **Security Management and Best Practices:** Policy and Governance: Developing wireless security policies and compliance requirements - GDPR, HIPAA. Risk Assessment and Management - Identifying and mitigating risks in wireless environments Future Trends in Wireless Security: Zero-trust networks, 6G security, and AI for proactive threat detection.

Text Book

- Jim Doherty and Neil Anderson, “Wireless and mobile device security”, 2nd Edition, Jones & Bartlett Learning, 2021.

Reference Books& web resources

- Frank Adelstein, K.S.Gupta “Fundamentals of Mobile and Pervasive Computing”, 1st Edition, Tata McGraw Hill, 2010
- Bruce Potter and Bob Fleck: “802.11 Security”, 1st Edition, O’Reilly, 2005.
- James Kempf: “Guide to Wireless Network Security, Springer, 2010
- James Kempf, “Wireless Internet Security – Architecture and Protocols”, Cambridge University Press, 2008.
- Andreas Kolokithas, “G Hacking Wireless Networks: The Ultimate Hands-on Guide”, CreateSpace Independent Publishing Platform, 2015.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**Introduction to the Course, COs POs**	1
	Overview of Wireless Communication	
2	Characteristics, architecture - Wi-Fi, Bluetooth, cellular networks	1
3	Security Challenges - Open nature of wireless communication	1
4	resource constraints, mobility, and scalability	1
5	Threat Landscape - Eavesdropping, spoofing, denial of service, and unauthorized access	2
6	Standards and Frameworks: IEEE 802.11 security standards	2
7	cellular network security standards - 3G, 4G, 5G	2
	Cryptography in Wireless Networks	

8	Role of Cryptography in Wireless Security: Ensuring confidentiality, integrity, and authentication	2
9	Key distribution for wireless networks.	1
10	Cryptographic Protocols - WPA, WPA2, WPA3, and EAP	1
11	Emerging Encryption Techniques - Lightweight cryptography for resource-constrained devices	2
	Attacks and Countermeasures	
12	Wi-Fi Security Issues - WEP vulnerabilities, WPA/WPA2 flaws	2
13	KRACK attacks. Attack Vectors - Man-in-the-middle, replay attacks, session hijacking, and rogue access points	1
14	Intrusion Detection and Prevention - Wireless IDS/IPS tools and techniques	1
15	Case Studies: Real-world wireless network breaches and analysis of countermeasures	1
	Mobile Network Security	
16	Cellular Network Architectures - 3G/4G/5G	1
17	security features and vulnerabilities	1
18	Mobile Device Security: Threats such as malware, phishing, and unauthorized applications	2
19	Authentication and Identity Management - SIM-based authentication, 2FA, and biometric authentication	2
	Emerging Wireless Technologies	
20	IoT Security Challenges - Device heterogeneity, resource constraints, and protocol vulnerabilities	2
21	Protocols and Standards - Zigbee, LoRaWAN, and BLE security mechanisms	2
22	Security in 5G Networks: Threats, use cases, and advanced encryption methods. Emerging Threats: AI-based attacks and drone security	1
	Security Management and Best Practices - -:	
23	Policy and Governance: Developing wireless security policies and compliance requirements	1
24	GDPR, HIPAA. Risk Assessment and Management	1
25	Identifying and mitigating risks in wireless environments Future Trends in Wireless Security	1
26	Zero-trust networks, 6G security, and AI for proactive threat detection.	1
	TOTAL	**36**

Course Designers:

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22ECRU0	BIOMEDICAL SIGNAL PROCESSING

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

The objective of this course is to provide a firm foundation in cutting-edge biomedical signaling systems, including current coverage of issues that are pertinent to industry. This course focuses on biological signals, signal processing, and evaluating methods and findings in order to optimize clinical applications. It also includes automated classification and decision-making approaches to aid in diagnosis.

Prerequisite

Nil

Course Outcomes

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

CO Number	Course Outcome Statement	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the nature of biomedical signals and their artifacts.	TPS 2	70	60
CO2	Remove artifacts in biomedical signals with time domain and frequency domain filters	TPS 3	70	60
CO3	Identify the discrete signal epochs in a biomedical signal and correlate them with events in the related physiological process	TPS 3	70	60
CO4	Perform spectral analysis of biomedical signals and systems with suitable signal processing methods	TPS 3	70	60
CO5	Detect the presence of a wavelet in a noisy biosignal using structural features and template matching techniques for monitoring and automatic classification.	TPS 3	70	60
CO6	Apply signal classification and recognition methods to address biomedical problems by analyzing the bio signals from biomedical instruments and wearable devices	TPS 3	70	60

Mapping with Programme Outcomes and Programme Specific Outcomes

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	M	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	M	M	L	-	-	-	M	-	-
CO3	S	M	L	-	-	M	M	L	-	-	-	M	-	-
CO4	S	M	L	-	-	M	M	L	-	-	-	M	-	-
CO5	S	M	L	-	-	M	M	L	L	-	-	M	-	-
CO5	S	M	L	-	-	M	M	L	L	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern:

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II * (%)					
TPS Scale / CO	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	20	-				-						-	5	-
CO2	-	10	30		100		-						-	5	10
CO3	-	10	30				-						-	5	15
CO4	-						-	15	20				-	5	15
CO5	-						-	15	20		100		-	5	15
CO6								10	20					5	15
Total	**-**	**40**	**60**		**100**		**-**	**40**	**60**		**100**		**-**	**30**	**70**

Syllabus

Introduction to Biomedical Signals: Nature of Biomedical Signals, Examples of Biomedical Signals- Electromygraphy (EMG), Electrocardiography (ECG), Electroencephalography (EEG), Electrogastrogtam (EGG), Phonocardiogram (PCG), Photoplethysmography (PPG), Vibromyogram (VMG) and Vibroarthrogram (VAG), Biomedical Signal Processing and Applications

Filtering for Removal of Artifacts: Time Domain Filters –Synchronized averaging, Moving-average filters, Derivative based operators, Frequency-domain Filters –Removal of high-frequency noise and low-frequency noise - Butterworth filters, Removal of periodic artifacts using Notch and Comb filters.

Event Detection: Derivative based methods for QRS detection, The Pan-Tompkins algorithm for QRS detection, Detection of EEG rhythms, EEG spike-and-wave detection**.**

Frequency domain characterization of biomedical signals: Estimation of power spectral density function: The periodogram - Effect of myocardial elasticity on heart sound spectra, Frequency analysis of murmurs to diagnose valvular defects, Averaged periodogram - Synchronized averaging of PCG spectra.

Wavelet Detection in Biomedical Signals: Wavelet detection in ECG – structural features, matched filtering, adaptive wavelet detection, detection of overlapping wavelets.

Case Studies for Pattern Classification and Diagnostic Decision: Supervised and unsupervised classification - Diagnosis of bundle-branch block, identification of Normal or ectopic ECG beat, detecting an alpha rhythm, detecting the presence of murmur, signal detection from wearable devices.

Text Books

1. Rangaraj M. Rangayyan, 2nd edition, Biomedical Signal Analysis-A case study approach‟, Wiley- Interscience / IEEE Press, 2015.
2. Arnon Cohen, Bio-Medical Signal Processing Vol I and Vol II, CRC Press Inc., Boca Rato, Florida 1999.

Reference Books

1. https://archive.nptel.ac.in/courses/108/105/108105101/
2. Emmanuel C. Ifeachor, Barrie W.Jervis, second edition, Digital Signal processing- A Practical Approach‟ Pearson education Ltd., 2002
3. Raghuveer M. Rao and AjithS.Bopardikar, Wavelets transform – Introduction to theory and its applications, Pearson Education, India 2000
4. Willis J. Tompkins, Biomedical Digital Signal Processing, Prentice Hall of India, New Delhi, 2003.

Course Contents and Lecture Schedule

Module No	Topic	No. of Lectures
1	**Introduction to Biomedical Signals**	
1.1	Nature of Biomedical Signals	1
1.2	Examples of Biomedical Signals- Electromygraphy (EMG), Electrocardiography (ECG), Electroencephalography (EEG),	2
1.3	Electrogastrogtam (EGG), Phonocardiogram (PCG), Photoplethysmography (PPG)	1
1.4	Vibromyogram (VMG) and Vibroarthrogram (VAG)	1
1.5	Biomedical Signal Processing and Applications	1
2	**Filtering for Removal of Artifacts**	
2.1	Time Domain Filters –Synchronized averaging, Moving-average filters	1
2.2	Derivative based operators	1
2.3	Frequency-domain Filters –Removal of high-frequency noise and low-frequency noise - Butterworth filters	2
2.4	Removal of periodic artifacts using Notch and Comb filters	2
3	**Event Detection**	
3.1	Derivative based methods for QRS detection	1
3.2	The Pan-Tompkins algorithm for QRS detection	2
3.3	Detection of EEG rhythms	2
3.4	EEG spike-and-wave detection	1
4	**Frequency domain characterization of biomedical signals**	
4.1	Estimation of power spectral density function: The periodogram	1
4.2	Effect of myocardial elasticity on heart sound spectra	1
4.3	Frequency analysis of murmurs to diagnose valvular defects	2
4.4	Averaged periodogram	1
4.5	Synchronized averaging of PCG spectra	1
5	**Wavelet Detection in Biomedical Signals**	
5.1	Wavelet detection in ECG – structural features	2
5.2	Matched filtering	1
5.3	Adaptive wavelet detection	1
5.4	Detection of overlapping wavelets.	2
6	**Case Studies for Pattern Classification and Diagnostic Decision**	
6.1	Supervised and unsupervised classification	2
6.2	Diagnosis of bundle-branch block	1
6.3	Identification of Normal or ectopic ECG beat	1
6.4	Detecting an alpha rhythm, Detecting the presence of murmur	1
6.5	Signal detection from wearable devices	1
	Total	**36 hrs**

Course Designers:

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22ECRV0	DEEP LEARNING FOR VISION

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

The advancements in Computer Vision and Deep Learning have significantly transformed the way machines interpret and interact with visual data, driving innovation across various industries such as healthcare, autonomous systems, and entertainment. This course provides an insight on computer vision and its intersection with deep learning technologies.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the image formation, representation, and the role of linear filtering techniques.	TPS 2	70	60
CO2	Implement feature extraction techniques.	TPS 3	70	60
CO3	Demonstrate deep feed-forward neural networks, optimization techniques.	TPS 3	70	60
CO4	Implement CNN architectures for Vision tasks.	TPS 3	70	60
CO5	Investigate the generative models in real time application.	TPS 4	70	60
CO6	Design and optimize DNN models for complex vision applications.	TPS 6	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	L	L	L	M	M	-	-	M	L	L
CO2	S	M	L	L	L	L	L	M	M	-	-	M	L	L
CO3	S	M	L	L	L	L	L	M	M	-	-	M	-	L
CO4	S	M	L	L	L	L	L	M	M	-	-	M	-	L
CO5	S	M	L	L	L	L	L	M	M	-	-	M	-	L
CO6	S	M	L	L	L	L	L	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

<table>
<tr><th rowspan="2"></th><th colspan="6">Assessment - I</th><th colspan="6">Assessment - II</th><th rowspan="2" colspan="3">Terminal Exam(%)</th></tr>
<tr><th colspan="3">CAT – I(%)</th><th colspan="3">Assg. I *(%)</th><th colspan="3">CAT – II(%)</th><th colspan="3">Assg. II *(%)</th></tr>
<tr><th>TPS Scale / CO</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>CO1</td><td>-</td><td>10</td><td>20</td><td rowspan="3" colspan="3">100</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>4</td><td>10</td></tr>
<tr><td>CO2</td><td>-</td><td>10</td><td>20</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>4</td><td>10</td></tr>
<tr><td>CO3</td><td>-</td><td>10</td><td>30</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>4</td><td>15</td></tr>
<tr><td>CO4</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>10</td><td>20</td><td rowspan="3" colspan="3">100</td><td>-</td><td>-</td><td>15</td></tr>
<tr><td>CO5</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>10</td><td>30</td><td>-</td><td>4</td><td>15</td></tr>
<tr><td>CO6</td><td>-</td><td></td><td></td><td colspan="3"></td><td>-</td><td>10</td><td>20</td><td>-</td><td>4</td><td>15</td></tr>
<tr><td>Total</td><td>-</td><td>30</td><td>70</td><td colspan="3">100</td><td>-</td><td>30</td><td>70</td><td colspan="3">100</td><td>-</td><td>20</td><td>80</td></tr>
</table>

Syllabus

COMPUTER VISION BASICS

Introduction to Image Formation and Representation; Linear Filtering, Correlation, Convolution Visual Features and Representations: Edge, Blobs, Corner Detection; Visual Features extraction: Bag-of-words, VLAD; RANSAC, Hough transform.

INTRODUCTION TO DEEP LEARNING

Deep Feed-Forward Neural Networks – Gradient Descent – Back-Propagation – Vanishing Gradient Problem – Mitigation – Rectified Linear Unit (ReLU) – Heuristics for Avoiding Bad Local Minima – Heuristics for Faster Training – Nestorov Accelerated Gradient Descent – Regularization for Deep Learning – Dropout – Adversarial Training – Optimization for Training Deep Models.

VISUALIZATION AND UNDERSTANDING CNN

Convolutional Neural Networks (CNNs): Introduction to CNNs; Evolution of CNN Architectures: AlexNet, ZFNet, VGG. Visualization of Kernels; Backprop-to-image/ Deconvolution Methods; Deep Dream, Hallucination, Neural Style Transfer; CAM, Grad-CAM.

CNN and RNN FOR IMAGE AND VIDEO PROCESSING

CNNs for Recognition, Verification, Detection, Segmentation: CNNs for Recognition and Verification (Siamese Networks, Triplet Loss, Contrastive Loss, Ranking Loss); CNNs for Detection: Background of Object Detection, R-CNN, Fast R-CNN. CNNs for Segmentation: FCN, SegNet. Recurrent Neural Networks (RNNs): Review of RNNs; CNN + RNN Models for Video Understanding: Spatio-temporal Models, Action/Activity Recognition.

DEEP GENERATIVE MODELS

Deep Generative Models: Review of (Popular), Deep Generative Models: GANs, VAEs Variants and Applications of Generative Models in Vision: Applications: Image Editing, Inpainting, Superresolution, 3D Object Generation.

Text Book

- Ian Goodfellow Yoshua Bengio Aaron Courville, “Deep Learning”, MIT Press, 2017.
- Ragav Venkatesan, Baoxin Li, “Convolutional Neural Networks in Visual Computing”, CRC Press, 2018.

Reference Books & web resources

- Rajalingappaa Shanmugamani, Deep Learning for Computer Vision, Packt Publishing, 2018.
- David Forsyth, Jean Ponce, Computer Vision: A Modern Approach, Pearson, 2002.
- V.Kishore Ayyadevara, Yeshwanth Reddy, Modern Computer Vision with PyTorch, Packt Publishing Ltd., 2020.
- Goodfellow, Y, Bengio, A. Courville, “Deep Learning”, MIT Press, 2016.
- Richard Szeliski, Computer Vision: Algorithms and Applications, 2010.
- Simon Prince, Computer Vision: Models, Learning, and Inference, 2012.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**COMPUTER VISION BASICS**	
1.1	Introduction to Image Formation and representation	1
1.2	Linear Filtering, Correlation, Convolution	1
1.3	Visual Features and Representations: Edge, Blobs, Corner Detection;	1
1.4	Bag-of-words	1
1.5	VLAD	1
1.6	RANSAC	
1.7	Hough transform	1
2	**INTRODUCTION TO DEEP LEARNING**	
2.1	Deep Feed-Forward Neural Networks	2
2.2	Gradient Descent	

2.3	Back-Propagation	
2.4	Vanishing Gradient Problem – Mitigation	1
2.5	Rectified Linear Unit (ReLU)	
2.6	Heuristics for Avoiding Bad Local Minima – Heuristics for Faster Training	2
2.7	Nestorov Accelerated Gradient Descent	
2.8	Regularization for Deep Learning	
2.9	Dropout	1
2.10	Adversarial Training	
2.11	Optimization for Training Deep Models.	
3	**VISUALIZATION AND UNDERSTANDING CNN**	
3.1	Introduction to CNNs	1
3.2	AlexNet	1
3.3	ZFNet	
3.4	VGG	1
3.5	Backprop-to-image	3
3.6	Deconvolution Methods	
3.7	Deep Dream	
3.8	Hallucination	
3.9	Neural Style Transfer	2
3.10	CAM	
3.11	Grad-CAM	
4	**CNN and RNN FOR IMAGE AND VIDEO PROCESSING**	
4.1	CNNs for Recognition and Verification (Siamese Networks, Triplet Loss, Contrastive Loss, Ranking Loss)	2
4.2	CNNs for Detection: Background of Object Detection, R-CNN, Fast R-CNN	2
4.4	CNNs for Segmentation: FCN, SegNet.	1
4.6	Recurrent Neural Networks (RNNs)	2
	CNN + RNN Models for Video Understanding: Spatio-temporal Models, Action/Activity Recognition	1
5	**DEEP GENERATIVE MODELS**	
5.1	Generative Adversarial Models (GANs)	1
5.2	Variational AutoEncoders(VAEs)	1
5.3	Variants and Applications of Generative Models in Vision	2
5.4	Image Editing	1
5.5	Inpainting	2
5.6	Superresolution	1
5.7	3D Object Generation	
	TOTAL	**36**

Course Designers:

Dr.B. Sathya Bama sbece@tce.edu
Dr.S. Mohamed Mansoor Roomi smmroomi@tce.edu
Dr.M. Senthilarasi msiece@tce.edu

22ECPW0	SOFT COMPUTING

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

This course provides the foundation on basic principles and methodologies of soft computing, emphasizing their practical applications. The integration of soft computing techniques, such as Fuzzy Logic, Neural Networks, and Genetic Algorithms, has revolutionized problem-solving in fields where traditional methods struggle to provide optimal solutions

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the concepts of fuzzy sets, membership functions, fuzzy relations, and fuzzy reasoning, and their applications in uncertainty modeling.	TPS 2	70	60
CO2	Develop fuzzy inference systems using fuzzy rules and reasoning to address real-world decision-making and control problems.	TPS 3	70	60
CO3	Explain the working principles of supervised and unsupervised neural networks.	TPS 3	70	60
CO4	Employ genetic to optimize functions and solve complex computational problems.	TPS 3	70	60
CO5	Demonstrate an adaptive neuro-fuzzy inference systems (ANFIS).	TPS 3	70	60
CO6	Construct a hybrid framework to develop intelligent systems capable of solving multi-domain challenges.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	L	-	-	-	-	-	-	M	L	L
CO2	S	M	L	L	L	-	-	-	-	-	-	M	L	L
CO3	S	M	L	L	L	-	-	-	-	-	-	M	-	L
CO4	S	M	L	L	L	-	-	-	-	-	-	M	-	L
CO5	S	M	L	L	L	-	-	-	-	-	-	M	-	L
CO6	S	M	L	L	L	-	-	-	-	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)					
TPS / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20				-						-	4	10
CO2	-	10	20		100		-						-	4	10
CO3	-	10	30				-						-	4	15
CO4	-						-	10	20				-	-	15
CO5	-						-	10	30		100		-	4	15
CO6	-						-	10	20				-	4	15
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

FUZZY LOGIC

Introduction - Fuzzy Logic - Fuzzy Sets, Fuzzy Membership Functions, Operations on Fuzzy Sets, Fuzzy Relations, Operations on Fuzzy Relations, Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems.

NEURAL NETWORKS

Supervised Learning Neural Networks – Perceptrons - Backpropagation -Multilayer Perceptrons – Unsupervised Learning Neural Networks – Kohonen Self-Organizing Networks.

GENETIC ALGORITHMS

Chromosome Encoding Schemes -Population initialization and selection methods - Evaluation function - Genetic operators- Cross over – Mutation - Fitness Function – Maximizing function.

NEURO FUZZY MODELING

ANFIS architecture – hybrid learning – ANFIS as universal approximator – Coactive Neuro fuzzy modeling – Framework – Neuron functions for adaptive networks – Neuro fuzzy spectrum - Analysis of Adaptive Learning Capability.

APPLICATIONS

Modeling a two input sine function - Printed Character Recognition – Fuzzy filtered neural networks – Plasma Spectrum Analysis – Hand written neural recognition - Soft Computing for Color Recipe Prediction.

Text Book

- Himanshu Singh, Yunis Ahmad Lone, Deep Neuro-Fuzzy Systems with Python Case Studies and Applications from the Industry, Apress, 2020.

Reference Books & web resources

- Roj Kaushik and Sunita Tiwari, Soft Computing-Fundamentals Techniques and Applications, 1st Edition, McGraw Hill, 2018
- S. Rajasekaran and G.A.V.Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithms”, PHI, 2003.
- Samir Roy, Udit Chakraborthy, Introduction to Soft Computing, Neuro Fuzzy and Genetic Algorithms, Pearson Education, 2013.
- S.N. Sivanandam, S.N. Deepa, Principles of Soft Computing, Third Edition, Wiley India Pvt Ltd, 2019.
- Jyh-Shing Roger Jang, Chuen-Tsai. Sun, Eiji Mizutani, Neuro-fuzzy and soft computing: A computational approach to learning and machine intelligence. Upper Saddle River, NJ, Prentice Hall, 1997.
- R.Eberhart, P.Simpson and R.Dobbins, “Computational Intelligence - PC Tools”, AP Professional, Boston, 1996.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**FUZZY LOGIC**	
1.1	Introduction - Fuzzy Logic	1
1.2	Fuzzy Sets	1
1.3	Fuzzy Membership Functions	1
1.4	Operations on Fuzzy Sets	1
1.5	Fuzzy Relations	1
1.6	Operations on Fuzzy Relations	
1.7	Fuzzy Rules and Fuzzy Reasoning	1
1.8	Fuzzy Inference Systems	1
2	**NEURAL NETWORKS**	
2.1	Supervised Learning Neural Networks	1
2.2	Perceptrons	1
2.3	Backpropagation	2
2.4	Multilayer Perceptrons	1

2.5	Unsupervised Learning Neural Networks	1
2.6	Kohonen Self-Organizing Networks	1
3	**GENETIC ALGORITHMS**	
3.1	Chromosome Encoding Schemes	1
3.2	Population initialization and selection methods	1
3.3	Evaluation function	1
3.4	Genetic operators	1
3.5	Cross over	1
3.6	Mutation	
3.7	Fitness Function	1
3.8	Maximizing function	1
4	**NEURO FUZZY MODELING**	
4.1	ANFIS architecture	1
4.2	Hybrid learning	1
4.3	ANFIS as universal approximator	1
4.4	Coactive Neuro fuzzy modeling	1
4.5	Framework	1
4.6	Neuron functions for adaptive networks	1
4.7	Neuro fuzzy spectrum - Analysis of Adaptive Learning Capability	1
5	**APPLICATIONS**	
5.1	Modeling a two input sine function	1
5.2	Printed Character Recognition	2
5.3	Fuzzy filtered neural networks	1
5.4	Plasma Spectrum Analysis	1
5.5	Hand written neural recognition	1
5.6	Soft Computing for Color Recipe Prediction	2
	TOTAL	**36**

Course Designers:

Dr.M.Senthilarasi msiece@tce.edu
Dr.S.Mohamed Mansoor Roomi smmroomi@tce.edu

22ECPX0	SYSTEM DESIGN WITH ARM CORTEX

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

Embedded systems are vital to modern technology, driving innovation in industries such as healthcare, automotive, and IoT. This course introduces learners to the fundamentals of embedded systems, focusing on the STM32 microcontroller series in the ARM Cortex-M4 architecture. Divided into five modules, the course blends theoretical knowledge with practical applications, covering topics such as embedded system basics, Cortex-M4 architecture, peripheral interfacing, and programming techniques. The final module includes real-world case studies, such as sensor and motor interfacing, to equip learners for hands-on projects. Designed for students, professionals, and hobbyists, this course empowers participants to design, program, and deploy embedded solutions effectively across diverse fields.

Prerequisite

Nil

Course Outcomes

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

Course Outcomes

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand embedded systems fundamentals, applications, and ARM Cortex-M series basics.	TPS2	70	70
CO2	Understand ARM Cortex-M4 architecture, memory organization, and interrupt handling.	TPS3	70	70
CO3	Apply knowledge of GPIO, timers, UART, SPI, I2C, ADC, DAC, and PWM for interfacing.	TPS3	70	70
CO4	Apply development environment setup for programming Cortex-M4 applications.	TPS3	70	70
CO5	Apply programming techniques for GPIO, timers, PWM, and NVIC interrupt handling.	TPS3	70	70
CO6	Apply interfacing techniques for LCDs, sensors, and motors with ARM Cortex-M4.	TPS3	70	70

Mapping with Programme outcomes

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PS O1**	**PS O2**	**PS O2**
CO1	M	L		-	-	-	L	L	L	L	L	L	-	L
CO2	M	M	L	L	-	-	L	L	L	L	L	L	L	L
CO3	S	M	L	-	S	-	L	L	L	L	L	M	L	L
CO4	S	M	L	L	S	L	L	L	L	L	L	M	L	L
CO5	S	M	M	L	-	L	L	L	L	L	L	M	-	L
CO6	S	M	L	L	-	-	L	L	L	L	L	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

<table>
<tr><td rowspan="2"></td><td colspan="6">Assessment - I</td><td colspan="6">Assessment - II</td><td colspan="3" rowspan="2">Terminal Exam (%)</td></tr>
<tr><td colspan="3">CAT – I (%)</td><td colspan="3">Ass. I * (%)</td><td colspan="3">CAT – II (%)</td><td colspan="3">Ass. II * (%)</td></tr>
<tr><td>TPS
CO</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>CO1</td><td>-</td><td>30</td><td>-</td><td colspan="3" rowspan="3">100</td><td>-</td><td>30</td><td>-</td><td colspan="3">-</td><td>-</td><td>15</td><td>-</td></tr>
<tr><td>CO2</td><td>-</td><td>30</td><td>-</td><td>-</td><td>30</td><td>-</td><td colspan="3">-</td><td>-</td><td>15</td><td>-</td></tr>
<tr><td>CO3</td><td>-</td><td>20</td><td>20</td><td>-</td><td>20</td><td>20</td><td colspan="3">-</td><td>-</td><td>10</td><td>10</td></tr>
<tr><td>CO4</td><td>-</td><td>-</td><td>-</td><td colspan="3">-</td><td>-</td><td>-</td><td>-</td><td colspan="3" rowspan="3">100</td><td>-</td><td>-</td><td>20</td></tr>
<tr><td>CO5</td><td>-</td><td>-</td><td>-</td><td colspan="3">-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>15</td></tr>
<tr><td>CO6</td><td>-</td><td>-</td><td>-</td><td colspan="3">-</td><td>-</td><td>-</td><td>-</td><td></td><td></td><td>15</td></tr>
<tr><td>Total</td><td>-</td><td>80</td><td>20</td><td colspan="3">100</td><td>-</td><td>80</td><td>20</td><td colspan="3">100</td><td>-</td><td>40</td><td>60</td></tr>
</table>

Syllabus

Module 1: Introduction to Embedded Systems

Overview of embedded systems and their applications, Microcontrollers vs. Microprocessors, CISC and RISC, Introduction to the Arm architecture and the Cortex-M series

Module 2: ARM Cortex-M4 CPU Core Architecture

Key features and architecture of Cortex-M4, Registers and their functions, Instruction set and assembly language programming, Interrupts and exception handling, Memory: Flash, SRAM, and ROM, Memory organization and addressing modes, Stack and heap memory management, Memory-mapped I/O, Floating-Point Unit (FPU) and DSP instructions

Module 3: Peripherals and I/O Interfaces

GPIO (General-Purpose Input/Output), Timers and counters, UART (Universal Asynchronous Receiver/Transmitter), SPI (Serial Peripheral Interface), I2C (Inter-Integrated Circuit), ADC (Analog-to-Digital Converter), DAC (Digital to Analog Converter), PWM (Pulse Width Modulation), Sensor Interfacing.

Module 4: Programming for Cortex-M4

Setting up the development environment (IDE, compiler, debugger),GPIO (General Purpose Input Output) programming, Timers and PWM (Pulse Width Modulation)programming, Interrupt handling and NVIC Programming.

Module 5: Case Study

LCD and Keyboard interfacing, Temperature sensor interfacing, Stepper Motor, Servo Motor, DC motor interfacing.

Text Book

- Carmine Noviello, “*Mastering STM32”*, Leanpub, 1st Edition, 2017.
- Muhammad Ali Mazidi Shujen Chen Eshragh Ghaemi, “STM32 Arm Programming for Embedded Systems”, Microdigitaled, 14 May 2018.
- Jonathan W. Valvano, “Embedded Systems: Introduction to ARM Cortex-M Microcontrollers, Createspace Independent Publishing Platform; 5th ed. edition 2016.

Reference Books& web resources

- Yifeng Zhu, “Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C”, E-Man Press LLC, 4th Edition, 2021.
- Joseph Yiu, “The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors”, Newnes, 3rd Edition, 2013.

Course Contents and Lecture Schedule

Module No	Topic	No of Lecture
1	Introduction to Embedded Systems	
1.1	Overview of Embedded Systems and Applications	1
1.2	Microcontrollers vs. Microprocessors CISC and RISC Architectures	1
1.3	Introduction to ARM Architecture – ARM7TDMI ARM Cortex-M Series	1
2	ARM Cortex-M4 CPU Core Architecture	
2.1	Key Features and Architecture of Cortex-M4-Regsiters	1
2.2	Instruction Set and Assembly Language Programming	2
2.3	Interrupts and Exception Handling	1
2.4	Memory Types: Flash, SRAM, ROM	1
2.5	Memory Organization and Addressing Modes	1
2.6	Stack and Heap Memory Management	1
2.7	Memory-Mapped I/O,	1
2.8	Floating-Point Unit (FPU) and DSP Instructions	2
3	Peripherals and I/O Interfaces	
3.1	GPIO (General-Purpose Input/Output)	1
3.2	Timers and Counters	1
3.3	Registers and Modes of Operation	1
3.4	UART and its registers	1
3.5	SPI and its registers	1
3.6	I2C and Its registers	1
3.7	ADC, and DAC	1
4	Peripherals and I/O Interfaces (continued)	
4.1	PWM (Pulse Width Modulation)	1
4.2	Sensor Interfacing Basics	1
4.3	Overview of Real-Time Applications Using STM32 Peripherals	1
5	Programming for Cortex-M4	
5.1	Setting Up the STM32 Development Environment (IDE, Compiler, Debugger)	1
5.2	GPIO Programming with STM32	1
5.3	Timers and PWM Programming Using STM32CubeMX	1
5.4	Interrupt Handling and NVIC Programming	1
6	Case Studies	
6.1	LCD and Keyboard Interfacing	2
6.1	Temperature Sensor Interfacing	1
6.2	Stepper Motor and Servo Motor Interfacing	2
6.3	DC Motor Interfacing	1
6.4	Capstone Project: Designing an Embedded System Using STM32	1
	Total	**36**

12 Weeks :36 Hours
Each week: 3 Hours

Course Designers:

Dr K.Hariharan, khh@tce.edu
Dr G.Prbhakaran gpece@tce.edu

22ECRY0	MIMO OFDM SYSTEMS

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

High data rate wireless systems with very small symbol periods usually face unacceptable Inter-symbol interference (ISI) originated from multipath propagation and inherent delay spread. Orthogonal frequency division multiplexing (OFDM) is a multicarrier based technique for mitigating ISI to improve capacity in the wireless system with spectral efficiency. On the other hand, MIMO systems have risen attention of the wireless academic community and industry because their promise to increase the capacity and performance with acceptable bit error rate (BER) proportionally with the number of antennas. MIMO OFDM is an attractive air interface solution for next generation wireless local area networks and wireless metropolitan area networks and next generation mobile cellular wireless systems

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Develop a systemic framework to study the nature of the wireless channel, especially with respect to key properties such as inter-symbol interference and, time-varying characteristics amongst others.	TPS3	70	70
CO2	Construct channels from statistical descriptions and develop models for SISO, SIMO, MISO, and MIMO channel systems	TPS3	70	70
CO3	Determine the capacity of space time wireless channels for random and correlated MIMO scenarios.	TPS3	70	70
CO4	Examine how spatial diversity techniques, including transmit and receive diversity, enhance communication performance by improving symbol error rates in fading channels.	TPS3	70	70
CO5	Interpret the differences between single-carrier and multi-carrier transmission and understand the advantages of orthogonality in wideband systems.	TPS3	70	70
CO6	Analyze the impact of symbol time offset (STO) and carrier frequency offset (CFO) in OFDM systems and understand synchronization techniques to mitigate these issues	TPS4	70	70
CO7	Analyze the channel estimation techniques in OFDM systems, including pilot structure and training symbol-based Least Squares and Minimum Mean Square Error estimation.	TPS4	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	M	-	M	M	-	-	-	M	L	L
CO2	S	M	L	-	M	-	M	M	-	-	-	M	L	L
CO3	S	M	L	-	M	-	M	M	-	-	-	M	L	L
CO4	S	M	L	-	M	-	M	M	-	-	-	M	L	L
CO5	S	M	L	-	M	-	M	M	-	-	-	M	L	L
CO6	S	S	M	L	M	-	M	M	-	-	-	S	L	L
CO7	S	S	M	L	M	-	M	M	-	-	-	S	L	L
Overall	S	M	L	-	M	-	M	M	-	-	-	M	L	L

Assessment Pattern:

	Assessment – I						**Assessment - II**						**Terminal Exam** (%)		
	CAT – I (%)			**Assignment I** (%)			**CAT – II** (%)			**Assignment II** (%)					
TPS Scale CO	**2**	**3**	**4**	**2**	**3**	**4**	**2**	**3**	**4**	**2**	**3**	**4**	**2**	**3**	**4**
CO1	5	20		100									4	10	
CO2	5	20											4	10	
CO3	5	30											2	10	
CO4	5	10					5	25		100			2	10	
CO5							5	25					4	10	
CO6							5	15					2	15	
CO7							5	15					2	15	
Total	20	80					20	80					20	80	

Syllabus

Space Time Propagation: The wireless channel, scattering models in macrocells, channel at ST random field, Scattering functions **Space Time Channel Model:** SISO, SIMO, MISO and MIMO Channel Models, Scattering channel Model, Extended Channel Model, Random Matrix Model, Statistical Cluster Model, **Capacity of Space Time Wireless Channels:** Frequency Flat Fading channel with Perfect CSIT and in the absence of CSIT, Frequency Selective Fading channel with Perfect CSIT and in the absence of CSIT, Random MIMO channel, Correlated MIMO channel, **Spatial Diversity:** Transmit Diversity: Cyclic Delay Diversity, Space Time coding in the absence of CSIT, Optimal Pre filtering with CSIT for Maximum data rate and minimum error rate, Receive diversity: Selection Combining, Threshold Combining, Equal Gain Combining, Maximal Ratio Combining, Diversity gain, Array gain, Multiplexing gain **Wideband Digital Communications:** OFDM Systems, Single-Carrier vs. Multi-Carrier Transmission, Basic Principle of OFDM, MATLAB Simulation of Orthogonality testing, OFDM Modulation and Demodulation, MATLAB Simulation of BER of OFDM Scheme, Water-Filling Algorithm for Frequency-Domain Link Adaptation

OFDM Synchronization- Effect of Symbol Time Offset (STO), Effect of Carrier Frequency Offset (CFO), MATLAB Simulation of Time-Domain Estimation Techniques for STO, MATLAB Simulation of Time-Domain Estimation Techniques for CFO **Channel Estimation**- Pilot Structure, MATLAB Simulation of Training Symbol-Based LS and MMSE (with and without DFT) Channel Estimation, PAPR Reduction- Introduction to PAPR, MATLAB Simulation of PAPR Analysis, MATLAB Simulation of BER of OFDM with PAPR Reduction Techniques, MATLAB Simulation of System Performance with PAPR Reduction Code

Text Book

- Paulraj, R. Nabar and D Gore, "Introduction to Space-Time Wireless Communications", Cambridge University Press, 2003.
- Yong Soo Cho, Jaekwon Kim, Won Young Yang and Chung G.Kang, MIMO-OFDM Wireless Communications with MATLAB, John Wiley & Sons (Asia) Pte Ltd, 2010

Reference Books& web resources

- David Tse and Pramod Viswanath, "Fundamentals of Wireless Communications", Cambridge University Press, First Asian Edition, 2006.
- Yong Soo Cho, Jaekwon Kim, Won Young Yang, Chung G. Kang, "MIMO OFDM Wireless Communications with Matlab" John Wiley & sons (Asia) pte Ltd, 2010
- Lajos Hanzo, Yosef (Jos) Akhtman Li Wang, Ming Jiang "MIMO-OFDM for LTE, Wi-Fi and WiMAX ", John Wiley & Sons Ltd, 2011
- Tolga M. Duman, Ali Ghrayeb "Coding for MIMO Communication Systems" John Wiley & Sons Ltd, 2007,
- Ezio Biglieri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, "MIMO Wireless communications" Cambridge University press, 2007

Course Contents and Lecture Schedule

No.	Topic	Lecture Hours
1	**Space Time Propagation**	
1.1	The wireless channel,	1
1.2	scattering models in macrocells	1
1.3	channel at ST random field, Scattering functions	1
2	**Space Time Channel Model**	
2.1	SISO, SIMO, MISO and MIMO Channel Models	1
2.2	Scattering channel Model	1
2.3	Extended Channel Model	1
2.4	Random Matrix Model	1
2.5	Statistical Cluster Model	1
3	**Capacity of Space Time Wireless Channels**	
3.1	Frequency Flat Fading channel with Perfect CSIT and in the absence of CSIT	1
3.2	Frequency Selective Fading channel with Perfect CSIT and in the absence of CSIT	1
3.3	Random MIMO channel	1
3.4	Correlated MIMO channel	1
4	**Spatial Diversity**	
4.1	Transmit Diversity: Cyclic Delay Diversity	1
4.2	Space Time coding in the absence of CSIT	1
4.3	Optimal Pre filtering with CSIT for Maximum data rate and minimum error rate	1
4.4	Receive diversity: Selection Combining, Threshold Combining, Equal Gain Combining, Maximal Ratio Combining	1
4.5	Diversity gain, Array gain, Multiplexing gain	1
5	**Wideband Digital Communications**	
5.1	OFDM Systems, Single-Carrier vs. Multi-Carrier Transmission	1
5.2	Basic Principle of OFDM	1
5.3	MATLAB Simulation of Orthogonality testing	1
5.4	OFDM Modulation and Demodulation	1
5.5	MATLAB Simulation of BER of OFDM Scheme	1
5.6	Water-Filling Algorithm for Frequency-Domain Link Adaptation	1

6	**OFDM Synchronization**	
6.1	Effect of Symbol Time Offset (STO)	2
6.2	Effect of Carrier Frequency Offset (CFO)	2
6.3	MATLAB Simulation of Time-Domain Estimation Techniques for STO	1
6.4	MATLAB Simulation of Time-Domain Estimation Techniques for CFO	1
7	**Channel Estimation**	
7.1	Pilot Structure	1
7.2	MATLAB Simulation of Training Symbol-Based LS and MMSE (with and without DFT)	1
7.3	Channel Estimation	1
7.4	PAPR Reduction- Introduction to PAPR	1
7.5	MATLAB Simulation of PAPR Analysis	1
7.6	MATLAB Simulation of BER of OFDM with PAPR Reduction Techniques	1
7.7	MATLAB Simulation of System Performance with PAPR Reduction Code	1
Total		**36**

12 Weeks :36 Hours
Each week: 3 Hours

Course Designers:

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22ECRZ0	HARDWARE SECURITY

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

Hardware security is a critical domain within cybersecurity, focusing on protecting physical devices, integrated circuits, and hardware components from tampering, unauthorized access, and malicious attacks. Unlike software security, which addresses vulnerabilities in code and applications, hardware security emphasizes the integrity, confidentiality, and reliability of the foundational physical layers of computing systems.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the digital System design vulnerabilities	TPS 2	70	75
CO2	Apply cryptographic algorithms in FPGA	TPS 3	70	70
CO3	Analyze the vulnerabilities of Modular Exponentiation in cryptography	TPS 3	70	65
CO4	Analyze physical attacks and its countermeasures	TPS 4	70	65
CO5	Analyze side channel attacks and its countermeasures	TPS 4	70	65
CO6	Apply the design techniques to prevent IP and IC Piracy	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	M	M	-	-	M	-	L
CO2	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO3	S	M	M	L	-	-	-	M	M	-	-	M	-	L
CO4	S	M	M	L	-	-	-	M	M	-	-	M	-	L
CO5	S	M	M	L	-	-	-	M	M	-	-	M	-	L
CO6	S	M	L	-	-	-	-	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment – I							Assessment – II							Terminal Exam(%)		
	CAT – I(%)			Assg. I *(%)				CAT – II(%)			Assg. II *(%)						
TPS / CO	1	2	3	1	2	3	4	1	2	3	1	2	3	4	1	2	3
CO1	-	10	20					-							-	6	-
CO2	-	10	20	100				-							-	5	15
CO3	-	10	30					-							-	5	15
CO4	-							-	10	20					-	5	15
CO5	-							-	10	30	100				-	5	15
CO6	-							-	10	20					-	4	10
Total	-	**30**	**70**	**100**				**-**	**30**	**70**	**100**				**-**	**30**	**70**

Syllabus

Digital System Design: Basics and Vulnerabilities - Digital system specification, digital system implementation function simplification and don't care conditions, sequential system specification, sequential system implementation, vulnerabilities in digital logic design **Hardware Security Primitives:** Basics of the Mathematical theory of public key cryptography, Basics of digital design on FPGA, classification using Support Vector Machines, cryptographic hardware and their implementation, optimization of cryptographic hardware on FPGA, Physically Unclonable Functions (PUF), PUF implementations, PUF quality evaluation, Design techniques to increase PUF response quality **Physical Attacks and Modular Exponentiation:** Physical attacks (PA) basics, physical attacks and countermeasures, building secure systems, Modular Exponentiation (ME) basics, ME in cryptography, ME implementation and vulnerability, Montgomery reduction. Case Study: Kocher′s Attack on DES, Template Attack, Cache Attacks **Side Channel Attacks and Countermeasures: I**ntroduction to side channel attacks, memory vulnerabilities and cache attacks, power analysis, more attacks and countermeasures, modified modular exponentiation. **Modern IC Design and Manufacturing Practices:** Hardware Intellectual Property (IP) Piracy and IC Piracy, Design Techniques to Prevent IP and IC Piracy, good watermarks, fingerprinting, hardware metering, Using PUFs to prevent Hardware Piracy, Model Building Attacks on PUFs Case Study: SVM Modeling of Arbiter PUFs, Genetic Programming based Modeling of Ring Oscillator PUF

Text Books

- Debdeep Mukhopadhyay and Rajat Subhra Chakraborty, "Hardware Security: Design, Threats, and Safeguards", CRC Press

Reference Books:

- Ahmad-Reza Sadeghi and David Naccache (eds.): Towards Hardware-intrinsic Security: Theory and Practice, Springer.
- Ted Huffmire et al: Handbook of FPGA Design Security, Springer.
- Stefan Mangard, Elisabeth Oswald, Thomas Popp: Power analysis attacks - revealing the secrets of smart cards. Springer 2007.
- Doug Stinson, Cryptography Theory and Practice, CRC Press.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**Introduction to the Course, COs POs**	1
	Digital System Design	
2	Basics and Vulnerabilities, Digital system specification	2
3	digital system implementation function simplification and don't care conditions	1
4	sequential system specification sequential system implementation	1
5	vulnerabilities in digital logic design	1
	Hardware Security Primitives	
7	Basics of the Mathematical theory of public key cryptography	2
8	Basics of digital design on FPGA, classification using Support Vector Machines	1
9	cryptographic hardware and their implementation, optimization of cryptographic hardware on FPGA	1
10	Physically Unclonable Functions (PUF), PUF implementations,	1
11	PUF quality evaluation	1

12	Design techniques to increase PUF response quality	2
	Physical Attacks and Modular Exponentiation	
13	**P**hysical attacks (PA) basics, physical attacks and countermeasures, building secure systems	2
14	Modular Exponentiation (ME) basics ME in cryptography	1
15	ME implementation and vulnerability, Montgomery reduction.	1
16	Case Study: Kocher's Attack on DES, Template Attack, Cache Attacks	2
	Side Channel Attacks and Countermeasures	
17	**I**ntroduction to side channel attacks,	2
18	memory vulnerabilities and cache attacks,	2
19	power analysis, more attacks and countermeasures,	2
20	modified modular exponentiation	2
	Modern IC Design and Manufacturing Practices	
21	Hardware Intellectual Property (IP) Piracy and IC Piracy,	2
22	Design Techniques to Prevent IP and IC Piracy,	2
23	good watermarks, fingerprinting, hardware metering,	2
24	Using PUFs to prevent Hardware Piracy, Model Building Attacks on PUFs	2
	TOTAL	**36**

12 Weeks :36 Hours
Each week: 3 Hours

Course Designers:

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22ECPY0	INTRODUCTION TO ARTIFICIAL INTELLIGENCE

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

This course on Introduction to Artificial Intelligence offers a comprehensive journey into the core concepts and applications of AI, from its foundations to advanced techniques. Beginning with an overview of AI, its history, and societal impact, the course covers Machine Learning and its workflows, key algorithms, and real-world case studies. It further explores Deep Learning, neural networks, CNN architectures, and hands-on model implementation, followed by insights into RNNs, LSTMs, and their applications in NLP. The course also introduces Reinforcement Learning principles, culminating in practical case studies across diverse domains such as speech processing and image generation.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the fundamentals of Artificial Intelligence, Machine Learning and Deep Learning.	TPS 2	70	60
CO2	Implement supervised and unsupervised learning models, perform feature engineering, and utilize algorithms like decision trees, SVMs, and ensemble methods for solving real-world problems.	TPS 3	70	60
CO3	Implement neural networks, including CNNs and transfer learning approaches, for tasks like image classification and natural language processing.	TPS 3	70	60
CO4	Evaluate the role of RNNs, LSTMs, and GRUs to address challenges in sequence modeling and natural language applications.	TPS 4	70	60
CO5	Develop the reinforcement learning model to solve complex problems.	TPS 3	70	60
CO6	Solve real-world challenges such as speech processing, disease classification, crop type prediction, and text-to-image generation.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	S	S	M	L	L	-	-	L	M	M	-	M	L	L
CO2	S	S	M	L	M	-	-	L	M	M	-	M	L	L
CO3	S	S	M	M	M	-	-	L	M	M	-	M	-	L
CO4	S	S	M	M	M	-	-	L	M	M	-	M	-	L
CO5	S	S	M	M	M	-	-	L	M	M	-	M	-	L
CO6	S	S	M	M	M	-	-	L	M	M	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO \ TPS Scale	Assessment - I						Assessment - II						Terminal Exam(%)		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	20		100		-						-	4	10
CO2	-	10	20				-						-	4	15
CO3	-	10	30				-						-	4	15
CO4	-						-	10	30		100		-	-	15
CO5	-						-	10	20				-	4	15
CO6	-						-	10	20				-	4	10
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

INTRODUCTION

Artificial Intelligence (AI), AI versus Machine Learning versus Deep Learning, History and evolution of AI, Turing test, Applications of AI- Impact on jobs and society, AI Ethics and Implications- Bias, fairness, and transparency in AI, Overview of Emerging trends- ChatGPT, Bard.

MACHINE LEARNING

Introduction to Machine Learning , Categorization of Learning -Supervised, unsupervised, and reinforcement learning, ML Workflow, Feature Engineering- Key Concepts -data, features, data preprocessing, target variables, Feature Selection, Classifiers- K-means, PCA, Linear Regression, Logistic Regression, Decision Trees and Random Forests, k-Nearest Neighbors, Support Vector Machines, Ensemble Learning, Evaluation criteria-Training, testing, and validation splits, k-fold, Evaluation metrics (accuracy, precision, recall, F1-score), Case study -Predictive modeling (House price prediction), Case study- Classification (Spam email detection and Image Classification)

DEEP LEARNING

Introduction to Neural Networks, Biological inspiration of neural networks, Building a Simple Neural Network - neurons, activation functions, layers, Multi-layer perceptron (MLP), Forward and backward propagation, Convolutional Neural Networks (CNNs), convolution, pooling, fully connected layer, Architecture of CNNs -LeNet, AlexNet, VGG, ResNet, Applications of CNNs, Implementation of a simple CNN model using python. Transfer Learning and pre-trained models like BERT or GPT for NLP and ResNet for vision.

RECURRENT NEURAL NETWORKS (RNNS) AND LSTMS

Introduction to RNNs, Sequence modeling and applications in NLP, Issues with vanishing gradients, Long Short-Term Memory (LSTM) Networks, Architecture and benefits of LSTMs, GRUs, Bidirectional LSTMs.

REINFORCEMENT LEARNING

Introduction to Reinforcement Learning, Concepts: agents, environment, rewards, and policies, Exploration vs. exploitation, Key Algorithms, Q-learning, Deep Q-Networks (DQN), Diffusion Models (DALL-E 2, Stable Diffusion), Multi-Agent Reinforcement Learning.

CASE STUDIES

Speech Processing, Disease Classification, Crop type Classification, Text to Image Generation, In-painting.

Text Book

- Stuart Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, 4th edition, Pearson, 2021.
- Ian Goodfellow Yoshua Bengio Aaron Courville, “Deep Learning”, MIT Press, 2017.
- How AI Thinks: How we built it, how it can help us, and how we can control it, Nigel Toon, Transworld Digital, 2024.
- Tom Mitchell, Machine Learning, McGraw Hill, 1997.

Reference Books & web resources

- K. R. Murphy. "Machine Learning - A Probabilistic Perspective", 1st Edition, The MIT Press, 2012.
- C. M. Bishop. "Pattern Recognition and Machine Learning," Springer, 2006.
- Ethem Alpaydin, Introduction to Machine Learning, Third edition, MIT Press, 2014.
- Richard S. Sutton and Andrew G. Barto, Reinforcement Learning, The MIT Press, 2018
- Trevor Hastie, Robert Tibshirani, Jerome Friedman; The Elements of Statistical Learning, Second Edition, Springer, 2009.
- Richard O. Duda, Peter E. Hart, David G. Stork; Pattern Classification, Second Edition, John Wiley & Sons, November 2000.
- Shai Shalev-Shwartz, Shai Ben-David; Understanding Machine Learning: From Theory to Algorithms, First Edition, Cambridge University Press, 2014.
- Richard S. Sutton and Andrew G. Barto; Reinforcement Learning: An Introduction, 2nd Edition, MIT Press, 2020.
- Christoph Molnar; Interpretable Machine Learning, Leanpub Publisher, 2019.
- https://onlinecourses.nptel.ac.in/noc22_cs56/preview, By Prof. Mausam, IIT Delhi.
- https://onlinecourses.nptel.ac.in/noc24_cs88/preview, By Prof. Deepak Khemani, IIT Madras.
- https://onlinecourses.nptel.ac.in/noc24_cs81/preview, By Prof. Sudeshna Sarkar, IIT Kharagpur.

Course Contents and Lecture Schedule

Week	Topic	Lecture Hours
1	**INTRODUCTION**	
1.1	Artificial Intelligence(AI)	1
1.2	AI versus Machine Learning versus Deep Learning	
1.3	History and evolution of AI	
1.4	Turing test	
1.5	Applications of AI- Impact on jobs and society	1
1.6	AI Ethics and Implications- Bias, fairness, and transparency in AI	1
1.7	Overview of Emerging trends- ChatGPT, Bard	
2 – 4	**MACHINE LEARNING**	
2.1	Introduction to Machine Learning	1
2.2	Categorization of Learning -Supervised, unsupervised, and reinforcement learning	
2.3	ML Workflow	1
2.4	Feature Engineering- Key Concepts -data, features, data preprocessing, target variables	1
2.5	Feature Selection	1
3.1	Classifiers- K-means, PCA, Linear Regression, Logistic Regression, Decision Trees and Random Forests, k-Nearest Neighbors, Support Vector Machines, Ensemble Learning,	1
4.1	Evaluation criteria-Training, testing, and validation splits, k-fold,	1
4.2	Evaluation metrics (accuracy, precision, recall, F1-score),	1
4.3	Case study -Predictive modeling (House price prediction),	1
4.4	Case study- Classification (Spam email detection and Image Classification)	1
5 – 8	**DEEP LEARNING**	
5.1	Introduction to Neural Networks	1
5.2	Biological inspiration of neural networks	
5.3	Building a Simple Neural Network - neurons, activation functions, layers	1
5.4	Multi-layer perceptron (MLP)	1

5.5	Forward and backward propagation	2
6.1	Convolutional Neural Networks (CNNs) - convolution, pooling, fully connected layer	1
6.2	Architecture of CNNs -LeNet, AlexNet, VGG, ResNet,	1
6.3	Applications of CNNs,	1
7.1	Implementation of a simple CNN model using python.	2
7.2	Transfer Learning and pre-trained models like BERT or GPT for NLP and ResNet for vision	2
8	Optimization and Tuning	3
9	**RECURRENT NEURAL NETWORKS (RNNS) AND LSTMS**	
9.1	Introduction to RNNs	1
9.2	Sequence modeling and applications in NLP	
9.3	Issues with vanishing gradients	1
9.4	Long Short-Term Memory (LSTM) Networks	
9.5	Architecture and benefits of LSTMs	
9.6	GRUs	1
9.7	Bidirectional LSTMs	
10 -11	**REINFORCEMENT LEARNING**	
10.1	Introduction to Reinforcement Learning	1
10.2	Agents, environment, rewards, and policies	
10.3	Exploration vs. exploitation,	1
10.4	Q-learning	1
11.1	Deep Q-Networks (DQN)	1
11.2	Diffusion Models (DALL-E 2, Stable Diffusion)	1
11.3	Multi-Agent Reinforcement Learning	1
12	**CASE STUDIES**	
12.1	Speech Processing	1
12.2	Disease Classification	1
12.3	Crop type Classification	
12.4	Text to Image Generation	1
12.5	In-painting	
	TOTAL	**36**

12 Weeks :36 Hours
Each week: 3 Hours

Course Designers:

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DETAILED SYLLABI

FOR

ELECTIVE COURSES FOR MINOR
(for the students admitted from the academic year 2022-23)

B. E. / B.Tech. DEGREE PROGRAMME

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution Affiliated to Anna University)
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22ECQA0	CONSUMER ELECTRONICS AND SYSTEMS

Category	L	T	P	Credit
MINOR	3	0	0	3

Preamble

This course provides a comprehensive understanding of the technologies behind the devices we use daily, from food storage and preparation systems to home automation and entertainment solutions.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Comprehend the evolution and significance of consumer electronics, identifying the core components of typical consumer devices and their functionalities.	TPS 2	70	60
CO2	Explain the working principles, applications, and energy efficiency of kitchen and food preparation appliances.	TPS 2	70	60
CO3	Examine the technical and operational aspects of cleaning and hygiene devices.	TPS 4	70	60
CO4	Analyze the technologies behind audio-visual entertainment systems.	TPS 4	70	60
CO5	Investigate the features, integration, and applications of smart devices.	TPS 4	70	60
CO6	Identify advancements in consumer electronics and their impact on lifestyle, focusing on sustainable and energy-efficient innovations.	TPS 3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	S	S	L	L	-	-	-	L	M	M	-	M	L	L
CO2	S	S	L	L	-	-	-	L	M	M	-	M	L	L
CO3	S	S	L	L	-	-	-	L	M	M	-	M	-	L
CO4	S	S	L	L	-	-	-	L	M	M	-	M	-	L
CO5	S	S	L	L	-	-	-	L	M	M	-	M	-	L
CO6	S	S	L	L	-	-	-	L	M	M	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern*

	Assessment - I						Assessment - II						Terminal Exam(%)		
CO \ TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20				-						-	4	10
CO2	-	10	20		100		-						-	4	15
CO3	-	10	30				-						-	4	15
CO4	-						-	10	30				-	-	15
CO5	-						-	10	20		100		-	4	15
CO6	-						-	10	20				-	4	10
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

INTRODUCTION
Overview, Era of consumer electronics and systems, Components of a typical consumer device.
FOOD STORAGE AND PREPARATION SYSTEM
Refrigerator, freezer, cold storage, induction stove, microwave oven, toaster, electric rice cooker, mixer, grinder, egg beater, juicer, coffee maker
FOUNDATIONAL SYSTEM FOR COMFORT
Inverter, UPS, battery backup, solar panel, Air Conditioner, HVAC, water heater, Water purifier- RO, UV, mineralizer, Geyser, Dehumidifier, Ceiling fan, Exhaust fan, Vacuum Cleaner
CLEANING AND HYGINE SYSTEM
Washing machine, dryers, steam irons, garment steamers, dish washer, trimmer, fitness trackers, Pulse oximeter
ENTERTAINMENT AND PERSONAL COMFORT DEVICES
Microphone, loudspeaker, amplifier, equalizer, Dolby, TDS, sound bars and Audio Mixers, LED, OLED, Micro LED, QLED, Home Theatre, OTT
SMART HOME
Robotic Vacuum Cleaner, Smart refrigerator, Smart Washing machine, Smart TV, Smart Watches, Smart lighting and power control, Interactive Gadgets- Alexa, Siri, and Google Home

Text Book

- Bali S.P, “Consumer Electronics”, Pearson Education, 2022.
- Amit Dhir, “The Digital Consumer Technology Handbook A Comprehensive Guide to Devices, Standards, Future Directions, and Programmable Logic Solutions” Elsevier 2004.

Reference Books

- Jordan Frith, "Smartphones as Locative Media ", Wiley. 2014.
- R.S. Khandpur, “Troubleshooting Electronic Equipment: Includes Repair and Maintenance”, Second Edition, McGraw Hill Education (India) Private Limited., 2003.
- Philp Hoff "Consumer Electronics for Engineers" - Cambridge University Press.1998.
- Lal A. K, “Trouble Shooting and Maintenance of Electronics Equipments”, McGraw Hill Education, 2020.
- Thomas M. Coughlin, "Digital Storage in Consumer Electronics", Elsevier and Newness 2012.
- Nick Vandome, Smart homes in easy steps, - Master smart technology for your home 2018.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**INTRODUCTION**	
1.1	Overview, Era of consumer electronics and systems	1
1.2	Components of a typical consumer device	1
2	**FOOD STORAGE AND PREPARATION SYSTEM**	
2.1	Refrigerator	1
2.2	Freezer and cold storage	1
2.3	Induction stove	1
2.4	Microwave oven	1
2.5	Toaster	1
2.6	Electric rice cooker	
2.7	Mixer and grinder	1
2.8	Egg beater	
2.9	Juicer	1
2.10	Coffee maker	
3	**FOUNDATIONAL SYSTEM FOR COMFORT**	
3.1	Inverter	1
3.2	UPS and Battery backup	1

3.3	Solar panel	1
3.4	Air Conditioner	1
3.5	HVAC	
3.6	Solar Water heater	1
3.7	Geyser	
3.8	Water purifier- RO, UV, mineralizer	1
3.9	Dehumidifier	
3.10	Ceiling fan, Exhaust fan	1
3.11	Vacuum Cleaner	
4	**CLEANING AND HYGINE SYSTEM**	
4.1	Washing machine	1
4.2	Dryers	1
4.3	Steam irons	1
4.4	Garment steamers	
4.5	Dish washer	1
4.6	Trimmer	1
4.7	Fitness trackers	1
5	**ENTERTAINMENT AND PERSONAL COMFORT DEVICES**	
5.1	Microphone	1
5.2	Loudspeaker	1
5.3	Dolby	1
5.4	DTS	
5.5	Sound bars	1
5.6	Audio Mixers	
5.7	LED	1
5.8	OLED	
5.9	Micro LED	1
5.10	QLED	
5.11	Home Theatre	1
5.12	OTT	
6	**SMART HOME**	
6.1	Robotic Vacuum Cleaner	1
6.2	Smart refrigerator	1
6.3	Smart Washing machine	1
6.4	Smart TV	1
6.5	Smart Watches	1
6.6	Smart lighting and power control	1
6.7	Interactive Gadgets- Alexa, Siri, and Google Home	1
	TOTAL	**36**

Course Designers:

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22ECQB0	MULTIMEDIA SYSTEMS

Category	L	T	P	Credit
MINOR	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.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Identify the properties of different media streams	TPS 2	70	75
CO2	Apply suitable digitization mechanisms for multimedia.	TPS 3	70	70
CO3	Compare lossless and lossy compression algorithms.	TPS 3	70	70
CO4	Use suitable techniques to compress text and Images	TPS 3	70	70
CO5	Apply the compression techniques for transporting audio and video-based data.	TPS 3	70	70
CO6	Analyse different communication networks to support multimedia applications.	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	M	M	-	-	M	-	L
CO2	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO3	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO4	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO5	S	M	L	-	-	-	-	M	M	-	-	M	-	L
CO6	S	M	L	-	-	-	-	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment – I						Assessment – II						Terminal Exam(%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20				-						-	6	-
CO2	-	10	20		100		-						-	5	15
CO3	-	10	30				-						-	5	15
CO4	-						-	10	20				-	5	15
CO5	-						-	10	30		100		-	5	15
CO6	-						-	10	20				-	4	10
Total	-	30	70		100		-	30	70		100		-	30	70

Syllabus

Multimedia Information: Discrete and Continuous Media, Analog and Digital Signals: Analog/Digital Converter, Text and Static Data, Audio: digitizing Sound, Graphics, Images and Video, Digital Sampling: Nyquist's theorem. **Multimedia Information Representation:** Digital Audio **-** Nyquist Sample Rate and Bit Size, MIDI: definition, components, hardware aspects, Messages, Channels, Structured Audio, , Common Digital Audio Formats, Graphic/Image File Formats: 24-bit and 8-bit colors, Bit Maps, Gray Scale and Dithering, Graphic Formats: GIF, JPEG, TIF, PNG, and RGB Color Models, Chrominance and Luminance - NTSC and PAL **Compression Algorithms:** Need for Compression: Basics of Information Theory, Shannon and Kolmogorov: Lossless and Loss Compression, Lossless Compression Algorithms: Repetitive Sequence Suppression, Run-Length Encoding, Entropy Encoding; Shannon-Fano Algorithm; Huffman Coding; Arithmetic Coding, Source Coding Techniques: Transform and Differential Coding, Frequency Domain **Multimedia Compression Techniques**: Text and image compression**-**Static Huffman coding, Dynamic Huffman coding. JPEG standards. Audio and video compression**-**Audio compression-differential pulse code modulation, adaptive predictive coding, linear predictive coding, MPEG audio coders, Video compression principles, H.261, MPEG standards. **Multimedia Communications** 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

Text Book

- Ronald L. Kurtz, Russell Dean Vines, Cloud Security: A Comprehensive Guide to Secure Cloud Computing, 30 July 2010
- J. R. Winkler, "Securing the cloud: Cloud Computer Security Techniques and Tactics", Syngress, 2011

Reference Books& web resources

- Charlie Kaufman, Radia Perlman, Mike Speciner, "Network Security: Private Communication in a Public World", Prentice Hall, 2010
- Atul Kahate, **"**Cryptography and Network Security", 2nd edition, Tata Mc Graw hill, India., 2008.
- Robert Bragg, Mark Rhodes, "Network Security: The complete reference", Tata Mc Graw hill, India, 2004.
- Chris Dotson "Practical Cloud Security", O'Reilly Media, 2019.

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
1	**Introduction to the Course, COs POs**	1
	Multimedia Information	
2	Discrete and Continuous Media, Analog and Digital Signals	1
3	Analog/Digital Converter,	1
4	Text and Static Data, Audio: digitizing Sound,	1
5	Graphics, Images and Video	2
6	Digital Sampling: Nyquist's theorem	2
	Multimedia Information Representation	
7	Digital Audio **-** Nyquist Sample Rate and Bit Size	2
8	MIDI: definition, components, hardware aspects, Messages, Channels	2
9	Structured Audio, Common Digital Audio Formats	1
10	Graphic/Image File Formats: 24-bit and 8-bit colors, Bit Maps, Gray Scale and Dithering	1
11	Graphic Formats: GIF, JPEG, TIF, PNG	2

12	RGB Color Models, Chrominance and Luminance - NTSC and PAL	2
	Compression Algorithms	
13	Need for Compression: Basics of Information Theory, Shannon and Kolmogorov, Lossless and Loss Compression	1
14	Lossless Compression Algorithms: Repetitive Sequence Suppression, Run-Length Encoding	1
15	Entropy Encoding; Shannon-Fano Algorithm; Huffman Coding; Arithmetic Coding	2
16	Source Coding Techniques: Transform and Differential Coding, Frequency Domain	1
	Multimedia Compression Techniques	
17	Text compression-Static Huffman coding, Dynamic Huffman coding	2
18	image compression- JPEG standards	2
19	Audio compression-differential pulse code modulation, adaptive predictive coding, linear predictive coding, MPEG audio coders	2
20	Video compression principles, H.261, MPEG standards.	2
	Multimedia Communications	
21	Multimedia networks-telephone networks, data networks, broadcast television networks	2
22	integrated services digital networks, broadcast multiservice networks.	1
23	Multimedia applications- interpersonal communications	1
24	interactive applications over the internet, entertainment application	1
	TOTAL	**36**

Course Designers:

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22ECQC0	IMAGING SYSTEMS

Category	L	T	P	Credit
MINOR	3	0	0	3

Preamble

The goal of this course is to broaden the student's understanding of image systems beyond the basic concepts. It focuses on techniques for analyzing image systems in both the frequency and spatial domains, improving image quality through enhancement methods, understanding segmentation and compression techniques, and exploring their real-world applications.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the imaging technologies and image representation	TPS 2	70	60
CO2	Enhance and restore images in spatial and frequency domains using noise models, filtering concepts, and transforms	TPS 3	70	60
CO3	Segment given images in terms of point, line, edge, and region	TPS 3	70	60
CO4	Apply morphological operations and texture analysis on given images	TPS 3	70	60
CO5	Implement compression techniques for various imaging modalities	TPS 3	70	60
CO6	Analyze different imaging applications like facial recognition, medical imaging analysis and video motion analysis with case studies	TPS 4	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	L	L	L	M	M	-	-	M	L	L
CO2	S	M	L	L	L	L	L	M	M	-	-	M	L	L
CO3	S	M	L	L	L	L	L	M	M	-	-	M	-	L
CO4	S	M	L	L	L	L	L	M	M	-	-	M	-	L
CO5	S	M	L	L	L	L	L	M	M	-	-	M	-	L
CO6	S	M	L	L	L	L	L	M	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam(%)		
	CAT – I(%)			Assg. I *(%)			CAT – II(%)			Assg. II *(%)					
TPS / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	10	20				-						-	4	10
CO2	-	10	20		100		-						-	4	10
CO3	-	10	30				-						-	4	15
CO4	-						-	10	20				-	-	15
CO5	-						-	10	30		100		-	4	15
CO6	-						-	10	20				-	4	15
Total	**-**	**30**	**70**		**100**		**-**	**30**	**70**		**100**		**-**	**20**	**80**

Syllabus

IMAGING FUNDAMENTALS

Introduction to Imaging Technologies-Photographic- X-Ray, MRI, SAR, IR imaging, CT imaging and Ultrasound Imaging–Image Representations

IMAGE QUALITY ENHANCEMENT

Spatial Filtering:

Contrast - Noise Models: Gaussian noise, Poisson noise, Salt-and-pepper noise, Speckle noise- Sharpness –Gray level Transformation – Histogram processing –spatial filtering – smoothing, sharpening filters

Frequency Domain: Image transforms- DFT, DCT, Frequency Domain Filtering

PROCESSING AND ANALYZING IMAGES

Point Detection- Line Detection –Edge Detection - Canny operator – Segmentation – Morphological operations, Shape of Regions- Chain Code, Shape numbers, Texture –Co-Occurrence Matrix.

IMAGE COMPRESSION

Bit plane coding, JPEG, JPEG2000 and H.264 for video compression.

IMAGING APPLICATIONS

System design- Optical character Recognition– Face and Facial feature Extraction - Video motion Analysis- Image Fusion, Medical Imaging Analysis, Object detection and Change Detection

Text Book

- Rafael.C.Gonzalez and Richard.E. Woods, ―Digital Image Processing, 4th edition, Pearson/Prentice Hall Education, 2018

Reference Books& web resources

- Earl Gose, Richard Johnson Baugh, ―Pattern Recognition and Image analysis‖, Prentice Hall India Pvt Ltd, 2006
- William.K.Pratt, ―Digital Image Processing‖, 4th edition, A John Wiley and Publications,2007.
- G.W.Awcock & R.Thomas, ―Applied Image Processing‖ McGraw-Hill Inc.1996.
- Frank.Y.Shih, ―Image Processing and Pattern Recognition Fundamentals and Techniques‖, A John Wiley & sons publication,2010

Course Contents and Lecture Schedule

#	Topic	Lecture Hours
	Introduction to the Course, COs POs	1
1	**IMAGING FUNDAMENTALS**	
1.1	Introduction to Imaging Technologies - Photographic	1
1.2	X-Ray, MRI	1
1.3	SAR, IR imaging	1
1.4	CT imaging and Ultrasound Imaging	1
1.5	Image Representations	1
2	**IMAGE QUALITY ENHANCEMENT :**	
2.1	**Spatial Filtering:** Contrast - Noise Models: Gaussian noise	1
2.2	Poisson noise, Salt-and-pepper noise, Speckle noise - Sharpness	1
2.3	Gray level Transformation	1
2.4	Histogram processing	1
2.5	spatial filtering – smoothing, sharpening filters	1
2.7	**Frequency Domain:** Image transforms - DFT	1
2.8	DCT	1
2.9	Frequency Domain Filtering	1
3	**PROCESSING AND ANALYZING IMAGES**	
3.1	Point Detection - Line Detection	1

3.2	Edge Detection - Canny operator	1
3.3	Segmentation	1
3.4	Morphological operations	1
3.5	Shape of Regions- Chain Code, Shape numbers,	1
3.6	Texture	1
3.7	Co-Occurrence Matrix.	1
4	**IMAGE COMPRESSION**	
4.1	Bit plane coding	1
4.2	JPEG	2
4.4	JPEG2000	2
4.6	H.264 for video compression.	2
5	**IMAGING APPLICATIONS**	
5.1	System design- Optical character Recognition	1
5.2	Face and Facial feature Extraction	1
5.3	Video motion Analysis	2
5.4	Image Fusion	1
5.5	Medical Imaging Analysis	2
5.6	Object detection and Change Detection	1
	TOTAL	**36**

Course Designers:

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22ECQD0	BIOMEDICAL INSTRUMENTATION

Category	L	T	P	Credit
MINOR	3	0	0	3

Preamble

Biomedical Instrumentation is an interdisciplinary field that combines principles of engineering, biology, and medicine to design and develop devices and systems for diagnosing, monitoring, and treating medical conditions. This course provides a comprehensive understanding of the concepts, technologies, and methodologies used in the development and application of biomedical devices.

Prerequisite

Nil

Course Outcomes

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

COs	Course Outcome Statement	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the principles of bio-potential generation and propagation and measurement of biopotential using different types of electrodes.	TPS 2	70	60
CO2	Apply standard electrode configurations for ECG, EEG, EMG, ERG, and EOG, and differentiate unipolar, bipolar, and average modes in various biomedical applications	TPS 3	70	60
CO3	Classify the amplifiers used in biomedical signal acquisition.	TPS 3	70	60
CO4	To measure temperature, respiration, pulse rate, blood pressure, blood flow, and cardiac output using different methods.	TPS 3	70	60
CO5	To measure bio-chemicals in our body using different sensors.	TPS 3	70	60

Mapping with Programme Outcomes and Programme Specific Outcomes

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	M	M	-	-	-	M	M	-	-
CO2	S	M	L	-	-	M	M	-	-	-	M	M	-	-
CO3	S	M	L	-	-	M	-	-	-	-	M	M	-	-
CO4	S	M	L	-	-	M	M	-	M	-	M	M	-	-
CO5	S	M	L	-	-	M	M	-	M	-	M	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern:

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II * (%)					
CO \ TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	-	20	30				-						-	10	-
CO2	-	10	20		100		-						-	5	20
CO3	-	10	10				-	10	10				-	5	15
CO4	-						-	10	30		100		-	5	20
CO5	-						-	20	20				-	5	15
Total	-	**40**	**60**		**100**		-	**40**	**60**		**100**		-	**30**	**70**

Syllabus

Bio Potential Electrodes: Origin of bio potential and its propagation. Electrode-electrolyte interface, electrode–Skin interface, half-cell potential, impedance, polarization effects of electrode – nonpolarizable electrodes. Types of electrodes - Recording problems.

Electrode Configurations: Bio signals characteristics – frequency and amplitude ranges. ECG – Einthoven’s triangle, standard 12 lead system. EEG – 10-20 electrode system, unipolar, bipolar and average mode. EMG, ERG and EOG – unipolar and bipolar mode.

Bio Amplifier: Need for bio-amplifier – Classification - single ended, differential and isolated -Chopper amplifier. Power line interference.

Measurement of Non-Electrical Parameter: Temperature, respiration rate and pulse rate measurements. Blood Pressure: indirect methods and direct methods, Pressure amplifiers - systolic, diastolic, mean detector circuit. Blood flow and cardiac output measurement, Electromagnetic and ultrasound blood flow measurement.

Bio-Chemical Measurement: Biochemical sensors - pH, pO2 and pCo2, Ion selective Field effect Transistor (ISFET), Immunologically sensitive FET (IMFET), Non-invasive blood gas monitoring, Blood glucose monitors, Electronic Noses, Lab-on-chip.

Text Books

- John G. Webster, Medical Instrumentation Application and Design, John Wiley and sons, Fourth edition, 2010.
- Andrew G. Webb, Principles of Biomedical Instrumentation, Cambridge University Press, 2018.

Reference Books

- Leslie Cromwell, “Biomedical Instrumentation and measurement”, Prentice Hall of India, New Delhi, 2007.
- Khandpur R.S, “Handbook of Biomedical Instrumentation”, Tata McGraw-Hill, New Delhi, 2003.
- Standard Handbook of Biomedical Engineering & Design – Myer Kutz, McGraw-Hill Publisher, 2003.
- Sudip Paul, Angana Saikia, Vinayak Majhi, and Vinay Kumar Pandey, “Introduction to Biomedical Instrumentation and Its Applications", Elsevier, 2022.

Course Contents and Lecture Schedule

Module No	Topic	No. of Lectures
1	**Bio Potential Electrodes**	
1.1	Origin of bio potential and its propagation	1
1.2	Electrode-electrolyte interface, electrode–Skin interface	1
1.3	Half-cell potential, impedance,	1
1.4	Polarization effects of electrode, nonpolarizable electrodes	1
1.5	Types of electrodes - Recording problems.	2
2	**Electrode Configurations**	
2.1	Bio signals characteristics – frequency and amplitude ranges	1
2.2	ECG – Einthoven’s triangle, standard 12 lead system.	1
2.3	EEG – 10-20 electrode system, unipolar, bipolar and average mode	2
2.4	EMG, ERG and EOG – unipolar and bipolar mode.	2
3	**Bio Amplifier**	
3.1	Need for bio-amplifier	1
3.2	Classification-single ended, differential and isolated amplifier	4
3.3	Chopper amplifier	2
3.4	Power line interference	1
4	**Measurement Of Non-Electrical Parameter**	
4.1	Temperature, respiration rate and pulse rate measurements.	2

4.2	Blood Pressure: indirect methods and direct methods	1
4.3	Pressure amplifiers - systolic, diastolic, mean detector circuit.	2
4.4	Blood flow and cardiac output measurement	2
4.5	Electromagnetic and ultrasound blood flow measurement.	1
5	**BIO-CHEMICAL MEASUREMENT**	
5.1	Biochemical sensors - pH, pO2 and pCo2	2
5.2	Ion selective Field effect Transistor (ISFET)	1
5.3	Immunologically sensitive FET (IMFET)	1
5.4	Non-invasive blood gas monitoring	1
5.5	Blood glucose monitors	1
5.6	Electronic Noses	1
5.7	Lab-on-chip	1
	Total	**36 hrs**

Course Designers:

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Dr.S.J.Thiruvengadam sjt@tce.edu.

22ECQE0	CMOS VLSI SYSTEM AND CIRCUITS

Category	L	T	P	Credit
MINOR	3	0	0	3

Preamble

In today's rapidly evolving technological landscape, the ability to design, develop, and innovate electronic products is an essential skill across a wide array of disciplines. whether you are interested in consumer electronics, medical devices, IoT products, or any other field, this course will provide you with the essential skills and knowledge needed to contribute to the creation of next-generation electronic products. This course begins with the introduction of semiconductor materials and devices like PN junction diode, Bipolar Junction Transistor (BJT) and Field Effect Transistor (FET). It proceeds with design of some basic circuits for processing applications like amplification, Oscillation and Filtering. It also guides through the digital information processing of both combinational and sequential logic circuits. Finally, the course ends by giving an insight into the Integrated Circuit technologies like TTL and CMOS.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the properties of semiconductor material and the principle of operation of PN junction diode.	TPS3	70	70
CO2	Explain the physical structure, characteristics and electrical parameters of BJT and FET devices.	TPS3	70	70
CO3	Describe the process of biasing the transistor for amplifier and switching applications.	TPS3	70	70
CO4	Explain the principle of operation of oscillators and filter circuit for different applications.	TPS3	70	70
CO5	Describe the representation of digital signals and functioning of combinational logic circuits.	TPS3	70	70
CO6	Explain the working of synchronous sequential logic circuit and IC logic families.	TPS4	70	70
CO7	Understand the organization of CMOS Integrated Circuits for SoC and SiP.	TPS4	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	M	-	M	M	-	-	-	M	L	L
CO2	S	M	L	-	M	-	M	M	-	-	-	M	L	L
CO3	S	M	L	-	M	-	M	M	-	-	-	M	L	L
CO4	S	M	L	-	M	-	M	M	-	-	-	M	L	L
CO5	S	M	L	-	M	-	M	M	-	-	-	M	L	L
CO6	S	S	M	L	M	-	M	M	-	-	-	S	L	L
CO7	S	S	M	L	M	-	M	M	-	-	-	S	L	L
Overall	S	M	L	-	M	-	M	M	-	-	-	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern:

<table>
<tr><td rowspan="2"></td><td colspan="6">Assessment – I</td><td colspan="6">Assessment - II</td><td colspan="3" rowspan="2">Terminal Exam (%)</td></tr>
<tr><td colspan="3">CAT – I (%)</td><td colspan="3">Assignment I (%)</td><td colspan="3">CAT – II (%)</td><td colspan="3">Assignment II (%)</td></tr>
<tr><td>TPS
Scale
CO</td><td>2</td><td>3</td><td>4</td><td>2</td><td>3</td><td>4</td><td>2</td><td>3</td><td>4</td><td>2</td><td>3</td><td>4</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>CO1</td><td>5</td><td>20</td><td></td><td colspan="3" rowspan="3">100</td><td></td><td></td><td></td><td colspan="3"></td><td>4</td><td>10</td><td></td></tr>
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<tr><td>CO3</td><td>5</td><td>30</td><td></td><td></td><td></td><td></td><td colspan="3"></td><td>2</td><td>10</td><td></td></tr>
<tr><td>CO4</td><td>5</td><td>10</td><td></td><td colspan="3"></td><td>5</td><td>25</td><td></td><td colspan="3" rowspan="4">100</td><td>2</td><td>10</td><td></td></tr>
<tr><td>CO5</td><td></td><td></td><td></td><td colspan="3"></td><td>5</td><td>25</td><td></td><td>4</td><td>10</td><td></td></tr>
<tr><td>CO6</td><td></td><td></td><td></td><td colspan="3"></td><td>5</td><td>15</td><td></td><td>2</td><td>15</td><td></td></tr>
<tr><td>CO7</td><td></td><td></td><td></td><td colspan="3"></td><td>5</td><td>15</td><td></td><td>2</td><td>15</td><td></td></tr>
<tr><td>Total</td><td>20</td><td>80</td><td></td><td colspan="3"></td><td>20</td><td>80</td><td></td><td colspan="3"></td><td>20</td><td>80</td><td></td></tr>
</table>

Syllabus

Fundamentals of Electronics: Semiconductors in daily life, semiconducting material properties-Structure of Semiconductor material, Energy bands. PN junction diode: Biasing of PN Junction, I-V characteristics of PN Junction, Ideal diode equation.
Bipolar Junction Transistor: Bipolar Junction Transistor; Physical Structure and Modes of operation, Operation in Active Mode, circuit symbols and conventions, Types of BJT configuration.

Field Effect Transistor: Ideal MOS capacitor structure, Accumulation and inversion regimes, Ideal C-V characteristics, Introduction to FET, Features of FET, Junction field effect transistor, Construction, working principle, Introduction to MOSFET, Types of MOSFET, Working Principle of MOSFET, I-V characteristics.
Amplifiers: Biasing, Stability and Frequency analysis, Types of amplifiers and Effect of negative feedback, Operational amplifier and its applications
Oscillator: Need for Oscillators, Positive feedback, Frequency Selective Networks - RC and LC, Crystal Oscillator at the system level.
Filters: Concept and types of filters, Active Integrators and Differentiators – Timing Diagrams
Digital Information Processing: Basis of Digital System, Number systems and Codes, Methods of base conversions, Code Converters and their Applications.
Digital Devices: Basic Gates, Universal Gates, Design of combinational circuits: Adder, Subtractor, Multiplier, Divider, Multiplexer, De Multiplexer, Encoder and Decoder.
Synchronous Sequential Logic Circuits: Latch, Flip-flop, Counters, Shift Registers.
Logic Families: Resistor Transistor Logic (RTL), Diode Transistor Logic (DTL).
CMOS ICs: Static CMOS: Pass Transistor, Transmission Gates, Tristate Logic; Clocked CMOS Logic, Applications of ICs.
1Trends in Integrated Circuits: Silicon on Chip (SoC), Silicon in Package (SiP).

Text Book

- Dr. N. B Balamurugan, “Analog Electronic Devices: Theory and Practical”, AICTE Book, 2023.
- M. Morris Mano and Michael D. Ciletti, “Digital Design: With an Introduction to the Verilog HDLVHDL, and System Verilog, Sixth Edition, Pearson, 2018.
- Malvino Albert P., Bates David J., Hoppe Patrick E. “Electronic Principles”, McGraw Hill: Ninth Edition, 2021.
- V.K Mehta, Rohit Mehta,” Principles of Electronics”, S Chand, seventh edition, 2014.
- R P Jain, “Modern Digital Electronics”, McGraw Hill Education, fourth edition, 2009.

Reference Books& web resources

- N. Weste and David Harris," CMOS VLSI Design: A circuits and systems perspective" 4thEdition, Pearson, 2022.
- N. Weste and K. Eshraghian, "Principles of CMOS VLSI Design", Second Edition, Addison-Wesley, 1993.
- R. Jacob Baker, "CMOS: Circuit Design, Layout, and Simulation", Wiley-IEEE, Revised Second Edition, 2008.
- Wayne Wolf, "Modern VLSI Design: System on Chip", Pearson Education, 2002.
- MIT Open courseware: http://ocw.mit.edu/courses/electrical-engineering-andcomputer-science/6-374-analysis-and-design-of-digital-integrated-circuits/.
- By Prof. Sudeb Dasgupta, IIT Roorkee, CMOS Digital VLSI Design.

Course Contents and Lecture Schedule

No.	Topic	Lecture Hours
1.	**Fundamentals of Electronics**	
1.1	Semiconductor in daily life, material properties	1
1.2	Structure of semiconductor material energy bands	1
1.3	PN junction diode: Biasing, I-V characteristics, Ideal diode equation	1
2.	**Bipolar Junction Transistor**	
2.1	Physical structure, Symbols and modes of operation	1
2.2	Types of BJT configuration	1
2.3	I-V characteristics,	1
3.	**Field Effect Transistor**	
3.1	MOS capacitor structure, Accumulation and inversion regimes, Ideal C-V characteristics.	1
3.2	Introduction to FET, JFET: construction, working principle, I-V characteristics	1
3.3	Introduction to MOSFET: construction, working principle, I-V characteristics	1
4.	**Amplifiers**	
4.1	Biasing, Stability and Frequency analysis	1
4.2	Types of amplifiers and Effect of negative feedback	1
4.3	Operational amplifier and its applications	1
5.	**Oscillator**	
5.1	Need for Oscillators and positive feedback system	1
5.2	Frequency selective networks - RC and LC	1
5.3	Crystal Oscillator at system level	1
6.	**Filters**	
6.1	Types of filters and its applications	1
6.2	Filter parameters, Time domain and frequency domain responses	1
6.3	Analog and digital filter implementation	1
7.	**Digital Information Processing and devices**	
7.1	Basics of Digital system, Number systems and codes	1
7.2	Methods of base conversions	1
7.3	Code converters and their applications	1
8.	**Digital Devices**	
8.1	Basic gates, Universal gates: Truth table, logic expression and symbols	1
8.2	Combinational Circuits	1
8.3	Arithmetic circuits	1
8.4	Multiplexers and De multiplexers,	1

8.5	Encoder and decoders.	1
9.	**Synchronous Sequential Logic circuits**	
9.1	Latch and Flip flop	1
9.2	Counters	1
9.3	Shift Registers.	1
10.	**Logic Families**	
10.1	Resistor Transistor Logic	1
10.2	Diode Transistor Logic	1
11.	**CMOS ICs**	
11.1	Static CMOS: pass transistor, Transmission gates	1
11.2	Tristate Logic: Clocked CMOS logic	1
11.3	Application of ICs	1
12.	**Trends in Integrated Circuits**	
12.1	Silicon on Chip (SOC)	1
12.2	Silicon in Package (SIP)	1
Total		**36**

12 Weeks :36 Hours
Each week: 3 Hours

Course Designers:

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22ECQF0	TELECOMMUNICATION SYSTEMS

Category	L	T	P	Credit
MINOR	3	0	0	3

Preamble

The field of telecommunications has revolutionized global connectivity, enabling seamless communication across diverse platforms. This syllabus is designed to provide a comprehensive understanding of telecommunication systems, transmission media, wireless technologies, and modern network architectures. It delves into the fundamental principles, technological advancements, and emerging trends such as Artificial Intelligence, Software-Defined Networking, and Quantum Communication. By equipping learners with both theoretical knowledge and practical insights, this curriculum aims to empower the next generation of professionals to innovate and excel in the dynamic telecommunications industry.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcomes	TPS Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Understand the principles of telecommunication systems, including standards, architectures, and the evolution of communication technologies.	TPS2	70	70
CO2	Analyse various transmission media, different types of Antennas used in Cellular and wireless communication systems	TPS3	70	70
CO3	Understand the mechanism of wave propagation and atmospheric effects	TPS2	70	70
CO4	Apply modulation and multiplexing concepts to understand wireless channels, multipath, and mobility.	TPS3	70	70
CO5	Apply optical fiber and satellite communication principles in design of efficient wireless systems.	TPS3	70	70
CO6	Evaluate the design and functioning of modern telecom networks, including Voice over IP (VoIP), IMS, and wireless networking protocols.	TPS3	70	70
CO7	Explore emerging telecommunication systems, including Artificial Intelligence, Software-Defined Networking, IoT integration, and Quantum Communication, to address future	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	L	-	-	M	-	M	M	-	-	-	L	-	L
CO2	S	M	L	-	M	-	M	M	-	-	-	L	-	-
CO3	M	L	-	-	M	-	M	M	-	-	-	M	-	L
CO4	S	M	L	-	M	-	M	M	-	-	-	M	-	L
CO5	S	M	L	-	M	-	M	M	-	-	-	M	-	L
CO6	S	M	L	-	M	-	M	M	-	-	-	M	-	L
CO7	S	M	L	-	M	-	M	M	-	-	-	M	-	L
Overall	S	M	L	-	M	-	M	M	-	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern:

	Assessment – I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assignment I (%)			CAT – II (%)			Assignment II (%)					
TPS / CO	2	3	4	2	3	4	2	3	4	2	3	4	2	3	4
CO1	5	30		100									5	10	
CO2	5	20											5	10	
CO3	5	20											4	10	
CO4	5	10								100			4	10	
CO5							10	30					4	10	
CO6							10	20					4	10	
CO7							10	20					4	10	
Total	**20**	**80**					**30**	**70**					**30**	**70**	

Syllabus

Telecommunication System: Telecomm Standards, Communication System Architecture, Historical development, Terminology and Concepts, Types of Communication, System, Cellular System - Transmitter & Receiver, Recent Technologies.
Transmission Media and Wave Propagation: Transmission Media, Wired TL Types, Wave Propagation Mechanism, Modes of Propagation, Antenna Types and Atmospheric Effects, Cellular System - Frequency reuse, Channel assignments, Handoff, System Capacity.
Base band Wireless System: Wireless Channel Propagation, Multipath, Mobility, Multiplexing, Modulation Techniques- Analog and Digital, Optical fiber communication spectrum, Sources, Detectors, Satellite Communication System.
Telecom Networks: Layered Architecture, Voice over Internet Protocol Technology, Modern Network- Internet Protocol IMS - Mobile/Cellular Systems Network Functions - 6G, Wireless Networks.
Emerging Telecom systems: Artificial Intelligence, Machine Learning in PHY Layer and Networks, Multi hopping for Anti-Jamming, Edge Intelligence, Cloud Fog Architectures. AI-Radio Access Network: Software Defined Radio, Internet of Things, Software Defined Networking, Quantum Communication.

Text Book

- Telecommunication System Engineering, Roger L. Freeman, Wiley, July 2015. 3rd Edition.
- Modern Telecommunications Basic Principles and Practices, Martin J N Sibley, 2018 CRC.

Reference Books & web resources

- The Telecommunications Handbook: Engineering Guidelines for Fixed, Mobile, and Satellite Systems. Wiley. Penttinen, Jyrki T. J. 2015
- Foundations for Microwave Engineering. Wiley. Collin, R. E. 2000
- Electromagnetics with Applications (5th Edition). McGraw-Hill. Kraus, J. D., & Fleisch,
- Antenna Theory: Analysis and Design (4th Edition). Wiley. Balanis, C. A. 1999
- Wireless Communications: Principles and Practice (2nd Edition). Prentice Hall, T.S Rappaport. 2016.
- Optical Fiber Communications (5th Edition). McGraw-Hill. In-depth study of optical spectrum, sources, and detectors. Keiser, G. 2013
- Introduction to Satellite Communication (3rd Edition). Wiley. 2014
- Fundamental concepts of satellite communication systems. Elbert, B. R. 2008.
- Data Communications and Networking (5th Edition). McGraw-Hill. Forouzan B. A. 2013.

- IP Telephony: Deploying VoIP Protocols and Systems. Wiley. Hersent, O. Petit, J. P. & Gurle, D. 2005.
- Computer Networking: A Top-Down Approach (7th Ed.). Kurose, J., & Ross, K. .2016.
- Quantum Networking. Wiley. 2014 Van Meter, R. 2014.

No.	Topic	Lecture Hours	COs
1	**Telecommunication System**		
1.1	Telecomm Standards, Communication System Architecture,	2	CO1
1.2	Historical development, Terminology and Concepts,	1	CO1
1.3	Types of Communication, Cellular System – Transmitter & Receiver,	2	CO1
1.4	Satellite system, Recent Technologies.	2	CO1
2	**Transmission Media and Wave Propagation**		
2.1	Transmission Media, Wired TL Types,	2	CO2
2.2	Wave Propagation Mechanism, Antenna Types	3	CO2
2.3	Modes of Propagation and Atmospheric Effects	2	CO3
2.4	Cellular System - Frequency reuse, Channel assignments	1	CO3
2.5	Handoff, System Capacity.	1	CO3
3	**Base band Wireless System**:		
3.1	Wireless Channel Propagation, Multipath	2	CO4
2	Mobility, Multiplexing, Modulation Techniques	2	CO4
3.3	Analog and Digital, Optical fiber communication spectrum	2	CO5
3.4	Sources, Detectors, Satellite Communication System	2	CO5
4	**Telecom Networks:**		
4.1	Layered Architecture	1	CO6
4.2	Voice over Internet Protocol Technology,	1	CO6
4.3	Modern Network- Internet Protocol IMS	2	CO6
4.4	Mobile/Cellular Systems Network Functions	1	CO6
4.5	6G, Wireless Networks.	1	CO6
5	**Emerging Telecom systems:**		
5.1	Artificial Intelligence, Machine Learning in PHY Layer and Networks,	1	CO7
5.2	Multi hopping for Anti-Jamming, Edge Intelligence,	1	CO7
5.3	Cloud Fog Architectures. AI-Radio Access Network	2	CO7
5.4	Software Defined Radio, Internet of Things,	1	CO7
5.5	Software Defined Networking, Quantum Communication.	1	CO7
Total		**36**	

12 Weeks :36 Hours
Each week: 3 Hours

Course Designer

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SYLLABUS

FOR

VALUE ADDED COURSE

22ECVA0 PCB DESIGN

B.E. / B.Tech. DEGREE PROGRAMME

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
THIAGARAJAR COLLEGE OF ENGINEERING
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22ECVA0	PCB DESIGN

Category	L	T	P	Credit
VAC	3	0	0	0

Preamble

Printed Circuit Boards (PCBs) are fundamental to modern electronic systems, enabling the assembly and connection of electronic components in diverse applications. This course provides a comprehensive overview of PCB technology, starting with the basics of PCB types, materials, and design fundamentals, including schematic design and layout principles. It progresses to advanced topics such as high-speed design challenges, signal and power integrity, and power distribution networks, while also addressing electromagnetic interference (EMI) and electromagnetic compatibility (EMC) for high-speed PCBs. Practical aspects such as component placement, routing techniques, stack-up design, fabrication processes, and considerations for manufacturability, assembly, and testing are covered in detail. With a blend of theoretical knowledge and practical skills, the course prepares participants to design, fabricate, and troubleshoot PCBs for a wide range of advanced electronic applications.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcomes	TPS Scale
CO1	Understand PCB types and its applications with respect to PCB materials and PCB Design fundamentals	TPS 2
CO2	Demonstrate PCB Layout Design using PCB Design software - Schematic capture and Layout in software, Design verification tools and Design for manufacturability.	TPS 3
CO3	Demonstrate PCB fabrication process, quality control and Inspection for High-Speed PCB Design, signal integrity in High-Speed PCBs, transmission line theory, crosstalk and coupling mitigation.	TPS 3
CO4	Understand power Integrity Fundamentals and demonstrate Power Distribution Networks Design and Simulation.	TPS 3
CO5	Understand EMI/EMC Fundamentals, EMI Mitigation Techniques, EMC Testing and Compliance, PCB Stack up Design for High-Speed PCBs.	TPS 2
CO6	Understand the Differential Pair Routing, High-Speed Trace Routing, Via Optimization and Signal Return Paths and demonstrate Simulation and Testing of High-Speed PCBs.	TPS 3

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	M	L	-	L
CO2	S	M	L	-	M	-	-	M	-	-	M	M	-	L
CO3	S	M	L	-	M	-	-	M	-	-	M	M	-	L
CO4	S	M	L	-	M	-	-	M	-	-	M	M	-	L
CO5	M	L	-	-	-	-	-	-	-	-	M	L	-	L
CO6	S	M	L	-	M	-	-	M	-	-	M	M	-	L

S- Strong; M-Medium; L-Low

Syllabus

Introduction to PCBs: Overview of PCB Types and Applications, PCB Materials and Properties, PCB Design Fundamentals, Electronic Components and Symbols, Schematic Design and Capture, Design Rules and Considerations

PCB Layout Design: Component Placement Techniques, PCB Layer Stack up, Routing and Signal Tracing, PCB Design Software, Introduction to PCB Design Software Tools, Schematic Capture and Layout in Software, Design Verification Tools, Design for Manufacturability (DFM), DFM Considerations for PCB Fabrication, Design for Assembly (DFA) and Testing (DFT)

PCB Fabrication Process: PCB Manufacturing Process Overview, Quality Control and Inspection, Fundamentals of High-Speed PCB Design, Overview of High-Speed Design Challenges, Electromagnetic Theory Basics, Key Concepts and Parameters, Signal Integrity (SI) in High-Speed PCBs, Transmission Line Theory, Crosstalk and Coupling Mitigation

Power Integrity (PI) and Power Distribution Networks (PDN): Power Integrity Fundamentals, PDN Design and Simulation, Mitigating Power Supply Noise

Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC): EMI/EMC Fundamentals, EMI Mitigation Techniques, EMC Testing and Compliance, PCB Stack up Design for High-Speed PCBs, Layer Stack up Design and Material Selection, Controlled Impedance and Dielectric Properties.

High-Speed Routing Techniques: Differential Pair Routing, High-Speed Trace Routing, Via Optimization and Signal Return Paths, Simulation and Testing of High-Speed PCBs, Signal Integrity and Power Integrity Simulation, PCB Testing Techniques for High-Speed Signals, Troubleshooting Common High-Speed Issues.

Reference Books& web resources

- Douglas Brooks, “Signal Integrity Issues and Printed Circuit Board Design” Prentice Hall, 2003.
- Bruce R. Archambeault ‘PCB DESIGN FOR REAL-WORLD EMI CONTROL” Kluwer series, springer, 2002.

Course Contents and Lecture Schedule

Module No	Topic	No of Lecture
1	**Introduction to PCBs:**	
1.1	Overview of PCB Types and Applications, PCB Materials and Properties, PCB Design Fundamentals,	1
1.2	Electronic Components and Symbols	1
1.3	Schematic Design and Capture, Design Rules and Considerations	1
2	**PCB Layout Design**,	
2.1	Component Placement Techniques	1
2.2	PCB Layer Stack up,	2
2.3	Routing and Signal Tracing,	1
2.4	PCB Design Software	1
2.5	Introduction to PCB Design Software Tools,	1
2.6	Schematic Capture and Layout in Software, Design Verification Tools,	1
2.7	Design for Manufacturability (DFM), DFM Considerations for PCB Fabrication	1
2.8	Design for Assembly (DFA) and Testing (DFT)	2
3	**PCB Fabrication Process:**	
3.1	PCB Manufacturing Process Overview, Quality Control and Inspection	1
3.2	Fundamentals of High-Speed PCB Design	1
3.3	Overview of High-Speed Design Challenges,	1
3.4	Electromagnetic Theory Basics, Key Concepts and Parameters,	1

3.5	Signal Integrity (SI) in High-Speed PCBs,	1
3.6	Transmission Line Theory	1
3.7	Crosstalk and Coupling Mitigation	1
4	**Power Integrity and Distribution Networks**	
4.1	Power Integrity Fundamentals,	1
4.2	PDN Design and Simulation,	1
4.3	Mitigating Power Supply Noise	1
5	**EMI and EMC:**	
5.1	EMI / EMC Fundamentals, EMI Mitigation Techniques, EMC Testing and Compliance,	2
5.2	PCB Stack up Design for High-Speed PCBs,	2
5.3	Layer Stack up Design and Material Selection,	1
5.4	Controlled Impedance and Dielectric Properties.	1
6	**High-Speed Routing Techniques:**	
6.1	Differential Pair Routing, High-Speed Trace Routing, Via Optimization and Signal Return Paths,	2
6.1	Simulation and Testing of High-Speed PCBs,	1
6.2	Signal Integrity and Power Integrity Simulation,	2
6.3	PCB Testing Techniques for High-Speed Signals,	1
6.5	Troubleshooting Common High-Speed Issues.	1
	Total	36

Course Designer:

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REVISED CO-PO-PSO MAPPING

B.E. DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
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22EC220 ELECTRONIC DEVICES														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	L	-	L	L	L	-	L	M	-	L
CO2	S	M	L	-	L	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	L	-	L	L	L	-	L	M	-	L
CO4	S	S	M	L	L	-	L	L	L	-	L	S	-	L
CO5	M	L	-	-	-	-	-	L	L	-	L	S	-	L
CO6	S	S	M	M	L	-	-	-	-	-	-	S	-	-
Overall	S	M	L	L	L	-	L	L	L	-	L	S	-	L

22EC230 ELECTRIC AND MAGNETIC CIRCUITS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO 1	PSO 2	P SO 3
CO1	S	M	L	L	L	-	L	M	M	-	-	S	L	L
CO2	S	M	L	L	L	-	L	M	M	-	-	S	L	L
CO3	S	M	L	L	-	-	L	M	M	-	-	S	-	L
CO4	S	M	L	L	-	-	L	M	M	-	L	S	-	L
CO5	S	M	L	L	-	-	L	M	M	-	L	S	-	L
CO6	S	M	L	L	-	-	L	M	M	-	-	S	-	L
Overall	S	M	L	L	-	-	L	M	M	-	-	S	-	L

22EC250 FIELD THEORY AND TRANSMISSION LINES														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	S	M	-	-	M	L	M	M	-	-	-	M		M
CO2	S	M	-	-	M	L	M	M	-	-	-	M		M
CO3	M	L	-	-	-	L	L	L	-	-	-	M	-	L
CO4	S	M	-	-	M	L	M	M	-	-	-	M		M
CO5	S	M	-	-	M	L	M	M	-	-	-	M		M
CO6	S	M	-	-	M	L	M	M	-	-	-	M		M
Overall	S	M			M	L	M	M				M		M

22EC240 DIGITAL CIRCUIT DESIGN														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	L	L	L	-	L	L	-	L
CO2	S	M	L	-	-	-	L	L	L	-	L	M	L	L
CO3	S	M	L	-	S	-	L	L	L	-	L	M	L	L
CO4	S	M	L	L	S	-	L	L	L	-	L	M	L	L
CO5	S	S	M	L	-	-	L	L	L	-	L	S	-	L
CO6	S	S	M	L	S	-	L	L	L	-	L	S	L	L
Overall	S	M	L	L	M	-	L	L	L	-	L	M	L	L

22EC260 PROBLEM SOLVING USING COMPUTERS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	M	-	S	-	-	S	M	-	-	M	-	L
CO2	S	M	M	-	S	-	-	S	M	-	-	M	-	L
CO3	S	M	M	-	S	-	-	S	M	-	-	M	-	L
CO4	S	M	M	-	S	-	-	S	M	-	-	M	-	L
CO5	S	M	M	-	S	-	-	S	M	-	-	M	-	L
CO6	S	M	M	-	S	-	-	S	M	-	-	M	-	L
Overall	S	M	M	-	S			S	M			M		L

22EC230 PYTHON PROGRAMMING														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	L	L	-	L	M	M	-	-	M	L	L
CO2	S	M	L	L	L	-	L	M	M	-	-	M	L	L
CO3	S	M	L	L	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	-	-	L	M	M	-	L	M	-	L
CO5	S	M	L	L	-	-	L	M	M	-	L	M	-	L
CO6	S	M	L	L	-	-	L	M	M	-	-	M	-	L
Overall	S	M	L	L	-	-	L	M	M	-	-	M	-	L

24EC280 DIGITAL CIRCUIT DESIGN LABORATORY														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	L	S	-	M	M	M	-	M	M	M	L
CO2	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO3	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO4	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO5	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO6	S	S	M	L	S	-	M	M	M	-	M	S	M	L
Overall	S	S	M	L	S	-	M	M	M	-	M	S	M	L

22EC330 NETWORK ANALYSIS AND SYNTHESIS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	L	L	-	L	M	M	-	-	M	L	L
CO2	S	M	L	L	L	-	L	M	M	-	-	M	L	L
CO3	S	M	L	L	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	-	-	L	M	M	-	L	M	-	L
CO5	S	M	L	L	-	-	L	M	M	-	L	M	-	L
CO6	S	M	L	L	-	-	L	M	M	-	-	M	-	L
Overall	S	M	L	L	-	-	L	M	M	-	-	M	-	L

22EC350 SIGNALS AND SYSTEMS													
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO2	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO3	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO4	S	S	M	L	S	-	-	-	M	-	-	S	M	-
CO5	S	S	M	L	S	-	-	-	M	-	-	S	M	-
CO6	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO7	S	M	L	-	-	-	-	-	M	-	-	M	M	-
Overall	S	M	L	-	-	-	-	-	M	-	-	M	M	-

22EC340 COMPUTER ORGANIZATION AND MICROPROCESSOR														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	L	L	L	L	L	L	-	L
CO2	M	M	L	L	-	-	L	L	L	L	L	-	L	L
CO3	S	M	L	-	S	-	L	L	L	L	L	M	L	L
CO4	S	M	L	L	S	L	L	L	L	L	L	M	L	L
CO5	S	M	L	L	-	L	L	L	L	L	L	M	-	L
CO6	S	L	L	L	-	-	L	L	L	L	L	-	L	L
Overall	S	M	L	L	L	-	L	L	L	L	L	L	L	L

23EC360 OBJECT ORIENTED PROGRAMMING														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	L	M	-	-	-	M	M	L	-	M
CO2	S	M	L	-	L	M	-	-	-	M	M	L	-	M
CO3	S	M	L	-	L	M	-	-	-	M	M	L	-	M
CO4	S	M	L	-	S	M	-	-	-	M	M	S	M	M
CO5	S	M	L	-	S	S	S	S	-	S	M	S	M	S
CO6	S	M	L	-	S	S	S	S	-	S	M	S	M	S
Overall	S	M	L	-	M	-	-	S	L	L	-	S	M	L

23EC370 ANALOG CIRCUIT DESIGN LABORATORY														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	M	L	S	-	M	M	M	-	M	M	M	L
CO2	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO3	S	M	L	-	S	-	M	M	M	-	M	M	M	L
CO4	S	M	L	-	S	-	M	M	M	-	M	M	M	L
CO5	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO6	S	M	M	L	S	-	M	M	M	-	M	M	M	L
Overall	S	S	M	0	S	0	0	M	L	-	-	S	M	L

23EC380 COMPUTER ARCHITECTURE LABORATORY														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	M	L	S	-	M	M	M	-	M	M	M	L
CO2	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO3	S	M	L	-	S	-	M	M	M	-	M	M	M	L
CO4	S	M	L	-	S	-	M	M	M	-	M	M	M	L
CO5	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO6	S	M	M	L	S	-	M	M	M	-	M	M	M	L
Overall	S	S	N	L	S	-	M	M	M	-	M	M	M	L

22EC420 MIXED SIGNAL CIRCUIT DESIGN														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	L	-	-	-	-	M	-	-	M	-	-
CO2	S	M	L	L	-	-	-	-	M	-	-	M	-	-
CO3	S	M	L	L	-	-	-	-	M	-	-	M	-	-
CO4	S	M	L	L	-	-	-	-	M	-	-	M	-	-
CO5	S	M	L	L	-	-	-	-	M	-	-	M	-	-
CO6	S	M	L	L	-	-	-	-	M	-	-	M	-	-
Overall	S	M	L	L	-	-	-	-	M	-	-	M	-	-

22EC430 RF CIRCUIT DESIGN														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PSO1	PSO2	PSO3
CO1	M	L		-	-	-	L	L	L	-	L	L	-	L
CO2	S	M	L	-	M	-	L	L	L	-	L	M	L	L
CO3	S	M	L	-	M	-	L	L	L	-	L	M	L	L
CO4	S	M	L	-	M	-	L	L	L	-	L	M	L	L
CO5	S	M	L	-	M	-	L	L	L	-	L	M	L	L
CO6	S	M	L	-	M	-	L	L	L	-	L	M	L	L
Overall	S	M	L		M		L	L	L		L	M	L	L

22EC450 DISCRETE TIME SIGNAL PROCESSING														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	S	-	M	M	-	-	-	M	L	-
CO2	S	M	L	-	S	-	M	M	-	-	-	M	L	-
CO3	S	M	L	-	S	-	M	M	-	-	-	M	L	-
CO4	S	M	L	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	S	-	M	M	-	-	-	M	L	-
CO6	S	M	L	-	S	-	M	M	-	-	-	M	L	-
CO7	S	M	L	-	S	-	M	M	-	-	-	M	L	-
Overall	S	M	L	-	S	-	M	M	-	-	-	M	L	-

23EC460 DATA STRUCTURES AND ALGORITHMS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO 1	PSO 2	P S O 3
CO1	S	M	M	L	L	-	L	M	M	-	-	M	M	L
CO2	S	M	M	L	L	-	L	M	M	-	-	M	M	L
CO3	S	M	M	L	L	-	L	M	M	-	L	M	M	L
CO4	S	S	M	L	L	-	L	M	M	-	L	S	M	L
CO5	S	M	M	M	L	-	L	M	M	-	L	M	M	L
CO6	S	M	M	M	L	-	L	M	M	-	L	M	M	L
Overall	S	S	M	M	L	0	L	M	L	0	L	S	M	L

23EC470 MICROCONTROLLERS AND EMBEDDED SYSTEMS LABORATORY														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO 1	PSO 2	P S O 3
CO1	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO2	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO3	S	M	L	-	S	-	M	M	M	-	M	M	M	L
CO4	S	M	L	-	S	-	M	M	M	-	M	M	M	L
CO5	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO6	S	S	M	L	S	-	M	M	M	-	M	S	M	L
Overall	S	S	M	L	S	-	M	M	L	-	L	S	M	L

22EC510 DATA COMMUNICATION NETWORKS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	L	M	M	-	-	M	-	L
CO2	S	M	L	-	-	-	L	M	M	-	-	M	-	L
CO3	S	M	L	-	-	-	L	M	M	-	-	M	-	L
CO4	S	S	M	L	-	-	L	M	M	-	L	S	L	L
CO5	S	S	M	L	-	-	L	M	M	-	L	S	L	L
CO6	S	M	L	-	-	-	L	M	M	-	-	M	-	L
Overall	S	M	L	-	-	-	L	M	M	-	-	M	-	L

22EC520 VLSI CIRCUITS AND SYSTEMS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO	PO	PSO	PSO	PSO
										10	11	1	2	3
CO1	S	M	M	L	L	-	-	-	-	-	-	M	-	-
CO2	M	M	L	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	M	L	L	-	-	-	-	-	-	M	-	-
CO4	S	S	M	L	L	-	-	-	-	-	-	S	-	-
CO5	S	M	M	M	L	-	-	-	-	-	-	M	-	-
CO6	S	M	M	M	L	-	-	-	-	-	-	M	-	-
Overall	S	M	M	L	-	-	-	-	-	-	-	M	-	-

22EC540- SENSORS AND INSTRUMENTATION

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO 1	PSO 2	P S O 3
CO1	M	M	L	L	L	-	L	M	M	-	-	L	L	L
CO2	M	M	L	L	L	-	L	M	M	-	-	L	L	L
CO3	S	M	L	L	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	-	-	L	M	M	-	L	M	-	L
CO5	M	M	L	L	-	-	L	M	M	-	L	L	-	L
CO6	S	M	L	L	-	-	L	M	M	-	-	M	-	L
Overall	M	M	L	L	-	-	L	M	M	-	L	M	-	L

22EC550 ANALOG AND DIGITAL COMMUNICATION

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	L	L	L	-	L	M	L	L
CO2	S	S	M	L	-	-	L	L	L	-	L	S	L	L
CO3	S	M	L	-	-	-	L	L	L	-	L	M	L	L
CO4	S	M	L	-	-	-	L	L	L	-	L	M	L	L
CO5	S	M	L	-	-	-	L	L	L	-	L	M	L	L
CO6	S	M	L	-	-	-	L	L	L	-	L	M	L	L
CO7	S	M	L	-	-	-	L	L	L	-	L	M	L	L
Overall	S	M	L	-	-	-	L	L	L	-	L	M	L	L

22EC530 ANTENNAS AND WAVE PROPAGATION

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2	PSO2
CO1	M	L	L	-	-	-	-	M	-	-	M	L	-	M
CO2	M	M	L	-	-	-	-	M	-	-	M	L	-	M
CO3	S	M	M	L	S	M	L	M	M	M	M	M	M	M
CO4	S	M	M	L	S	M	L	M	M	M	M	M	M	M
CO5	S	M	M	L	S	L	L	M	M	M	M	M	M	M
CO6	M	L	L	-	-	L	L	M	-	-	M	L	M	M
Overall	S	M	M	L	M	L	L	M	L	L	M	M	L	M

22EC570 DATA COMMUNICATION NETWORKING LABORATORY

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	S	-	M	M	M	-	-	M	M	L
CO2	S	M	L	-	S	-	M	M	M	-	-	M	M	L
CO3	S	M	L	-	S	-	M	M	M	-	-	M	M	L
CO4	S	S	M	L	S	-	M	M	M	-	L	M	M	L
CO5	S	M	L	-	S	-	M	M	M	-	L	M	M	L
CO6	S	S	M	L	S	-	M	M	M	-	-	M	M	L
Overall	S	M	L	-	S	-	M	M	M	-	-	M	M	L

22EC580 ANALOG AND DIGITAL COMMUNICATION LABORATORY														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO2	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO3	S	M	L	-	S	-	M	M	M	-	M	M	M	L
CO4	S	M	L	-	S	-	M	M	M	-	M	M	M	L
CO5	S	S	M	L	S	-	M	M	M	-	M	S	M	L
CO6	S	S	M	L	S	-	M	M	M	-	M	S	M	L
Overall	S	S	M	L	S	-	M	M	M	-	M	S	M	L

22EC610 ACCOUNTING AND FINANCE														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	M	M	S	S	S	S	M	-	-
CO2	S	M	L	-	-	M	M	S	S	S	M	M	-	-
CO3	S	M	L	-	-	-	S	S	S	S	S	M	-	-
CO4	S	M	L	-	M	M	S	S	S	S	M	M	-	-
CO5	S	M	L	-	S	M	S	S	S	M	M	M	-	-
CO6	S	M	L	-	-	M	S	S	M	M	S	M	-	-
Overall	S	M	L	-	-	M	S	S	S	S	M	M	-	-

22EC620 IMAGE PROCESSING														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	M		L	L	L	-	-	L	-	L
CO2	S	S	M	L	M	M	L	M	M	-	L	M	S	L
CO3	S	S	M	L	M	L	L	M	M	-	L	M	S	L
CO4	S	S	M	L	M	L	L	M	M	-	L	M	M	L
CO5	S	S	M	L	M	M	L	M	M	-	L	M	S	L
CO6	S	S	M	L	S	M	L	M	M	-	L	S	S	M
Overall	S	S	M	L	S	M	L	M	M	-	L	M	S	M

22EC630 OPTICAL AND WIRELESS COMMUNICATION														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	L	-	L
CO2	M	L	L	-	-	-	-	-	-	-	-	L	-	L
CO3	S	M	L	-	-	-	-	-	-	-	-	M	-	L
CO4	S	M	L	-	-	-	-	-	-	-	-	M	-	L
CO5	S	M	L	-	-	-	-	-	-	-	-	M	-	L
CO6	S	M	L	-	-	-	-	-	-	-	-	M	-	L
Overall	S	M	L	-	-	-	-	-	-	-	-	M	-	L

22ECPA0 ARTIFICIAL NEURAL NETWORKS FOR RF APPLICATIONS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	L	-	-	-	-	-	-	-	L	L	-	-
CO2	S	M	L	-	-	-	-	-	-	-	L	M	-	-
CO3	S	M	L	-	M	-	-	-	-	-	L	M	-	-
CO4	S	M	L	-	M	-	-	-	-	-	L	M	-	-
CO5	S	M	L	-	M	-	-	-	-	-	L	M	-	-
CO6	S	M	L	-	M	-	-	-	-	-	L	M	-	-
Overall	S	M	L		L						L	M		

22ECPC0 ADVANCED ANTENNA TECHNOLOGY														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	L	M	M	-	-	L	L	L
CO2	S	M	L	-	L	-	L	M	M	-	-	L	L	L
CO3	S	M	L	-	L	-	L	M	M	-	-	L	L	L
CO4	S	M	L	-	L	-	L	M	M	-	-	L	L	L
CO5	S	M	L	-	L	-	L	M	M	-	-	L	L	L
CO6	S	M	L	-	-	-	L	M	M	-	-	L	L	L
Overall	S	M	L		L		L	M	M			L	L	L

22ECPD0 COMPUTER VISION AND APPLICATIONS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	L	-	-	M	L	L	L
CO2	S	M	L	-	M	-	-	M	-	-	M	M	M	M
CO3	S	M	L	-	M	-	-	M	-	-	M	M	M	M
CO4	S	M	L	-	L	-	-	M	L	-	M	M	L	L
CO5	S	M	L	-	M	-	-	M	-	-	M	M	L	M
CO6	S	M	L	-	M	-	-	L	-	-	M	M	L	M
Overall	S	M	L	-	M	-	-	L	L	-	M	M	L	M

22ECPE0 SATELLITE REMOTE SENSING														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	M	M	M	L	-	-	L	L	L
CO2	S	M	L	-	M	S	M	M	L	-	-	M	L	L
CO3	S	M	L	L	M	S	M	M	L	-	-	M	-	L
CO4	S	M	L	L	-	S	M	M	L	-	-	M	-	L
CO5	S	M	L	-	-	S	M	M	L	-	-	M	-	L
CO6	S	M	L	L	L	S	M	M	L	-	M	M	-	L
Overall	S	M	L	L	L	S	M	M	L	-	M	M	L	L

22ECPF0 SATELLITE DATA ANALYSIS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	M	M	L	-	-	L	L	L
CO2	S	M	-	-	M	-	M	M	L	-	-	M	L	L
CO3	S	M	L	L	M	M	M	M	L	-	-	M	-	L
CO4	S	M	L	L	-	-	M	M	L	-	-	M	-	L
CO5	S	M	L	-	-	-	M	M	L	-	-	M	-	L
CO6	S	M	L	L	L	M	M	M	L	-	M	M	-	L
Overall	S	M	L	L	L	L	M	M	L	-	L	M	L	L

22ECPL0 IOT SYSTEM AND APPLICATIONS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	M	L	L	L	-	-	L	M	M	M	-	L	L	L
CO2	S	M	L	L	-	-	L	M	M	M	-	M	L	L
CO3	S	M	L	L	-	-	L	M	M	M	L	M	-	L
CO4	S	M	L	L	L	-	L	M	M	M	L	M	-	L
CO5	S	M	L	L	L	L	L	M	M	M	L	M	-	L
CO6	S	M	L	L	L	L	L	M	M	M	L	M	-	L
Overall	S	M	L	L	-	-	L	M	M	M	L	M	-	L
	3	2	1	1	0	0	1	2	2	2	1	2	0	1

22ECPP0 5G WIRELESS NETWORKS														
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	L	M	M	-	-	M	-	L
CO2	M	L	-	-	-	-	L	M	M	-	-	L	-	L
CO3	S	M	L	-	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	-	-	-	L	M	M	-	-	M	-	L
CO5	S	M	L	-	-	-	L	M	M	-	-	M	-	L
CO6	S	M	L	-	-	-	L	M	M	-	-	M	-	L
Overall	S	M	L	-	-	-	L	M	M	-	-	M	-	L

22ECPQ0 CRYPTOGRAPHY AND CYBERSECURITY														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	L	L	-	-	-	L	M	M	-	-	L	-	L
CO2	S	M	L	L	-	-	L	M	M	-	-	M	-	L
CO3	S	M	L	L	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	-	-	L	M	M	-	-	M	L	L
CO5	S	M	L	L	-	-	L	M	M	-	-	M	L	L
CO6	S	M	L	L	-	-	L	M	M	-	-	M	L	L
Overall	S	M	L	L	-	-	L	M	M	-	-	M	-	L

22ECPR0 CONTROL SYSTEMS													
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	L	-	M	M	M	-	L	M	-	M
CO2	S	M	L	-	L	-	M	M	M	-	L	M	-	M
CO3	S	M	L	-	L	-	M	M	M	-	L	M	-	M
CO4	S	M	L	-	L	-	M	M	M	-	L	M	-	M
C05	S	M	L	-	L	-	M	M	M	-	L	M	-	M
C06	S	M	L	-	L	-	M	M	M	-	L	M	-	M
Overall	S	M	L	-	L	-	M	M	M	-	L	M	-	M

22ECPS0 VLSI DEVICE MODELING														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	L	L	-	-	M	-	L
CO2	S	M	L	-	-	-	-	L	L	-	-	M	-	L
CO3	S	M	L	-	-	-	-	L	L	-	-	M	-	L
CO4	S	M	L	-	-	-	-	L	L	L	-	M	-	L
CO5	S	M	L	-	-	-	-	L	L	L	-	M	-	L
CO6	S	M	L	-	M	-	-	L	L	L	-	M	M	L
Overall	S	M	L	0	L	0	0	L	L	L	0	M	L	L

22ECGD0 APPLIED IMAGE PROCESSING														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	L	L	-	-		-	L	-	-
CO2	S	M	L	-	L	L	L	-	L	-	-	M	-	L
CO3	S	M	L	-	L	L	L	L	L	-	-	M	-	L
CO4	S	M	L	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	L	L	L	-	L	-	L	M	L	L
Overall	S	M	L	-	L	L	L	L	L	-	L	M	L	L

22ECGE0 COMPUTER VISION FOR ENGINEERING APPLICATIONS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	L	-	-	M	L	L	L
CO2	S	M	L	-	M	-	-	M	-	-	M	M	M	M
CO3	S	M	L	-	M	-	-	M	-	-	M	M	M	M
CO4	S	M	L	-	L	-	-	M	L	-	M	M	L	L
CO5	S	M	L	-	M	-	-	M	-	-	M	M	L	M
CO6	S	M	L	-	M	M	-	L	-	-	M	L	L	L
Overall	S	M	L	-	M	L	-	M	L	-	M	M	M	M

22ECRA0 SIGNAL INTEGRITY FOR HIGH-SPEED SYSTEM DESIGN														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	L	L	L	-	-	M	L	L
CO2	S	M	L	-	L	-	L	M	M	-	-	M	L	L
CO3	S	M	L	-	L	-	L	M	M	-	-	M	L	L
CO4	S	M	L	-	L	-	L	M	M	-	-	M	L	L
CO5	S	M	L	-	L	-	L	M	M	-	-	M	L	L
CO6	S	M	L	-	L	-	L	M	M	-	-	M	L	L
Overall	S	M	L		L		L	M	M			M	L	L

22ECRB0 MULTIMEDIA COMPRESSION TECHNIQUES														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	M	-	-
Overall	S	M	L	-	-	-	-	-	-	-	-	M	-	-

22ECRC0 ARRAY SIGNAL PROCESSING														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO2	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO3	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO4	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO5	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO6	S	M	L	-	-	-	-	-	M	-	-	M	M	-
Overall	S	M	L	-	-	-	-	-	M	-	-	M	M	-

22ECRD0 STATISTICAL SIGNAL PROCESSING														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	M	-	-	L	M	-
CO2	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO3	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO4	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO5	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO6	S	M	L	-	-	-	-	-	M	-	-	M	M	-
CO7	S	M	L	-	-	-	-	-	M	-	-	M	M	-
Overall	S	M	L	-	-	-	-	-	M	-	-	M	M	-

22ECRF0 ASIC DESIGN														
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	L	L	L	-	L	L	-	L
CO2	S	M	L	-	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	-	-	L	L	L	-	L	M	-	L
CO4	S	M	L	-	-	-	L	L	L	-	L	M	-	L
CO5	S	M	L	-	-	-	L	L	L	-	L	M	-	L
CO6	S	M	L	-	-	-	L	L	L	-	L	M	-	L
Overall	S	M	L	-	-	-	L	L	L	-	L	M	-	L

22ECRGO-REAL TIME SYSTEMS														
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	L	L	-	L	M	M	-	-	M	L	L
CO2	S	M	L	L	L	-	L	M	M	-	-	M	L	L
CO3	S	M	L	L	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	-	-	L	M	M	-	L	M	-	L
CO5	S	M	L	L	-	-	L	M	M	-	L	M	-	L
CO6	S	M	L	L	-	-	L	M	M	-	-	M	-	L
Overall	S	M	L	L	-	-	L	M	M	-	-	M	-	L

22ECRJ0 AD-HOC NETWORKS AND APPLICATIONS														
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	L	L	L	-	-	L	M	M	-	-	L	-	L
CO2	S	M	L	L	-	-	L	M	M	-	-	M	-	L
CO3	S	M	L	L	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	L	L	-	L	M	M	-	-	M	L	L
CO5	S	M	L	L	L	-	L	M	M	-	-	M	L	L
CO6	S	M	L	L	L	-	L	M	M	-	-	M	L	L
Overall	S	M	L	L	L	-	L	M	M	-	-	M	L	L

22ECRK0 BLOCKCHAIN AND APPLICATIONS														
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	L	M	M	-	-	M	-	L
CO2	M	L	-	-	-	-	L	M	M	-	-	L	-	L
CO3	S	M	L	-	-	-	L	M	M	-	-	M	-	L
CO4	S	M	L	-	-	-	L	M	M	-	-	M	-	L
CO5	S	M	L	-	-	-	L	M	M	-	-	M	-	L
CO6	S	M	L	-	-	-	L	M	M	-	-	M	-	L
Overall	S	M	L	-	-	-	L	M	M	-	-	M	-	L

22EC1A0 FIELD TESTS FOR 5G COMMUNICATION														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	M	-	L
CO2	S	M	L	-	S	-	-	M	M	-	-	M	M	L
CO3	S	M	L	-	S	-	-	M	M	-	-	M	M	L
Overall	L	L	-		L			L	-			L	L	L

22EC1C0 EMBEDDED FIRMWARE														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	M	-	S	-	-	M	L	-	L	M	M	L
CO2	S	M	L	-	S	-	-	M	L	-	L	M	M	L
CO3	S	M	L	-	S	-	-	M	L	-	L	M	M	M
CO4	S	M	L	-	S	-	-	M	L	-	L	M	M	M
Overall	S	M	L	-	S	-	-	M	L	-	L	M	M	L

22EC1B0 DEEP LEARNING WITH TENSOR FLOW														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	L	-	-	M	L	L	L
CO2	S	M	L	-	M	-	-	M	-	-	M	M	L	M
CO3	S	M	L	-	M	-	-	M	-	-	M	M	L	M
CO4	S	M	L	-	M	-	-	M	-	-	M	M	L	M
Overall	S	M	L	-	M	-	-	M	-	-	M	M	L	M

22EC1D0 AUTOMOTIVE RADAR SYSTEMS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	L	S	-	L
CO2	S	M	L	-	S	-	-	M	M	-	L	S	M	L
CO3	S	M	L	-	S	-	-	M	M	-	L	S	M	M
CO4	S	M	L	-	S	-	-	M	M	-	L	S	M	M
Overall	S	M	L		M			M	M		L	S	M	M

22EC1E0 VLSI IMPLEMENTATION OF COMMUNICATION TRANSCEIVERS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	L	M	-	L
CO2	S	M	L	-	S	-	-	M	M	-	L	M	M	L
CO3	S	M	L	-	S	-	-	M	M	-	L	M	M	M
CO4	S	M	L	-	S	-	-	M	M	-	L	M	M	M
Overall	S	M	L	-	M	-	-	M	M	-	L	M	M	M

22EC1F0 EMBEDDED SYSTEM HARDWARE														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	M	M	L	-	-	-	-	-	-	-	L	L	-	L
CO2	S	M	L	-	S	-	-	M	M	-	L	M	M	L
CO3	S	M	L	-	S	-	-	M	M	-	L	M	M	M
CO4	S	M	L	-	S	-	-	M	M	-	L	M	M	M
Overall	S	M	L	-	M	-	-	M	L	-	L	M	M	L

22EC1G0 GREEN NETWORKS														
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	L	S	-	L
CO2	S	S	L	-	S	-	-	M	M	-	L	S	M	L
CO3	S	M	L	-	S	-	-	M	M	-	L	S	S	S
CO4	S	M	L	-	S	-	-	M	S	-	L	S	M	M
Overall	S	M	L	-	S	-	-	M	M	-	L	S	M	M