RAJALAKSHMI ENGINEERING COLLEGE
An AUTONOMOUS Institution
Affiliated to ANNA UNIVERSITY, Chennai

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

REGULATIONS - 2023

CHOICE BASED CREDIT SYSTEM

VISION

To produce globally competent Electronics and Communication Engineers with a commitment to serve the society.

MISSION

M1 To impart training with the best of teaching expertise supported by excellent laboratory infrastructure and exposure to recent trends in the industry.

M2 To ensure that the students are molded into competent Electronics and Communication Engineers with the knowledge of computer applications and worthy citizens of the country.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOS)

PEO I

To provide students with sound foundation in the mathematical, scientific and engineering fundamentals necessary to formulate, analyze and solve engineering problems and to prepare them for post graduate studies and for successful careers in industries.

PEO II

To develop the ability among students to define engineering problems in the fields of electronics and communication engineering, and to employ necessary techniques, hardware, and communication tools for modern engineering applications.

PEO III

To instil the values, skills, leadership and team spirit for comprehensive and wholesome personality, to promote entrepreneurial interest among students and to create a fervor for use of engineering in addressing societal concerns.

PROGRAM OUTCOMES (POs)

Engineering graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: An ability to formulate solutions for practical societal requirements using communication engineering.

PSO2: To design and formulate solutions for industrial requirements using electronics and communication engineering.

PSO3: To understand and develop solutions required in multidisciplinary engineering fields.

CURRICULUM

SEMESTER I								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY COURSES								
1	HS23111	Technical Communication I	HS	2	2	0	0	2
2	GE23117	தமிழர் மரபு /Heritage of Tamils	HS	1	1	0	0	1
3	MA23111	Linear Algebra and Calculus	BS	4	3	1	0	4
LAB ORIENTED THEORY COURSES								
4	EC23131	Electron Devices	PC	5	3	0	2	4
5	CY23131	Chemistry for Electronics Engineering	BS	5	3	0	2	4
6	GE23131	Programming using C	ES	7	1	0	6	4
LABORATORY COURSE								
7	GE23122	Engineering Practices-Electrical and Electronics	ES	2	0	0	2	1
MANDATORY COURSE								
8	MC23111	Indian Constitution and Freedom Movement	MC	3	3	0	0	0
TOTAL				**29**	**16**	**1**	**12**	**20**

SEMESTER II								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY COURSES								
1	MA23212	Differential Equations and Complex Variables	BS	4	3	1	0	4
2	GE23217	தமிழரும் தொழில்நுட்பமும் / Tamils and Technology	HS	1	1	0	0	1
3	GE23111	Engineering Graphics	ES	6	2	0	4	4
LAB ORIENTED THEORY COURSES								
4	EE23132	Basic Electrical Engineering	ES	5	3	0	2	4
5	PH23232	Physics for Electronics Engineering	BS	5	3	0	2	4
6	CS23231	Data Structures	ES	7	3	0	4	5
LABORATORY COURSES								
7	GE23121	Engineering Practices-Civil and Mechanical	ES	2	0	0	2	1
8	HS23221/ HS23222	Technical Communication II / English for Professional Competence	HS	2	0	0	2	1
MANDATORY COURSE								
9	MC23112	Environmental Science and Engineering	MC	3	3	0	0	0
TOTAL				**35**	**18**	**1**	**16**	**24**

SEMESTER III								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY COURSES								
1	MA23312	Fourier Series and Number Theory	BS	4	3	1	0	4
2	EC23311	Analog Circuits–I	PC	3	3	0	0	3
3	EC23312	Electromagnetic Fields	PC	3	3	0	0	3
4	EC23313	Digital Principles and System Design	PC	3	3	0	0	3
LAB ORIENTED THEORY COURSES								
5	EC23332	Principles of Microprocessor and Microcontrollers	PC	5	3	0	2	4
6	CS23336	Introduction to Python Programming	ES	5	1	0	4	3
LABORATORY COURSE								
7	EC23321	Analog and Digital Circuits Laboratory	PC	4	0	0	4	2
			TOTAL	**27**	**16**	**1**	**10**	**22**

SEMESTER IV								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY COURSES								
1	EC23411	Signals and Systems	PC	3	3	0	0	3
2	EC23412	Transmission Lines and Waveguides	PC	3	3	0	0	3
3	EC23413	Communication Theory	PC	3	3	0	0	3
LAB ORIENTED THEORY COURSES								
4	EC23431	Analog Circuits-II	PC	5	3	0	2	4
5	MA23436	Probability and Random Processes	BS	5	3	0	2	4
LABORATORY COURSES								
6	GE23421	Soft Skills-I	EEC	2	0	0	2	1
7	CS23422	Python Programming for Machine Learning	ES	4	0	0	4	2
			TOTAL	**25**	**15**	**0**	**10**	**20**

SEMESTER V								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY COURSES								
1	EC23511	Control System Engineering	PC	3	2	1	0	3
2	EC23512	Modern Digital Communication	PC	3	3	0	0	3
3		Open Elective-I	OE	3	3	0	0	3
4		Professional Elective-I	PE	3	3	0	0	3
5		Professional Elective-II	PE	3	3	0	0	3
LAB ORIENTED THEORY COURSE								
6	EC23531	Digital Signal Processing	PC	5	2	1	2	4
LABORATORY COURSES								
7	EC23521	Communication Systems Laboratory	PC	4	0	0	4	2
8	EC23522	Internship	EEC	2	0	0	2	1
9	GE23521	Soft Skills-II	EEC	2	0	0	2	1
			TOTAL	**28**	**16**	**2**	**10**	**23**

SEMESTER VI								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY COURSES								
1	EC23611	Antenna Theory and Wave Propagation	PC	3	3	0	0	3
2		Open Elective-II	OE	3	3	0	0	3
LAB ORIENTED THEORY COURSES								
3	EC23631	VLSI and Chip Design	PC	5	3	0	2	4
4	EC23632	Communication Networks	PC	5	3	0	2	4
5	EC23633	Wireless Communication	PC	4	2	0	2	3
LABORATORY COURSES								
6	GE23621	Problem Solving Techniques	EEC	2	0	0	2	1
7	GE23627	Design Thinking and Innovation	EEC	4	0	0	4	2
			TOTAL	**26**	**14**	**0**	**12**	**20**

SEMESTER VII								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY COURSES								
1		Professional Elective-III	PE	3	3	0	0	3
2		Professional Elective- IV	PE	3	3	0	0	3
LAB ORIENTED THEORY COURSES								
3	EC23731	Optical Communication and Networks	PC	4	2	0	2	3
4	EC23732	RF and Microwave Engineering	PC	4	2	0	2	3
5	EC23733	Embedded and Real Time Systems	PC	5	3	0	2	4
LABORATORY COURSE								
6	EC23721	Artificial Intelligence and Machine Learning for Electronic Engineering	EEC	4	0	0	4	2
			TOTAL	**23**	**13**	**0**	**10**	**18**

SEMESTER VIII								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY COURSES								
1		Professional Elective-V	PE	3	3	0	0	3
2		Professional Elective-VI	PE	3	3	0	0	3
LABORATORY COURSE								
3	EC23821	Project work	EEC	20	0	0	20	10
			TOTAL	**26**	**6**	**0**	**20**	**16**
			TOTAL NUMBER OF CREDITS:	**163**				

B.E ELECTRONICS AND COMMUNICATION ENGINEERING
CREDITS DISTRIBUTION

S. NO	COURSE CATEGORY	CREDITS PER SEMESTER								PROPOSED CURRICULUM
		1	2	3	4	5	6	7	8	
1	HS	3	2							5
2	BS	8	8	4	4					24
3	ES	5	14	3	2					24
4	PC	4		15	13	12	14	10		68
5	PE					6		6	6	18
6	OE					3	3			6
7	GE									0
8	EEC				1	2	3	2	10	18
9	MC	*	*							Non credits
	Total	**20**	**24**	**22**	**20**	**23**	**20**	**18**	**16**	**163**

VERTICAL 1	VERTICAL 2	VERTICAL 3	VERTICAL 4	VERTICAL 5	VERTICAL 6
SIGNAL AND IMAGE PROCESSING	**RF AND ADVANCED COMMUNICATIONS**	**SEMICONDUCTOR AND VLSI DESIGN**	**HIGH SPEED NETWORKS**	**MEMS AND IOT**	**SPACE TECHNOLOGIES**
EC23A11 - Medical Electronics	EC23B11 - Information Theory and Coding	EC23C11 - System on Chip and FPGA Testing	EC23D11 - Wireless Networks	EC23E11 - Introduction to MEMS	EC23F11 - Satellite Communication
EC23A12 - Biosensing and its Analysis	EC23B12 - Cognitive Radio	EC23C12 - Physical Design Automation	EC23D12 - Wireless Sensor Networks	EC23E12 - MEMS and Microfluidic Technologies	EC23F12 - Radar Technologies
EC23A13 - Statistical Signal Processing	EC23B13 - Advanced Communication Systems	EC23C13 - Digital IC Design	EC23D13 - Network Routing Algorithms	EC23E13 - BioMEMS	EC23F13 - Avionics Systems
EC23A14 - Digital Image Processing	EC23B14 - Electromagnetic Interference and Compatibility	EC23C14 - Functional Verification of SOCs	EC23D14 - Multimedia Compression and Networking	EC23E14 – Biomaterial Science and Applications	EC23F14 - Positioning and Navigation Systems
EC23A15 - Image and Video Analysis	EC23B15 - Millimeter Wave Communication	EC23C15 - Computer System Architecture	EC23D15 - Internetworking Multimedia	EC23E15 - Nanotechnology for Engineering Applications	EC23F15 – Fundamentals of Remote Sensing
EC23A16 - Speech and Audio Processing	EC23B16 - Advanced Antenna Technologies	EC23C16 - Semiconductor Packaging	EC23D16 – Principles of Cryptography and Network Security	EC23E16 - Sensor Technology	EC23F16 - Space Mechanics
EC23A17 - Principles of Machine Learning	EC23B17 - RF Circuit Design and RADAR Engineering	EC23C17 - VLSI Testing and Testability	EC23D17 - Software Defined Networks	EC23E17 - IoT Communication Technologies	EC23F17 - Rocket Propulsion
EC23A18 - Introduction to Deep Learning	EC23B18 - 5G Physical Layer Technologies	EC23C18 - Computational VLSI and IoT for AI	EC23D18 - High Performance Computing for Cyber Physical Systems	EC23E18 - Industry 4.0 and IIoT	EC23F18 - Drone Technology in Engineering

PROFESSIONAL ELECTIVES (PE)

VERTICAL 1 - SIGNAL AND IMAGE PROCESSING								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
1	EC23A11	Medical Electronics	PE	3	3	0	0	3
2	EC23A12	Biosensing and its Analysis	PE	3	3	0	0	3
3	EC23A13	Statistical Signal Processing	PE	3	3	0	0	3
4	EC23A14	Digital Image Processing	PE	3	3	0	0	3
5	EC23A15	Image and Video Analysis	PE	3	3	0	0	3
6	EC23A16	Speech and Audio Processing	PE	3	3	0	0	3
7	EC23A17	Principles of Machine Learning	PE	3	3	0	0	3
8	EC23A18	Introduction to Deep Learning	PE	3	3	0	0	3

VERTICAL 2 - RF AND ADVANCED COMMUNICATIONS								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
1	EC23B11	Information Theory and Coding	PE	3	3	0	0	3
2	EC23B12	Cognitive Radio	PE	3	3	0	0	3
3	EC23B13	Advanced Communication Systems	PE	3	3	0	0	3
4	EC23B14	Electromagnetic Interference and Compatibility	PE	3	3	0	0	3
5	EC23B15	Millimeter Wave Communication	PE	3	3	0	0	3
6	EC23B16	Advanced Antenna Technologies	PE	3	3	0	0	3
7	EC23B17	RF Circuit Design and RADAR Engineering	PE	3	3	0	0	3
8	EC23B18	5G Physical Layer Technologies	PE	3	3	0	0	3

VERTICAL 3 - SEMICONDUCTOR AND VLSI DESIGN								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
1	EC23C11	System on Chip and FPGA Testing	PE	3	3	0	0	3
2	EC23C12	Physical Design Automation	PE	3	3	0	0	3
3	EC23C13	Digital IC Design	PE	3	3	0	0	3
4	EC23C14	Functional Verification of SOCs	PE	3	3	0	0	3
5	EC23C15	Computer System Architecture	PE	3	3	0	0	3
6	EC23C16	Semiconductor Packaging	PE	3	3	0	0	3
7	EC23C17	VLSI Testing and Testability	PE	3	3	0	0	3
8	EC23C18	Computational VLSI and IoT for AI	PE	3	3	0	0	3

VERTICAL 4 - HIGH SPEED NETWORKS								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
1	EC23D11	Wireless Networks	PE	3	3	0	0	3
2	EC23D12	Wireless Sensor Networks	PE	3	3	0	0	3
3	EC23D13	Network Routing Algorithms	PE	3	3	0	0	3
4	EC23D14	Multimedia Compression and Networking	PE	3	3	0	0	3
5	EC23D15	Internetworking Multimedia	PE	3	3	0	0	3
6	EC23D16	Principles of Cryptography and Network Security	PE	3	3	0	0	3
7	EC23D17	Software Defined Networks	PE	3	3	0	0	3
8	EC23D18	High Performance Computing for Cyber Physical Systems	PE	3	3	0	0	3

VERTICAL 5 - MEMS AND IOT								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
1	EC23E11	Introduction to MEMS	PE	3	3	0	0	3
2	EC23E12	MEMS and Microfluidic Technologies	PE	3	3	0	0	3
3	EC23E13	BioMEMS	PE	3	3	0	0	3
4	EC23E14	Biomaterial Science and Applications	PE	3	3	0	0	3
5	EC23E15	Nanotechnology for Engineering Applications	PE	3	3	0	0	3
6	EC23E16	Sensor Technology	PE	3	3	0	0	3
7	EC23E17	IoT Communication Technologies	PE	3	3	0	0	3
8	EC23E18	Industry 4.0 and IIoT	PE	3	3	0	0	3

VERTICAL 6 - SPACE TECHNOLOGIES								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
1	EC23F11	Satellite Communication	PE	3	3	0	0	3
2	EC23F12	Radar Technologies	PE	3	3	0	0	3
3	EC23F13	Avionics Systems	PE	3	3	0	0	3
4	EC23F14	Positioning and Navigation Systems	PE	3	3	0	0	3
5	EC23F15	Fundamentals of Remote Sensing	PE	3	3	0	0	3
6	EC23F16	Space Mechanics	PE	3	3	0	0	3
7	EC23F17	Rocket Propulsion	PE	3	3	0	0	3
8	EC23F18	Drone Technology in Engineering	PE	3	3	0	0	3

OPEN ELECTIVES OFFERED BY ECE TO OTHER DEPARTMENTS

S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
1	OEC2311	MEMS and its applications	OE	3	3	0	0	3
2	OEC2312	Consumer Electronics	OE	3	3	0	0	3
3	OEC2313	Electronics Engineering	OE	3	3	0	0	3

SEMESTER – I

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
HS23111	TECHNICAL COMMUNICATION I	HS	2	0	0	2
Common to all branches of B.E/B. Tech programmes – First Semester						

Objectives:
• To facilitate students develop their comprehension skills
• To enable students to improve their receptive skills
• To equip learners with better vocabulary and enhance their writing skills
• To aid students speak effectively in all kinds of communicative contexts
• To improve the learners' basic proficiency in workplace communication

UNIT-I	DEVELOPING COMPREHENSION SKILLS	6
Listening: Introduction to Informational listening – Listening to Podcasts, News **Reading:** Intentional Reading - Short Narratives and Passages. **Speaking:** Introducing Oneself, Narrating a Story / Incident. **Writing:** Sequential Writing – connecting ideas using transitional words (Jumbled Sentences), Process Description **Grammar:** Verbs – Main & Auxiliary: Simple Tenses – Form, Function and Meaning. **Vocabulary:** Word formation – Prefix, Suffix, Compound Words.		
UNIT-II	**LISTENING AND EXTENDED READING**	**6**
Listening: Deep Listening – Listening to Talk Shows and Debates **Reading:** In-depth Reading - Scanning Passages **Speaking:** Describing Current Issues, Happenings, etc.., **Writing:** Note Making, Note Taking – Paragraph Writing **Grammar:** Continuous Tenses, Prepositions, Articles **Vocabulary:** One Word Substitutes, Phrasal Verbs.		
UNIT-III	**FORMAL WRITING AND VERBAL ABILITY**	**6**
Listening: Listening to Lectures and Taking Notes **Reading:** Interpretation of Tables, Charts and Graphs **Speaking:** SWOT Analysis on Oneself **Writing:** Formal Letter Writing and Email Writing **Grammar:** Perfect Tenses, Phrases and Clauses, Discourse Markers **Vocabulary :** Verbal Analogy / Cloze Exercise		
UNIT-IV	**ENHANCING SPEAKING ABILITY**	**6**
Listening: Listening to eminent voices of one's interest (Martin Luther King, APJ Abdul Kalam, etc..) **Reading:** Timed Reading, Filling KWL Chart. **Speaking:** Just a Minute, Impromptu **Writing:** Check-list, Instructions. **Grammar:** 'Wh' Questions / 'Yes' or 'No' Questions, Imperatives **Vocabulary:** Synonyms, Antonyms, Different forms of the same words.		
UNIT-V	**LANGUAGE FOR WORKPLACE**	**6**
Listening: Extensive Listening (Audio books, rendering of poems, etc.) **Reading:** Extensive reading (Jigsaw Reading, Short Stories, Novels) **Speaking:** Short Presentations on Technical Topics **Writing:** Recommendations, Essay Writing **Grammar:** Impersonal Passive, Reported Speech, Concord **Vocabulary :** Informal Vocabulary and Formal Substitutes		
Total Contact Hours: 30		

Course Outcomes: On completion of the course, students will be able to
• apply their comprehension skills and interpret different contents effortlessly
• read and comprehend various texts and audio visual contents
• infer data from graphs and charts and communicate it efficiently in varied contexts
• participate effectively in diverse speaking situations
• to present, discuss and coordinate with their peers in workplace using their language skills

Suggested Activities:

- Ice breaker
- Just A Minute
- Ship wreck
- Hot seat
- Vocabulary building
- Chinese whispers
- Case study

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Book(s):

1. Effective Technical Communication by M. Ashraf Rizvi (Author) 2nd Edition Paperback 2017
2. Sylvan Barnet and Hugo Bedau, 'Critical Thinking Reading and Writing', Bedford/st. Martin's: Fifth Edition (June 28, 2004)
3. Meenakshi Upadhyay, Arun Sharma – Verbal Ability and Reading Comprehension.
4. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press

Reference Book(s) / Web links:

1. Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English With Answers 2nd Edition by Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor)
2. Reading Development and Difficulties By Kate Cain
3. The 7 Habits of Highly Effective People by Stephen Covey, Simon and Schuster, UK
4. Everybody Writes: Your Go-To Guide to Creating Ridiculously Good Content Hardcover by Ann Handley (Author)

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
HS23111. 1	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23111. 2	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23111. 3	-	1	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23111. 4	-	-	-	2	-	-	-	-	1	3	-	-	-	-	-
HS23111. 5	-	-	-	1	-	-	-	-	1	3	-	-	-	-	-
Average	**-**	**1**	**-**	**1.2**	**-**	**-**	**-**	**-**	**1**	**3**	**-**	**-**	**-**	**-**	**-**

அலகு I மொழி மற்றும் இலக்கியம்: 3

இந்திய மொழிக் குடும்பங்கள் - திராவிட மொழிகள் - தமிழ் ஒரு செம்மொழி - தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமய சார்பற்ற தன்மை - சங்க இலக்கியத்தில் பகிர்தல் அறம் - திருக்குறளில் மேலாண்மைக் கருத்துக்கள் - தமிழிக் 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 நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்: 3

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

அலகு IV தமிழர்களின் திணைக் கோட்பாடுகள்: 3

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

அலகு V இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு: 3

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

Total Contact Hours: 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.

Course Code	Course Title	Category	L	T	P	C
MA23111	LINEAR ALGEBRA AND CALCULUS	BS	3	1	0	4
Common to I sem. B.E. - CSE, EEE, ECE, BME and B. Tech. - IT.						

Objectives:

- To introduce the matrix techniques and to explain the nature of the matrix.
- To collect the matrix algebra techniques and the concepts of basis and dimension in vector spaces.
- To construct normalization of vectors and ortho-normal vectors.
- To understand techniques of calculus which are applied in the Engineering problems.
- To apply the techniques of Integration in finding area and volumes.

UNIT-I	MATRICES	12

Matrices - Eigenvalues and eigenvectors - Diagonalization of matrices using orthogonal transformation - Cayley-Hamilton Theorem(without proof) - Quadratic forms - Reduction to canonical form using orthogonal transformation - Numerical computation of Eigen value using Power method.

UNIT-II	LINEAR TRANSFORMATION	12

Vector spaces – Subspaces – Linear combinations and system of Linear equations – Linear independence and Linear dependence – Bases and Dimensions – Linear Transformation – Matrix representation of Linear Transformation - Null space, Range space and dimension theorem (without proof).

UNIT-III	INNER PRODUCT SPACES	12

Inner product and norms - Gram Schmidt orthonormalization process - QR Factorization - Singular value decomposition.

UNIT-IV	FUNCTIONS OF SEVERAL VARIABLES	12

Partial differentiation–Total derivative–Change of variables–Jacobians–Partial differentiation of implicit functions–Taylor's series for functions of two variables–Maxima and minima of functions of two variables–Lagrange's method of undetermined multipliers.

UNIT-V	MULTIPLE INTEGRALS	12

Double integrals–Change of order of integration–Area enclosed by plane curves–Triple integrals–Volume of solids–Numerical computation of double integrals-trapezoidal rule.

Total Contact Hours: 60

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

- Demonstrate the matrix techniques in solving the related problems in engineering and technology.
- Apply the concepts of basis and dimension in vector spaces to the solution of related complex engineering problems.
- Construct orthonormal basis by the concepts of normalization in inner products and to analyse complex engineering problems.
- Interpret the problems in Engineering and Technology using the principles of mathematical calculus.
- Evaluate multiple integrals to conduct investigations of complex problems.

Suggested Activities:

- Problem solving sessions
- Activity based learning
- Implementation of small module

Suggested Evaluation Methods:

- Problem solving in tutorial sessions
- Assignment problems
- Quizzes and class test
- Discussion in classroom

Text Book(s):
1. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, New Delhi, 43rd Edition, 2014.
2. T Veerarajan, Linear Algebra and Partial Differential Equations, Mc Graw Hill Education, 2019.
3. Friedberg, A.H., Insel, A.J. and Spence, L., Elementary Linear Algebra, a matrix approach, 2nd edition, Pearson, 2014.
4. T Veerarajan, Engineering Mathematics –I, McGraw Hill Education, 2018.
5. Introduction to linear algebra, 5th Edition, Gilbert Strang, 2016. Wellesley Publishers.

Reference Book(s) / Web links:
1. Ramana. B.V., "Higher Engineering Mathematics", McGraw Hill Education Pvt. Ltd, New Delhi, 2018.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and Sons, 10th Edition, New Delhi, 2016.
3. Bali, N.P. and Manish Goyal, A Text Book of Engineering Mathematics, Lakshmi Publications Pvt. Ltd., New Delhi, 2006.
4. Advanced Engineering Mathematics, (Seventh Edition), Peter V. O'Neil, Thomson Learning, 2020.
5. Williams, G, “Linear Algebra with Applications”, Jones & Bartlett Learning, First Indian Edition, New Delhi, 2017.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23111. 1	3	2	1	-	-	-	-	-	-	-	1	-	-	1	-
MA23111.2	3	3	-	-	-	-	-	-	-	-	-	-	-	1	-
MA23111.3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
MA23111.4	2	2	-	-	-	-	-	-	-	-	1	1	-	-	-
MA23111.5	2	2	-	-	-	-	-	-	-	-	-	1	1	-	-
Average	**2.6**	**2.2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**1**	**1**	**-**

Course Code	Course Title	Category	L	T	P	C
EC23131	ELECTRON DEVICES	PC	3	0	2	4

Objectives:

- To acquire knowledge about the PN junction diode
- To study in detail about the operation and characteristic features of the BJT
- To introduce the operation and characteristic features of JFET and MOSFET
- To study the biasing techniques of BJT, JFET and MOSFET
- To understand the operation and characteristic features of special semiconductor devices

UNIT-I	**SEMICONDUCTOR DIODE**	**9**
Introduction to Semiconductor Physics, PN junction diode, current equations, energy band diagram, diffusion and drift current densities, forward and reverse bias characteristics, Transition and Diffusion capacitances, Switching characteristics, Applications of PN junction diode- Rectifiers, clippers and clampers.		
UNIT-II	**BJT**	**9**
NPN and PNP configurations and their characteristics, Early effect, current equations, input and output characteristics of CE, CB and CC, h-parameter model, Hybrid -π model, Eber's Moll model		
UNIT-III	**JFET AND MOSFET**	**9**
JFET: N-channel and P-channel, drain and transfer characteristics, MOSFET: D-MOSFET, E-MOSFET, Drain and Transfer characteristics.		
UNIT-IV	**BIASING OF FET AND BJT AMPLIFIERS**	**9**
BJT - DC Load line, operating point, various biasing methods of BJT, Bias compensation, Thermal stability, Biasing of JFET and MOSFET		
UNIT-V	**SPECIAL SEMICONDUCTOR DEVICES**	**9**
Schottky barrier diode, Zener diode, Varactor diode, Tunnel diode, UJT, SCR, DIAC, TRIAC, Dual-Gate MOSFETS, FinFET, PIN-FET		
		Total Contact Hours: 45

Description of the Experiments:	**Total Contact Hours: 30**
1. Characteristics of PN junction diode.	
2. Characteristics of Zener diode.	
3. Characteristics of BJT.	
4. Clippers and Clampers.	
5. Characteristics of JFET.	
6. Characteristics of UJT.	
7. SCR Characteristics.	

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

- Demonstrate the operation and characteristics of the PN junction diode
- Develop a high degree of familiarity with the terminal characteristics of the BJT
- Identify the characteristics of FETs and MOSFETs
- Analyze various types of biasing for the BJT
- Identify a suitable semiconductor device for any given application

Suggested Activities:

- Video lecture
- PPT
- Role Play
- Quizzes
- VLAB

Suggested Evaluation Methods:

- MCQ
- Assignment

Text Book(s):
1. Robert L. Boylestad, Louis Nashelsky, "Electronic Devices and Circuit Theory," 11th edition, PrenticeHall, 2012.
2. D. Neamen , D. Biswas "Semiconductor Physics and Devices," 4/e, Mc Graw-Hill Education, 2012.
3. Salivahanan.S, "Electronic Devices", 3/e, Mc Graw-Hill Education, 2019.

Reference Book(s) / Web links:
1. G. Streetman, and S. K. Banerjee, "Solid State Electronic Devices," 7th edition, Pearson, 2014.
2. S. M. Sze and K. N. Kwok, "Physics of Semiconductor Devices," 3rd edition, John Wiley & Sons, 2006.
3. C.T. Sah, "Fundamentals of solid state electronics," World Scientific Publishing Co. Inc, 1991.
4. Y. Tsividis and M. Colin, "Operation and Modeling of the MOS Transistor," Oxford Univ.Press, 2011
5. All-in-One Electronic Simplified, A.K. Maini, Khanna Publishing House.

Lab equipment required:

S. No.	Name of the Equipment	Quantity Required
1	CRO Function generator Power supply Voltmeters Ammeters Multimeters	18 18 35 60 60 10
2	BJT, FET, PN DIODE, Zener diode, UJT, SCR	Each 50
3	Breadboard	30
4	Connecting wires	As required

Suggested Evaluation Methods:

- Model Practical
- Viva
- Observation and Record

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23131.1	3	3	2	3	1	1	1	2	1	1	2	2	2	2	2
EC23131.2	3	3	2	3	1	1	1	2	1	1	2	2	2	2	2
EC23131.3	3	3	2	3	2	1	1	2	1	1	2	2	3	3	2
EC23131.4	3	2	3	2	2	2	1	2	2	1	2	2	2	2	2
EC23131.5	3	2	3	2	1	2	1	2	2	1	2	2	2	2	2
Average	**3**	**2.6**	**2.4**	**2.6**	**1.4**	**1.4**	**1**	**2**	**1.4**	**1**	**2**	**2**	**2.2**	**2.2**	**2**

Course Code	Course Title	Category	L	T	P	C
CY23131	CHEMISTRY FOR ELECTRONICS ENGINEERING	BS	3	0	2	4
Common to B.E. - ECE, BME, EEE, MCT and R&A						

Objectives:
• To understand the principles of electrochemical processes
• To explore the functioning of sensors and their applications in industries and health care
• To get familiarized with the functioning of batteries and fuel cells
• To acquire knowledge on polymeric materials used in electronics
• To develop proficiency in nanomaterials

UNIT-I	DYNAMIC ELECTROCHEMISTRY	9
Applied Electrochemistry: Electrode Potential - EMF series - Corrosion- Causes, Consequences and Prevention. Surface Preparation- electropolishing -Electroplating of copper, electrophoretic deposition - Electrochemical machining, electrochemical etching - electrochemical etching of Cu from PCB.		
UNIT-II	**ELECTROCHEMICAL SENSORS**	**9**
Electrodes - reference electrodes - ion-selective electrode, determination of electrode potential- Galvanic and concentration cells - potentiometric, amperometric and conductometric methods of analysis - potentiometric sensor, optical sensor, thermal sensor, chemical biosignals- sensors for health care – glucose and urea sensors, gas sensors for CO_2, O_2 and NH_3 sensing- blood oxygen sensor.		
UNIT-III	**ELECTROCHEMICAL ENERGY SYSTEMS**	**9**
Batteries- types - characteristics-fabrication and working of lead-acid battery- NICAD battery – Nickel metal hydride batteries -lithium-ion battery - Supercapacitors- introduction - types - electrochemical double layer capacitor - activated carbon - carbon aerogels. Fuel cells - classification – principle, working and applications of hydrogen-oxygen fuel cell - solid oxide fuel cell - direct methanol fuel cell and proton exchange membrane fuel cells-biofuel cells.		
UNIT-IV	**POLYMERS IN ELECTRONICS**	**9**
Conducting polymers - **c**onducting mechanisms- polyaniline, Poly pyrrole - photonic polymers - photo resists - Introduction, Liquid crystalline phases, Identification of the mesophases, Lyotropic main chain liquid crystalline polymers, Thermotropic main chain liquid crystal polymers, Applications of liquid Crystals in Displays (LCDs) - Organic LEDs-functioning-advantages and disadvantages over conventional LEDs- commercial uses.		
UNIT-V	**NANO MATERIALS**	**9**
Introduction-Types of nanomaterials-Emergence and challenges in nanotechnology- Synthesis routes for nanomaterials: Bottom-up and top-down approaches- Sol-gel, precipitation, Hydrothermal, Solvothermal, Microwave irradiation, Chemical Vapour Deposition (CVD), Electro deposition- Properties of nanomaterials- Mechanical properties, Chemical, Optical, Electrical and Magnetic properties-applications of nanomaterials.		
Total Contact Hours: 45		

Description of the Experiments:	Total Contact Hours: 30
1. Construction and determination of EMF of simple electrochemical cells and concentration cells	
2. Estimation of acids by pH metry	
3. Determination of corrosion rate on mild steel by weight loss method	
4. Estimation of mixture of acids by conductometry	
5. Estimation of extent of corrosion of iron pieces by potentiometry	
6. Estimation of copper / ferrous ions by spectrophotometry	
7. Estimation of DO by using sensors	
8. Estimation of concentration of sulphate/chloride ions in the given sample solution.	
9. Determination of molecular weight of a polymer by viscometry method	
10. Synthesis of nanomaterials by simple precipitation method	

Course Outcomes: On completion of the course, students will be able to
• Apply the knowledge of electrochemistry in exploring electrochemical processes.
• Associate the knowledge of sensors in health care and in pollution abatement
• Recognize the types of batteries and fuel cells
• Employ advanced materials in industrial applications and display techniques
• Develop nano and biomaterials for medical applications

Suggested Activities:

- Electroplating process by group of students
- Ceramic coating on implant materials
- Electropolishing of metals and alloys

Suggested Evaluation Methods:

- Continuous assessment tests
- Assignments
- Model lab examination
- End semester examination

Text Book(s):	
1.	P. C. Jain and Monika Jain, "Engineering Chemistry", DhanpatRai Publishing Company (P) Ltd, New Delhi, 2015
2.	O.G.Palanna, "Engineering Chemistry", McGraw Hill Education (India) Pvt, Ltd, New Delhi, 2017
3.	Shikha Agarwal "Engineering Chemistry-Fundamentals and applications", Cambridge University Press, New Delhi, 2015

Reference Book(s) / Web links:	
1.	Gowarikar V. R., Viswanathan N.V. and Jayadev Sreedhar, —Polymer Science, New Age International (P) Ltd., New Delhi, 2011
2.	Sujata V Bhat, "Biomaterials", Narosa Publishing House, New Delhi, 2002
3.	PradeepT, "A Text Book of Nanoscience and Nanotechnology", Tata McGraw Hill, New Delhi, 2012
4.	An Introduction to Nanomaterials and Nanoscience (PB 2020) : Asim K Das, Mahua Das, CBS publishers and distributors Pvt. Ltd.
5.	NPTEL course Elementary Electrochemistry course url - **https://onlinecourses.nptel.ac.in/noc23_cy19/preview**
6.	For downloading text/reference books the weblink is given below can be used **http://libgen.rs/**

Lab equipment required:

S. No.	Name of the Equipment	Quantity Required
1.	Oxygen sensors	10
2.	Ion selective electrodes for various ions in solution	10
3	Spectrophotometer	4
4	Magnetic stirrer with hot plate	10

Suggested Evaluation Methods:

- Experiment based viva
- Quizzes

Web links for virtual lab (if any)
https://drive.google.com/drive/folders/1k8g7fGRJ0Dl8FPbjQYg4l5jS1U9qIXnJ

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CY23131. 1	2	2	1	-	-	-	-	-	-	-	-	1	-	1	1
CY23131.2	3	2	1	-	-	1	1	-	-	-	-	1	-	1	1
CY23131.3	2	1	1	-	-	-	-	-	-	-	-	-	-	-	1
CY23131.4	2	1	1	-	-	-	-	-	-	-	-	1	-	-	1
CY23131.5	3	2	2	-	-	-	-	-	-	-	-	1	-	-	1
Average	**2.4**	**1.6**	**1.2**	**-**	**-**	**1`**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**

Course Code	Course Title	Category	L	T	P	C
GE23131	PROGRAMMING USING C	ES	1	0	6	4

Objectives:
• To develop C programs using basic programming constructs
• To develop C programs using arrays and strings
• To do searching and sorting algorithms in C
• To develop applications in C using user defined functions and recursive functions
• To develop applications in C using pointers and structures

List of Experiments:
1. Overview of C, Constants, Variables and Data Types
2. Operators and Expressions, Managing Input and Output Operations
3. Decision Making and Branching
4. Decision Making and Looping
5. Nested Loops - while and for, Jumps in Loops
6. One-Dimensional Arrays
7. Searching Algorithms - Linear and Binary
8. Sorting Algorithms - Bubble and Selection
9. Two-Dimensional and Multi-dimensional Arrays
10. Character Arrays and Strings Handling Functions
11. User-Defined Functions - Recursive Functions
12. Passing Arrays and Strings to Functions
13. Scope, Visibility and Lifetime of Variables
14. Structures and Unions
15. Pointers
16. The Preprocessor
Total Contact Hours: 105
Lab Requirement: GCC Compiler for Windows/Linux

Text Book(s):
1. Brian W. Kernighan and Dennis M. Ritchie, "The C Programming Language", Second Edition, PHI
2. Byron Gottfried, "Programming in C", Second Edition, Schaum Outline Series

Reference Book(s) / Web links:
• Herbert Schildt, "C: The Complete Reference", Fourth Edition, McGraw Hill.
• YashavantKanetkar, "Let Us C", BPB Publications
• E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill
• NPTEL course , "Problem Solving Through Programming In C", By Prof. Anupam Basu, IIT Kharagpur

Course Outcomes: On completion of the course, the students will be able to
• Formulate simple algorithms for arithmetic and logical problems.
• Implement conditional branching, iteration and recursion.
• Decompose a problem into functions and synthesize a complete program using divide and conquer approach.
• Use arrays, pointers and structures to formulate algorithms and programs.
• Apply programming to solve matrix addition and multiplication problems and searching and sorting problems.

Suggested Activities:

- Practice small and tricky codes
- Practice problems in portals like Digital café
- Debugging the codes
- Completing the function definitions etc

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23131.1	1	2	2	2	1	-	-	-	1	2	1	1	2	3	-
GE23131.2	1	1	1	1	1	-	-	-	-	-	1	1	2	2	-
GE23131.3	1	1	2	1	1	-	-	-	-	-	1	1	2	2	-
GE23131.4	2	2	3	2	1	-	-	-	1	-	2	1	2	2	2
GE23131.5	2	2	3	2	1	-	-	-	-	-	2	1	2	2	2
Average	**1.4**	**1.6**	**2.2**	**1.6**	**1.0**	**-**	**-**	**-**	**1.0**	**2.0**	**1.4**	**1.0**	**2.0**	**2.2**	**2.0**

Course Code	Course Title	Category	L	T	P	C
GE23122	ENGINEERING PRACTICES - ELECTRICAL AND ELECTRONICS	ES	0	0	2	1

Objectives:
• To provide hands-on experience on various basic engineering practices in Electrical Engineering.
• To provide hands-on experience on various basic engineering practices in Electronics Engineering.

List of Experiments:	
A. ELECTRICAL ENGINEERING PRACTICE	
1	Residential house wiring using switches, fuses, indicators, lamp and energy meter.
2	Fluorescent lamp wiring.
3	Stair case wiring.
4	Measurement of electrical quantities – voltage, current, power & power factor in RL circuit.
5	Measurement of earth resistance using Megger.
6	Study of Ceiling Fan and Iron Box
B. ELECTRONICS ENGINEERING PRACTICE	
1	Study of electronic components and equipment – Resistor, colour coding, measurement of AC signal parameters (peak-peak, rms period, frequency) using CRO/DSO.
2	Measurement of electrical quantities using Multimeter Testing of electronic components.
3	Study of logic gates: AND, OR, EXOR and NOT.
4	Generation of Clock Signals.
5	Soldering practice – Components Devices and Circuits – Using general purpose PCB.
6	Measurement of ripple factor of Half-wave and Full-wave Rectifiers.
	Total Contact Hours: 30

Course Outcomes: On completion of the course, the students will be able to
• fabricate the basic electrical circuits
• implement the house wiring circuits
• fabricate the electronic circuits
• verify the truth table of logic gates
• design the Half-wave and Full-wave Rectifiers using diodes and passive components

Suggested Evaluation Methods:

- Experiment based viva

Reference Book(s):

1. Bawa H.S., "Workshop Practice", Tata McGraw – Hill Publishing Company Limited, 2007.
2. Jeyachandran K., Natarajan S. & Balasubramanian S., "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
3. Jeyapoovan T., Saravanapandian M. & Pranitha S., "Engineering Practices Lab Manual", Vikas Publishing House Pvt.Ltd, 2006.
4. Rajendra Prasad A. &Sarma P.M.M.S., "Workshop Practice", Sree Sai Publication, 2002.

Lab Equipment Required:

S.No.	Name of the Equipment	Quantity Required
1	Residential house wiring using switches, fuse, indicator, lamp and energy	3 Nos
2	Fluorescent lamp wiring.	3 Nos
3	Stair case wiring	3 Nos
4	Measurement of electrical quantities – voltage, current, power & power factor	2 Nos
5	Study purpose items: Iron box, Ceiling fan.	2 each
6	Megger (250V/500V)	2 Nos.
7	Soldering guns	10 Nos.
8	Assorted electronic components for making circuits	50 Nos.
9	Small PCBs	10 Nos.
10	Multimeters	10 Nos.
11	Digital trainer kit	5 Nos.
12	CRO	8 Nos.
13	Transformer	8 Nos.
14	Function Generator	8 Nos.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23122.1	3	3	3	2	-	-	2	-	3	2	-	3	-	1	1
GE23122.2	3	3	2	2	-	-	2	-	3	2	-	3	-	1	1
GE23122.3	3	3	3	2	-	-	2	-	3	2	-	3	-	1	1
GE23122.4	3	3	3	2	-	-	-	-	3	2	-	3	-	1	1
GE23122.5	3	3	3	2	-	-	-	-	3	2	-	3	-	1	1
Average	**3**	**3**	**2.67**	**2**	**-**	**-**	**2**	**-**	**3**	**2**	**-**	**3**	**-**	**1**	**1**

Course Code	Course Title	Category	L	T	P	C
MC23111	INDIAN CONSTITUTION AND FREEDOM MOVEMENT	MC	3	0	0	0
Common to all branches of B.E/B. Tech Programmes – First / Second / Third Semester						

Objectives:
• To apprehend the sacrifices made by the freedom fighters.
• To inculcate the values enshrined in the Indian constitution.
• To instil a sense of responsibility as the citizens of India.
• To familiarise about the functions of the various levels of Government.
• To be informed about Constitutional and Non- Constitutional bodies.

UNIT-I	INDIAN FREEDOM MOVEMENT	9
British Colonialism in India-Colonial administration till 1857- Revolt of 1857- Early Resistance to British Rule-Rise of Nationalism in India-**I**ndian Freedom Struggle under Mahatma Gandhi-Non- Cooperation Movement-Civil Disobedience Movement- Quit India Movement-British Official response to National movement- Independence of India Act 1947-Freedom and Partition.		
UNIT-II	**CONSTITUTION OF INDIA**	**9**
Historical Background – Indian Constitution: Constitution' meaning of the term, Sources and constitutional history, Constituent Assembly of India – Philosophical foundations of the Indian Constitution – Preamble – Fundamental Rights – Directive Principles of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies for citizens.		
UNIT-III	**STRUCTURE AND FUNCTIONS OF CENTRAL GOVERNMENT**	**9**
Union Government – Structure of the Union Government and Functions – President – Vice President – Prime Minister – Cabinet – Parliament – Supreme Court of India – Judicial Review.		
UNIT-IV	**STRUCTURE AND FUNCTION OF STATE GOVERNMENT AND LOCAL BODY**	**9**
State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts- Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Pachayati Raj: Introduction, Elected officials and their roles, Village level: Role of Elected and Appointed officials.		
UNIT-V	**CONSTITUTIONAL FUNCTIONS AND BODIES**	**9**
Indian Federal System – Centre – State Relations – President's Rule – Constitutional Functionaries – Assessment of working of the Parliamentary System in India- CAG, Election Commission, UPSC, GST Council and other Constitutional bodies-. NITI Aayog, Lokpal, National Development Council and other Non –Constitutional bodies.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• appreciate the sacrifices made by freedom fighters during freedom movement.
• be responsible citizens and abide by the rules of the Indian constitution.
• be aware of the functions of the Indian government.
• be knowledgeable about the functions of the state Government and the Local bodies.
• apply the knowledge on constitutional functions and role of constitutional bodies and non-constitutional bodies.

Suggested Activities:

- Famous speeches from around the world relating to independence
- Case study
- Quiz on Portfolio and Cabinet
- Discussions on International Associations like the UN, BRICS, QUAD
- Presentation on issues around the world

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):

1. M. Laxmikanth , "Indian Polity:, McGraw-Hill, New Delhi.
2. Durga Das Basu, "Introduction to the Constitution of India ", Lexis Nexis, New Delhi. 21st ed 2013.
3. P K Agarwal and K N Chaturvedi ,PrabhatPrakashan, New Delhi, 1st ed , 2017.

Reference Book(s) / Web links:

1. Sharma, Brij Kishore, "Introduction to the Constitution of India:, Prentice Hall of India, New Delhi.
2. U.R.Gahai, "Indian Political System ", New Academic Publishing House, Jalaendhar
3. Bipan Chandra, India's Struggle for Independence, Penguin Books, 2016.
4. Maciver and Page, "Society: An Introduction Analysis ", Mac Milan India Ltd., New Delhi.2nd ed, 2014.
5. Bipan Chandra, History of Modern India, Orient Black Swan, 2009.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MC23111. 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MC23111.2	-	-	-	-	-	-	-	-		-	-	-	-	-	-
MC23111.3	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-
MC23111.4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
MC23111.5	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-
Average	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**

SEMESTER – II

Course Code	Course Title	Category	L	T	P	C
MA23212	DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLES	BS	3	1	0	4
Common to II Sem. B.E. –AERO, AUTO, BME, CIVIL, EEE, ECE, MECH, MCT, R&A and B. Tech. - BT, FT & CHEM						

Objectives:

- To provide students with an introduction to the theory of ordinary differential equations through applications, methods of solution, and numerical approximations.
- To introduce students to how to solve linear Partial Differential with different methods.
- To enable the students to study the Laplace Transforms, properties of Laplace Transform, inverse Laplace Transform and some applications to solve the differential equations and integral equations.
- To explain the concept of a vector integration in a plane and in space.
- To describe basic properties of complex variables and to have the ability to compute complex integrals.

UNIT-I	**ORDINARY DIFFERENTIAL EQUATIONS**	**12**
Second and higher order Linear differential equations with constant coefficients - Method of variation of parameters – Legendre's linear equations – Numerical solution of ODE - Single Step methods: Taylor's series method, Euler's method.		
UNIT-II	**PARTIAL DIFFERENTIAL EQUATIONS**	**12**
Formation of partial differential equations - Classification of PDE – Solutions of standard types of first order partial differential equations - Lagrange's linear equation –Linear homogeneous partial differential equations of second and higher order with constant coefficients.		
UNIT-III	**LAPLACE TRANSFORM**	**12**
Laplace transform –Basic properties – Transforms of derivatives and integrals of functions - Transforms of unit step function and impulse functions, periodic functions. Inverse Laplace transform – Problems using Convolution theorem – Solution of linear ODE of second order with constant coefficients using Laplace transformation techniques		
UNIT-IV	**VECTOR CALCULUS**	**12**
Gradient, divergence and curl – Directional derivative – Irrotational and Solenoidal vector fields – Vector integration – Green's theorem in a plane, Gauss divergence theorem and Stokes' theorem (excluding proofs) – Simple applications involving cubes and rectangular parallelopipeds.		
UNIT-V	**COMPLEX VARIABLES**	**12**
Analytic functions — Construction of analytic function - Bilinear transformation –Singularities – Cauchy's integral theorem (without proof) - Residues – Residue theorem (without proof) - Simple problems - Contour integral over $\|z\|=1$.		
		Total Contact Hours: 60

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

- Apply the methods as a potent tool in the solution of a variety of problems in the natural sciences and technology.
- Develop specific methodologies, techniques and resources in Partial differential equations to conduct research and produce innovative results in the area of specialisation.
- Use Laplace transform and inverse transform techniques to solve the complex problems in engineering and technology.
- Apply the concepts in multivariable analysis, including space curves; directional derivative; gradient; multiple integrals; line and surface integrals; vector fields; divergence, curl ; the theorems of Green and Stokes, and the divergence theorem in different fields of engineering.
- Demonstrate the concept of Analytic functions, conformal mapping and complex integration in solving Engineering problems.

Suggested Activities:

- Problem solving sessions
- Activity based learning

Suggested Evaluation Methods:

- Problem solving in tutorial sessions
- Assignment problems
- Quizzes and class test
- Discussion in classroom

Text Book(s):

1. Grewal B.S., "Higher Engineering Mathematics ", Khanna Publishers, New Delhi, 43rd Edition, 2014.
2. Veerarajan. T, Engineering Mathematics –II, Mc Graw Hill Education, 2018.
3. Erwin Kreyszig," Advanced Engineering Mathematics ", John Wiley and Sons, 10th Edition, New Delhi, 2016.
4. Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, 4th Edition, New Delhi, 2011.
5. Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics", Narosa Publications, 5th Edition, New Delhi, 2017.

Reference Book(s) / Web links:

1. Ramana. B.V., "Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
2. T Veerarajan, Transforms and Partial Differential Equations, Third Edition, 2018.
3. Bali, N.P. and Manish Goyal, A Text Book of Engineering Mathematics, Lakshmi Publications Pvt. Ltd., New Delhi, 4th Edition 2006.
4. Peter V.O'Neil, "Advanced Engineering Mathematics", Cengage Learning India Pvt., Ltd, 7th Edition, New Delhi, 2012.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23212.1	3	2	1	-	-	-	-	-	-	-	-	1	-	-	1
MA23212.2	3	2	1	-	-	-	-	-	-	-	-	1	-	-	1
MA23212.3	3	2	1	-	-	-	-	-	-	-	-	-	-	-	1
MA23212.4	2	2	1	-	-	-	-	-	-	-	-	-	-	-	1
MA23212.5	3	2	1	-	-	-	-	-	-	-	-	1	-	-	1
Average	**2.8**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**1**

GE23217	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 - பண்டங்களில் கீறல் குறியீடுகள்.

அலகு II வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்: 3

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப்பொருட்களில் 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 - செட்டிநாடு 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 - கல்நடைகளுக்காக 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 Contact Hours: 15

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.

Course Code	Course Title	Category	L	T	P	C
GE23111	ENGINEERING GRAPHICS	ES	2	0	4	4

Objectives:
• To understand the importance of the drawing in engineering applications
• To develop graphic skills for communication of concepts, ideas and design of engineering products
• To expose them to existing national standards related to technical drawings.
• To improve their visualization skills so that they can apply this skill in developing new products.
• To improve their technical communication skill in the form of communicative drawings

CONCEPTS AND CONVENTIONS (Not for Examination)		**1**
Importance of graphics in engineering applications–Use of drafting instruments– BIS conventions and specifications–Size, layout and folding of drawing sheets– Lettering and dimensioning. Basic Geometrical constructions.		
UNIT-I	**PLANE CURVES AND PROJECTION OF POINTS**	**5 + 12**
Curves used in engineering practices: Conics–Construction of ellipse, parabola and hyperbola by eccentricity method – Cycloidal Curves–Construction of cycloid, epicycloid and hypocycloid – Construction of involutes of square and circle– Drawing of tangents and normal to the above curves. Principles of Projection and Projection of points.		
UNIT-II	**PROJECTION OF LINES AND PLANE SURFACES**	**6 + 12**
Projection of straight lines (First angle projection) inclined to both the principal planes – Determination of true lengths and true inclinations by rotating line method Projection of planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method.		
UNIT-III	**PROJECTION OF SOLIDS AND PROJECTION OF SECTIONED SOLIDS**	**6 + 12**
Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is inclined to one of the principal planes by rotating object method. Sectioning of solids in simple vertical position when the cutting plane is inclined to HP and perpendicular to VP – obtaining true shape of the section. Practicing three-dimensional modeling of simple objects by CAD software (Not for examination)		
UNIT-IV	**DEVELOPMENT OF SURFACE AND ISOMETRIC PROJECTIONS**	**6 + 12**
Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids cylinders and cones. Principles of isometric projection–isometric scale–Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinders and cones Model making of isometric projection of combination of solids as assignment (Not for End semester)		
UNIT-V	**FREE HAND SKETCHING AND PERSPECTIVE PROJECTIONS**	**6 + 12**
Free Hand sketching: Freehand sketching of multiple views from pictorial views of objects - Freehand sketching of pictorial views of object from multiple views Perspective projection of simple solids-Prisms, pyramids, cylinder and cone by visual ray method.		
		Total Contact Hours: (L=30; P=60) 90 Periods

Course Outcomes: On completion of the course, students will be able to
• To construct different plane curves and to comprehend the theory of projection
• To draw the basic views related to projection of lines and planes
• To draw the projection of simple solids and to draw the projection of development of surfaces of Sectioned solids in simple vertical position
• To draw the orthographic projection from pictorial objects and Isometric projections of simple solids
• To visualize Perspective view of simple solids

Text Book(s):
1. Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House, 50th Edition, 2010.
2. Natarajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2017.

Reference Book(s) / Web links:
1. Varghese P I., "Engineering Graphics", McGraw Hill Education (I) Pvt. Ltd., 2013.
2. V.B Sikka "Civil Engineering Drawing", S.K Kataria & Sons, New Delhi.
3. Venugopal K. and Prabhu Raja V., "Engineering Graphics", New Age International (P) Limited, 2008.
4. Gopalakrishna K.R., "Engineering Drawing" (Vol. I&II combined), Subhas Stores, Bangalore, 2017.
5. Basant Agarwal and Agarwal C.M., "Engineering Drawing", McGraw Hill Publishing Company Limited, New Delhi, 2018.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23111.1	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
GE23111.2	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
GE23111.3	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
GE23111.4	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
GE23111.5	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
Average	**3**	**2**	**2**	**1**	**-**	**1**	**-**	**2**	**2**	**2**	**-**	**2**	**-**	**-**	**-**

Course Code	Course Title	Category	L	T	P	C
EE23132	BASIC ELECTRICAL ENGINEERING	ES	3	0	2	4

Objectives:
• To provide knowledge on the analysis of DC circuits.
• To teach methods of analysis of AC circuits.
• To impart knowledge on principles of operation of electrical machines.
• To teach the basics of electrical safety measures.
• To provide hands on experience on electric circuits and machines

UNIT-I	DC CIRCUITS	9
Electrical circuit elements (R, L and C), voltage and current sources, Kirchhoff's laws, Mesh and Nodal Analysis, Superposition, Thevenin's, Norton's Theorems and Maximum Power Transfer Theorem		
UNIT-II	**AC CIRCUITS**	**9**
Representation of sinusoidal waveforms, Power and Power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations. Three phase balanced circuits.		
UNIT-III	**DC MOTORS AND TRANSFORMERS**	**9**
Construction, working and characteristics of DC motors. Construction, principle of operation of single-phase Transformer, EMF Equation.		
UNIT-IV	**AC ROTATING MACHINES**	**9**
Construction and basic working of three phase Alternators and Induction motors, Construction and Types of single-phase induction motors- Construction and basic working of Stepper motor, Permanent magnet Brushless Motor (PMBLDC) (Qualitative Treatment Only).		
UNIT-V	**ELECTRICAL SAFETY MEASURES**	**9**
Primary and secondary hazards- arc, blast, shocks-causes and effects-safety equipment- flash and thermal protection -Safety in the use of portable tools - Preventive maintenance- Types of earthing and its importance-Safety precautions for electrical appliances- National electrical Safety code - Indian electricity acts and rules		
		Total Contact Hours: 45

List of Experiments:	
1. Kirchhoff's laws	
2. Network theorems (Thevenin's , Norton's and Maximum Power Transfer Theorems)	
3. Determination of Impedance and Current in RL, RC and RLC series circuits	
4. Measurement of voltage and current in three phase balanced star & delta connected loads	
5. Load test on DC shunt motor (Virtual Lab)	
6. Load test on single-phase transformer (Virtual Lab)	
7. Load test on three phase induction motor (Virtual Lab)	
8. Load test on Single phase induction motor	
	Contact Hours: 30
	Total Contact Hours: 75

Course Outcomes: On completion of the course, students will be able to
• analyse DC circuits and apply circuit theorems.
• calculate the power and power factor in AC circuits
• comprehend the principles of electrical machines.
• realise the electrical safety precautions.
• experimentally analyze the electric circuits and machines.

Suggested Activities:
• Problem solving sessions

Suggested Evaluation Methods:
• Quizzes • Class Presentation / Discussion

Text Book(s):	
1.	E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
2.	J.B.Gupta, "Fundamentals of Electrical Engineering and Electronics" S.K.Kataria & Sons Publications, 2010.
3.	K.Venkataratnam, ―Special Electrical Machines‖, Universities Press (India) Private Limited, 2008.
4.	John Cadick, P.E. Mary Capelli-Schellpfeffer, M.D., M.P.A. Dennis K. Neitzel, C.P.E. "Al Winfield Electrical Safety Hand Book, fifth edition, The McGraw-Hill 2012.

Reference Book(s) / Web links:	
1.	Joseph A. Edminister, Mahmood, Nahri, "Electric Circuits" – Shaum Series and Systems", Schaum"s Outlines, Tata McGrawHill, Indian. 5th Edison , 2017
2.	D. C. Kulshreshtha, "Basic Electrical Engineering", McGraw Hill, 2009.
3.	D. Toro, "Electrical Engineering Fundamentals", Prentice Hall India, 1989.
4.	L. S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
5.	https://nptel.ac.in/courses/108108076
6.	E G Janardanan, ―Special Electrical Machines‖, Prentice Hall India Limited, 2013.
7.	Maxwell Adams.J, "Electrical safety- a guide to the causes and prevention of electric hazards",The Institution of Electric Engineers, 1994.

Lab Equipment Required:

S.No.	Name of the equipment	Quantity Required (for batch of 30 students
1.	**Verification of Kirchhoff's Laws** 1. DC Regulated Power supply (0 - 30 V variable) 2. Bread Board 3. Resistors 4. Ammeter (0-50)mA 5. Voltmeter (0-30)V 6. Multimeter 7. Connecting wires	 1 1 As per Circuit diagram 3 3 1 As Required
2.	**Verification of Network Theorems (Thevenins and Nortons)** 1. DC Regulated Power supply (0 - 30 V variable) 2. Bread Board 3. Resistors 4. Ammeter (0-50)mA 5. Voltmeter (0-30)V 6. Multimeter **7.** Connecting wires	 1 1 As per Circuit diagram 1 1 1 As Required
3.	**Determination of current and Impedance in RL, RC and RLC series circuit** 1. DC Regulated Power supply (0 - 30 V variable) 2. Resistors, Inductors and capacitors 3. Ammeter (0-50)mA 4. Voltmeter (0-30)V 5. Connecting wires	 1 As per Circuit diagram 1 1 As Required

4.	**Measurement of Voltage and Current in Three Phase Balanced Star and Delta Connected Loads** 1. Three phase star& delta connected load / Single phase load bank of suitable rating 2. Ammeter and Voltmeter 3. Connecting wires	3 As per Circuit diagram As Required
5.	**Load test on DC Shunt Motor.** 1. Ammeter MC (0-20A) 2. Voltmeter MC (0-300)V 3. Tachometer 4. Field Rheostat 500 Ω, 1.5 A 5. Connecting wires	 1 1 1 1 As Required
6.	**Load test on Single phase Transformer** 1. Ammeter (0-30) A, (0-5) A 2. Voltmeter (0-150)V, (0-300)V 3. Wattmeter – 300V, 5A, UPF 4. Autotransformer 5. Single phase Transformer 6. Connecting Wires	 1 1 1 1 1 As Required
7.	**Load Test on Three phase Induction Motor** 1. Ammeter MI (0-20A) 2. Voltmeter MI (0-300)V 3. Wattmeter – 300V, 30 A 4. Tachometer – Digital 5. Three phase Induction motor 6. Connecting Wires	 1 1 1 1 1 As required

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EE23132.1	3	3	3	3	-	3	1	1	2	1	1	1	-	-	-
EE23132.2	3	3	3	3	-	3	1	1	2	1	1	1	-	-	-
EE23132.3	3	3	3	3	-	3	1	1	2	1	1	1	-	-	-
EE23132.4	3	3	3	3	-	3	1	1	2	1	1	1	-	-	-
EE23132.5	3	3	3	3	-	3	3	1	2	1	1	1	-	-	-
Average	**3**	**3**	**3**	**3**	**-**	**3**	**1.4**	**1**	**2**	**1**	**1**	**1**	**-**	**-**	**-**

Course Code	Course Title	Category	L	T	P	C
PH23232	PHYSICS FOR ELECTRONICS ENGINEERING	BS	3	0	2	4
Common to II sem. B.E. – Electronics and Communication Engineering & Electrical and Electronics Engineering						

Objectives:
• To understand the essential principles of electron transport properties.
• To impart the knowledge on the properties of semiconductors.
• To become proficient in magnetic, superconducting and dielectric properties of materials.
• To expose the properties and applications of optical materials.
• To enhance the fundamental knowledge on quantum confinement and nano based devices.

UNIT-I	ELECTRICAL PROPERTIES OF MATERIALS	9
Classical free electron theory - expression for electrical conductivity - electrons in metals –Introduction to quantum physics- wave function-Schrodinger equation- particle in a box-one dimension - degenerate states - Fermi Dirac statistics - density of energy states – Quantum mechanical theory of electrical conductivity- electron effective mass – concept of hole.		
UNIT-II	**SEMICONDUCTOR PHYSICS**	**9**
Intrinsic semiconductors - energy band diagram - direct and indirect semiconductors - carrier concentration in intrinsic semiconductors-Band gap determination –extrinsic semiconductors - carrier concentration in N-type and P-type semiconductors. Hall effect-determination of Hall co-efficient and applications. PN and Metal–Semiconductor Junctions: Energy band diagram and Depletion Layer of a PN Junction, Built-in potential, Carrier injection under forward bias.		
UNIT-III	**MAGNETIC, SUPERCONDUCTOR AND DIELECTRIC PROPERTIES OF MATERIALS**	**9**
Magnetism in materials - magnetic field and induction - magnetization - magnetic permeability and susceptibility - types of magnetic materials - microscopic classification of magnetic materials. Ferromagnetism: domain theory. Superconductor: critical temperature, zero electric resistance, Meissner effect and critical magnetic field. Dielectric materials: Polarization processes - internal field -dielectric loss -high-k dielectrics.		
UNIT-IV	**OPTOELECTRONICS**	**9**
Classification of optical materials - carrier generation and recombination processes. Absorption, emission and scattering of light in metals, insulators and semiconductors (concepts only). Solar cell - photo detectors - LED - Organic LED –laser diodes - NLO materials-properties and applications.		
UNIT-V	**NANOELECTRONIC DEVICES**	**9**
Introduction - size dependence of Fermi energy- quantum confinement - quantum structures. quantum well, quantum wire and quantum dot structures. Tunnelling-Coulomb blockade effects - single electron phenomena and single electron transistor - magnetic semiconductors–spintronics - Quantum computing basics of q-bits, superposition and quantum entanglement (qualitative), MEMS: Cantilever.		
Contact Hours: 45		

List of Experiments:
1. Determination of Planck's constant using colour LED
2. Determination of Band gap of semiconducting material.
3. Determination of Hall coefficient of semiconductor.
4. Determine the hysteresis loss in the transformer core using B-H curve unit.
5. Determination of free space permeability using Helmholtz coil.
6. Determination of magnetic susceptibility of ferrous liquid using Quincke's Method.
7. Determination of Resonance frequency of LCR series circuit.
8. Determination of wavelength of diode laser using diffraction grating.
9. Determination of fill factor of solar cell.
10. Determination of quantum efficiency of photo diode from I-V Characteristic curve.
Contact Hours: 30
Total Contact Hours: 75

Course Outcomes: On completion of the course, students will be able to
• apply the concept of electron transport in devices.
• analyse the physical properties of semiconductors.
• analyse the properties of magnetic and dielectric materials.
• analyse the properties of optical materials used for optoelectronics.
• analyse the quantum behaviour of semiconductor MEMS and nanoelectronic devices.

Suggested Activities:
• Problem solving sessions

Suggested Evaluation Methods:
• Quizzes
• Class Presentation / Discussion

Text Book(s):
1. Kasap, S.O. Principles of Electronic Materials and Devices, McGraw-Hill Education, 2017.
2. Wahab, M.A. Solid State Physics: Structure and Properties of Materials. Narosa Publishing House, 2020.

Reference Book(s) / Web links:
1. Garcia, N. & Damask, A. Physics for Computer Science Students: with emphasis on Atomic and Semiconductor Physics. Springer-Verlag, 2012.
2. Hanson, G.W. Fundamentals of Nanoelectronics. Pearson Education, 2009.
3. Rogers, B., Adams, J. & Pennathur, S. Nanotechnology: Understanding Small Systems. CRC Press, 2014.
4. S. O. Pillai, Solid State Physics (Multi colour Edition) , New Age International, 2018.
5. Umesh K Mishra & Jasprit Singh, Semiconductor Device Physics and Design, Springer, 2008.

Lab Equipment Required:

S. No	Name of the equipment	Quantity Required
1	Band gap of a semiconductor setup	8
2	Hall coefficient of semiconductor setup	4
3	B-H curve setup and CRO	6
4	Determination of permeability of free space - Helmholtz coil setup	5
5	Magnetic Susceptibility– Quincke's tube, Electromagnet, Power supply Traveling Microscope	4
6	LCR circuit kit	7
7	Solar cell parameters setup	6
8	Determination of Plank's constant - Rheostat, Multimeter, LED	8
9	Photo diode Characteristics.	6
10	Wavelength of Laser and Characteristics -Laser source and grating plate.	6

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PH23232.1	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
PH23232.2	3	2	1	-	-	-	-	-	-	-	-	1	1	1	-
PH23232. 3	3	2	1	-	-	-	-	-	-	-	-	-	1	1	-
PH23232. 4	3	2	1	-	-	-	-	-	-	-	-	1	1	1	-
PH23232.5	3	2	1	-	-	-	-	-	-	-	-	1	1	1	-
Average	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**1**	**-**

Course Code	Course Title	Category	L	T	P	C
CS23231	DATA STRUCTURES	ES	3	0	4	5

Objectives:	
•	To apply the concepts of Linked List in the applications of various linear data structures.
•	To demonstrate the understanding of stacks, queues and their applications.
•	To apply the concepts of Linked List in the applications of various nonlinear data structures.
•	To understand the implementation of graphs and their applications.
•	To be able to incorporate various sorting and hashing techniques in real time scenarios

UNIT-I	LINEAR DATA STRUCTURES – LIST	9
Self-Referential Structures, Dynamic Memory Allocation, Linked list implementation - Singly Linked List, Doubly Linked List, Circular Linked List, Applications of List.		
UNIT-II	**LINEAR DATA STRUCTURES – STACKS, QUEUES**	**9**
Stack – Operations, Array and Linked list implementation, Applications – Evaluation of Arithmetic Expressions, Queues- Operations, Array and Linked list Implementation.		
UNIT-III	**NON LINEAR DATA STRUCTURES – TREES**	**9**
Tree Terminologies, Binary Tree Representation, Tree Traversals, Binary Search Trees, Binary Heap, Height Balance ees – AVL Trees.		
UNIT-IV	**NON LINEAR DATA STRUCTURES – GRAPHS**	**9**
Representation of Graphs, Topological Sort, Depth First Search and Breadth-First Search , Minimum Spanning Tree – Prim's Algorithm, Shortest path algorithm – Dijikstra's Algorithm.		
UNIT-V	**SEARCHING, SORTING AND HASHING TECHNIQUES**	**9**
Sorting Techniques –Insertion Sort, Quick Sort, Merge Sort, Hashing- Hashing functions – Mid square, Division, Folding, Collision Resolution Techniques – Separate Chaining – Open Addressing – Rehashing.		
		Contact Hours: 45

Course Outcomes: On completion of the course, students will be able to
• Understand and apply the various concepts of Linear data structures
• Understand and apply the various concepts of Non Linear data structures.
• Understand and apply the various sorting and Hashing concepts.
• Analyse and apply the suitable data structure for their research.
• Choose efficient data structures and apply them to solve real world problems.

Suggested Activities:

- Role play- Linked List (Unit 1).
- Mind Map, Poster Design - Stack and Queue (Unit 2).
- Flipped Classroom - Binary Heap (Unit 3).
- Poster Design - Graph (Unit4).
- Implementation of small module- Hashing (Unit5).

Suggested Evaluation Methods:

- Assignment problems - Linked List (Unit 1).
- Tutorial problems - Applications – Evaluation of Arithmetic Expressions (Unit 2).
- Quizzes - BST and Binary Heap (Unit 3).
- Tutorial problems- Graph traversal (Unit 4).
- Quizzes - Hashing and Sorting (Unit5) .

Text Book(s):

1. "Data Structures and Algorithm Analysis in C", Mark Allen Weiss, 2nd Edition, Pearson Education, 2005
2. "Data Structures and Algorithm Analysis in C++ - Anna University, Mark Allen Weiss, Pearson Education, 2017.

Reference Book(s) :

1. "Data Structures Using C and C++", Langsam, Augenstein and Tanenbaum, 2nd Edition, Pearson Education, 2015.
2. Thomas H. Cormen, Charles E. Leiserson, Ronald L.Rivest, Clifford Stein, Introduction to Algorithms", Fourth Edition, Mcgraw Hill/ MIT Press, 2022.

List of Experiments:

1. Implementation of Single Linked List (Insertion, Deletion and Display).
2. Implementation of Doubly Linked List (Insertion, Deletion and Display).
3. Implementation of Stack using Array and Linked List implementation.
4. Implementation of Queue using Array and Linked List implementation.
5. Implementation of Binary Search Tree and perform Tree Traversal Techniques.
6. Program to perform Quick Sort
7. Program to perform Merge Sort
8. Program to perform Linear Probing.
9. Program to perform Rehashing.
10. Mini Project:
    - Contact book application using Linked List.
    - Dictionary using Binary search trees.
    - Snake Game.
    - Chess Game.
    - Travel Planner (Shortest Path Algorithm).
    - Tic-Tac-Toe Game.
    - Library Management System.
    - Project Management System.
    - other projects.

Contact Hours: 60

Total Contact Hours: 105

Platform Needed: GCC Compiler for Windows/Linux

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

- Analyze the various data structure concepts.
- Implement Stacks and Queue concepts for solving real-world problems.
- Analyze and structure the linear data structure using tree concepts.
- Critically Analyse various non-linear data structures algorithms.
- Apply different Sorting, Searching and Hashing algorithms.

Web links for Theory & Lab(if any):

Data Structures - GeeksforGeeks

Data Structures | DS Tutorial - javatpoint

Data Structure and Types (programiz.com)

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CS23231.1	1	2	1	2	1	-	-	-	-	-	-	1	1	2	-
CS23231.2	1	1	2	1	1	-	-	-	-	-	-	2	2	2	-
CS23231.3	1	1	2	1	1	-	-	-	-	-	-	2	2	2	-
CS23231.4	1	1	2	1	1	-	-	-	-	-	-	2	2	2	-
CS23231.5	1	1	2	1	1	-	-	-	-	-	-	1	1	2	-
Average	**1.0**	**1.2**	**1.8**	**1.2**	**1.0**	**-**	**-**	**-**	**-**	**-**	**-**	**1.6**	**1.6**	**2.0**	**-**

Course Code	Course Title	Category	L	T	P	C
GE23121	ENGINEERING PRACTICES – CIVIL AND MECHANICAL	ES	0	0	2	1

Objectives:

- To provide exposure to the students with hands on experience on various basic engineering practices in Civil and Mechanical Engineering.

List of Experiments:

CIVIL ENGINEERING PRACTICE

1. Study of pipeline joints, its location and functions: valves, taps, couplings, unions, reducers, and elbows in household fittings.
2. Preparation of basic plumbing line sketches for wash basins, water heaters, etc.
3. Hands-on-exercise: Basic pipe connections – Pipe connections with different joining components.

Carpentry Works:

4. Study of joints in roofs, doors, windows and furniture.
5. Hands-on-exercise: Woodwork, joints by sawing, planning and chiselling.

MECHANICAL ENGINEERING PRACTICE

6. Preparation of butt joints, lap joints and T- joints by Shielded metal arc welding.
7. Gas welding practice.

Basic Machining:

8. Simple Turning and Taper turning
9. Drilling Practice

Sheet Metal Work:

10. Forming & Bending:
11. Model making – Trays and funnels
12. Different type of joints.

Machine Assembly Practice:

13. Study of centrifugal pump
14. Study of air conditioner

Total Contact Hours: 30

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

- perform plumbing activities for residential and industrial buildings considering safety aspects while gaining clear understanding on pipeline location and functions of joints like valves, taps, couplings, unions, reducers, elbows, etc.
- perform wood working carpentry activities like sawing, planning, cutting, etc. while having clear understanding of the joints in roofs, doors, windows and furniture.
- produce joints like L joint, T joint, Lap joint, Butt joint, etc. through arc welding process while acquiring in depth knowledge in the principle of operation of welding and other accessories
- perform operations like Turning, Step turning, Taper turning, etc. in lathe and Drilling operation in drilling machine
- perform sheet metal operations like Forming, Bending, etc. and fabricating models like Trays, funnels, etc.

Lab Equipment Required:

S.No.	Name of the Equipment	Quantity Required (For a Batch of 30 Students)
1	Assorted components for plumbing consisting of metallic pipes, plastic pipes, flexible pipes, couplings, unions, elbows, plugs and other fittings meter.	15 Sets
2	Plumbing vice (fitted to work bench)	15 Nos
3	Carpentry vice (fitted to work bench)	15 Nos
4	Standard woodworking tools	15 Sets
5	Models of industrial trusses, door joints, furniture joints	5 each
6	Power Tools: (a) Rotary Hammer (b) Circular Saw (c) Electric Planer (d) Hand Drilling Machine (e) Jigsaw (f) Cutoff Machine	Each 1 No.
7	Arc welding transformer with cables and holders	5 Nos
8	Welding booth with exhaust facility	5 Nos
9	Welding accessories like welding shield, chipping hammer, wire brush, etc.	5 Sets
10	Oxygen and acetylene gas cylinders, blow pipe and other welding outfit	1 No
11	Centre lathe	5 Nos
12	Standard Sheet metal working tools	2 sets
13	Study-purpose items: centrifugal pump, air-conditioner	1 each

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23121.1	1	-	-	-	-	1	-	-	-	-	-	1	-	1	1
GE23121.2	1	-	-	-	-	1	-	-	-	-	-	1	-	1	1
GE23121.3	1	-	-	-	-	1	-	-	-	-	-	1	-	1	1
GE23121.4	1	-	-	-	-	1	-	-	-	-	-	1	-	1	1
GE23121.5	1	-	-	-	-	1	-	-	-	-	-	1	-	1	1
Average	**1.0**	**-**	**-**	**-**	**-**	**1.0**	**-**	**-**	**-**	**-**	**-**	**1.0**	**-**	**1.0**	**1.0**

Course Code	Course Title	Category	L	T	P	C
HS23221	TECHNICAL COMMUNICATION II	HS	0	0	2	1
Common to all branches of B.E/B. Tech programmes –Second Semester						

Objectives:
• To facilitate students to improve their vocabulary for a better communication
• To enable learners to understand and reproduce language
• To aid students to write technical reports in a convincing manner
• To expose students to different sentence structures
• To equip learners to present their ideas in an efficient manner

UNIT-I	VOCABULARY FOR BETTER COMMUNICATION	6
Listening: Telephonic Conversations and TV News **Reading:** Newspapers and Magazines **Speaking:** Conversational Practice: Speaking in a given situation, Asking permission and requesting etc.., **Writing:** Job Application Letter and Resume **Grammar:** Reference words: pronouns and determiners **Vocabulary:** Guessing meanings of words in different contexts.		
UNIT-II	**FUNCTIONAL LANGUAGE ASPECTS**	**6**
Listening: Motivational listening – listening to real life challenges **Reading:** Articles and Technical reports **Speaking:** Using Polite Expressions, Indirect Questions **Writing:** Paraphrasing a Text, Poem **Grammar:** Purpose Statements, Cause and Effect Expressions **Vocabulary:** Neologisms.		
UNIT-III	**TECHNICAL REPORTWRITING**	**6**
Listening: Empathetic Listening – Giving Solutions to Problems **Reading:** Inferential Reading **Speaking:** Dialogues – Interviewing Celebrities / Leaders / Sportspersons, etc.., **Writing:** Report Writing **Grammar:** Functional Usage of Expressions – used to, gone / been, etc.., **Vocabulary:** Words Often Confused		
UNIT-IV	**STRUCTURAL GRAMMAR**	**6**
Listening: Comprehension (IELTS practice tests) **Reading:** Intensive Reading for specific information **Speaking:** Pick and Talk **Writing:** Proposals **Grammar:** Sentence Structures – Simple, Compound, Complex Sentences **Vocabulary:** Replacing dull words with vivid ones		
UNIT-V	**PRESENTATION SKILLS**	**6**
Listening: Discriminative listening – sarcasm, irony, pun, etc.., **Reading:** Practice of chunking – breaking up reading materials **Speaking:** Mini presentation on some topic **Writing:** Minutes of the meeting **Grammar:** Correction of Errors **Vocabulary:** Advanced vocabulary – fixing appropriate words in the given context.		
Total Contact Hours: 30		

Course Outcomes: On completion of the course, students will be able to
• communicate effectively using appropriate vocabulary
• use the acquired language skills to comprehend various types of language contents
• evaluate different texts and write effective technical content
• use appropriate sentence structures to convey their thoughts in varied contexts
• present their concepts and ideas in an effective manner

Suggested Activities:

- Story Lines
- One truth and two lies
- Hang Man
- Pictionary
- Word Scramble
- Case study

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Book(s):

1. Raymond Murphy, "Intermediate English Grammar," Second Edition , Cambridge University Press, 2018
2. Meenakshi Raman & Sangeeta Sharma, "Technical Communication" Third Edition, Oxford University Press, 2015
3. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press

Reference Book(s) / Web links:

1. Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor), "Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English With Answers" 2nd Edition
2. Dale Carnegie, "The Art of Public Speaking," Insight Press
3. Jack C. Richards & Theodore S. Rodgers, " Approaches and Methods in Language Teaching, Second Edition, Cambridge University Press

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
HS23221. 1	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-
HS23221. 2	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23221. 3	-	2	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23221. 4	-	-	-	1	-	-	-	-	2	3	-	-	-	-	-
HS23221. 5	-	-	-	1	-	-	-	-	2	2	-	-	-	-	-
Average	**-**	**2**	**-**	**1**	**-**	**-**	**-**	**-**	**2**	**2.6**	**-**	**-**	**-**	**-**	**-**

Course Code	Course Title	Category	L	T	P	C
HS23222	ENGLISH FOR PROFESSIONAL COMPETENCE	HS	0	0	2	1
Common to all branches of B.E/B. Tech programmes –Second Semester						

Objectives:
• To facilitate the learners in acquiring listening and reading competence
• To enable the learners to communicate effectively through written and oral medium
• To assist the learners in preparing for competitive examinations
• To train the students in acquiring corporate skills
• To inculcate professional standards among the students and make them realize their responsibility in addressing the challenges

UNIT-I	RECEPTIVE SKILLS	6
Listening – Comprehensive Listening – Watching the news – Listening to a peer giving presentation, etc. – Critical Listening – Watching a televised debate, Listening to poems – **Reading** – Extensive Reading – Short stories and One-act Plays – Intensive Reading – Articles or Editorials in Magazines, Blog posts on topics like science and technology, arts, etc.		
UNIT-II	**PRODUCTIVE SKILLS**	**6**
Speaking – Demonstrative Speaking – Process description through visual aids – Persuasive Speaking – Convincing the listener with the speaker's view – **Writing** – Descriptive Writing - Describing a place, person, process – Subjective Writing – Autobiography, Writing based on personal opinions and interpretations		
UNIT-III	**ENGLISH FOR COMPETITIVE EXAMS**	**6**
An introduction to International English Language Testing System (IELTS) – Test of English as a Foreign Language (TOEFL) – Graduate Record Examination (GRE) – Civil Service, Indian Economic Service Examination, Indian Statistical Service Examination, Combined Defence Services Examination, Staff Selection- (Language Related) – Aptitude tests.		
UNIT-IV	**CORPORATE SKILLS**	**6**
Critical Thinking and Problem Solving – Case Study, Brainstorming, Q & A Discussion – **Team work and Collaboration** – Activities like Office Debates, Perfect Square, Blind Retriever, etc. – **Professionalism and Strong Work Ethics** – Integrity, Resilience, Accountability, Adaptability, Growth Mind set		
UNIT-V	**PROJECT WORK**	**6**
Case Study based on the challenges faced by the employers and the employees – Devise Plan, Provide Solution		
Total Contact Hours: 30		

Course Outcomes: On completion of the course, students will be able to
• interpret and respond appropriately in the listening and reading contexts.
• express themselves effectively in spoken and written communication
• apply their acquired language skills in writing the competitive examinations
• exhibit their professional skills in their work place
• identify the challenges in the work place and suggest strategies solutions

Suggested Activities:
• Online Quizzes on Vocabulary • Online Quizzes on grammar • Communication Gap Exercises • Presentations • Word Building Games • Case study

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Books:

1. How to Read Better & Faster, Norman Lewis, Goyal Publishers
2. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine Chuen Meng Goh, Cambridge University Press
3. The Official Cambridge Guide To IELTS by Pauline Cullen, Cambridge University Press
4. The 7 Habits of Highly Effective People by Stephen Covey, Simon and Schuster, UK

Reference Book(s) / Web links:

1. Board of Editors. Sure Outcomes. A Communication Skills Course for Undergraduate Engineers and Technologists. Orient Black Swan Limited, Hyderabad, 2013.
2. Hartley, Mary. "The Power of Listening," Jaico Publishing House; First Edition (2015).
3. Chambers, Harry. "Effective Communication Skills for Scientific and Technical Professionals," Persues Publishing, Cambridge, Massachusetts, 2000.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
HS23222. 1	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 2	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 4	-	-	-	-	-	-	2	2	-	3	-	-	-	-	-
HS23222. 5	-	-	1	-	-	-	2	-	-	3	-	-	-	-	-
Average	**-**	**1**	**1**	**-**	**-**	**-**	**2**	**2**	**-**	**3**	**-**	**-**	**-**	**-**	**-**

Course Code	Course Title	Category	L	T	P	C
MC23112	ENVIRONMENTAL SCIENCE AND ENGINEERING	MC	3	0	0	0
Common to B.E. /B.Tech all branches except CSBS						

Objectives:
• To develop the understanding of environmental and associated issues
• To develop an attitude of concern for the environment
• To promote enthusiasm in participating environmental protection initiatives
• To nurture skills to solve environmental degradation issues
• To develop the knowledge about the environmental laws

UNIT-I	AIR AND NOISE POLLUTION	9
Definition –sources of air pollution –chemical and photochemical reactions in the atmosphere - formation of smog, PAN, acid rain, ozone depletion, particulate pollutants-Air quality standards-Air quality indices - control of particulate air pollutants-gravitational settling chambers,cyclone separators, wet collectors, fabric filters (Bag-house filter), electrostatic precipitators (ESP)-catalytic converters. Noise pollution –sources - health effects - standards- measurement and control methods.		
UNIT-II	**WATER POLLUTION AND ITS MANAGEMENT**	**9**
Definition-causes-effects of water pollution-point and nonpoint sources of wastewater-marine pollution - thermal pollution - Control of water pollution by physical, chemical and biological methods – wastewater treatment-primary, secondary and tertiary treatment-sources and characteristics of industrial effluents- zero liquid discharge.		
UNIT-III	**SOLID WASTE AND HAZARDOUS WASTE MANAGEMENT**	**9**
Solid waste – types- municipal solid waste management: sources, characteristics, collection, and transportation- sanitary landfill, recycling, composting, incineration, energy recovery options from waste - Hazardous waste – types, characteristics, and health impact - hazardous waste management: neutralization, oxidation reduction, precipitation, solidification, stabilization, incineration and final disposal. E-waste-definition-sources-effects on human health and environment- E-waste management- steps involved - Role of E-waste management within the initiatives of the Govt. of India- Swachh Bharat Mission.		
UNIT-IV	**SUSTAINABLE DEVELOPMENT**	**9**
Sustainable development- concept-dimensions-sustainable development goals - value education- gender equality – food security - poverty – hunger - famine - Twelve principles of green chemistry - Green technology - definition, importance - Cleaner development mechanism - carbon credits, carbon trading, carbon sequestration, eco labeling-International conventions and protocols-Disaster management.		
UNIT-V	**ENVIRONMENTAL MANAGEMENT AND LEGISLATION**	**9**
Environmental Management systems - ISO 14000 series- Environmental audit-Environmental Impact Assessment- life cycle assessment- h uman health risk assessment - Environmental Lawsand Policy- Objectives - Polluter pays principle, Precautionary principle - The Environment (Protection) Act 1986 - Role of Information technology in environment and human health.		
Total Contact Hours:45		

Course Outcomes: On completion of the course, the students will be able to
• Associate air and noise quality standards with environment and human health.
• Illustrate the significance of water and devise control measures for water pollution.
• Analyze solid wastes and hazardous wastes.
• Outline the goals of sustainable development in an integrated perspective.
• Comprehend the significance of environmental laws.

Suggested Evaluation Methods:

- Continuous assessment tests
- Assignments
- Case studies, class room presentations (or) site visit

Text Book(s):

1. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016
2. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publisher, 2018.
3. Johri R., E-waste: implications, regulations, and management in India and current global best practices, TERI Press, New Delhi

Reference Book(s) / Web links:

1. R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38. Edition 2010.
2. Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3. Fowler B, Electronic Waste – 1 st Edition (Toxicology and Public Health Issues), 2017 Elsevier
4. NPTEL course url
   https://onlinecourses.nptel.ac.in/noc19_ge22/NPTEL
   https://news.mit.edu/2013/ewaste-mit
5. For downloading text/reference books the weblink is given below can be used **http://libgen.rs/**

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MC23112.1	1	2	3	1	-	2	2	2	1	1	1	2	-	-	-
MC23112.2	1	2	3	1	-	2	2	2	1	1	1	2	-	-	-
MC23112.3	-	-	3	1	-	2	3	2	1	-	1	2	-	-	1
MC23112.4	-	1	2	1	1	3	3	2	1	1	1	2	-	-	-
MC23112.5	-	1	2	-	-	2	2	2	1	2	2	2	-	-	-
Average	**0.4**	**1.2**	**2.6**	**0.8**	**0.2**	**2.2**	**2.4**	**2**	**1**	**1**	**1.2**	**2**	**-**	**-**	**0.2**

SEMESTER – III

Course Code	Course Title	Category	L	T	P	C
MA23312	FOURIER SERIES AND NUMBER THEORY	BS	3	1	0	4
Common to III Sem. B.E. – EEE, ECE, BME, CSE and B.Tech. IT.						

Objectives:
• To express Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory.
• To represent continuous function arising in wave and heat propagation, signals and systems using Fourier Transforms
• To provide various numerical methods in solving problems that occurs in the field of Engineering and Technology.
• To introduce and apply the concepts of finite fields and congruences.
• To present a rigorous development of Number Theory using axioms, definitions, examples, theorems and their proofs.

UNIT-I	FOURIER SERIES	12
Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series –Parseval's identity – Harmonic analysis.		
UNIT-II	**FOURIER TRANSFORMS**	**12**
Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity - Application to boundary value problems.		
UNIT-III	**NUMERICAL SOLUTIONS OF BOUNDARY VALUE PROBLEMS**	**12**
Finite difference method for solving second order differential equations - Finite difference techniques for the solution of two-dimensional Laplace and Poisson equations on rectangular domain – One dimensional heat flow equation by implicit and explicit methods – One Dimensional Wave Equation by Explicit method		
UNIT-IV	**CONGRUENCES**	**12**
Finite Fields -Linear Diophantine equations – Congruence's – Linear Congruence's – Applications: Divisibility tests – Modular exponentiation-Chinese remainder theorem – 2 x 2 linear systems.		
UNIT-V	**CLASSICAL THEOREMS IN NUMBER THEORY**	**12**
Wilson's theorem – Fermat's little theorem – Euler's theorem – Euler's Phi functions – Tau and Sigma functions.		
Total Contact Hours:60		

Course Outcomes: On completion of the course, students will be able to
• Demonstrate Fourier series to study the behaviour of periodic functions and their applications in engineering problems such as system communications, digital signal processing and field theory.
• Apply the shifting theorems, Fourier integral theorems, Inverse Fourier sine and cosine transforms appropriate problems in engineering and technology.
• Solve differential equations numerically that arise in course of solving complex engineering problems.
• Explain the fundamental concepts of finite fields and congruence, and their role in modern mathematics and applied contexts.
• Work effectively as part of a group to solve challenging problems in Number Theory.

Suggested Activities:
• Problem solving sessions • Tutorial sessions by involving two faculty members

Suggested Evaluation Methods:
• Problem solving in tutorial sessions • Assignment problems • Quizzes and class test • Discussion in classroom

Text Book(s):
1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India, 2015.
2. Veerarajan. T., "Transforms and Partial Differential Equations", Tata McGraw Hill Education Pvt.Ltd.,New Delhi, Second reprint, 2016.
3. Grimaldi, R.P and Ramana, B.V., "Discrete and Combinatorial Mathematics", Pearson Education, 5th Edition, New Delhi, 2007.
4. Koshy, T., “Elementary Number Theory with Applications”, Elsevier Publications, New Delhi, 2002.
5. Grewal B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014.

Reference Book(s) / Web links:
1. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company Limited, New Delhi, 2017.
2. Glyn James, "Advanced Modern Engineering Mathematics", 4th Edition, Pearson Education, 2016
3. GrewalB.S., and Grewal. J.S., "Numerical Methods in Engineering and Science", 11th Edition, Khanna Publishers, New Delhi, 2013.
4. Lidl, R. and Pitz, G, "Applied Abstract Algebra", Springer Verlag, New Delhi, 2nd Edition, 2006.
5. Niven, I., Zuckerman.H.S., and Montgomery, H.L., “An Introduction to Theory of Numbers”, John Wiley and Sons , Singapore, 2004.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23312.1	3	3	3	2	1	-	-	-	-	-	-	1	2	1	2
MA23312. 2	3	3	3	2	1	-	-	-	-	-	-	1	2	1	2
MA23312.3	3	3	3	2	2	-	-	-	-	-	1	2	1	2	2
MA23312. 4	3	3	3	2	2	-	-	-	-	-	1	2	1	2	2
MA23312. 5	3	3	3	3	2	-	-	-	-	-	-	2	1	2	2
Average	**3**	**3**	**3**	**2.2**	**1.6**	**-**	**-**	**-**	**-**	**-**	**1**	**1.6**	**1.4**	**1.6**	**2**

Course Code	Course Title	Category	L	T	P	C
EC23311	ANALOG CIRCUITS- I	PC	3	0	0	3

Objectives:

- To analyse the BJT amplifiers using small signal model
- To analyse the FET amplifiers using small signal model
- To determine the frequency response of BJT and FET amplifiers
- To analyse Feedback Amplifiers and Oscillators
- To understand the concepts of Power Amplifiers and IC MOSFET

UNIT-I	**BJT SMALL SIGNAL AMPLIFIERS**	**9**
Small signal analysis of common emitter, common collector and common base amplifiers, Differential amplifiers, Cascaded amplifier, Cascoded amplifier		
UNIT-II	**JFET AND MOSFET AMPLIFIERS**	**9**
Small signal analysis of JFET and MOSFET- common source amplifier, voltage swing limitations, source follower and common gate amplifier, BiMOS Cascode amplifier		
UNIT-III	**FREQUENCY ANALYSIS OF BJT AND FET AMPLIFIERS**	**9**
Low frequency analysis of BJT and FET, Miller effect, High frequency analysis of CE and FET CS amplifier, short circuit current gain of CC amplifier, cut-off frequencies of CE and CB amplifiers (f_α and f_β), Gain bandwidth product, determination of bandwidth for multistage amplifiers		
UNIT-IV	**FEEDBACK AMPLIFIERS AND OSCILLATORS**	**9**
Feedback topologies-voltage series, current series, voltage shunt, current shunt, effect of feedback on gain, bandwidth, noise and non-linear distortion. Oscillators-Introduction, Bark-hausen Criterion, Analysis of RC oscillators, LC oscillators.		
UNIT-V	**POWER AMPLIFIERS AND IC MOSFET**	**9**
Power amplifiers-Class A, Class B, Class C and Class D, Buck and Boost converter, IC biasing- current steering circuit using MOSFET, Amplifier with active loads – Enhancement and depletion load, CMOS- common source amplifier, source follower and differential amplifier- CMRR.		
		Total Contact Hours: 45

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

- Identify DC and AC characteristics of BJT amplifier circuits
- Explain DC and AC characteristics of FET amplifier circuits
- Determine the frequency response of BJT and FET amplifiers
- Analyse Feedback Amplifiers and Oscillators
- Design the Power Amplifiers and IC MOSFET Amplifier

Suggested Activities:

- Problem solving sessions – Design of CS MOSFET Amplifiers with emphasis on aspect ratio of the channel
- Flipped classroom – CMOS Memory devices

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems – Design a CMOS inverter for a high noise margin.
- Quizzes – Frequency response of BJT, FET, gain bandwidth product.

Text Book(s):

1. Donald. A. Neamen, Electronic Circuit Analysis and Design – 2nd Edition, Tata McGraw Hill, 2009.
2. Robert L. Boylestad and Louis Nasheresky, “Electronic Devices and Circuit Theory”, 10th Edition, Pearson Education / PHI, 2008
3. R.S.Sedha, "A Text Book of Applied Electronics" S.Chand publishing 2008.

Reference Book(s) / Web links:
• BehzadRazavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw Hill, 2007.
• Millman.J. and Halkias C.C, "Integrated Electronics", McGraw Hill, 2001.
• D.Schilling and C.Belove, "Electronic Circuits", 3rd Edition, McGraw Hill, 1989.
• David A., "Bell Electronic Devices and Circuits", Oxford Higher Education Press, 5th Edition, 2010

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23311.1	3	3	3	1	3	-	-	-	1	-	2	1	1	1	3
EC23311.2	3	3	3	2	3	-	-	-	1	-	2	1	1	1	3
EC23311.3	3	2	1	3	3	-	-	-	1	-	2	1	1	1	3
EC23311.4	3	3	3	3	-	1	1	-	1	-	2	3	2	3	3
EC23311.5	3	2	1	3	-	1	1	-	1	-	-	3	2	3	3
Average	**3**	**2.6**	**2.2**	**2.4**	**1.8**	**0.4**	**0.4**	**-**	**1**	**-**	**1.6**	**1.8**	**1.4**	**1.8**	**3**

Course Code	Course Title	Category	L	T	P	C
EC23312	ELECTROMAGNETIC FIELDS	PC	3	0	0	3

Objectives:
• To understand the basics of static electric field and the associated laws.
• To attain knowledge on the basics of static magnetic field and Maxwell's equations.
• To study the waves in homogeneous medium.
• To learn the reflection and refraction of plane waves.
• To impart knowledge on applications of static field and FEM.

UNIT-I	STATIONARY ELECTRIC FIELDS	9
Coulomb's law and field intensity, Electric flux density, Gauss's law, Applications of Gauss law for point and infinite line charge distributions, Electric potential, Relationship between E and V, an electric dipole. Boundary conditions for dielectric-dielectric interface. Poisson's and Laplace equation. Capacitance, Capacitance of various geometries using Laplace equations.		
UNIT-II	**STATIONARY MAGNETIC FIELDS & MAXWELL'S EQUATIONS**	**9**
Biot-Savart Law, Magnetic field Intensity, Magnetic flux and magnetic flux density, Estimation of Magnetic field intensity for finite straight conductor. Ampere's circuital law, Application of Ampere's law on infinitely long coaxial transmission line. Scalar and Vector magnetic potentials. Inductance of Solenoid and Toroid. Magnetic boundary condition. Integral and differential form of Maxwell's equations.		
UNIT-III	**ELECTROMAGNETIC WAVES IN A HOMOGENOUS MEDIUM (Qualitative only)**	**9**
Constitutive relations, Solution for free-space conditions, Uniform plane-wave propagation, Uniform plane waves, Relation between E and H in a uniform plane wave, Wave equation for a conducting medium, Wave propagation in lossless medium, Wave propagation in a conducting medium. Conductors and dielectrics, Wave propagation in good dielectric, Wave propagation in good conductor, Depth of penetration, Polarization of uniform plane wave.		
UNIT-IV	**REFLECTION AND REFRACTION OF PLANE WAVES (Qualitative only)**	**9**
Reflection by a perfect conductor – Normal incidence. Reflection by a perfect conductor – Oblique incidence, E perpendicular to the plane of incidence, E parallel to the plane of incidence. Reflection by a perfect dielectric – Normal incidence. Reflection by a perfect insulator – Oblique incidence, perpendicular polarization, parallel polarization, Snell's law, Brewster angle, Total internal reflection. Poynting's Theorem. Power flow for a plane wave, Power flow in a concentric cable. Instantaneous, average and complex Poynting vector.		
UNIT-V	**COMPUTATIONAL ELECTROMAGNETICS AND APPLICATIONS**	**9**
The finite element method – finite element discretization, element governing equations, assembling all the elements, solving the resulting equations by iteration method and band matrix method. Applications – Electrostatic discharge, Magnetic Levitation.		
Total Contact Hours: 45		

Course Outcomes: On completion of course, students will be able to
• Describe electro-static theory and apply them for modelling and analysis of capacitors.
• Explain magneto-static theory for modelling and analysis of inductors.
• Characterize uniform plane wave and its propagation in various media.
• Analyse the reflection and refraction of waves at media interface.
• Apply the static field concepts for various applications.

Suggested Activities:

- Problem solving sessions- Coulomb's law and field intensity, Electric flux density, Poisson's and Laplace equation, Magnetic field Intensity, Magnetic flux and magnetic flux density.
- Flipped classroom - Snell's law, Brewster angle.
- Survey on various applications of Gauss law and Ampere's circuital law.

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes - Capacitance of various geometries using Laplace equations and Integral and differential form of Maxwell's equation.
- Class Presentation/Discussion – Finite Element Method.

Text Book(s):

- Mathew N. O. Sadiku, 'Principles of Electromagnetics', 4th Edition, Oxford University Press Inc., First Indian edition, 2009. (Unit I, II & V).
- E.C.Jordan and K.G. Balmain, 'Electromagnetic Waves and Radiating Systems', Prentice Hall of India, 2006. (Unit III, IV).

Reference Book(s) / Web links:

- W.H.Hayt and A.Buck,Engineering Electro Magnetics , 8th Edition, Mc Graw Hill, 2011
- R.K. Shevgaonkar, Electromagnetic Waves, Tata McGraw Hill India, 2005.
- Ramo, Whinnery and Van Duzer: "Fields and Waves in Communications Electronics" John Wiley & Sons, 3rd edition 2003.
- Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 2010.
- G.S.N Raju, 'Electromagnetic Field Theory and Transmission Lines' Pearson Education, First edition, 2005.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23312.1	3	2	2	2	1	1	1	1	2	1	1	2	2	2	1
EC23312.2	3	2	2	2	1	1	1	1	2	1	1	2	2	2	1
EC23312.3	3	2	2	1	1	1	1	1	1	1	1	1	2	2	1
EC23312.4	3	2	2	1	1	1	1	1	1	1	1	1	2	2	1
EC23312.5	3	3	2	2	1	1	2	1	1	3	2	3	3	2	3
Average	**3**	**2.2**	**2**	**1.6**	**1**	**1**	**1.2**	**1**	**1.4**	**1.4**	**1.2**	**1.8**	**2.2**	**2**	**1.4**

Course Code	Course Title	Category	L	T	P	C
EC23313	DIGITAL PRINCIPLES AND SYSTEM DESIGN	PC	3	0	0	3

Objectives:

- To learn basic postulates of Boolean algebra and infer the methods for simplifying Boolean expressions.
- To illustrate the formal procedures for the design of Combinational circuits and HDL models for the same.
- To extrapolate the design of Synchronous Sequential circuits using Flip-Flops.
- To know the design procedure of Asynchronous Sequential circuits and its problems.
- To understand the concept of Programmable Logic Devices for the design of digital circuits.

UNIT-I	MINIMIZATION TECHNIQUES AND LOGIC GATES	9

Fundamentals: Boolean postulates and laws, De-Morgan's Theorem, Principle of Duality, Boolean expression, Minterm, Maxterm, Sum of Products (SOP), Product of Sums (POS).

Minimization Techniques: Minimization of Boolean expressions using Boolean laws, Karnaugh map, Quine McCluskey method of minimization, don't care conditions.

Logic Gates: Implementation of Logic Functions using gates, NAND–NOR implementations.

UNIT-II	COMBINATIONAL CIRCUITS	9

Half adder and Full adder, Half subtractor and Full subtractor, Binary to Gray and Gray to Binary Code converters, 3-bit Parity generator and 4-bit Parity checker, 2-bit Magnitude Comparator, Multiplexer – Logical function using Multiplexer and Demultiplexer, Encoder, Decoder, BCD to Seven Segment Display Decoder.

Verilog HDL: Introduction to HDL, Module declaration, Gate delays, Boolean expressions, Modelling Techniques – Gate Level, Data Flow and Behavioral. HDL models for combinational circuits - Full adder, full subtractor, multiplexer and demultiplexer, decoder.

UNIT-III	SYNCHRONOUS SEQUENTIAL CIRCUITS	9

Memory elements: Latches, Flip-flops: RS, JK, D, T, Master-Slave, Triggering of Flip Flops, Realization of one flip flop using other flip flop.

Design: Synchronous and Asynchronous counters - Up/Down counter, Modulo–N counter. Shift Registers - SISO, SIPO, PISO, PIPO, Shift Register Counters - Ring counter, Shift counter.

Verilog HDL: HDL models for Sequential circuits - Flip-Flops - JK, D, shift register, Ripple counter.

UNIT-IV	ASYNCHRONOUS SEQUENTIAL CIRCUITS	9

Analysis of Fundamental and Pulse mode asynchronous sequential circuits, Design of Fundamental and Pulse mode Circuit, Problems in Asynchronous Sequential Circuits- Races, Cycles and Hazards.

UNIT-V	PROGRAMMABLE LOGIC DEVICES & HDL	9

Programmable Logic Devices (PLD): Programmable Logic Array (PLA), Programmable Array Logic (PAL), Field Programmable Gate Arrays (FPGA), Complex Programmable Logic Devices (CPLD), Implementation of Combinational Logic Circuits using PROM, PLA, PAL.

Total Contact Hours: 45

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

- Simplify the Boolean expressions using basic postulates of Boolean algebra with suitable minimization.
- Apply the procedure to design and implement combinational circuits and HDL models for the same.
- Construct Synchronous Sequential circuits using Flip-Flops.
- Design Asynchronous Sequential circuits and analyse its problems.
- Implement digital circuits using Programmable Logic Devices.

Suggested Activities:

- Problem solving sessions - Tabulation method
- Flipped classroom - FPGA, CPLD

Suggested Evaluation Methods:

- Tutorial problems - Fundamental and pulse mode asynchronous sequential circuits.
- Assignment problems - K-map, Quine Mc-Cluskey method
- Quizzes - Boolean postulates and Flip-flop tables

Text Book(s):
1. M. Morris Mano, "Digital Design", 4th Edition, Prentice Hall of India Pvt. Ltd., 2008 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2003.
2. Charles H.Roth. "Fundamentals of Logic Design", 7th Edition, Thomson Learning, 2014.

Reference Book(s) / Web links:
1. Thomas L. Floyd, "Digital Fundamentals", 10th Edition, Pearson Education Inc, 2011.
2. John F.Wakerly, "Digital Design", Fourth Edition, Pearson/PHI, 2008
3. John.M Yarbrough, "Digital Logic Applications and Design", Thomson Learning, 2006.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23313.1	3	2	2	2	1	1	1	1	1	1	-	1	3	1	1
EC23313.2	3	3	3	2	2	3	2	1	2	1	2	1	3	3	2
EC23313.3	3	3	3	3	2	3	2	2	2	1	2	2	3	3	2
EC23313.4	3	3	3	3	2	2	2	2	2	1	2	2	3	3	2
EC23313.5	3	3	3	3	3	3	2	2	2	2	2	3	3	3	2
Average	**3**	**2.8**	**2.8**	**2.6**	**2**	**2.4**	**1.8**	**1.6**	**1.8**	**1.2**	**2**	**1.8**	**3**	**2.6**	**1.8**

Course Code	Course Title	Category	L	T	P	C
EC23332	PRINCIPLES OF MICROPROCESSOR AND MICROCONTROLLERS	PC	3	0	2	4

Objectives:
• To learn the concepts of 8086 architecture and multi-processor configuration.
• To understand the methods of interfacing peripheral devices to a microprocessor.
• To recognize the functionality of 8051 microcontroller.
• To realize the functionality of ARM Processor.
• To interpret the Arduino usage and its applications.

UNIT-I	THE 8086 MICROPROCESSOR	9
8086 architecture – 8086 signals – Addressing modes –Instruction set– Assembly Language Programming– Maximum mode and Minimum mode. Coprocessor, closely coupled and Loosely Coupled multiprocessor configurations.		
UNIT-II	**PERIPHERALS & INTERFACING**	**9**
Introduction to IO – Programmable peripheral interface (8255)–Programmable Timer/controller (8253) –Keyboard /display controller (8279) – Serial communication interface (8251) – D/A and A/D Interface–Programmable Interrupt controller (8259).		
UNIT-III	**THE 8051 MICROCONTROLLER**	**9**
Architecture of 8051 – Special Function Registers (SFRs) - I/O Pins Ports- Timers – Interrupts – Serial communication - Instruction set - Addressing modes - Assembly language programming. Case study –Stepper motor & traffic light control using 8051.		
UNIT-IV	**ARM PROCESSOR**	**9**
Introduction to ARM Processor-ARM Processor–Processor Families – Features of ARM - ARM7 TDMI Architecture – Programmer's Model – Interrupts and Exceptions- Operating Modes– Addressing Modes – ARM Instruction Set.		
UNIT-V	**ARDUINO MICROCONTROLLER**	**9**
ATmega328P microcontroller Pin configuration and architecture - Concept of digital and analog ports- Serial Communication with Arduino - Basics of Embedded C programming for Arduino- Interfacing of Led, Switch, Temperature, Motion, Light and Gas Sensor with Arduino-Interfacing of Relay Switch and Servo Motor with Arduino.		
Total Contact Hour : 45		

Description of the Experiments:	Total Contact Hours: 30
8086 Microprocessor	
1. 16-bit Arithmetic Operations	
2. Logical operations	
3. String manipulations	
8086 Programs using MASM	
4. Display a message	
5. Password checking	
Peripherals and Interfacing	
6. 8279 - Key board and Display Controller	
7. 8255 - Parallel interface	
8. 8253– Timer interface	
8051 Microcontroller	
9. 8-bit Arithmetic Operations	
10. Stepper Motor Control	
Tinkercad Experiment: Interfacing with Sensors and Actuators	
11. LED and switch Interfacing with ARDUINO	
12. Motion Sensor Interfacing and Light Sensor Interfacing with ARDUINO	
13. Gas Sensor Interfacing and Servo Motor Interfacing with ARDUINO	

Course Outcomes: On completion of course, students will be able to
• Compose Assembly-language program to perform basic operations using 8086 Microprocessor.
• Code and Interface various peripherals with 8086 and 8051.
• Perform Assembly-language program to perform basic operations using 8051 Microcontroller.
• Develop project for different applications using advanced Microcontrollers.
• Interface various peripherals with Arduino.

Suggested Activities:

- Problem solving sessions - Solving simple programming
- Flipped classroom – Instruction set 8051

Suggested Evaluation Methods:

- Assignment problems – Programming of 8086, 8051
- Quizzes – Architecture, Instruction set topics
- Class Presentation/Discussion- Architecture topics

Text Book(s):	
1.	A.K. Ray, K.M. Bhurchandi, - Advanced Microprocessor and Peripherals, Second edition, Tata McGraw-Hill, 2010.
2.	Mohamed Ali Mazidi, Janice Gillispie Mazidi, Rolin Mc Kinlay, "The 8051 Microcontroller and Embedded Systems: Using Assembly and C", Second Edition, Pearson education, 2011.
3.	Massimo Banzi, "Getting started with Arduino" 2nd Edition, Orelly 2011.

Reference Book(s) / Web links:	
1.	Doughlas V. Hall, "Microprocessors and Interfacing, Programming and Hardware", TMH, 2012
2.	Kenneth J. Ayala, "The 8086 Microprocessor: Programming & Interfacing the PC", Delmar Publishers, 2007.
3.	Steve Furber, "ARM system On Chip Architecture", Addison Wesley, 2000

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1	8086 Microprocessor trainer kit	18
2	8051 Microcontroller trainer kit	18
3	PC with MASM software	5
4	8255 Parallel Interface	3
5	8253 timer Interface	3
6	8279 Keyboard display Interface	3
7	CRO	3
8	Stepper motor interface	3

Suggested Evaluation Methods:

- Experiment based viva
- Quizzes
- Mini Project

Web links for virtual lab (if any):

- Real Time Embedded Systems Laboratory (iitkgp.ac.in)

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23332.1	3	3	3	2	1	1	1	1	2	2	3	3	2	3	3
EC23332.2	3	3	3	2	1	1	1	1	2	2	3	3	2	3	3
EC23332.3	3	3	3	2	1	1	1	1	2	2	3	3	2	3	3
EC23332.4	3	3	3	2	1	1	1	1	2	2	3	3	3	3	3
EC23332.5	3	3	2	3	2	1	1	1	2	2	3	3	2	3	3
Average	**3**	**3**	**2.8**	**2.2**	**1.2**	**1**	**1**	**1**	**2**	**2**	**3**	**3**	**2.2**	**3**	**3**

Course Code	Course Title	Category	L	T	P	C
CS23336	INTRODUCTION TO PYTHON PROGRAMMING	ES	1	0	4	3
Common to all branches of B. E. / B.Tech program (Except–CSE, CSBS, CSD, IT, AI/ML, CYBER SECURITY, AI/DS)						

Objectives:
• To understand computers, programming languages and their generations and essential skills for a logical thinking for problem solving.
• To write, test, and debug simple Python programs with conditionals, and loops and functions
• To develop Python programs with defining functions and calling them
• To understand and write python programs with compound data-lists, tuples, dictionaries
• To search, sort, read and write data from /to files in Python.

List of Experiments:
1. Study of algorithms, flowcharts and pseudocodes.
2. Introduction to Python Programming and Python IDLE/Anaconda distribution.
3. Experiments based on Variables, Data types and Operators in Python.
4. Coding Standards and Formatting Output.
5. Algorithmic Approach: Selection control structures.
6. Algorithmic Approach: Iteration control structures.
7. Experiments based on Strings and its operations.
8. Experiments based on Lists and its operations.
9. Experiments based on Tuples and its operations.
10. Experiments based on Sets and its operations.
11. Experiments based on Dictionary and its operations.
12. Functions: Built-in functions.
13. Functions: User-defined functions.
14. Functions: Recursive functions.
15. Searching techniques: Linear and Binary.
16. Sorting techniques: Bubble and Merge Sort.
17. Experiments based on files and its operations.
Contact Hours:75

Course Outcomes: On completion of the course, students will be able to:
• Understand the working principle of a computer and identify the purpose of a computer programming language and ability to identify an appropriate approach to solve the problem.
• Write, test, and debug simple Python programs with conditionals and loops.
• Develop Python programs step - wise by defining functions and calling them.
• Use Python lists, tuples, dictionaries for representing compound data.
• Apply searching, sorting on data and efficiently handle data using flat files.

Suggested Evaluation Methods:

- Experiment based viva

Text Book(s):
1. Allen B. Downey, Think Python : How to Think Like a Computer Scientist, Second edition,UpdatedforPython3, Shroff/ O'Reilly Publishers, 2016 (http://greenteapress.com/wp/think-python/)
2. Guido Van Rossum and Fred L. Drake Jr, An Introduction to Python-Revised and updated for Python3.2, Network Theory Ltd., 2011.

Reference Book(s) / Web links:
1. John V Guttag, Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press, 2013.
2. Robert Sedgewick, Kevin Wayne, Robert Dondero, Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd, 2016.
3. Timothy A.Budd, Exploring Python, Mc-Graw Hill Education (India) Private Ltd., 2015.
4. Kenneth A. Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2012.
5. Charles Dierbach, Introduction to Computer Science using Python: A Computational Problem Solving Focus, Wiley India Edition, 2013.
6. Paul Gries, Jennifer Campbell and Jason Montojo, Practical Programming: An Introduction to Computer Science using Python3, Second edition, Pragmatic Programmers, LLC, 2013.

Lab Requirements:

Python3 interpreter for Windows/Linux

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CS23336.1	2	2	2	2	1	-	-	-	1	1	1	1	3	3	-
CS23336.2	2	1	1	1	1	-	-	-	-	-	1	1	3	2	-
CS23336.3	1	1	2	1	2	-	-	-	-	-	1	1	2	3	2
CS23336.4	2	2	3	2	2	-	-	-	-	-	2	1	2	2	2
CS23336.5	2	2	3	2	3	-	-	-	-	-	2	1	2	2	2
Average	**1.8**	**1.6**	**2.2**	**1.6**	**1.8**	**0.0**	**0.0**	**0.0**	**0.2**	**0.2**	**1.4**	**1**	**2.4**	**2.4**	**2**

Course Code	Course Title	Category	L	T	P	C
EC23321	ANALOG AND DIGITAL CIRCUITS LABORATORY	PC	0	0	4	2

Objectives:

- To understand the characteristics, design and analyse the frequency response of CE, CB, CC and CS amplifiers.
- To analyse the CMRR value of differential amplifier and frequency response of Feedback amplifiers.
- To design and implement combinational circuits like Converter, Mux/ Demux.
- To design and implement sequential circuits like Counters, Shift Registers.
- To simulate analog circuits using PSPICE and digital circuits using Verilog HDL.

Description of the Experiments:

List of Analog Experiments

1. Frequency Response of CE, CB, CC amplifiers.
2. Frequency Response of CS amplifier.
3. Differential amplifier- CMRR measurement.
4. Frequency Response of Feedback amplifiers.
5. Realization of Common Emitter and Common Source amplifiers using PSPICE.

List of Digital Experiments

6. Design and Implementation of Binary to Gray and Gray to Binary code converters using logic gates.
7. Design and Implementation of Multiplexer and De-multiplexer using logic gates.
8. Design and Implementation of BCD Synchronous and Decade, Mod-14 Asynchronous counters.
9. Implementation of SISO, SIPO, PISO and PIPO shift registers using Flip- Flop.
10. Realization of digital circuits using Verilog HDL
    Combination Circuits: Half adder, Full adder, Half subtractor, Full subtractor, Multiplexer, Demultiplexer
    Sequential circuits: Flip Flops, Shift Registers, Counters.

Total Contact Hours: 60

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

- Design and analyse CE, CB, CC and CS amplifiers.
- Measure CMRR of differential amplifier and frequency response of feedback amplifiers.
- Design and implement combinational circuits.
- Design and implement sequential circuits.
- Simulate analog and digital circuits.

Suggested Evaluation Methods:

- Experiment based viva

Reference Book(s) / Web links:

1. Donald .A. Neamen, Electronic Circuit Analysis and Design – 2nd Edition, Tata McGraw Hill, 2009.
2. Robert L. Boylestad and Louis Nasheresky, "Electronic Devices and Circuit Theory", 10th Edition, Pearson Education / PHI, 2008.
3. M. Morris Mano, "Digital Design", 4th Edition, Prentice Hall of India Pvt. Ltd., 2008 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2003.
4. Charles H.Roth. "Fundamentals of Logic Design", 7th Edition, Thomson Learning, 2014.

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1	CRO (30MHz)	15
2	Signal Generator /Function Generators (3 MHz)	15
3	Dual Regulated Power Supplies (0 - 30V)	15
4	Standalone desktop PCs with SPICE software (any public domain or commercial software)	15
5	Transistor/FET (BJT-NPN-PNP and NMOS/PMOS)	50
6	Dual power supply/single mode power supply	15
7	Resistors, Capacitors, Inductors	50
8	Diodes, Zener diode	10
9	IC Trainer Kit	15
10	Bread Boards	15
11	Computer with HDL software (any public domain or commercial software)	15
12	Seven segment display	15
13	Multimeter	15
14	ICs 7400/ 7402 / 7404 / 7486 / 7408 /7432 / 7483 / 74150 / 74151 / 74147 /7445 / 7476/7491/ 555 / 7494 / 7447 /74180 / 7485 / 7473 / 74138 / 7411 /7474	50

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23321.1	3	3	3	3	2	2	2	2	3	3	2	2	2	2	2
EC23321.2	3	3	3	3	2	2	2	2	3	3	2	2	2	2	2
EC23321.3	3	3	3	3	2	2	2	2	3	3	2	2	2	2	2
EC23321.4	3	3	3	3	2	2	2	2	3	3	2	2	2	2	2
EC23321.5	3	3	3	2	3	2	2	2	3	3	2	3	2	2	2
Average	**3**	**3**	**3**	**2.8**	**2.2**	**2**	**2**	**2**	**3**	**3**	**2**	**2.2**	**2**	**2**	**2**

SEMESTER – IV

Course Code	Course Title	Category	L	T	P	C
EC23411	SIGNALS AND SYSTEMS	PC	3	0	0	3

Objectives:

- To understand the basic properties of Signals & Systems and the various methods of classification
- To learn Fourier transform, Laplace transform & Z- transform for signals and systems analysis
- To learn the characteristics of CT and DT LTI systems using Laplace transform & Z- transform

UNIT-I	**CONTINOUS TIME AND DISCRETE TIME SIGNALS**	**9**

Continuous time signals (CT signals) & Discrete time signals (DT signals) - Step, Ramp, Pulse, Impulse, Complex exponential and Sinusoidal signals. Classification of CT and DT signals- Periodic & Aperiodic signals, Deterministic & Random signals, Energy & Power signals, Even and Odd signals.

UNIT-II	**CONTINOUS TIME AND DISCRETE TIME SYSTEMS**	**9**

CT systems and DT systems - Classification of systems: Static & Dynamic, Linear & Nonlinear, Time-variant & Time-invariant, Causal & Non-causal, Stable & Unstable. Convolution integrals and Convolution sum.

UNIT-III	**FOURIER ANALYSIS FOR CT SIGNALS AND SYSTEMS**	**9**

Trigonometric Fourier series analysis - Fourier Transforms, Properties of Fourier transform, Fourier Transforms in CT signal analysis, CT system characterization using Fourier transforms.

UNIT-IV	**LAPLACE TRANSFORM FOR CT SIGNALS AND SYSTEMS**	**9**

Laplace Transforms, The region of convergence for Laplace transform, Properties of Laplace transform, Laplace Transforms in CT signal analysis, LTI systems characterized by differential equations.

UNIT-V	**Z-TRANSFORM FOR DT SIGNALS AND SYSTEMS**	**9**

Z-Transforms, ROC, Properties of Z-transform, Inverse Z- Transform- long division method and partial fraction expansion, Z-Transforms in DT signal analysis, Z-transforms in analysis of DT systems.

Total Contact Hours:45

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

- Distinguish the basic properties of Signals
- Identify the basic properties of Systems
- Extrapolate the properties of Fourier transform in signals and systems analysis
- Characterize continuous time LTI systems using Laplace Transforms
- Analyze discrete time signals and LTI systems using Z transform

Suggested Activities:

- Problem solving sessions for all units

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes

Text Book(s):

1. Allan V.Oppenheim, S.Wilsky and S.H.Nawab, “Signals and Systems”, Second edition, Pearson, 2007.
2. B. P. Lathi, “Principles of Linear Systems and Signals”, Third edition, Oxford, 2017.
3. P. Ramakrishna Rao & Shankar Prakriya, Signals and Systems, 2e,Tata McGraw Hill,2013

Reference Book(s) / Web links:

1. R.E.Zeimer, W.H.Tranter and R.D.Fannin, “Signals & Systems - Continuous and Discrete”, Pearson, 2007.
2. John Alan Stuller, “An Introduction to Signals and Systems”, Thomson, 2007.
3. M.J.Roberts, “Signals & Systems Analysis using Transform Methods & MATLAB”, Tata McGraw Hill, 2007.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23411.1	3	3	2	2	1	1	-	-	1	1	1	3	2	3	1
EC23411.2	3	3	2	2	1	1	-	-	1	1	1	3	2	3	2
EC23411.3	3	3	2	2	1	1	-	-	1	1	1	3	2	3	2
EC23411.4	3	3	2	2	1	1	-	-	1	1	1	3	2	3	2
EC23411.5	3	3	2	2	1	1	-	-	1	1	1	3	2	3	2
Average	**3**	**3**	**2**	**2**	**1**	**1**	**-**	**-**	**1**	**1**	**1**	**3**	**2**	**3**	**1.8**

Course Code	Course Title	Category	L	T	P	C
EC23412	TRANSMISSION LINES AND WAVEGUIDES	PC	3	0	0	3

Objectives:
• To impart knowledge on filter design.
• To introduce the basics of transmission lines and losses.
• To expose the usage of Smith Chart for impedance matching techniques.
• To impart knowledge on propagation of waves between parallel planes.
• To provide exposure on the wave propagation in waveguides.

UNIT-I	**PASSIVE FILTERS**	**9**
Filter fundamentals, Design of filters: Constant K - Low Pass, High Pass, Band Pass, Band elimination, m- derived sections - low pass, high pass.		
UNIT-II	**TRANSMISSION LINE THEORY**	**9**
A line of cascaded T sections- The transmission line: general solution - The infinite line - Wavelength, velocity of propagation - Waveform distortion - The distortion-less line -Inductance loading – Campbell's Equation- Line not terminated in Zo - Reflection coefficient - Standing waves, Nodes, Standing Wave Ratio – Line calculation- Input and transfer impedance - Open and short-circuited lines.		
UNIT-III	**IMPEDANCE MATCHING IN HIGH FREQUENCY LINES**	**9**
Impedance matching: Quarter wave transformer - Impedance matching by stubs - Single stub and double stub matching - Smith chart - Solutions of problems using Smith chart - Single and double stub matching design using Smith chart.		
UNIT-IV	**GUIDED WAVES BETWEEN PARALLEL PLANES**	**9**
Application of the restrictions to Maxwell's equations – Transmission of TM waves between parallel planes – Transmission of TE waves between parallel planes. Transmission of TEM waves between parallel planes. Velocities of the waves – Characteristic impedances of planes.		
UNIT-V	**WAVEGUIDES**	**9**
Application of Maxwell's equations to the rectangular wave guide. TM waves in the rectangular guide. TE waves in the rectangular guide, Bessel functions- Introduction to cylindrical waveguides.		
		Total Contact Hours: 45

Course Outcomes: On completion of the course, students will be able to
• Design different types of filters using Constant-K and m-derived sections.
• Recall general solution for the transmission lines and identify issues in lines.
• Construct stub matching networks using Smith chart.
• Determine the field components, wave impedance and characteristic parameters when TE, TM propagate between parallel planes.
• Analyze the propagation of waves in waveguides.

Suggested Activities:

- Problem solving sessions.
- Flipped classroom – Open circuited and short circuited lines.

Suggested Evaluation Methods:

- Tutorial problems- Smith chart
- Assignment problems

Text Book(s):

1. John D Ryder, "Networks, lines and fields", 2nd Edition, Prentice Hall India, 2010.

Reference Book(s) / Web links:

1. E.C.Jordan and K.G. Balmain, ―Electromagnetic Waves and Radiating Systems, Prentice Hall of India, 2006.
2. G.S.N Raju "Electromagnetic Field Theory and Transmission Lines, Pearson Education, First edition 2005.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23412.1	3	3	2	2	1	1	-	-	1	1	1	3	2	3	1
EC23412.2	3	3	2	2	1	1	-	-	1	1	1	3	2	3	2
EC23412.3	3	3	2	2	1	1	-	-	1	1	1	3	2	3	2
EC23412.4	3	3	2	2	1	1	-	-	1	1	1	3	2	3	2
EC23412.5	3	3	2	2	1	1	-	-	1	1	1	3	2	3	2
Average	**3**	**3**	**2**	**2**	**1**	**1**	**-**	**-**	**1**	**1**	**1**	**3**	**2**	**3**	**1.8**

Course Code	Course Title	Category	L	T	P	C
EC23413	COMMUNICATION THEORY	PC	3	0	0	3

Objectives:
• To introduce the concepts of amplitude modulation and demodulation with spectral characteristics
• To learn the concepts of angle modulation
• To know the effect of noise on communication systems
• To understand the concepts of source coding techniques
• To learn the concepts of pulse modulation techniques and mathematical models of communication channel

UNIT-I	AMPLITUDE MODULATION	9
Amplitude Modulation-DSBFC, DSBSC, SSB, VSB , Modulation index, Spectra, Power relations and Bandwidth, AM Generation – Square law modulator, DSBSC Generation–Balanced modulator, SSB Generation – Phase Shift method, VSB Generation – Filter Method, Demodulation-DSBFC-Envelope detector, DSBSC-coherent detector, SSB-SC-Coherent detector, Hilbert Transform, Pre-envelope & complex envelope–Comparison of different AM techniques, Supeheterodyne Receiver, Frequency Division Multiplexing.		
UNIT-II	**ANGLE MODULATION**	**9**
Phase and frequency modulation, Narrow Band and Wide band FM – Modulation index, Spectra and Transmission Bandwidth –FM modulation–Direct and Indirect methods, FM Demodulation – FM to AM conversion, FM Discriminator – PLL as FM demodulator, Stereo FM.		
UNIT-III	**NOISE CHARACTERIZATION**	**9**
Noise sources and types, Noise figure and noise temperature in cascaded amplifiers, Narrow band noise, Representation of narrow band noise in terms of In-phase and quadrature components, Noise performance in AM systems-DSBFC, DSBSC, Noise performance in FM system, Pre-emphasis and De-emphasis, Capture effect.		
UNIT-IV	**INFORMATION THEORY**	**9**
Measure of Information, Rate of information, Entropy, Source coding theorem - Shannon-Fano codes & Huffman codes, Discrete Memoryless channel, Mutual information, Channel Capacity, Shannon-Hartley theorem.		
UNIT-V	**PULSE MODULATION & MATHEMATICAL MODELS OF COMMUNICATION CHANNEL**	**9**
Generation of PAM, PWM and PPM, Comparison of different pulse modulation techniques, Communication Channel Classification, Performance Measure of Communication Systems, Additive Noise channel, Linear Filter Channel, Linear Time-Variant Filter Channel.		
Total Contact Hours: 45		

Course Outcomes: On completion of course, students will be able to
• Compare the various amplitude modulation and demodulation techniques and bandwidth requirement
• Describe the principles of angle modulation techniques
• Analyze the noise performance on various AM and FM systems
• Apply the various source coding techniques on communication systems
• Describe the various pulse code modulation techniques and mathematical models of communication channel

Suggested Activities:

- Problem solving sessions.
- Flipped classroom.

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quiz

Text Book(s):

1. Simon Haykin, "Communication Systems", 4th Edition John Wiley & sons, 2001

Reference Book(s)

1. Amitabha Bhattacharya, "Digital Communication", 7th reprint, McGraw Hill Education, 2017.
2. Dennis Roddy &John Coolen, "Electronic Communications" 4th Edition, Pearson Education, 2008.
3. J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems", 2nd Edition, Pearson Education, 2006.
4. B.P.Lathi, "Modern Digital and Analog Communication Systems", 3rd Edition, Oxford University Press, 2007

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23413.1	3	2	2	2	1	1	-	-	1	1	1	2	3	3	2
EC23413.2	3	2	2	1	1	1	-	-	1	1	1	2	3	3	2
EC23413.3	3	2	2	1	1	1	-	-	1	1	1	2	3	3	2
EC23413.4	3	3	3	2	1	1	-	-	1	1	1	2	3	3	3
EC23413.5	3	1	1	1	1	1	-	-	1	1	1	2	3	3	2
Average	**3**	**2**	**2**	**1.4**	**1**	**1**	**-**	**-**	**1**	**1**	**1**	**2**	**3**	**3**	**2.2**

Course Code	Course Title	Category	L	T	P	C
EC23431	ANALOG CIRCUITS II	PC	3	0	2	4

Objectives:
• To study the characteristics of OP-AMP
• To understand the functioning of OP-AMP and design OP-AMP based circuits
• To learn the applications of analog multipliers and PLL
• To study OP-AMP based ADC and DAC
• To gain knowledge on special function ICs

UNIT-I	OPERATIONAL AMPLFIER AND ITS CHARACTERISTICS	9
Introduction, ideal op-amp, Op-amp-internal circuit, Inverting, non-inverting and DC and AC characteristics, slew rate, frequency compensation techniques.		
UNIT-II	**APPLICATIONS OF OPERATIONAL AMPLFIER**	**9**
Differential amplifiers, Instrumentation amplifiers, integrator and differentiator, summing amplifier, precision rectifier, Schmitt trigger, comparator and their applications, oscillators and multivibrator. Active filters: Low pass, high pass.		
UNIT-III	**ANALOG MULTIPLIER AND PLL**	**9**
Analog Multiplier using Emitter Coupled Transistor pair, Gilbert Multiplier cell, Operation of the basic PLL, closed loop analysis, Voltage controlled oscillator, application of PLL for AM detection, FM detection, FSK modulator and demodulator, Frequency synthesizers.		
UNIT-IV	**DIGITAL TO ANALOG AND ANALOG TO DIGITAL CONVERTERS**	**9**
Digital-to-analog converters (DAC): Weighted resistor, R-2R ladder, Analog to-digital converters (ADC): Single slope, dual slope, successive approximation, flash type.		
UNIT-V	**SPECIAL FUNCTION ICs**	**9**
Timer IC 555, IC Voltage regulators: Three terminal fixed and Adjustable voltage regulators, IC 723 general purpose regulator, Monolithic switching regulator. Frequency to Voltage and Voltage to Frequency converters, Audio Power amplifier, Video Amplifier, Isolation Amplifier, Optocouplers and fibre optic IC.		
		Contact Hours: 45

Description of the Experiments:	Contact Hours: 30
1. Inverting, non-inverting and differential amplifiers using op-amp	
2. Integrator and differentiator using op-amp	
3. Astable multivibrator and Schmitt trigger using op-amp	
4. RC phase shift oscillator using op-amp	
5. Monostable multivibrator using IC 555 timer	
6. R-2R Ladder DAC	
7. DC power supply using LM317 (or) LM723	
8. P-SPICE Simulation of: (a) Multivibrator and Schmitt Trigger Circuit (b) Low pass and band stop active filters	
9. Mini project	

Course Outcomes: On completion of the course, students will be able to
• Describe the op-amp characteristics
• Analyse and design op-amp based circuits
• Implement ADC and DAC
• Design Analog multipliers and PLL
• Design and demonstrate the performance of Multivibrators and Power supplies

Suggested Activities:
• Problem solving sessions- Op amp applications ADC DAC • Flipped classroom – Timers, Switched Mode Power Supply • Activity based learning- Quiz- Instruction set

Suggested Evaluation Methods:

- Tutorial problems – ADC and DAC
- Assignment problems – Active filters
- Quizzes-Op Amp and Regulators
- Class Presentation/Discussion- 555 timer and SMPS

Text Book(s):

1. D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New Age International Pvt. Ltd., 2000
2. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 3rd Edition, Tata Mc Graw-Hill, 2007
3. Adel.S. Sedra, Kenneth C. Smith, "Micro Electronic Circuits", 6th Edition, Oxford University Press, 2010.
4. Ramakant A. Gayakwad, "OP-AMP and Linear ICs", 4th Edition, Prentice Hall / Pearson Education, 2015.

Reference Book(s) / Web links:

1. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw Hill, 2007.
2. Paul Gray, Hurst, Lewis, Meyer "Analysis and Design of Analog Integrated Circuits", 4th Edition, John Willey& Sons 2005
3. Millman.J. and Halkias C.C, "Integrated Electronics", McGraw Hill, 2001.
4. Analog Electronics, L.K. Maheshwari, Laxmi Publications
5. J. Millman and A. Grabel, Microelectronics, 2nd edition, McGraw Hill, 1988.
6. P. Horowitz and W. Hill, The Art of Electronics, 2nd edition, Cambridge University Press, 1989
7. Paul R. Gray and Robert G.Meyer, Analysis and Design of Analog Integrated Circuits, John Wiley, 3rd Edition
8. J.V. Wait, L.P. Huelsman and GA Korn, Introduction to Operational Amplifier theory and applications, McGraw Hill, 1992

Web links for virtual lab:

1. http://www.vlab.co.in/ba-nptel-labs-electronics-and-communications
2. https://www.circuitlab.com/

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1	Power Supply +15 or -15 volts	15
2	Power Supply +5 Volts	15
3	DSO / CRO	15
4	Function Generator	15
5	IC Tester	1
6	Multimeter	5

Suggested Evaluation Methods:

- Experiment based viva
- Online and offline quizzes

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23431.1	3	*2*	2	2	2	1	1	1	2	1	1	2	2	2	2
EC23431.2	3	*2*	2	2	2	1	1	1	2	1	1	2	2	2	2
EC23431.3	3	*2*	2	1	2	1	1	1	2	1	1	2	2	2	2
EC23431.4	3	*2*	2	1	2	1	1	1	3	2	3	2	2	2	2
EC23431.5	3	*2*	2	2	2	1	1	1	3	2	3	2	2	2	2
Average	**3**	**2**	**2**	**1.4**	**2**	**1**	**1**	**1**	**2.4**	**1.4**	**1.8**	**2**	**2**	**2**	**2**

Course Code	Course Title	Category	L	T	P	C
MA23436	PROBABILITY AND RANDOM PROCESSES	BS	3	0	2	4
Common to IV sem. B.E - ECE and BME						

Objectives:
• To apply the theoretical discrete and continuous probability distributions in the relevant application areas.
• To provide the required mathematical support in real life problems and develop probabilistic models which can be used in several areas of science and engineering.
• To classify random processes and to know the concepts of strict stationary, wide-sense stationary and ergodicity.
• To provide necessary concepts in spectral densities and correlation analysis.
• To explain linear time invariant systems with random inputs.

UNIT-I	ONE DIMENSIONAL RANDOM VARIABLES	9
One dimensional Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential and Normal distributions .		
UNIT-II	**TWO DIMENSIONAL RANDOM VARIABLES**	**9**
Two Dimensional Random Variables: Joint distributions – Marginal and conditional distributions - Moments – Covariance – Correlation and Linear regression – Transformation of random variables-Applications of Central Limit Theorem.		
UNIT-III	**RANDOM PROCESS**	**9**
Classification of Random Process: Stationary process – Binomial process – Gaussian process - Markov process - Poisson process and its properties – Discrete parameter Markov chain – Chapman Kolmogorov Theorem (without proof) – Limiting distributions.		
UNIT-IV	**SPECTRAL DENSITIES**	**9**
Auto correlation functions – Cross correlation functions – Properties – Power spectral density – Cross spectral density – Properties.		
UNIT-V	**LINEAR SYSTEMS WITH RANDOM INPUTS**	**9**
Linear time invariant system – System transfer function – Linear systems with random inputs – Auto correlation and Cross correlation functions of input and output.		
Total Contact Hours: 45		

List of Experiment (using MATLAB Software)	Total Contact Hours: 30
1.Basic functions in MATLAB	
2.Mathematical functions in MATLAB	
3.Plotting data sets using MATLAB	
4.Control flow -Loops	
5.Reading and writing data sets – importing data sets	
6. Probability Distributions - PDF, CDF for Binomial, Poisson, Exponential, Uniform and Normal Distributions.	
7.Correlation and regression	
8.Fourier Transform using MATLAB	
9.Linear system with random inputs	
10.Analysis of Power spectral density – signal processing tool box.	
Lab Requirements: 30 Personal Computers	

Course Outcomes: On completion of the course, the students will be able to
• Apply the basic concepts of probability, one dimensional and two dimensional Random Variables in the engineering and technology problems.
• Analyse the data using correlation and regression in real life situation.
• Classify random processes and to apply the concepts of strict stationary, wide-sense stationary and ergodicity in the solution of complex engineering problems.
• Develop skills in solving problems on power spectral density function relevant to the various branches of engineering.
• Interpret linear time invariant systems with random inputs.

Suggested Activities:

- Problem solving sessions
- Smart classroom sessions

Suggested Evaluation Methods:

- Problem solving in tutorial sessions
- Assignment problems
- Quizzes and class test
- Discussion in classroom

Text Book(s):
1. Veerarajan T, 'Probability, Statistics and Random Processes with Queueing Theory and Queueing Networks'.
2. McGraw Hill, 2016. 2 Johnson R.A. and Gupta. C.B., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 7th Edition, 2007.
3. Oliver Ibe, "Fundamentals of Applied Probability and Random Processes", Elsevier, 1st Indian Reprint, 2014.
4. Peebles. P.Z., "Probability, Random Variables and Random Signal Principles", Tata Mc Graw Hill, second Edition, New Delhi, 2000.

Reference Book(s) / Web links:
1. Jhon wiley & Sons .Erwin Kreyszig., "Advanced Engineering Mathematics", Pearson Education, Asia, 7th Edition, 2007.
2. Ramana. B.V., "Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
3. Yates R. D. and Goodman. D.J., "Probability and Stochastic Processes- A Friendly Introduction for Electrical and Computer Engineers ", 2nd Edition, Wiley India Pvt. Ltd., Bangalore, 2014
4. Stark H., and Woods. J.W., "Probability and Random Processes with Applications to Signal Processing", 3rd Edition,Pearson Education, Asia, 2002.
5. Miller S.L. and Childers. D.G., "Probability and Random Processes with Applications to Signal Processing and Communications", Academic Press, 2004.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23436.1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	1
MA23436.2	2	2	1	1	-	-	-	-	-	-	-	1	-	-	1
MA23436.3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	1
MA23436.4	3	2	1	-	-	-	-	-	-	-	-	1	1	-	1
MA23436.5	3	2	1	-	-	-	-	-	-	-	-	1	1	-	1
Average	**2.8**	**2**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**1**

Course Code	Course Title	Category	L	T	P	C
GE23421	SOFT SKILLS-I	EEC	0	0	2	1

Objectives:
• To help students break out of shyness.
• To build confidence.
• To enhance English communication skills.
• To encourage students' creative thinking to help them frame their own opinions.

Learning and Teaching Strategy:

The program is completely student centric where the focus is on activities led by students which include role plays, discussions, debates other games as well. These activities would be supplemented by interactive use of technology and brief trainer input.

Week	Activity Name	Description	Objective
1	Introduction	The trainer and the college facilitator talk to the students about the course and in turn the students introduce themselves.	To set expectations about the course and the students are made aware of the rules and regulations involved in this program
2	If I ruled the world	This is a quick and useful game by getting students to form a circle and provide their point of view. Each student then repeats what the other has said and comes up with their own opinion.	The aim of this activity is to for students to get to know each other and also develop their listening skills as well as learning how to agree and disagree politely.
3	Picture Narrating	This activity is based on several sequential pictures. Students are asked to tell the story taking place in the sequential pictures by paying attention to the criteria provided by the teacher as a rubric. Rubrics can include the vocabulary or structures they need to use while narrating.	The aim of this activity is to make the students develop creative way of thinking.
4	Brainstorming	On a given topic, students can produce ideas in a limited time. Depending on the context, either individual or group brainstorming is effective and learners generate ideas quickly and freely. The good characteristics of brainstorming are that the students are not criticized for their ideas so students will be open to sharing new ideas.	The activity aims at making the students speak freely without the fear of being criticized. It also encourages students to come up with their own opinions.
5	Debate	Is competition necessary in regards to the learning process?	The aim of this activity is to develop the students ability to debate and think out of the box
6	Short Talks	Here the students are given topics for which they take one minute to prepare and two minutes to speak. They can write down points but can't read them out they can only use it as a reference.	The activity aims at breaking the students' shyness and encouraging them to standup in front of the class and speak. It also aims at creating awareness that they are restricted for time so they only speak points that are relevant and important.
7	Debate	Will posting students' grades on bulletin boards publicly motivate them to perform better or is it humiliating?	This activity aims at enhancing the students unbiased thought process when it comes to exams and grades as well as develop their skills to debate
8	The Art of diplomacy	The facilitator proceeds to share multiple concepts of conversation and helps the participants to identify the	The aim of the lesson is to provide an opportunity for the participants to

		various methods of being diplomatic and how do deal with misinformation.	learn about body language and choosing the appropriate words for conversation.
9	Debate	Are humans too dependent on computers?	The aim of this activity is to test the students debating skills and thought process with a topic that affects everybody in daily life.
10	Story Completion	The teacher starts to tell a story but after 2 sentences he/she asks students to work in groups to create the rest of the story which includes the plot and the ending.	This activity aims at building their narrating skills as well as their creativity and ability to work in a team.
11	Role play debate	Students scrutinize different points of view or perspectives related to an issue. For example, a debate about the question "Should students be required to wear uniforms at school?" might yield a range of opinions. Those might include views expressed by a student (or perhaps two students – one representing each side of the issue), a parent, a school principal, a police officer, a teacher, the owner of a clothing store, and others.	The aim of this activity is to get students to speak based on other people's perspective instead of their own. The students take the role of various characters and debate accordingly.
12	I Couldn't Disagree More	This is a game where students practice rebuttal techniques where one student provides a thought or an idea and the other students starts with the phrase I couldn't disagree more and continues with his opinion	The aim of this activity is to improve general communication skills and confidence.
	Feedback	At the end of the session in the final week (12) the trainer would provide feedback to the students on best practices for future benefits	The aim is to do both give feedback to students as well as obtain feedback on the course from them.

Course Outcomes: On completion of the course, the students will be able to
• Be more confident.
• Speak in front of a large audience.
• Be better creative thinkers.
• Be spontaneous.
• Know the importance of communicating in English.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23421.1	-	-	-	-	-	2	-	2	3	3	2	3	-	-	3
GE23421.2	-	-	-	-	-	2	-	2	3	3	2	3	-	-	3
GE23421.3	2	3	3	3	2	-	-	2	2	2	2	3	2	3	3
GE23421.4	-	2	-	-	-	-	-	-	3	3	2	3	-	-	3
GE23421.5	-	2	-	-	-	-	-	-	3	3	2	3	-	-	3
Average	**2**	**2.33**	**3**	**3**	**2**	**2**	**-**	**2**	**2.8**	**2.8**	**2**	**3**	**2**	**3**	**3**

Course Code	Course Title	Category	L	T	P	C
CS23422	PYTHON PROGRAMMING FOR MACHINE LEARNING	ES	0	0	4	2

Objectives:
• To understand the relationship of the data collected for decision making.
• To know the concept of principal components, factor analysis and cluster analysis for profiling and interpreting the data collected.
• Lay the foundation of machine learning and its practical applications and prepare students for real-time problem-solving in data science.
• Develop self-learning algorithms using training data to classify or predict the outcome of future datasets.
• Distinguish overtraining and techniques to avoid it such as cross-validation.

List of Experiments:
1. NumPy Basics: Arrays and Vectorized Computation
2. Getting Started with pandas
3. Data Loading, Storage, and File Formats
4. Data Cleaning and Preparation
5. Data Wrangling: Join, Combine, and Reshape
6. Plotting and Visualization
7. Data Aggregation and Group Operations
8. Time Series
9. Supervised Learning
10. Unsupervised Learning and Pre-processing
11. Representing Data and Engineering Features
12. Model Evaluation and Improvement
Contact Hours: 60

Course Outcomes: On completion of the course, the students will be able to
• Develop a sound understanding of current, modern computational statistical approaches and their application to a variety of datasets.
• Analyze and perform an evaluation of learning algorithms and model selection.
• Compare the strengths and weaknesses of many popular machine learning approaches.
• Appreciate the underlying mathematical relationships within and across machine learning algorithms and the paradigms of supervised and unsupervised learning.
• Design and implement various machine learning algorithms in a range of real-world applications.

Text Book(s):
1. Wes McKinney, Python for Data Analysis - Data wrangling with pandas, Numpy, and ipython, Second Edition, O'Reilly Media Inc, 2017.
2. Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python - A Guide for Data Scientists, First Edition, O'Reilly Media Inc, 2016.

Reference Book(s) / Web links:
1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, O'Reilly Media Inc, 2019.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CS23422.1	2	2	2	2	1	-	-	-	1	1	1	1	3	3	-
CS23422.2	2	1	1	1	1	-	-	-	-	-	1	1	3	2	-
CS23422.3	1	1	2	1	2	-	-	-	-	-	1	1	2	3	2
CS23422.4	2	2	3	2	2	-	-	-	-	-	2	1	2	2	2
CS23422.5	2	2	3	2	3	-	-	-	-	-	2	1	2	2	2
Average	**1.8**	**1.6**	**2.2**	**1.6**	**1.8**	**0.0**	**0.0**	**0.0**	**0.2**	**0.2**	**1.4**	**1**	**2.4**	**2.4**	**2**

SEMESTER V

Course Code	Course Title	Category	L	T	P	C
EC23511	CONTROL SYSTEM ENGINEERING	PC	2	1	0	3

Objectives:
• To understand the elements of control system and their modeling using various techniques
• To learn time response analysis of various systems
• To study the frequency response characteristics of the systems
• To depict different methods for stability analysis
• To introduce the state variable analysis for CT and DT systems

UNIT-I	**CONTROL SYSTEM MODELING**	**9**
Basic elements of Control System, Open loop and Closed loop systems, Differential equation, Transfer function, Modelling of Electrical and Mechanical systems, Block diagram reduction techniques, Signal flow graph.		
UNIT-II	**TIME RESPONSE ANALYSIS**	**9**
Time response analysis - first order systems, Impulse and Step response analysis of second order systems, Steady state errors, P, PI, PD and PID Controllers.		
UNIT-III	**FREQUENCY RESPONSE ANALYSIS**	**9**
Frequency Response analysis - Bode Plot, Polar Plot, Constant M & N circles, Compensators (Qualitative Approach) - Lead, Lag, and Lead-Lag		
UNIT-IV	**STABILITY ANALYSIS**	**9**
Stability analysis – Routh Array, Hurwitz criterion, Root Locus technique - construction of Root Locus, dominant Poles, Nyquist Stability criterion-Relative Stability		
UNIT-V	**STATE VARIABLE ANALYSIS**	**9**
State space representation of Continuous Time systems, State equations, Transfer function from state variable representation, Solutions of the state equations, Concepts of Controllability and Observability, Introduction to State space representation for Discrete time systems (Qualitative approach).		
	Total Contact Hours: 45	

Course Outcomes: On completion of the course, students will be able to
• Compute the transfer function of different physical systems
• Examine the time domain specifications and calculate the steady state error
• Illustrate the frequency response characteristics of systems
• Determine the stability of systems using Routh-Hurwitz, Nyquist stability and Root Locus technique
• Analyze the state space model of continuous and discrete systems

Suggested Activities:

- Problem solving sessions – Tutorial classes
- Flipped classroom
- Activity Based Learning

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes

Text Book(s):
1. J.Nagrath and M.Gopal, “Control System Engineering”, New Age International Publishers, 5th Edition, 2007.
2. M.Gopal, “Control System – Principles and Design”, Tata McGraw Hill, 2nd Edition, 2006.

Reference Book(s) / Web links:
1. Benjamin.C.Kuo, “Automatic control systems”, Prentice Hall of India, 7th Edition, 1995.
2. Schaum‟s Outline Series, “Feedback and Control Systems” Tata Mc Graw-Hill, 2007.
3. Joseph J. DiStefano, Allen R. Stubberud, Schaum's Outline of ―Feedback and Control Systems, McGraw-Hill Education; 2nd edition 2013.
4. S.K.Bhattacharya, “Control Systems Engineering” Pearson Education, 2012

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23511.1	3	3	3	2	1	1	1	1	1	1	1	1	3	3	2
EC23511.2	3	3	3	2	3	2	2	1	1	2	1	2	3	3	2
EC23511.3	3	3	3	3	3	2	2	1	1	2	1	2	3	3	2
EC23511.4	3	3	3	3	3	2	2	1	1	2	1	2	3	3	2
EC23511.5	3	3	3	3	3	3	2	1	1	2	1	3	3	3	2
Average	**3**	**3**	**3**	**2.6**	**2.6**	**2**	**1.8**	**1**	**1**	**1.8**	**1**	**2**	**3**	**3**	**2**

Course Code	Course Title	Category	L	T	P	C
EC23512	MODERN DIGITAL COMMUNICATION	PC	3	0	0	3

Objectives:

- To understand the functional components and principles of digital communication system
- To study the various waveform coding schemes
- To learn the various baseband and band pass schemes and its effect on signal transmission.
- To know the fundamentals of error control coding schemes.
- To understand the concepts of various emerging technologies in Digital Communication.

UNIT-I	**QUANTIZATION AND PULSE MODULATION**	**9**

Review of Lowpass Sampling, Aliasing, Signal reconstruction - Quantization - Uniform & non-uniform quantization - Quantization noise - Logarithmic companding of speech signal - Overview of PAM, PWM, PPM. Encoder and Decoder of PCM.

UNIT-II	**WAVEFORM CODING**	**9**

DPCM -ADPCM - Delta modulation - ADM - Linear Predictive Coding, Line codes and its properties – TDM.

UNIT-III	**BASEBAND AND PASSBAND TRANSMISSION**	**9**

ISI - Nyquist criterion for distortionless transmission - Pulse shaping - Eye pattern – Correlative coding. Generation, detection and BER analysis of coherent BPSK, BFSK, QPSK, QAM.

UNIT-IV	**ERROR CONTROL CODING**	**9**

Channel coding theorem - Linear Block Codes - Hamming codes - Cyclic codes, Convolutional codes - Viterbi decoder. Overview of Turbo codes.

UNIT-V	**EMERGING DIGITAL COMMUNICATION TECHNOLOGIES**	**9**

Multi-carrier modulation schemes in 4G and 5G- Principle and transceiver- OFDM, Filter Bank Multi-carrier (FBMC), Universal Filtered Multi-carrier (UFMC), Generalized Frequency Division Multi-carrier (GFDM). Case study-IEEE 802.11 Physical layer design using OFDM.

Total Contact Hours: 45

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

- Classify various blocks in the design of digital communication systems
- Describe and analyze the various waveform coding schemes
- Interpret the baseband transmission schemes and analyze the error performance of various Band pass signalling schemes
- Evaluate the performance of error control coding schemes
- Describe the concepts of emerging multi-carrier technologies in 4G and 5G

Suggested Activities:

- Problem solving sessions.
- Flipped classroom – Multiple access techniques.
- Seminar
- MATLAB simulation

Suggested Evaluation Methods:

- CAT
- Assignment problems
- Quizzes and class test
- Discussion in classroom

Text Book(s):
1. Simon Haykin, "Communication Systems", 4th Edition, John Wiley, 2000.
2. S. Haykin, "Digital Communications", John Wiley, 2005.
3. Andreas.F. Molisch, "Wireless Communications", Second edition, John Wiley – India, 2011.
4. Afif Osseiran, Jose. F. Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.

Reference Book(s) / Web links:
1. B. Sklar, "Digital Communication Fundamentals and Applications", 2nd Edition, Pearson Education, 2009.
2. Andreas Goldsmith, Wireless Communications, Cambridge University Press, 2007.
3. H P Hsu, Schaum Outline Series – "Analog and Digital Communications", TMH 2006
4. J.G Proakis, "Digital Communications", 5th Edition, Tata McGraw Hill Company, 2008.
5. Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications", Springer, 2016.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23512.1	3	3	2	2	3	1	1	1	1	3	1	-	3	3	2
EC23512.2	3	3	2	2	3	1	1	1	1	3	2	-	3	3	2
EC23512.3	3	3	2	2	3	1	1	1	1	3	2	1	3	3	2
EC23512.4	3	3	2	3	3	1	1	1	1	3	3	2	3	3	2
EC23512.5	3	3	2	2	3	1	1	1	1	3	3	3	3	3	2
Average	**3**	**3**	**2**	**2.2**	**3**	**1**	**1**	**1**	**1**	**3**	**2.2**	**2**	**3**	**3**	**2**

Course Code	Course Title	Category	L	T	P	C
EC23531	DIGITAL SIGNAL PROCESSING	PC	2	1	2	4

Objectives:
• To study about the DFT for spectral analysis
• To understand the FFT and its applications in linear filtering
• To design IIR filters and analyse its characteristics.
• To construct FIR filters and analyse its characteristics.
• To study the various quantization effects due to finite word length

UNIT-I	DISCRETE FOURIER TRANSFORM	9
The Discrete Fourier Transform, DFT &IDFT, Properties of the DFT: Periodicity, Linearity and Symmetry properties, Multiplication of two DFTs and Circular Convolution, auto – correlation and cross – correlation, Filtering of long data sequences – Overlap add and save methods.		
UNIT-II	**FAST-FOURIER-TRANSFORM (FFT) ALGORITHMS**	**9**
Efficient Computation of the DFT: Radix-2 FFT algorithms for the computation of DFT and IDFT--decimation in-time and decimation-in-frequency algorithms. IDFT using FFT algorithms.		
UNIT-III	**INFINITE IMPULSE RESPONSE FILTERS**	**9**
Infinite Impulse response Filter Format, Characteristics of practical frequency selective filters – Characteristics of Analog Butterworth Filters and Chebyshev Type – I filters (Up to 3^{rd} order for LPF, HPF, BPF, BSF) – Design of digital filter using impulse invariance technique and Bilinear Transformation. Realization of IIR Filters in Direct form I and II.		
UNIT-IV	**FINITE IMPULSE RESPONSE FILTERS**	**9**
Characteristics of practical frequency -selective filters, Symmetric and Antisymmetric FIR filters, Design of Linear-phase FIR filters using windows- Rectangular, Hamming, Hanning, Bartlett windows. Design of FIR filters using frequency sampling method. Realization of FIR Systems: transversal and Polyphase structure		
UNIT-V	**FINITE WORD LENGTH EFFECTS**	**9**
Fixed point and floating point number representation - ADC - quantization - truncation and rounding - quantization noise - input / output quantization - coefficient quantization error - product quantization error - overflow error - limit cycle oscillations due to product quantization and summation - scaling to prevent overflow.		
		Total Contact Hours: 45

Description of the Experiments:	Total Contact Hours: 30
MATLAB Based Experiments	
1. Generation of sequences	
2. Linear Convolution and Circular Convolution	
3. Spectrum analysis of DFT and IDFT	
4. IIR filter design using Butterworth approximation and Chebyshev approximation (LPF,HPF,BPF,BSF)	
5. FIR filter design using Rectangular , Hanning and Hamming (LPF, HPF, BPF,BSF)	
6. Multirate sampling : Decimation and Interpolation	
DSP Processor Based Experiments	
7. MAC operations of signals	
8. Waveform generation of signals	

Course Outcomes: On completion of course, students will be able to
• Apply DFT for the analysis of digital signals & systems
• Perform frequency transforms for linear filtering using FFT
• Design digital IIR filters for any given specifications and applications
• Design digital FIR Filters for any given specifications and applications
• Understand the quantisation process in finite word length

Suggested Activities:

- Problem solving sessions
- Flipped classroom

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems

Text Book(s):
1. John G. Proakis and Dimitris G.Manolakis, Digital Signal Processing – Principles, Algorithms and Applications, Fourth Edition, Pearson Education / Prentice Hall, 2007.
2. Sanjit K. Mitra, "Digital Signal Processing – A Computer Based Approach", Tata Mc Graw Hill, 2007.
3. A. V. Oppenheim, R.W. Schafer and J.R. Buck, Discrete-Time Signal Processing", 8th Indian Reprint, Pearson, 2014.

Reference Book(s) / Web links:
1. Digital Signal processing - S.Salivahanan, 4th Edition The McGraw hill, 2019
2. Emmanuel C. Ifeachor & Barrie. W. Jervis, "Digital Signal Processing", 2nd Edition, Pearson Education, 2002.

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1	PCs	15
2	MATLAB software	10
3	16 – bit DSP processor	5

Suggested Evaluation Methods :

- Experiment based viva
- Quizzes
- Mini Project

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23531.1	3	3	3	3	3	2	1	2	2	2	1	2	3	3	2
EC23531.2	3	3	3	3	3	2	1	2	2	2	1	2	3	3	2
EC23531.3	3	3	3	3	3	2	1	2	2	2	1	2	3	3	2
EC23531.4	3	3	3	3	3	2	1	2	2	2	1	2	3	3	2
EC23531.5	3	3	3	3	3	2	1	2	2	2	1	2	3	3	2
Average	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**2**	**2**	**2**	**1**	**2**	**3**	**3**	**2**

Course Code	Course Title	Category	L	T	P	C
EC23521	COMMUNICATION SYSTEMS LABORATORY	PC	0	0	4	2

Objectives:
• To visualize the effects of sampling and TDM
• To implement and classify AM & FM modulation and demodulation
• To implement PCM & DM
• To simulate and compare Digital Modulation schemes
• To simulate spread spectrum techniques

Description of the Experiments:	Total Contact Hours: 60
1. Signal Sampling and reconstruction	
2. Time Division Multiplexing	
3. AM Modulation and Demodulation	
4. FM Modulation and Demodulation	
5. Pulse Code Modulation and Demodulation	
6. Delta Modulation and Demodulation	
7. Line coding schemes	
8. Simulation of ASK, BPSK, BFSK, QPSK, and DPSK schemes	
9. Simulation of Direct sequence spread spectrum technique	
10. Simulation of Frequency hopping spectrum technique	
11. Simulation of Linear block codes	
12. Simulation of Cyclic codes	

Course Outcomes: On completion of the course, the students will be able to
• Simulate & validate the various functional modules of a communication system
• Understand the various waveform coding schemes
• Interpret the Digital baseband transmission methods
• Demonstrate their knowledge in base band signalling schemes
• Apply various channel coding schemes

Suggested Evaluation Methods:

- Experiment based viva
- Quizzes
- Mini Project

Web links for virtual lab:
• Virtual Labs (rajalakshmi.org)
• Academics - Study Materials | Rajalakshmi Engineering College (REC)

Lab equipment required:

S. No.	Name of the Equipment	Quantity Required
1.	Sampling and reconstruction Kit	2
2.	Time division multiplexing Kit	2
3.	AM Modulation and Demodulation Kit	2
4.	FM Modulation and Demodulation Kit	2
5.	Pulse Code Modulation and Demodulation Kit	2
6.	Delta Modulation and Demodulation Kit	2
7.	Line coding Kit	2
8.	PC	4

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23521.1	3	3	2	3	3	1	1	1	3	3	3	3	3	3	2
EC23521.2	3	3	2	3	3	1	1	1	3	3	3	3	3	3	2
EC23521.3	3	3	2	3	3	1	1	1	3	3	3	3	3	3	2
EC23521.4	3	3	2	3	3	1	1	1	3	3	3	3	3	3	2
EC23521.5	3	3	2	3	3	1	1	1	3	3	3	3	3	3	2
Average	**3**	**3**	**2**	**3**	**3**	**1**	**1**	**1**	**3**	**3**	**3**	**3**	**3**	**3**	**2**

Course Code	Course Title	Category	L	T	P	C
EC23522	INTERNSHIP	EEC	0	0	2	1

Objectives:
• To establish connection with industry/ laboratory/research institute
• To get knowledge on the existing process in the industry and develop skills to solve real world problems
• To develop a prototype through hands-on-training in the industry/ laboratory/research institute

Course Description:
The Internship in Electronics and Communication Engineering based applications is a unique opportunity for undergraduate engineering students to gain practical experience in the domains of Wireless networks, Image and Signal processing, RF systems, antennas, embedded systems, VLSI design, and IoT applications. This course offers a holistic approach to engineering, where students can apply their knowledge to real-world projects that incorporate these three critical areas.

Course Format:

- *1 Credit Internship*

The course consists of a minimum of 2 weeks internship with an industrial partner, along with pre- and post-internship activities.

- *Internship for Credit transfer:*

The students may also undergo Industrial training optionally, for a minimum period of 6 weeks, curriculum during summer / winter vacation and earn 3 credits. In this case the training has to be undergone continuously for the entire period. If the student earns 3 credits in Industrial Training / Internship, then he/she may optionally drop any one of the Elective courses.

Course Schedule:

Pre-Internship Activities

1. Orientation to the internship program.
2. Resume and cover letter preparation.
3. Interview skills and techniques.
4. Internship site selection and matching.
5. Ethical and professional responsibilities of engineers.

Internship:

1. Hands-on work experience at an industrial partner's site.
2. Regular meetings with a designated mentor or supervisor.
3. Completion of assigned tasks and projects.
4. Documentation of work and learning experiences.

Post-Internship Activities

1. Peer feedback and discussion.
2. Report Generation
    - *Format*

    No. Of pages – 10
    Paper Size – A4
    Font Size – 12, Times New Roman
    Spacing – Double Spacing
3. Evaluation of the learning outcomes, career planning and goal setting.

4. Assessment by panel members based on the following components:
   a. Presentation.
   b. Prototype Demonstration
   c. Report Submission
      - *Title Page:*

      Title of the training work
      Company Name & address
      Period of training
      Name, Branch & Roll No.
      Name of the institute
      - *Inside the report:*

      Content, Acknowledgement, & Declaration by the students
      Introduction
      Description of the industry
      Description of the work carried out
      Details of the data collection, analysis carried out design carried out, programme development, experiments performed etc.
      Results
      Conclusions
      References
      Appendices
      Internship Certificate

Course Outcomes: On completion of the course, the students will be able to
• Apply engineering principles and concepts to real-world industrial projects.
• Develop problem-solving and critical thinking skills in an industrial context.
• Gain practical experience in teamwork, communication, and project management.
• Understand the ethical and professional responsibilities of an engineer.
• Explore various career paths and opportunities in the engineering industry.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23522.1	3	1	-	2	2	3	-	-	-	-	-	-	2	3	2
EC23522.2	-	-	3	3	-	-	-	-	-	-	-	-	3	3	3
EC23522.3	-	-	-	-	-	-	-	3	3	3	3	-	-	-	1
EC23522.4	-	-	-	-	-	3	3	3	-	-	-	-	1	-	-
EC23522.5	-	-	-	-	-	-	-	-	-	-	-	3	3	3	3
Average	**3**	**1**	**3**	**2.5**	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**2.25**	**3**	**2.25**

Course Code	Course Title	Category	L	T	P	C
GE23521	SOFT SKILLS-II	EEC	0	0	2	1

Objectives:
• To help students break out of shyness.
• To build confidence.
• To enhance English communication skills.
• To encourage students' creative thinking to help them frame their own opinions.

Learning and Teaching Strategy:

The program is completely student centric where the focus is on activities led by students which include role plays, discussions, debates other games as well. These activities would be supplemented by interactive use of technology and brief trainer input.

Week	Activity Name	Description	Objective
1	The News hour	Students are made to read news articles from the English newspapers. The students also have to find words and their meaning from the article they have not come across before and share it with the group. They then use these words in sentences of their own	The aim of this activity is not only to get the students to read the newspaper but also aims at enhancing the students' vocabulary.
2	Court Case	The facilitator provides the participants the premise of a story and proceeds to convert the story into a court case. The students are required, department-wise to debate and provide their points to win the case for their clients.	The aim of the lesson is to encourage creative and out-of-the -box thinking to ensure a good debate and defense skills.
3	The ultimate weekend	The students design activities they are going to do over the weekend and they have to invite their classmates to join in the activity. The students move around the class and talk to other students and invite them.	The aim of this activity is to develop the art of conversation among students. It also aims at practicing the grammatical structures of "going to" "have to" and asking questions.
4	The Four Corners	This is a debate game that uses four corners of the classroom to get students moving. The following is written on the 4 corners of the room "Strongly Agree, Somewhat Agree, Somewhat Disagree and Strongly Disagree". The topics are then given to the class and students move to the corner that they feel best explains their opinions	This activity aims at getting students to come up with their own opinions and stand by it instead of being overshadowed by others and forcing themselves to change based on others opinions.
5	Debate	Boarding school or day school? Which is more beneficial for a student?	The aim of this activity is to encourage students to draw up feasible points on the advantages and benefits of both. And enhance their debating ability
6	Grand Master	The facilitator starts the session by keeping an individual in mind, upon which the students guess it only through "Yes or No" questions. Post few trials the students are given same opportunity to do the same with the crowd.	The aim of the lesson is designed to teach the art of questioning. It also helps to enhance the students' speaking and listening skills.
7	Debate	Does violence on the TV and Video games influence children negatively?	This activity aims at encouraging the students to debate on real life scenarios that most students spend a lot of time on.
8	Turn Tables	This is a speaking activity where the students need to speak for and against the given topics when the facilitator shouts out 'Turn Table'.	The aim of this activity is to make the participants become spontaneous and have good presence of mind.
9	Debate	Do marks define the capabilities of a student?	This debate activity aims at allowing the students to argue on this worrisome adage of marks.
10	FictionAD	The Participants are asked to create an Ad for a	The activity aims at developing their

		challenging topic only using fictional characters.	creativity and presentation skills.
11	Debate	Are social networking sites effective, or are they just a sophisticated means for stalking people?	This activity aims at refining the students debating skills on a very real life situation
12	Talent Hunt	Talent Hunt is a fun activity where the students are selected at random and supported to present any of their own skills.	The aim of this activity is designed to evoke their inner talents and break the shyness and the fear of participating in front of a crowd
	Feedback	At the end of the session in the final week (12) the trainer would provide feedback to the students on best practices for future benefits.	The aim is to do both give feedback to students as well as obtain feedback on the course from them.

Course Outcomes: On completion of the course, the students will be able to
• Be more confident.
• Speak in front of a large audience without hesitation.
• Think creatively.
• Speak impromptu.
• Communicate in English

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23521.1	-	-	-	-	-	-	-	-	3	3	2	3	-	-	2
GE23521.2	-	-	-	-	-	-	-	-	3	3	2	3	-	-	2
GE23521.3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
GE23521.4	-	-	-	-	-	-	-	-	3	3	2	3	-	-	2
GE23521.5	-	-	-	-	-	-	-	-	3	3	2	3	-	-	2
Average	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2.8**	**2.8**	**2**	**2.8**	**2**	**2**	**2**

SEMESTER VI

Course Code	Course Title	Category	L	T	P	C
EC23611	ANTENNA THEORY AND WAVE PROPAGATION	PC	3	0	0	3

Objectives:
• To give insight of the radiation parameters and radiation phenomena of antenna
• To apply array theory on antennas
• To make them understand various aperture and slot antennas used in practical applications
• To learn frequency independent antennas and measurement of antenna parameters
• To create awareness about the different types of propagation of radio waves at different frequencies

UNIT-I	**FUNDAMENTALS OF RADIATION**	**9**
Antenna parameters - Radiation pattern, Gain, Directivity, Effective aperture, Radiation Resistance, Bandwidth, Beam width, Polarization, Polarization mismatch-Polarization loss factor and efficiency, Antenna noise temperature, Radiation from oscillating dipole, Half wave dipole, Folded dipole and Yagi-Uda array.		
UNIT-II	**ANTENNA ARRAYS**	**9**
N-element linear array, Broadside and end fire array, Two element array, Pattern multiplication, Phased arrays, Adaptive array and Smart antennas, Binomial array.		
UNIT-III	**APERTURE AND SLOT ANTENNAS**	**9**
Huygens' principle, Horn antenna, Reflector antenna-Feeding structures, Aperture blockage, Slot antennas- Babinet's principle, Microstrip antennas – Radiation mechanism, Feeding methods, Applications.		
UNIT-IV	**SPECIAL ANTENNAS AND MEASUREMENTS**	**9**
Principle of frequency independent antennas -Spiral antenna, Helical antenna, Log periodic dipole array. Modern Antennas: Reconfigurable antennas, Wearable antennas. Measurements: Measurement of Gain, Radiation pattern, VSWR.		
UNIT-V	**PROPAGATION OF RADIO WAVES**	**9**
Ground wave propagation – Plane earth reflection. Space wave propagation – Field strength relation, Super refraction, Scattering phenomena, Fading. Sky wave propagation – Structural details of the Ionosphere, Ray path, critical frequency, MUF, LUF, OF, Virtual height, Skip distance.		
		Total Contact Hours: 45

Course Outcomes: On completion of the course, students will be able to
• Understand the fundamentals of antenna by gaining knowledge in radiation parameters and mechanisms.
• Apply the concepts of array in N-element antenna systems.
• Comprehend and appreciate the significance and role of aperture and slot antennas in the present contemporary world.
• Interpret the radiation characteristics of various advanced antennas.
• Summarize the various radio waves propagation mechanisms

Suggested Activities:

- Problem solving sessions
- Activity based learning
- Implementation of small module

Suggested Evaluation Methods:

- Assignments and group assignments
- Quizzes and class test
- Continuous assessment tests and end semester examination
- Class Presentation/Discussion

Text Book(s):
1. John D Kraus, Ronald J Marhefka, Ahmed S Khan, “Antennas and Wave Propagation”, McGraw Hill, 5th Edition, 2017.
2. Constantine A Balanis, "Antenna Theory Analysis and Design", Wiley India, 4th Edition, 2016.

Reference Book(s) / Web links:
1. R.E.Collin, “Antennas and Radio wave propagation”, McGraw Hill, 1985.
2. S. Drabowitch, "Modern Antennas", Springer Publications, 2nd Edition, 2007.
3. Robert S.Elliott, "Antenna theory and Design", Wiley student edition, 2010
4. Debatosh Guha and Yahia M.M. Antar, “Microstrip and Printed Antennas-New Trends, Techniques and Applications”, A John Wiley and Sons, 2011.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23611.1	3	3	3	3	3	1	1	1	1	1	1	2	3	1	1
EC23611.2	3	3	3	3	3	2	2	1	2	2	2	2	3	3	2
EC23611.3	3	3	3	3	3	2	2	2	2	2	2	2	3	3	2
EC23611.4	3	3	3	2	2	2	2	2	2	2	2	2	3	3	2
EC23611.5	3	2	2	2	1	1	1	2	1	1	1	2	3	2	1
Average	**3**	**2.8**	**2.8**	**2.6**	**2.4**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**2**	**3**	**2.4**	**1.6**

Course Code	Course Title	Category	L	T	P	C
EC23631	VLSI AND CHIP DESIGN	PC	3	0	2	4

Objectives:
• To study the fundamentals of CMOS circuits and its characteristics.
• To realize combinational and sequential digital circuits.
• To design arithmetic building blocks and Compare different FPGA architectures with testability of VLSI circuits.
• To analyse various digital circuits using HDL and verify using simulated results.
• To provide hands on to implement digital circuits with professional design (EDA) platforms.

UNIT-I	MOS TRANSISTOR PRINCIPLE	9
Introduction to MOS Transistors- Manufacturing Process in IC- Fabrication of transistors- Ideal I-V Characteristics, C-V Characteristics, Non ideal I-V Effects, DC Transfer characteristics. Stick diagram, CMOS Layout Design rules, Layout-CMOS Inverter, NAND, NOR gates.		
UNIT-II	**COMBINATIONAL LOGIC CIRCUITS**	**9**
Examples of Combinational logic design, Propagation delay-Elmore delay, Logical Effort, Parasitic delay. Static CMOS-Ratioed Circuits - Pseudo nMOS, Pass Transistor Logic-CPL, Transmission gate. Dynamic CMOS-Domino logic, Dynamic Power, Static Power.		
UNIT-III	**SEQUENTIAL LOGIC CIRCUITS**	**9**
Static Latches and Registers- Multiplexer based latches, Master slave Edge triggered register, Dynamic Latches and Registers-Dynamic Transmission Gate Edge-triggered Registers, C^2MOS register, Pipelining and timing issues.		
UNIT-IV	**DESIGNING ARITHMETIC BUILDING BLOCKS AND SUBSYSTEM**	**9**
Data Paths, Adders-Ripple carry adder, Multipliers-Array Multiplier, Barrel Shifters, Memory Architectures and Building Blocks. Memory core-Read write memory.		
UNIT-V	**IMPLEMENTATION STRATEGIES AND TESTING**	**9**
Introduction to FPGA and HDL -ASIC Design-Full-Custom design and Semi-Custom design- FPGA building block architectures. Design for Testability: Ad Hoc Testing, Scan Design.		
	Total Contact Hours: 45	

Description of the Experiments (Based on HDL and FPGA):	Total Contact Hours:30
1. Design an Arithmetic circuits (Adder and multiplier) using HDL. Simulate it using Xilinx/Altera Software and implement by Xilinx/Altera FPGA.	
2. Design counters using HDL. Simulate it using Xilinx/Altera Software and implement by Xilinx/Altera FPGA.	
3. Design a PRBS generators using HDL. Simulate it using Xilinx/Altera Software and implement by Xilinx/Altera FPGA.	
4. List of Experiments (Based on Cadence/Mentor Graphics/Tanner/equivalent EDA Tools)	
5. Design and simulate a CMOS inverter using digital flow, Manual/Automatic Layout Generation.	
6. Design and simulate CMOS basic gates.	

Course Outcomes: On completion of the course, students will be able to
• Demonstrate the digital building blocks using MOS transistor.
• Analyze combinational and sequential MOS circuits and power strategies.
• Design and implementation of arithmetic building blocks, FPGA design flow and testing.
• Create HDL code for digital integrated circuit and Import the logic modules into FPGA Boards.
• Simulate and Extract the layouts of Digital Blocks using EDA tools.

Suggested Activities:

- Problem solving sessions-Propagation delay calculation(Unit 2
- Flipped classroom – Power dissipation(Unit-2)
- Survey on various storage technologies-Memory Core(Unit-4)
- Activity Based Learning – Layout(Unit -1)
- Implementation of small module – Implementation of Adder and multiplier using Xilinx/Altera FPGA.

Suggested Evaluation Methods:

- Tutorial problems -Logical Effort, Parasitic delay(Unit 2)
- Assignment problems –NOR & NAND Layout(Unit -1)
- Quizzes - FPGA building block architectures(Unit 5)
- Class Presentation/Discussion-C^2MOS register(Unit 3)

Text Book(s):
1. Neil H.E. Weste, David Money Harris ―CMOS VLSI Design: A Circuits and Systems Perspective‖, 4th Edition, Pearson, 2017 (UNIT I, II, V).
2. Jan M. Rabaey ,Anantha Chandrakasan, Borivoje. Nikolic, Digital Integrated Circuits: A Design perspective‖,
3. Second Edition, Pearson , 2016.(UNIT III,IV).
4. M J Smith, "Application Specific Integrated Circuits", Addisson Wesley, 2014.(Unit V).

Reference Book(s) / Web links:
1. Sung-Mo kang, Yusuf leblebici, Chulwoo Kim ―CMOS Digital Integrated Circuits: Analysis& Design‖,4th edition McGraw Hill Education,2018.
2. Wayne Wolf, ―Modern VLSI Design: System On Chip Design, Pearson Education, 2007.
3. Jacob Baker "CMOS: Circuit Design, Layout, and Simulation, Third Edition", Wiley IEEE Press 2010.

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1	Xilinx ISE/Altera Quartus/ equivalent EDA Tools along with Xilinx/Altera/equivalent FPGA Boards.	10
2	Cadence/Synopsis/ Mentor Graphics /Tanner/equivalent EDA Tools.	10

Web links for virtual lab
https://www.iitg.ac.in/cseweb/vlab/vlsi/
http://cse14-iiith.vlabs.ac.in/List%20of%20experiments.html?domain=Computer%20Science

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23631.1	3	2	2	2	2	2	3	1	2	2	2	3	3	2	2
EC23631.2	2	3	3	2	3	3	2	1	3	3	3	3	2	3	3
EC23631.3	3	2	2	3	2	3	3	1	3	3	3	3	3	3	2
EC23631.4	3	2	3	3	3	2	2	1	3	2	3	3	2	3	3
EC23631.5	3	3	3	2	3	3	3	1	3	3	3	3	2	3	3
Average	**2.8**	**2.4**	**2.6**	**2.4**	**2.6**	**2.6**	**2.6**	**1**	**2.8**	**2.6**	**2.8**	**3**	**2.4**	**2.8**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23632	COMMUNICATION NETWORKS	PC	3	0	2	4

Objectives:
• To introduce the layered communication architectures and understand various physical, data link layer protocols
• To analyze different protocols and routing algorithms for network layer and protocols for transport layer
• To assess transport and application layer protocols with security issues.
• To create communication between two desktop computers using Inter-networking devices using protocols and routing algorithms.
• To configure network using simulation tools.

UNIT-I	INTRODUCTION TO DATA COMMUNICATIONS	9
Data Communication, Networks, Protocols and standards, Line configuration, Topology, Transmission mode, OSI reference model - layers and duties. TCP/IP reference model – layers and duties, Addressing. IEEE standards:-IEEE802.3, IEEE802.11, Bluetooth.		
UNIT-II	**DATA LINK LAYER**	**9**
Introduction to the Link Layer, The Services Provided by the Link Layer, Error detection and correction-Types of error, CRC, Checksum, Framing, Flow control and error control, HDLC-frames. Multiple access- Random access, Controlled access.		
UNIT-III	**THE NETWORK LAYER**	**9**
Connecting Devices, Logical Addressing-IPV4, IPV6, Transition from IPV4 to IPV6, Address mapping–Basics of ARP, RARP, BOOTP and DHCP, ICMP, IGMP, Network routing algorithms – Distance vector routing and Link state routing.		
UNIT-IV	**TRANSPORT LAYER**	**9**
Process-process delivery:-UDP, TCP-Features, segment, connection, Flow control, Congestion control in TCP, Quality of services.		
UNIT-V	**APPLICATION LAYER**	**9**
Basics of Application protocols: DNS, HTTP, FTP and SMTP, Network management protocol: SNMP, VoIP signaling protocol: H.323 standard, Fundamentals of Data security: Cryptography–Asymmetric, Encryption – RSA Algorithm, Symmetric Encryption – AES algorithm.		
		Total Contact Hours:45

Description of the Experiments:	Total Contact Hours:30
• Implementation of error detection/error correction techniques	
• Implementation of stop and wait protocol	
• Implementation of distance vector and link state routing algorithm	
• Encryption and decryption	
• Study of Network Simulator (NS) / Configuring network using Cisco Packet Tracer configure	

Course Outcomes: On completion of the course, the students will be able to
• Well versed on the layer communication architecture and their data link layer networking.
• Compare and understand different protocols and routing algorithms for an efficient network.
• Design a network for a particular application and analyze the security performance of the network.
• Communicate between two desktop computers and implement the different protocols using sockets and routing algorithms using packet tracer.
• Implement network simulation using NS

Suggested Activities:
• Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
• Survey on various storage technologies
• Activity Based Learning
• Implementation of various topologies in connecting the network

Suggested Evaluation Methods:

- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):

1. Behrouz. A. Forouzan, Data Communication and Networking, 4th Edition, Tata McGraw Hill.
2. Stallings .W, Data and Computer Communication, 9th Edition, Prentice Hall of India, 2011.
3. Tanenbaum, A.S, Computer Networks, 5th Edition, Prentice Hall of India, 2013.

Reference Book(s) / Web links:

1. Keshav.S, An Engineering approach to Computer Networking, Addision– Wesley, 2010.
2. Larry L. Peterson, Bruce S. Davie, "Computer Networks: A Systems Approach", Fifth Edition, Morgan Kaufmann Publishers, 2011.

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1	PC with 4 GB RAM & 128 GB ROM with WINDOWS OS & LINUX with C program Complier.	30
2	NS Software package	5
3	CISCO packet tracer	10

Suggested Evaluation Methods:

- Experiment based viva
- Quizzes
- Mini Project

Web links for virtual lab (if any)

https://cse29-iiith.vlabs.ac.in/

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23632.1	2	3	2	2	2	3	3	1	2	3	3	3	3	3	3
EC23632.2	3	3	2	3	3	2	2	1	3	3	3	2	2	3	3
EC23632 3	3	3	3	3	3	2	2	1	3	3	3	2	2	3	2
EC23632 4	3	2	3	2	3	3	2	1	3	3	2	3	3	2	3
EC23632.5	3	2	3	3	3	2	3	1	3	3	3	3	3	3	3
Average	**2.8**	**2.6**	**2.6**	**2.6**	**2.8**	**2.4**	**2.4**	**1**	**2.8**	**3**	**2.8**	**2.6**	**2.6**	**2.8**	**2.8**

Course Code	Course Title	Category	L	T	P	C
EC23633	WIRELESS COMMUNICATION	PC	2	0	2	3

Objectives:
• To know the characteristic of wireless channel
• To learn the various cellular architectures
• To understand the concepts behind various digital signalling schemes for fading channels and basics of Software Defined Radio
• To be familiar with the various multipath mitigation techniques
• To analyse the various multiple antenna systems

UNIT-I	WIRELESS CHANNELS	6
Large scale path loss – Path loss models: Free space and Two-Ray models -Link budget design – Small scale fading- Parameters of mobile multipath channels –Coherence bandwidth – Doppler spread &coherence time, Fading due to Multipath time delay spread – flat fading – frequency selective fading – Fading due to Doppler spread – fast fading – slow fading.		
UNIT-II	**CELLULAR ARCHITECTURE**	**6**
TDMA, FDMA, CDMA, Cellular concept- Frequency reuse – channel assignment- handoff- interference & system capacity– Coverage and capacity improvement.		
UNIT-III	**DIGITAL SIGNALING FOR FADING CHANNELS**	**6**
Structure of a wireless communication link, $\pi/4$-DQPSK, Minimum Shift Keying, Gaussian Minimum Shift Keying, Spread spectrum -PN sequences, Direct Sequence and Frequency Hopping Spread Spectrum systems.		
UNIT-IV	**MULTIPATH MITIGATION TECHNIQUES**	**6**
Adaptive equalization, LMS algorithm, Diversity – Micro and Macro diversity – transmitter diversity, receiver diversity, Error probability in fading channels with diversity reception, Rake receiver.		
UNIT-V	**MIMO AND SDR**	**6**
MIMO systems – spatial multiplexing -System model -Pre-coding – Beamforming- Channel state information-capacity in fading and non-fading channels. Introduction to SDR- Basic hardware and software architecture of SDR- Spectrum sensing		
Total Contact Hours: 30		

Description of the Experiments:	Total Contact Hours: 30
1. BER performance of digital modulation scheme in AWGN & Rayleigh fading channel.	
2. BER performance of CDMA system.	
3. Equalizer design using LMS algorithm.	
4. Simulation of MIMO communication	
5. Study of Software Defined Radio	
6. OFDM signal transmission and reception using software defined radio	
7. Spectrum sensing using software defined radio	

Course Outcomes: On completion of the course, the students will be able to
• Characterize the mathematical model of wireless channels
• Demonstrate the cellular concept of wireless communication system
• Design and implement various signalling schemes for fading channels and familiarize the concepts of SDR
• Analyse and compare the performance of multipath mitigation techniques
• Design and implement MIMO systems and analyse their performance

Suggested Activities:

- Activity Based Learning
- Seminar
- Group Discussion

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):
1. Rappaport,T.S., "Wireless communications", Second Edition, Pearson Education, 2010.
2. Andreas.F. Molisch,"Wireless Communications", Second edition-John Wiley – India, 2011.
3. Simon Haykin, Michael Moher, "Modern Wireless Communication", Pearson Education, 2011.
4. Bruce A. Fette, "Cognitive Radio Technology", Elsevier, 2009.

Reference Book(s) / Web links:
1. David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.
2. Upena Dalal, "Wireless Communication", Oxford University Press, Edition 4, 2009.
3. Van Nee, R. and Ramji Prasad, "OFDM for wireless multimedia communications", Artech House, 2000.
4. Andreas Goldsmith, Wireless Communications, Cambridge University Press, 2007.
5. Joseph MitolaIII, "Software Radio Architecture: Object-Oriented Approaches to Wireless System Engineering", John Wiley & Sons Ltd. 2000.

Lab equipment required:

S. No.	Name of the Equipment	Quantity Required
1	Software Defined Radio	3
2	PC with MATLAB software	15

Suggested Evaluation Methods:

- Experiment based viva
- Quizzes

Web links for virtual lab
http://vlabs.iitkgp.ernet.in/fcmc/
https://www.etti.unibw.de/labalive/

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23633.1	3	3	2	2	2	2	2	1	2	3	2	2	3	3	2
EC23633.2	3	3	2	2	3	2	2	2	2	3	2	3	3	3	2
EC23633.3	3	3	2	2	3	2	2	1	1	3	2	2	3	3	2
EC23633.4	3	3	2	3	3	2	2	1	1	3	3	2	3	3	2
EC23633.5	3	3	2	2	3	2	2	2	2	3	3	3	3	3	2
Average	**3**	**3**	**2**	**2.2**	**2.8**	**2**	**2**	**1.4**	**1.6**	**3**	**2.2**	**2.4**	**3**	**3**	**2**

Course Code	Course Title	Category	L	T	P	C
GE23621	PROBLEM SOLVING TECHNIQUES	EEC	0	0	2	1

Objectives:
• To improve the numerical ability.
• To improve problem-solving skills.

S.No.	Topics
1	Numbers system
2	Reading comprehension
3	Data arrangements and Blood relations
4	Time and Work
5	Sentence correction
6	Coding & Decoding, Series, Analogy, Odd man out and Visual reasoning
7	Percentages, Simple interest and Compound interest
8	Sentence completion and Para-jumbles
9	Profit and Loss, Partnerships and Averages
10	Permutation, Combination and Probability
11	Data interpretation and Data sufficiency
12	Logarithms, Progressions, Geometry and Quadratic equations.
13	Time, Speed and Distance

Course Outcomes: On completion of the course, the students will be able to
• Have mental alertness
• Have numerical ability
• Solve quantitative aptitude problems with more confident

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23621.1	1	2	2	2	1	-	-	-	1	2	1	1	2	-	1
GE23621.2	1	1	1	1	1	-	-	-	-	-	1	1	-	-	2
GE23621.3	1	1	2	1	1	-	-	-	-	-	1	1	-	-	2
GE23621.4	2	2	3	2	1	-	-	-	1	-	2	1	-	-	2
GE23621.5	2	2	3	2	1	-	-	-	-	-	2	1	-	-	2
Average	**1.4**	**1.6**	**2.2**	**1.6**	**1**	**-**	**-**	**-**	**1**	**2**	**1.4**	**1**	**2**	**-**	**1.8**

Course Code	Course Title	Category	L	T	P	C
GE23627	DESIGN THINKING AND INNOVATION	EEC	0	0	4	2

Objectives:
• To understand the design thinking concepts and deep understanding of user needs and experiences.
• To find the problem statement and to develop innovative design solutions that address identified user challenges
• To master the process of prototyping and iterating on designs
• To conduct thorough market analysis and financial planning
• To effectively communicate design concepts and findings.

UNIT I	**INTRODUCTION TO DESIGN THINKING**	**12**
The design thinking concepts - Different design thinking models - Details of Stanford Design thinking process: Empathize, Define, Ideate, Prototype, Test. **Activities:** • Case studies of successful domain-based Design Thinking and Innovative projects • Group discussions on design thinking.		
UNIT II	**EMPATHIZE AND DEFINE**	**12**
User research methods (interviews, surveys, observation, contextual inquiry) - Persona development- Journey mapping – Brainstorming Defining the design problem statement. **Activities:** • Conducting user interviews and surveys • Creating user personas and journey maps • Identifying key user needs and pain points • Analyze the user needs and brainstorming to define problem statement.		
UNIT-III	**IDEATE AND CREATE**	**12**
Brainstorming techniques (e.g., mind mapping, SCAMPER) - Ideation tools (e.g., design thinking tools, concept sketching) - Concept generation and evaluation (e.g. Brainstorming). **Activities:** • Group brainstorming sessions to select the best idea • Creating concept sketches and prototypes • Evaluating ideas based on user needs and feasibility.		
UNIT IV	**PROTOTYPE AND TEST**	**12**
Low, Medium and high-level fidelity for Prototyping-Usability testing -Iterative design. **Activities:** • Building low-fidelity prototypes (e.g., paper prototypes) • Conducting usability tests with users • Iterating on designs based on feedback.		
UNIT-V	**MARKET ANALYSIS AND IMPLEMENTATION**	**12**
Market research and analysis - Business model development- Financial Planning-Implementation strategies. **Activities:** • Conducting market research • Developing a business model canvas • Creating a financial projection • Developing an implementation plan.		
Total Contact Hours: 60		

Course Outcomes: On completion of the course, the students will be able to
• Construct design challenge and reframe the design challenge into design opportunity.
• Interview the user, and know the feelings of users to foster deep user understanding and be able to uncover the deep user insights and needs.
• Develop ideas and prototypes by brainstorming.
• Organize the user walkthrough experience to test prototype
• Develop smart strategies and implementation plan that will deliver/achieve the idea/solution deduced from earlier phases.

Assessment:

- Encourage students to work on real-world design challenges based on the user needs
- Group presentations
- Quizzes and exams
- Evaluation of Project report and viva and also encourage the students for filing patent/ copyright / presenting in conference / publishing in journal

Text Book(s):
1. Handbook of Design Thinking by Christian Müller-Roterberg, Kindle Direct Publishing, 2018.
2. Design Thinking – A Beginner's Perspective, by E Balagurusamy, Bindu Vijakumar, MC Graw Hill, 2024.

Reference Book(s) / Web links:
1. Design Thinking for Entrepreneurs and Small Businesses: Putting the Power of Design to Work – by Beverly Rudkin Ingle, Apress; 1st Edition, 2013.
2. Design Thinking: Understanding How Designers Think and Work by Nigel Cross, Bloomsbury Visual Arts; 2nd editions 2023.

Web links:
1. Design thinking Guide https://www.rcsc.gov.bt/wp-content/uploads/2017/07/dt-guide-book-master-copy.pdf
2. NPTEL Course on Design Thinking and Innovation By Ravi Poovaiah; https://onlinecourses.swayam2.ac.in/aic23_ge17/preview
3. IITB Design course tools and Resources https://www.dsource.in/resource

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23627.1	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
GE23627.2	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
GE23627.3	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
GE23627.4	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
GE23627.5	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
Average	**3**	**2**	**3**	**3**	**3**	**2**	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**2**

SEMESTER VII

Course Code	Course Title	Category	L	T	P	C
EC23731	OPTICAL COMMUNICATION AND NETWORKS	PC	2	0	2	3

Objectives:
• To acquire the knowledge of optical fiber transmission mechanisms and various fiber types.
• To study the different factors which produces signal degradation in fibers
• To learn the concept of sources and power coupling in optical communication
• To understand the trends of optical fiber measurement systems.
• To enrich the concept of optical networks.

UNIT-I	**INTRODUCTION TO OPTICAL FIBERS**	**6**
Elements of an Optical Fiber Transmission link-Basic Optical Laws and Definitions-Total internal reflection, Acceptance angle, Numerical aperture, Skew rays - Optical fiber modes and Configurations – Fiber types -Mode theory of Circular wave guides- Overview of modes, Linearly Polarized modes.		
UNIT-II	**SIGNAL DEGRADATION IN OPTICAL FIBERS**	**6**
Attenuation - Absorption, Scattering losses, Bending losses, Core and Cladding losses. Signal distortion in Optical Wave guides- Group delay, Material dispersion, Waveguide dispersion, Polarization mode dispersion, Intermodal dispersion.		
UNIT-III	**FIBER OPTICAL SOURCES AND COUPLING**	**6**
Direct and indirect band gap materials-LED structures -Light source materials -Quantum efficiency and LED power. Lasers diodes-modes and Threshold condition - Rate equations -External quantum efficiency. Introduction to Quantum laser. Power launching and coupling-Lensing schemes-Fiber - to- Fiber joints-Fiber splicing		
UNIT-IV	**FIBER OPTIC RECEIVER AND MEASUREMENTS**	**6**
Principles of Photodetectors – PIN & APD - Fundamental receiver operation- Receiver configuration– Digital receiver performance - Probability of error – Quantum limit, Pre amplifiers. Test Equipment – OTDR - Fiber attenuation measurements- Dispersion measurements		
UNIT-V	**OPTICAL NETWORKS**	**6**
Basic networks – SONET / SDH – Broadcast and select WDM networks –Wavelength routed networks – Non- linear effects on Network performance. Solitons – Optical CDMA – Ultra high capacity networks- Introduction to Li-Fi.		
		Total Contact Hours: 30

Description of the Experiments:	**Total Contact Hours: 15**
1. DC Characteristics of LED and PHOTODIODE	
2. Measurement of losses in a given optical fiber (propagation loss, bending loss & connector loss)	
3. Measurement of numerical aperture and acceptance angle of the fiber	
4. Analog and Digital communication link using optical fiber	
5. Analysis of optical Fiber mode Characteristics	

Course Outcomes: On completion of the course, students will be able to
• Describe the various optical fiber modes and configurations
• Illustrate various signal degradation factors associated with optical fiber.
• Evaluate various optical sources and their use in the optical communication system to select the optimum transmitter.
• Analyze the optical receiver performance and measure various fiber parameters for designing optical fiber.
• Analyze the digital transmission and its associated parameters on system performance.

Text Book(s):
1. Gerd Keiser, "Optical Fiber Communications" McGraw -Hill International, 4th edition, 2010.
2. John. M. Senior, "Optical Fiber Communications, Principles and Practice", Prentice Hall of India, 3rd Edition, 2008

Reference Book(s) / Web links:
1. Ramaswami, Sivarajan and Sasaki "Optical Networks: A Practical Perspective", Morgan Kaufmann, 3rd Edition, 2009.
2. J.Gower, "Optical Communication System", Prentice Hall of India, 2001.
3. SvilenDimitrov and Harald Haas, "Principles of LED light Communications: Towards Networked Li-Fi ", Cambridge University Press , 2015.

Suggested Activities:

- Activity Based Learning – Demonstration of optical fiber transmission and cabling through animated videos
- Implementation of small module – Demonstration of LED's in home décor

Suggested Evaluation Methods:

- Tutorial problems – Acceptance angle, Numerical aperture, V-number and attenuation
- Assignment problems – LED (power and efficiency)
- Quizzes – LED
- Class Presentation/Discussion – optical CDMA

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1	Fiber Optical Trainer kit	8
2	CRO	8
3	Optical fiber cable	Few

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23731.1	3	3	2	2	1	1	2	1	2	1	2	2	1	3	1
EC23731.2	3	3	2	2	1	1	2	1	2	1	2	3	2	3	1
EC23731.3	3	3	2	2	1	2	2	1	1	1	2	2	2	3	2
EC23731.4	3	2	2	2	1	2	2	1	1	1	3	2	2	3	2
EC23731.5	3	2	2	2	1	2	2	1	2	1	3	3	2	3	2
Average	**3**	**2.6**	**2**	**2**	**1**	**1.6**	**2**	**1**	**1.6**	**1**	**2.2**	**2.4**	**1.8**	**3**	**1.6**

Course Code	Course Title	Category	L	T	P	C
EC23732	RF AND MICROWAVE ENGINEERING	PC	2	0	2	3

Objectives:
• To firmly establish knowledge on the properties S-parameters and microwave passive devices.
• To deal with the microwave solid-state and vacuum tube devices.
• To obtain basic knowledge on microwave measurement techniques.
• To inculcate understanding of the basics required for filter and matching network of RF systems.
• To obtain basic knowledge on microwave measurement techniques.

UNIT-I	MICROWAVE NETWORK THEORY AND PASSIVE DEVICES	6
Formulation of S-parameter, Properties of S-parameter, Theory and S-parameter formulation of passive components – Magic tee, Directional couplers, Isolator, Circulator.		
UNIT-II	**MICROWAVE SOLID-STATE AND VACUUM TUBE DEVICES**	**6**
Active devices: PIN diode and its application as PIN switch, Gunn diode and its application. Microwave Tubes: Reflex Klystron oscillator, Cylindrical Magnetron oscillator.		
UNIT-III	**MICROWAVE MEASUREMENTS**	**6**
Power measurements – Schottky barrier diode sensor, Bolometer, Power meter, Thermocouple sensor, Calorimetric method. Insertion loss and attenuation measurements. VSWR measurements – Low VSWR and High VSWR. Frequency measurements – wave meter method, slotted line method, down-conversion method.		
UNIT-IV	**RF FILTER AND MATCHING NETWORK**	**6**
Butterworth filter – Normalized parameters, Low pass filter design, High pass filter, Band pass filter, Band stop filter. Impedance matching using discrete components – L Matching Network. Problem solving using Smith chart.		
UNIT-V	**RF AMPLIFIERS**	**6**
Characteristics of Amplifiers, Amplifier power relations, Stability considerations, Single-stage transistor amplifier design – Design for maximum gain (Conjugate Matching).		
		Total Contact Hours:30

Description of the Experiments	Total Contact Hours:30
1. Reflex Klystron – Mode characteristics	
2. Gunn Diode- VI Characteristics	
3. Measurement of frequency, guide wavelength in a microwave test bench	
4. Measurement of VSWR and reflection coefficient in a microwave test bench	
5. Measurement of Radiation pattern and gain of horn antenna	
6. Directional Coupler Characteristics.	
7. S-parameter Measurement of Isolator.	
8. S-parameter Measurement of Magic Tee.	
9. Study of Extended Interaction Klystron (EIK), Gyrotron Oscillator, Microwave Photonic Generators, Solid-State Power Amplifiers (SSPA).	

Course Outcomes: On completion of the course, students will be able to
• Interpret various passive microwave devices used in microwave systems.
• Interpret various solid-state and vacuum tube microwave devices.
• Measure various microwave parameters
• Design and analyse the RF matching networks and RF filters
• Design and analyse the RF transistor amplifiers and design using conjugate match/gain circle.

Suggested Activities:

- Problem solving sessions
- Flipped classroom – Gunn Diode and PIN Diode

Suggested Evaluation Methods:

- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):

1. Annapurna Das and Sisir K Das, "Microwave Engineering", Tata Mc Graw Hill Publishing Company Ltd, New Delhi, Third edition, 2015.
2. Reinhold Ludwig and Gene Bogdanov, "RF Circuit Design: Theory and Applications", Pearson Education Inc., 2011, 2nd edition.
3. David M. Pozar,"Microwave Engineering", Wiley India (P) Ltd, New Delhi, 2011,4th edition.
4. E.Da.Silva, "High Frequency and Microwave Engineering", Butterworth Heinemann publications, Elsevier Science, 2001.

Reference Book(s) / Web links:

1. Samuel Y Liao, "Microwave Devices & Circuits", Prentice Hall of India, 2003, 3rd edition.
2. Robert E Colin, "Foundations for Microwave Engineering", John Wiley & Sons Inc, 2005.
3. Byron Edde, "Radar principles, Technology, Applications " PearsonPublications,2008.

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1	Klystron bench for mode characteristics	1
2	Microwave bench for Gunn diode characteristics	1
3	Microwave test bench for microwave parameters measurement	2
4	Microwave test bench for radiation parameter measurement of antenna	2
5	Microwave test bench for measuring the characteristics of directional coupler, power and attenuation	2
6	Microwave test bench of S-parameter measurement of the microwave components - Isolator, Magic Tee.	2

Suggested Evaluation Methods:

- Experiment based viva
- Mini Project

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23732.1	3	3	2	2	2	2	2	1	2	3	2	2	3	3	2
EC23732.2	3	3	2	2	3	2	2	2	2	3	2	3	3	3	2
EC23732.3	3	3	2	2	3	2	2	1	1	3	2	2	3	3	2
EC23732.4	3	3	2	3	3	2	2	1	1	3	3	2	3	3	2
EC23732.5	3	3	2	2	3	2	2	2	2	3	3	3	3	3	2
Average	**3**	**3**	**2**	**2.2**	**2.8**	**2**	**2**	**1.4**	**1.6**	**3**	**2.2**	**2.4**	**3**	**3**	**2**

Course Code	Course Title	Category	L	T	P	C
EC23733	EMBEDDED AND REAL TIME SYSTEMS	PC	3	0	2	4

Objectives:
• To learn the architecture and programming of ARM processor.
• To be familiar with the embedded computing platform design and analysis.
• To develop embedded platforms using real time operating system and scheduling techniques.
• To develop programs to interface I/Os with ARM processor.
• To analyze the building blocks of developed embedded platforms.

UNIT-I	INTRODUCTION TO EMBEDDED COMPUTING AND ARM PROCESSORS	9
Embedded system design process –Design example: GPS Moving map - Model train controller- Instruction sets preliminaries - ARM processor – supervisor mode, exceptions and traps – Co-processors – CPU: programming input and output - CPU performance- CPU power consumption.		
UNIT-II	**EMBEDDED COMPUTING PLATFORM DESIGN**	**9**
Designing with computing platforms – platform level performance analysis - Components for embedded programs- Models of programs- Assembly, linking and loading – compilation techniques- Software performance optimization – Program level energy and power analysis and optimization- Program validation and testing		
UNIT-III	**PROCESSES AND OPERATING SYSTEMS**	**9**
Introduction – Multiple tasks and multiple processes – Multi rate systems- Pre emptive real-time operating systems- Priority based scheduling- Inter process communication mechanisms – Evaluating operating system performance- Example Real Time Operating Systems-POSIX-Windows CE.		
UNIT-IV	**SYSTEM DESIGN TECHNIQUES AND NETWORKS**	**9**
Design methodologies- Design flows - Requirement analysis – Specifications-System analysis and architecture design – Quality assurance techniques- Distributed embedded systems: CAN bus, I2C – MPSoCs and shared memory multiprocessors		
UNIT-V	**CASE STUDY**	**9**
Data Compressor - Alarm clock - Software modem - Digital still camera - Telephone answering machine – Video accelerator.		
Total Contact Hours: 45		

Description of the Experiments	Total Contact Hours: 30
1. Interfacing of LED and Flashing of LEDS	
2. Interfacing using switches	
3. Interfacing of stepper motor	
4. Interfacing of ADC	
5. Interfacing of serial port	
6. Interfacing of keyboard and LCD	
7. Interfacing of DAC	
8. Interfacing of PWM	
9. Interfacing of temperature sensor	
10. Mini-project using LPC2148	

Course Outcomes: On completion of the course, students will be able to
• Understand architecture and programming of ARM Processor
• Develop and analyze embedded computing platform
• Develop real time embedded computing platform using scheduling algorithms
• Program ARM processor for interfacing with I/O devices
• Analyze the performance of developed embedded platforms

Suggested Activities:
• Problem sessions using scheduling algorithms • Flipped classroom – Case Study • Mini-project

Suggested Evaluation Methods:

- Brain storming – Requirement Analysis
- Quizzes
- Class Presentation/Discussion – Case study

Text Book(s):

1. Marilyn Wolf, "Computers as Components - Principles of Embedded Computing System Design", Third Edition "Morgan Kaufmann Publisher (An imprint from Elsevier), 2012.

Reference Book(s) / Web links:

1. Jonathan W.Valvano, "Embedded Microcomputer Systems Real Time Interfacing", 3rd Ed Cengage Learning, 2012.
2. David. E. Simon, "An Embedded Software Primer", 1st Edition, Fifth Impression, Addison-Wesley Professional, 2007.
3. Raymond J.A. Buhr, Donald L.Bailey, "An Introduction to Real-Time Systems- From Design to Networking with C/C++", Prentice Hall, 1999.
4. C.M. Krishna, Kang G. Shin, "Real-Time Systems", International Editions, McGraw Hill 1997.
5. K.V.K.K.Prasad, "Embedded Real-Time Systems: Concepts, Design & Programming", Dream Tech Press, 2005.
6. Sriram V Iyer, Pankaj Gupta, "Embedded Real Time Systems Programming", Tata McGraw Hill, 2004.

Lab equipment required:

S. No.	Name of the Equipment	Quantity Required
1	ARM Development Board – LPC2148	25
2	PCs	25
3	Stepper Motor	10
4	USB cable (System & Kit Interface)	25

Suggested Evaluation Methods:

- Experiment based viva
- Quizzes
- Mini Project

Web links for virtual lab:

- Real Time Embedded Systems Laboratory (ernet.in)

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23733.1	3	3	2	3	3	3	3	3	2	3	3	3	3	3	3
EC23733.2	3	2	2	2	1	2	2	2	2	3	2	3	3	2	2
EC23733.3	3	1	2	2	3	1	2	1	2	3	2	3	2	2	2
EC23733.4	3	2	2	3	1	2	2	2	2	3	2	3	2	1	2
EC23733.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	**3**	**2.2**	**2.2**	**2.6**	**2.2**	**2.2**	**2.4**	**2.2**	**2.2**	**3**	**2.4**	**3**	**2.6**	**2.8**	**2.4**

Course Code	Course Title	Category	L	T	P	C
EC23721	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR ELECTRONIC ENGINEERING	EEC	0	0	4	2

Objectives:
• To develop a strong foundation in AI and machine learning techniques applicable to various domains such as communication, healthcare and embedded systems.
• To enhance students' analytical and problem-solving skills in real-time data processing and decision-making using intelligent systems.
• To integrate emerging technologies like IoT, AI and MEMS into practical applications for industry-driven solutions.
• To enable students to design and implement intelligent control and classification systems for applications such as speech recognition, image processing, and seismic anomaly detection.
• To promote interdisciplinary research and innovation by combining machine learning with communication, signal processing, and embedded system applications.

List of Projects	Total Contact Hours: 60
1. Fuzzy logic and control systems	
2. Speech Signal Classification	
3. Image Classification and Processing	
4. Machine learning techniques for 5G communication networks	
5. Artificial Intelligence for Strategic planning in Wireless Sensor Networks	
6. IoT and Machine learning assisted Healthcare systems	
7. AI assisted vibration signal analysis to forecast seismic anomalies	
8. Integrating Machine learning with Embedded Real time Systems	
9. Machine learning for MEMS applications	
10. Fuzzy logic and control systems	

Course Outcomes: On completion of the course, students will be able to
• Design and implement AI-based models for communication networks, healthcare, and sensor networks.
• Apply fuzzy logic, signal processing, and embedded system design principles to solve real-world engineering problems.
• Develop and implement machine learning techniques for applications such as speech classification, seismic anomaly detection, and MEMS-based systems.
• Create innovative solutions for real-time data analysis and decision-making in 5G networks, IoT healthcare systems, and intelligent control systems.
• Acquire industry-relevant skills that prepare them for careers in AI-driven research, development, and entrepreneurship in electronics and communication engineering.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23721.1	3	3	3	3	1	3	3	3	1	2	-	2	2	3	3
EC23721.2	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
EC23721.3	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
EC23721.4	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
EC23721.5	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**2.6**	**2.2**	**2.2**	**2.2**	**2.6**	**2.8**	**3**	**2.8**	**2.8**	**3**	**3**

VERTICAL 1 – SIGNAL AND IMAGE PROCESSING

Course Code	Course Title	Category	L	T	P	C
EC23A11	MEDICAL ELECTRONICS	PE	3	0	0	3

Objectives:
• To introduce fundamentals of biomedical engineering
• To study measurement of certain important electrical and non-electrical parameters
• To understand the basic principles in imaging techniques
• To have a basic knowledge in life assisting and therapeutic devices
• To explore the applications of lasers and robots in medicine

UNIT-I	**ELECTRO-PHYSIOLOGY AND BIO-POTENTIAL RECORDING**	**9**
Bio Potential – Origin and recording methods - Basic components of a biomedical system- Bio electrodes- Bio Amplifiers- ECG, EEG, EMG: origin, Lead systems, waveforms, applications and recording techniques.		
UNIT-II	**MEASUREMENT OF NON ELECTRICAL PARAMETERS**	**9**
Colorimeter-Auto analyser- Blood cell counter-Measurement of blood pressure - Cardiac output - Heart rate – Blood flow measurement – spirometer –pH of blood –measurement of blood pCO2, pO2, finger-tip oxymeter.		
UNIT-III	**IMAGING MODALITIES AND ANALYSIS**	**9**
Radio graphic and fluoroscopic techniques – Computer tomography – MRI – PET-SPECT- Ultrasonography– Thermography – Different types of biotelemetry systems - Retinal Imaging - Imaging application in Biometric systems.		
UNIT-IV	**LIFE ASSISTING AND THERAPEUTIC DEVICES**	**9**
Pacemakers – Defibrillators – Ventilators– Diathermy – Heart – Lung machine –Dialysers – Lithotripsy - ICCU patient monitoring system- Nano Robots - Robotic surgery – Orthopedic prostheses fixation.		
UNIT-V	**LASERS AND ROBOTICS IN MEDICINE**	**9**
Introduction Automation and Robots, Classification, Specification, Notations, Bio Engineering Biologically Inspired Robots, Application in Rehabilitation – Interactive Therapy, Bionic Arm, Clinical and Surgical. Production of Lasers-types-Applications of Lasers in Medicine.		
Total Contact Hours: 45		

Course Outcomes: On completion of course, students will be able to
• Explain the philosophy of the bio potential, heart, brain and muscle
• Implement latest ideas for measurement of non-electrical devices
• Use modern methods of imaging and analyse
• Provide assist devices for various organs
• Apply lasers and robots for medical assistance/techniques

Suggested Activities:
• Activity Based Learning
• Mini projects

Suggested Evaluation Methods:
• Assignment problems
• Quizzes
• Class Presentation/Discussion

Text Book(s):
1. Leslie Cromwell, "Biomedical Instrumentation and Measurement", Prentice Hall of India, New Delhi, 2007.
2. Khandpur R.S, Handbook of Biomedical Instrumentation, Tata McGraw-Hill, New Delhi,2nd edition, 2003
3. Joseph J Carr and John M.Brown, Introduction to Biomedical Equipment Technology, John Wiley and sons, New York, 4th edition, 2012

Reference Book(s) / Web links:
1. John G. Webster, Medical Instrumentation Application and Design, John Wiley and sons, New York, 1998.
2. Ed. Joseph D. Bronzino, The Biomedical Engineering Hand Book, Third Edition, Boca Raton, CRC Press LLC, 2006.
3. M.Arumugam, 'Bio-Medical Instrumentation', Anuradha Agencies, 2003.
4. J.J.Craig, Introduction to Robotics, Pearson Education, 2005.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23A11.1	3	3	3	3	3	3	1	2	2	2	3	3	3	3	3
EC23A11.2	3	3	1	1	2	1	1	1	2	3	1	1	1	1	2
EC23A11.3	3	1	1	1	2	2	2	1	2	3	1	1	1	2	2
EC23A11.4	3	1	1	3	2	3	3	3	3	3	3	3	2	3	3
EC23A11.5	3	1	2	3	2	3	3	2	2	2	3	2	2	2	2
Average	**3**	**1.8**	**1.6**	**2.2**	**2.2**	**2.4**	**2**	**1.8**	**2.2**	**2.6**	**2.2**	**2**	**1.8**	**2.2**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23A12	BIOSENSING AND ITS ANALYSIS	PE	3	0	0	3

Objectives:
• To know the various functional blocks present in bio signal acquisition system
• To gain in depth knowledge about wavelet detection and multivariate analysis
• To develop a thorough knowledge on classification and recognition of biomedical signals

UNIT-I	BIOMEDICAL TRANSDUCERS AND AMPLIFIERS	9
Active and Passive Transducers- Categories, Characteristics and Applications. Signal conditioning units, Multichannel data acquisition system, various types of recorders.		
UNIT-II	**BIO AMPLIFIERS**	**9**
Necessity for low noise pre amplifiers- Characteristics of Bio Amplifier-Difference amplifier, Chopper amplifier, Instrumentation Amplifier and Isolation amplifier.		
UNIT-III	**ADAPTIVE FILTERING AND WAVELET DETECTION**	**9**
Filtering –adaptive noise cancelling in ECG, improved adaptive filtering in FECG, Wavelet detection in ECG – structural features, matched filtering, adaptive wavelet detection.		
UNIT-IV	**BIO SIGNAL CLASSIFICATION**	**9**
Signal classification – Statistical signal classification, linear discriminate function, direct feature selection and ordering, Back propagation neural network based classification.		
UNIT-V	**MULTIVARIATE ANALYSIS AND BIO SIGNAL RECOGNITION**	**9**
Multivariate component analysis – PCA and ICA. Recognition of ECG signal - Normal versus Ectopic ECG beats. Recognition of EEG signal- delta, theta, alpha and beta wave extraction.		
Total Contact Hours: 45		

Course Outcomes: On completion of course, students will be able to
• Identify the functional blocks required for bio signal acquisition
• Detect the suitable amplifiers required for various bio sensing applications
• Analyze the bio signals using Adaptive Filtering and Wavelets
• Classify various bio signals using different algorithms
• Analyze Multivariate methods for recognition of bio signals

Suggested Activities:

- Activity Based Learning
- Mini projects

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):

1. Geddes LA and Baker L.E Principals of Applied Biomedical Instrumentation , John Wiley and sons New York, 1975
2. Arnon Cohen, Bio-Medical Signal Processing Vol I and Vol II, CRC Press Inc., Boca Rato, Florida 1999.

Reference Book(s) / Web links:
1. Webster J.G Medical Instrumentation application and design – John Wiley and sons New York, 3rd edition 1999
2. Rangaraj M. Rangayyan, 'Biomedical Signal Analysis-A case study approach', WileyInterscience/IEEE Press, 2002

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23A12.1	2	3	2	2	3	2	2	2	2	2	1	2	3	2	1
EC23A12.2	2	3	2	2	2	2	2	2	2	2	1	2	3	2	1
EC23A12.3	2	3	2	2	2	2	2	2	2	2	1	2	3	2	1
EC23A12.4	2	3	2	2	2	2	2	2	2	2	1	2	3	2	1
EC23A12.5	2	3	2	2	2	2	2	2	2	2	1	2	3	2	1
Average	**2**	**3**	**2**	**2**	**2.2**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**3**	**2**	**1**

Course Code	Course Title	Category	L	T	P	C
EC23A13	STATISTICAL SIGNAL PROCESSING	PE	3	0	0	3

Objectives:
• To enrich the concepts related to stationary and non-stationary random signals
• To understand the principle and properties of estimation
• To introduce IIF and FIR filters for estimation of signal
• To emphasize the importance of true estimation of power spectral density
• To introduce the concept of adaptive filtering techniques

UNIT-I	RANDOM PROCESS	9
Introduction to Review of random variables, random processes, WSS processes, autocorrelation and auto covariance functions, Spectral representation of random signals, Wiener Khinchin theorem Properties of power spectral density, Gaussian Process and White noise process. Random signal modeling: MA(q), AR(p) , ARMA(p,q) models.		
UNIT-II	**PARAMETER ESTIMATION THEORY**	**9**
Principle of estimation and applications, Properties of estimates, unbiased and consistent estimators, Efficient estimators; Criteria of estimation: the methods of maximum likelihood and its properties; Baysean estimation: Mean square error and MMSE, Maximum a Posteriori(MAP) estimation		
UNIT-III	**ESTIMATION OF SIGNAL IN PRESENCE OF WHITE GAUSSIAN NOISE**	**9**
Linear Minimum Mean-Square Error (LMMSE) Filtering: Wiener Hoff Equation, FIR Wiener filter, Causal IIR Wiener filter, Non causal IIR Wiener filter		
UNIT-IV	**SPECTRAL ESTIMATION**	**9**
Estimated autocorrelation function, periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Blackman and Tukey method of smoothing periodogram, Levinson Durbin Algorithm		
UNIT-V	**FILTERING**	**9**
Adaptive Filtering: Principle and Application, Steepest Descent Algorithm Convergence characteristics; LMS algorithm, convergence, excess mean square error; Application of Adaptive filters.		
		Total Contact Hours: 45

Course Outcomes: On completion of course, students will be able to
• Identify the suitable model for noise removal
• Estimate the parameters and analyse using properties
• Design filters for processing random signal
• Select appropriate spectrum estimation method based on type of random signal
• Design adaptive systems

Suggested Activities:

- Problem solving sessions
- Activity based learning

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):
1. Monson H, Hayes, Statistical Digital Signal Processing and Modeling, John Wiley and Sons Inc., New York, Indian Reprint, 2008.
2. Adaptive Filter Theory, S. Haykin, Prentice-Hall, 4th edition, 2014

Reference Book(s) / Web links:
1. Sophocles J. Orfanidis, Optimum Signal Processing, An Introduction, McGraw Hill, 1990.
2. John G.Proakis, Dimitris G. Manolakis, Digital Signal Processing, Pearson, Fourth 2007.
3. Dwight F. Mix, Random Signal Processing, Prentice Hall, 1995.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23A13.1	3	3	3	3	3	3	3	2	2	2	1	3	3	3	1
EC23A13.2	3	3	3	3	3	3	3	2	2	2	1	3	3	3	1
EC23A13.3	3	3	3	3	3	3	3	2	2	2	1	3	3	3	1
EC23A13.4	3	3	3	3	3	3	3	2	2	2	1	3	3	3	1
EC23A13.5	3	3	3	3	3	3	3	2	2	2	1	3	3	3	1
Average	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**1**	**3**	**3**	**3**	**1**

Course Code	Course Title	Category	L	T	P	C
EC23A14	DIGITAL IMAGE PROCESSING	PE	3	0	0	3

Objectives:

- To learn digital image fundamentals.
- To be exposed to simple image enhancement techniques.
- To be exposed to simple image restoration techniques.
- To learn image segmentation.
- To be familiar with image compression techniques.

UNIT-I	**DIGITAL IMAGE FUNDAMENTALS**	**9**
Introduction - Steps in digital image processing, Components of digital image processing systems, brightness, contrast, hue, saturation, Image sensing and acquisition, Image sampling and quantization, Color image fundamentals.		
UNIT-II	**IMAGE ENHANCEMENT**	**9**
Noise distributions, Point processing, Image enhancement - Gray level transformations, Spatial averaging, Directional smoothing, Histogram and Histogram equalization, Homomorphic filtering and Color image enhancement.		
UNIT-III	**IMAGE RESTORATION**	**9**
Reasons for image degradation, Image restoration model, Constrained and Unconstrained Restorations, Restoration filters - Arithmetic mean, Geometric mean, Harmonic mean, Contra harmonic mean, median, midpoint, alpha trimmed, min and max filters, Adaptive mean filter, Adaptive median filter, Inverse filter and Wiener filter.		
UNIT-IV	**IMAGE SEGMENTATION**	**9**
Detection of discontinuities - Point detection, Line detection, Edge detection, Detection of continuities – Thresholding, Adaptive thresholding, Region based segmentation, Region based segmentation - Region growing, Region splitting and Merging, Edge linking via Hough transform.		
UNIT-V	**IMAGE COMPRESSION**	**9**
Need for data compression, Lossy and Lossless compression, Huffman coding, Run length codes, Shift codes, Arithmetic coding, Transform coding, JPEG and MPEG compression standards.		
		Total Contact Hours: 45

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

- Describe digital image fundamentals.
- Exhibit various image enhancement techniques.
- Exhibit various image restoration techniques.
- Explain various image segmentation techniques.
- Apply various image compression techniques.

Suggested Activities:

- Activity Based Learning
- Mini projects

Suggested Evaluation Methods:

- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):

1. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, Pearson, Second Edition, 2004.
2. Anil K. Jain, Fundamentals of Digital Image Processing', Pearson 2002.

Reference Book(s) / Web links:
1. Rafael C. Gonzalez, Richard E. Woods, Steven Eddins,' Digital Image Processing using MATLAB', Pearson Education, Inc., 2004.
2. Jeyaraman, Esakki raja, 'Digital image processing', TATA Mc Graw Hill .2009.
3. William K. Pratt, Digital Image Processing, John Wiley, New York, 2002.
4. Rafael C. Gonzalez, Richard E. Woods, Steven Eddins,' Digital Image Processing using MATLAB', Pearson Education, Inc., 2004.
5. Kenneth R. Castleman, Digital Image Processing, Pearson, 2006.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23A14.1	3	3	3	3	3	3	2	2	2	2	3	3	3	3	3
EC23A14.2	3	3	1	1	2	2	2	2	2	3	1	2	1	1	2
EC23A14.3	3	2	2	2	2	2	2	1	2	3	2	1	2	2	2
EC23A14.4	3	2	2	3	2	3	3	3	3	3	3	3	2	3	3
EC23A14.5	3	1	2	3	2	3	3	2	2	2	3	2	2	2	2
Average	**3**	**2.2**	**2.0**	**2.4**	**2.2**	**2.6**	**2.4**	**2.0**	**2.2**	**2.6**	**2.4**	**2.2**	**2.0**	**2.2**	**2.4**

Course Code	Course Title	Category	L	T	P	C
EC23A15	IMAGE AND VIDEO ANALYSIS	PE	3	0	0	3

Objectives:

- To impart knowledge on the basic principles and concepts in digital image and video analysis.
- To be exposed to feature extraction and texture analysis techniques.
- To learn about Object recognition and image retrieval methodologies.
- To be familiar with video processing, segmentation and tracking.
- To explore and demonstrate real time video analytics.

UNIT-I	**FEATURE EXTRACTION AND TEXTURE ANALYSIS**	**9**
Feature Extraction - Binary object feature, Histogram-based (Statistical) Features, Intensity features, Shape feature extraction. Texture Analysis - Concepts and classification, statistical, structural and spectral analysis.		
UNIT-II	**OBJECT RECOGNITION AND IMAGE RETRIEVAL**	**9**
Object Recognition -Patterns and pattern class, Bayes' Parametric classification, Feature Selection and Boosting, Template-Matching. Content Based Image Retrieval - Feature based image retrieval, Object Based Retrieval.		
UNIT-III	**DIGITAL VIDEO PROCESSING**	**9**
Digital Video, Sampling of video signal, Video Enhancement and Noise Reduction- Rate control and buffering, MPEG, H.264, Inter frame Filtering Techniques, Fundamentals of Motion Estimation and Motion Compensation.		
UNIT-IV	**VIDEO SEGMENTATION AND TRACKING**	**9**
Change Detection, Background modelling, Motion Segmentation, Simultaneous Motion Estimation and Segmentation, Motion Tracking, Multi-target/Multi-camera tracking.		
UNIT-V	**VIDEO ANALYSIS ACTION RECOGNITION**	**9**
Video Analysis Action Recognition, Video based rendering, Context and scene understanding. Case Study: Surveillance - Advanced Driver Assistance System.		
		Total Contact Hours: 45

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

- Illustrate the feature extraction techniques
- Demonstrate the image recognition and motion recognition
- Exhibit the processes involved in digital video processing.
- Explain various video segmentation techniques.
- Design and Analysis of video recognition in application

Suggested Activities:

- Activity Based Learning
- Mini projects

Suggested Evaluation Methods:

- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):

1. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, Pearson, Second Edition, 2004.
2. A. Murat Tekalp, "Digital Video Processing", Second Edition, Prentice Hall, 2015.

Reference Book(s) / Web links:
1. Oge Marques, ”Practical Image and Video Processing Using MATLAB”, Wiley-IEEE Press, 2011
2. Jeyaraman, Esakki raja, ‘Digital image processing’, TATA Mc Graw Hill, 2009.
3. Yu Jin Zhang, “Image Engineering: Processing, Analysis and Understanding”, Tsinghua University Press, 2009.
4. Mark Nixon and Alberto S. Aquado, “Feature Extraction & Image Processing for Computer Vision”, Third Edition, Academic Press, 2012
5. Boguslaw Cyganek,”Object Detection and Recognition in Digital Images: Theory and Practice”, Wiley 2013.

PO/PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
EC23A15.1	3	3	3	3	3	3	2	2	2	2	3	3	3	3	3
EC23A15.2	3	3	1	1	2	2	2	2	2	3	1	2	1	1	2
EC23A15.3	3	2	2	2	2	2	2	1	2	3	2	1	2	2	2
EC23A15.4	3	2	2	3	2	3	3	3	3	3	3	3	2	3	3
EC23A15.5	3	1	2	3	2	3	3	2	2	2	3	2	2	2	2
Average	**3**	**2.2**	**2.0**	**2.4**	**2.2**	**2.6**	**2.4**	**2.0**	**2.2**	**2.6**	**2.4**	**2.2**	**2.0**	**2.2**	**2.4**

Course Code	Course Title	Category	L	T	P	C
EC23A16	SPEECH AND AUDIO PROCESSING	PE	3	0	0	3

Objectives:
• To understand Speech production system and describe the fundamentals of speech
• To apply different speech analysis techniques
• To understand and evaluate statistical speech models
• To analyze and apply Text to Speech Synthesis models for real world applications
• To evaluate lossy and lossless audio coders

UNIT-I	MECHANICS OF SPEECH AND AUDIO	9
Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds; Acoustic Phonetics – Acoustics of speech production-Filter-Bank and LPC Methods-Psychoacoustics–Sound pressure level and loudness– Frequency analysis and critical bands-source-filter model of speech production.		
UNIT-II	**SPEECHANALYSIS**	**9**
Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures– mathematical and perceptual –Log–Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients.		
UNIT-III	**SPEECH MODELING AND RECOGNITION**	**9**
Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation, HMM Training and Testing-Large Vocabulary Continuous Speech Recognition: Architecture of Large vocabulary continuous speech recognition system–acoustics and language models –n-grams, Applications.		
UNIT-IV	**SPEECH SYNTHESIS**	**9**
Text-to-Speech Synthesis: Concatenative and Waveform synthesis methods, sub-word units for TTS, intelligibility and naturalness– role of prosody, Applications.		
UNIT-V	**DIGITAL AUDIO SIGNAL PROCESSING**	**9**
Lossless Audio Coding– Lossy Audio Coding- ISO- MPEG-1,2,2-Advaned, 4AAudio Coding- Digital Audio Restoration-Modelling of audio signals – Correlated Noise Pulse Removal-Pitch variation defects.		
Total Contact Hours: 45		

Course Outcomes: On completion of course, students will be able to
• Understand speech production system and acoustic- phonetics concept of speech
• Apply DSP concepts to process digitized speech data and to extract features
• Evaluate statistical models for Speech recognition applications
• Analyze Text-to-Speech synthesis methods
• Evaluate Audio coding algorithms

Suggested Activities:

- Problem solving sessions
- Flipped classroom
- Activity Based Learning

Suggested Evaluation Methods:

- Assignment problems
- Quizzes
- Class Presentation

Text Book(s):
1. Lawrence Rabiner and Biing-Hwang Juang, B.Yegnanarayana “Fundamentals of Speech Recognition”, Pearson Education, 2008.
2. Lawrence Rabiner and Ronald W.Schaffer, “Digital Processing of Speech signals”, Prentice Hall, 1978.

Reference Book(s) / Web links:
1. Ben Gold, Nelson Morgan, and Dan Ellis, Speech and Audio signal processing: processing and perception of speech and music, John Wiley &Sons, 2011.
2. Udo Zölzer, A John, “Digital Audio Signal Processing”, Second Edition, Wiley & sons Ltd, 2008.
3. John G. Beerends, Mark Kahrs, Karlheinz Brandenburg, “Applications of Digital Signal Processing to Audio And Acoustics”, Kluwer Academic Publishers, 2002.
4. Xuedong Huang, Alex Acero, Hsiao, Wuen Hon, “Spoken Language Processing”, Prentice Hall 2001.

PO/PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
EC23A16.1	3	1	-	3	2	1	3	2	1	2	1	1	3	2	2
EC23A16.2	3	3	2	2	3	2	2	2	1	2	1	1	3	3	2
EC23A16.3	3	3	2	3	3	3	2	2	1	2	1	1	3	3	2
EC23A16.4	3	3	2	2	3	3	2	2	1	2	1	1	3	3	3
EC23A16.5	3	3	3	3	3	3	2	2	3	3	1	1	3	3	2
Average	**3**	**2.6**	**1.8**	**2.6**	**2.8**	**2.4**	**2.2**	**2**	**1.4**	**2.2**	**1**	**1**	**3**	**2.8**	**2.2**

Course Code	Course Title	Category	L	T	P	C
EC23A17	PRINCIPLES OF MACHINE LEARNING	PE	3	0	0	3

Objectives:

- To know the basics of machine learning.
- To be exposed to linear models.
- To be familiar with basic machine learning algorithms with classification.
- To understand machine learning algorithms with clustering.
- To learn and apply reinforcement learning techniques.

UNIT-I	INTRODUCTION TO MACHINE LEARNING	9

Components of learning – learning models – geometric models – probabilistic models – logical models – grouping and grading–learning versus design–types of learning–supervised–unsupervised–reinforcement–theory of learning–feasibility of learning–error and noise–training versus testing–theory of generalization–generalization bound–
Approximation generalization tradeoff– bias and variance–learning curve.

UNIT-II	REGRESSION MODELS	9

Linearclassification–univariatelinearregression-bivariateregression–multivariatelinearregression–regularized regression–
Logistic regression. Naïve Baye's–Discriminant Functions-Probabilistic Generative Models-Probabilistic Discriminative Models–Bayesian Logistic Regression.

UNIT-III	SUPERVISED LEARNING	9

Perceptron:–multi layer neural networks–back propagation-learning neural networks structures – **Support Vector Machines:**–soft margin SVM–going beyond linearity– generalization and over fitting–regularization– validation.
Decision trees: Training and Visualizing a Decision Tree - Making Predictions - Estimating Class Probabilities – The CART Training Algorithm-Computational Complexity-Gini Impurity or Entropy-**Ensemble methods:** Bagging- Boosting- Boosting AdaBoost- Gradient Boosting–XGBoost.

UNIT-IV	UNSUPERVISED LEARNING	9

Clustering: Nearest neighbor models–K-means–clustering around Methods. **Dimensionality Reduction:**–Linear Discriminant Analysis–Principal Component Analysis – Factor Analysis–Independent Component Analysis.

UNIT-V	REINFORCEMENT LEARNING	9

Passive reinforcement learning–direct utility estimation–adaptive dynamic programming–temporal-difference learning – active reinforcement learning–exploration–learning an action utility function–Generalization in reinforcement learning–policy search–applications in game playing–applications in robot control.

Total Contact Hours: 45

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

- Understand fundamentals of machine learning.
- Apply the linear models fortuning parameters.
- Understand and explore the machine learning algorithms with classification.
- Apply machine learning algorithms with clustering and feature extraction.
- Apply reinforcement learning techniques for various applications.

Suggested Activities:

- Flipped classroom
- Activity based Learning

Suggested Evaluation Methods:

- Assignment problems
- Quizzes
- Class Presentation

Text Book(s):
1. Aurélien Géron-Hands-On Machine Learning with Scikit-Learn, Keras, and Tensor Flow, 2nd Edition. September 2019, Reilly Media, Inc., ISBN: 9781492032649.
2. Stephen Marsland,―Machine Learning– An Algorithmic Perspective‖, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
3. Shai Shalev-Shwartz and Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University press 2014.

Reference Book(s) / Web links:
1. Alex Smola and S.V.N.Vishwanathan," Introduction to Machine Learning", Cambridge University Press, 2008
2. Andreas C. Müller and Sarah Guido, "Introduction to Machine Learning with Python: A Guide for Data Scientists", O'Reilly Media, Inc, 2016.
3. S.Russel and P.Norvig, "Artificial Intelligence: A Modern Approach", Third Edition, Prentice Hall, 2009.
4. C.M.Bishop, "Pattern Recognition and Machine Learning", Springer, 2007.
5. https://www.coursera.org/lecture/python-machine-learning/introduction-4f2So
6. https://nptel.ac.in/courses/106/106/106106139/

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23A17.1	3	2	2	2	2	1	1	1	2	1	2	2	3	3	3
EC23A17.2	3	2	2	2	3	2	1	2	3	1	3	3	3	3	3
EC23A17.3	3	2	2	2	3	2	1	2	3	1	3	3	3	3	3
EC23A17.4	3	3	3	3	3	2	1	2	3	1	3	3	3	3	3
EC23A17.5	3	2	2	2	2	3	1	3	2	1	2	2	3	3	3
Average	**3**	**2.2**	**2**	**2.2**	**2.6**	**2**	**1**	**2**	**2.6**	**1**	**2.6**	**2.6**	**3**	**3**	**3**

Course Code	Course Title	Category	L	T	P	C
EC23A18	INTRODUCTION TO DEEP LEARNING	PE	3	0	0	3

Objectives:
• To understand the fundamentals of machine learning and deep learning.
• To familiarize various Training Techniques.
• To gain the knowledge required to handle image related data.
• To gain the knowledge required to handle continuous and time-series data.
• To familiarize generative deep learning.

UNIT-I	INTRODUCTION TO DEEP LEARNING	9
Introduction: History, AI vs ML vs DL, Deep Learning: Hardware, Data and Algorithms - Building blocks of neural networks: Data Representation - Gradient-based Optimization - Stochastic Gradient Descent – Back propagation - Anatomy of a Neural Network: Layers, Models, Loss Functions and Optimizers.		
UNIT-II	**TRAINING TECHNIQUES**	**9**
Numerical Differentiation – Gradient – Implementing a Training Algorithm - Stochastic Gradient Descent –Momentum – AdaGrad – Adam – Initial Weight Values – Regularization – Validating Hyper parameters.		
UNIT-III	**CONVOLUTIONAL NEURAL NETWORKS**	**9**
Introduction to Convnets: Convolution Operation - Max-Pooling Operation - Training a convnet - Data Preprocessing -Data Augmentation - Using pretrained Convnets. Back propagating through convolutions – Back propagation as Convolution with filters, Matrix Multiplications - Data Augmentation.		
UNIT-IV	**RECURRENT NEURAL NETWORKS**	**9**
Introduction - The Architecture of Recurrent Neural Networks - Language Modelling Example of RNN - Generating a Language Sample – Back propagation Through Time - Bidirectional Recurrent Networks - Multilayer Recurrent Networks - Long Short-Term Memory (LSTM) - Gated Recurrent Units (GRUs).		
UNIT-V	**GENERATIVE DEEP LEARNING**	**9**
Encoder Decoder architecture- Autoencoders, Variational Autoencoders, Adversarial Generative Networks.		
		Total Contact Hours: 45

Course Outcomes: On completion of course, students will be able to
• Understand the fundamentals of deep learning based on optimizations and back propagation and machine learning.
• Apply various training techniques.
• Implement convolutional neural network for image processing applications.
• Build networks to perform sentiment analysis and work on real-time time series data.
• Construct deep generative model for various applications.

Suggested Activities:
• Flipped classroom
• Activity based Learning

Suggested Evaluation Methods:
• Assignment problems
• Quizzes
• Class Presentation

Text Book(s):
1. Koki Saitoh, “Deep Learning from the Basics - Python and Deep Learning: Theory and Implementation”, 2021, Packt Publishing.
2. Francois Chollet, “Deep Learning with Python “, Manning Publications Company, First Edition, 2017. ISBN 978-1617294433.

Reference Book(s) / Web links:
1. Ian Goodfellow, YoshuaBengio and Aaron Courville, “Deep Learning”, MIT Press, First Edition, 2017, ISBN 978-0262035613.
2. Bengio, Yoshua. "Learning deep architectures for AI." Foundations and trends in Machine Learning 2.1, 2009.
3. https://www.geeksforgeeks.org/introduction-deep-learning/
4. https://www.analyticsvidhya.com/blog/2021/06/autoencoders-a-gentle-introduction/

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23A18.1	3	2	2	2	2	1	1	2	2	2	1	1	3	3	3
EC23A18.2	3	2	2	2	3	2	1	2	2	2	2	2	3	3	3
EC23A18.3	3	2	2	2	3	2	1	2	2	2	2	2	3	3	3
EC23A18.4	3	3	3	3	3	2	1	2	2	2	2	3	3	3	3
EC23A18.5	3	2	2	2	2	3	1	2	2	2	2	3	3	3	3
Average	**3**	**2.2**	**2**	**2.2**	**2.6**	**2**	**1**	**2**	**2**	**2**	**1.8**	**2.2**	**3**	**3**	**3**

VERTICAL 2 - RF AND ADVANCED COMMUNICATIONS

Course Code	Course Title	Category	L	T	P	C
EC23B11	INFORMATION THEORY AND CODING	PE	3	0	0	3

Objectives:
• To know the basic principles of information theory and text coding.
• To study the various voice coding techniques.
• To learn the concepts of image coding.
• To understand the principles of video coding techniques.
• To acquire knowledge on error control coding techniques.

UNIT-I	**INFORMATION THEORY AND TEXT CODING**	**9**
Information Measure, Entropy, Information rate, Kraft McMillan inequality, Source coding theorem, Shannon-Fano coding, Huffman coding, Extended Huffman coding , Adaptive Huffman Coding, Arithmetic Coding and LZW algorithm.		
UNIT-II	**VOICE CODING**	**9**
Adaptive Differential Pulse Code Modulation, Adaptive delta modulation, Adaptive sub band coding, Adaptive transform coding, Channel Vocoder, Linear Predictive Coding and comparison of various voice coding techniques.		
UNIT-III	**IMAGE CODING**	**9**
Image compression and its need, Shift codes, Arithmetic Coding, Run length coding, Transform coding and JPEG standards.		
UNIT-IV	**VIDEO CODING**	**9**
Video Compression: Principles-I, B, P frames, Motion estimation, Motion compensation, Introduction to H.261, MPEG Video compression standards.		
UNIT-V	**ERROR CONTROL CODING**	**9**
Convolutional codes, Cyclic codes, Cyclic Redundancy Check codes, Reed Solomon codes, BCH Codes, Repetition codes, Principle of Turbo coding and LDPC codes.		
		Total Contact Hours: 45

Course Outcomes: On completion of the course, students will be able to
• Recall various coding techniques for text compression.
• Classify the different voice coding techniques.
• Apply the various coding techniques for image compression.
• Describe the video coding techniques.
• Evaluate the various error control coding techniques.

Suggested Activities:

- Problem solving sessions- Text Coding and Error Control Coding
- Flipped classroom - Voice Coding

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):
1. Simon Haykin, “Digital Communications”, John Wiley and Sons, 2010.
2. K Sayood, “Introduction to Data Compression” 3/e, Elsevier 2006.

Reference Book(s) / Web links:
1. R Bose, “Information Theory, Coding and Cryptography”, TMH 2007.
2. S Gravano, “Introduction to Error Control Codes”, Oxford University Press 2007.
3. Amitabha Bhattacharya, “Digital Communication”, TMH 2006.
4. Mark Nelson, “Data Compression Book”, BPB Publication 1992.
5. Watkinson J, “Compression in Video and Audio”, Focal Press, London, 1995.
6. Rafael C. Gonzalez, Richard E. Woods, ‘Digital Image Processing', Pearson, Second Edition, 2004.
7. Fred Halsall, “Multimedia Communications: Applications, Networks, Protocols and Standards”, Pearson Education Asia, 2002.
8. Steven Roman, “Introduction to Coding and Information Theory”.1st ed.1996.
9. T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd ed. Wiley interscience,2006.
10. Nilotpal Manna, ArijitSaha “Information Theory, Coding and Cryptography” Pearson Education, 1st Edition, 2013
11. https://ocw.mit.edu/courses/6-441-information-theory-spring-2010/
12. https://nptel.ac.in/courses/117101053
13. http://web.stanford.edu/class/ee376a/files/scribes/lecture_notes.pdf
14. https://everythingvtu.wordpress.com/

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23B11.1	3	3	1	3	2	2	2	-	2	2	2	2	3	3	2
EC23B11.2	3	2	2	2	1	2	2	-	2	1	2	2	3	3	2
EC23B11.3	3	2	2	2	1	2	1	3	2	1	1	2	2	3	3
EC23B11.4	3	2	2	2	1	2	2	2	2	1	1	2	2	2	2
EC23B11.5	3	2	1	3	1	1	1	-	2	-	1	2	3	2	2
Average	**3**	**2.2**	**1.6**	**2.4**	**1.2**	**1.8**	**1.6**	**1**	**2**	**1**	**1.4**	**2**	**2.6**	**2.6**	**2.2**

Course Code	Course Title	Category	L	T	P	C
EC23B12	COGNITIVE RADIO	PE	3	0	0	3

Objectives:

- To study the basics of the software defined radio and its essential functionalities
- To understand the fundamentals of cognitive radio
- To learn the necessity of software defined radio architecture in development of cognitive radio
- To know the concept of cognitive radio architecture
- To understand the role of cognitive radio for next generation wireless networks and public safety.

UNIT-I	**SOFTWARE DEFINED RADIO AND ITS ARCHITECTURE**	**9**
History of Software Defined Radio (SDR)-an overview, Basic SDR- Essential functions of the software radio-Hardware architecture, Computational Processing Resources, Software architecture.		
UNIT-II	**INTRODUCTION TO COGNITIVE RADIO**	**9**
Cognitive Radio (CR)-vision, history and definition, Java reflection in cognitive radio, smart antennas, Cognitive techniques – Location awareness, environment awareness in cognitive radios.		
UNIT-III	**SDR AS A PLATFORM FOR CR**	**9**
Introduction- Hardware architecture for SDR with DSP techniques- Software architecture, key development concepts and tools-SDR development and design, component development, waveform development- cognitive waveform development.		
UNIT-IV	**COGNITIVE RADIO ARCHITECTURE**	**9**
Cognitive Radio- functions, components and design rules, Cognition cycle- orient, plan, decide and act phases, Inference Hierarchy- Atomic Stimuli, Primitive Sequences, Basic Sequences.		
UNIT-V	**NEXT GENERATION WIRELESS NETWORKS**	**9**
The XG Network architecture, spectrum sensing, spectrum management, spectrum mobility, spectrum sharing, upper layer issues, public safety and cognitive radio.		
	Total Contact Hours:45	

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

- Understand hardware and software architecture of SDR
- Analyze the functions of cognitive radio
- Design cognitive radio using SDR as a platform
- Development of architecture based on the functions of cognitive radio.
- Analyze the concepts behind the Cognitive radio based next generation wireless networks and its applications.

Suggested Activities:

- Flipped classroom - Essential functions of the software radio
- Seminar- public safety and cognitive radio
- GNU radio hands on training

Suggested Evaluation Methods:

- Assignment
- Quizzes
- Class Presentation/Discussion

Text Book(s):

1. BruceA.Fette,"Cognitive Radio Technology", Elsevier,2009.
2. Joseph Mitola III, "Software Radio Architecture: Object-Oriented Approaches to Wireless System Engineering", John Wiley & SonsLtd.2000.

Reference Book(s) / Web links:
1. Simon Haykin,"Cognitive Dynamic Systems: Perception-action Cycle, Radar and Radio", Cambridge University Press, 22-Mar-2012
2. ThomasW.Rondeau,CharlesW.Bostain,"Artificial Intelligence in Wireless communication",ARTECHHOUSE.2009
3. IanF.Akyildiz,Won–YeolLee, Mehmet C.Vuran, Shantidev Mohanty, "Next generation dynamic spectrum access/cognitive radio wireless networks: A Survey" Elsevier Computer Networks, May2006.
4. Alexander M. Wyglinski, Maziar Nekovee, Thomas Hou, ―Cognitive Radio Communications and Networks, Academic Press, Elsevier, 2010.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23B12.1	3	3	2	2	1	1	1	1	1	1	1	1	2	2	1
EC23B12.2	3	3	2	2	1	1	1	1	1	1	1	1	2	2	1
EC23B12.3	3	3	2	2	1	1	2	1	1	1	1	2	2	2	1
EC23B12.4	3	3	2	2	1	1	1	1	2	1	1	2	2	2	1
EC23B12.5	3	3	3	3	2	2	2	2	2	1	2	3	3	3	2
Average	**3**	**3**	**2.2**	**2.2**	**1.2**	**1.2**	**1.4**	**1.2**	**1.4**	**1**	**1.2**	**1.8**	**2.2**	**2.2**	**1.2**

Course Code	Course Title	Category	L	T	P	C
EC23B13	ADVANCED COMMUNICATION SYSTEMS	PE	3	0	0	3

Objectives:

- To know the fundamentals of microwave radio communications
- To acquire knowledge about digitized video and to explore the concepts of Digital Video Broadcasting (DVB) for TV Transmission
- To Comprehend the principles of modulation and to understand the transmission of digital TV signals over IP networks
- To explore about earth station technology and to understand the applications of satellite Communication
- To learn about the modern wireless communication systems and its evolution of cellular networks

UNIT-I	**MICROWAVE RADIO COMMUNICATIONS**	**9**
Introduction, Advantages and Disadvantages, Analog vs digital microwave, frequency vs amplitude Modulation, frequency modulated microwave radio system, FM microwave radio repeaters, Diversity, protection switching arrangements, FM microwave radio stations, microwave repeater station.		
UNIT-II	**DIGITAL TV**	**9**
Digital TV: Digitized Video, Source coding of Digitized Video, Compression of Frames, DCT based (JPED), Compression of Moving Pictures (MPEG). Basic blocks of MPEG2 and MPE4, Digital Video Broadcasting (DVB)		
UNIT-III	**MODULATION AND DISPLAY TECHNIQUES**	**9**
Modulation: QAM (DVB-S, DVB-C), OFDM for Terrestrial Digital TV(DVB –T). Reception of Digital TV Signals (Cable, Satellite and terrestrial). Digital TV over IP, Digital terrestrial TV for mobile Display Technologies: basic working of Plasma, LCD and LED Displays		
UNIT-IV	**SATELLITE COMMUNICATION AND SATELLITE SYSTESMS**	**9**
Satellite Communication systems, introduction, Kepler's laws, orbits, orbital effects, orbital perturbations, Satellite sub systems, Antennas, Transponders, earth station technology, Link calculation, Satellite systems- GEO systems, non-GEO communication systems, Satellite Applications- Global Positioning System, Very Small Aperture Terminal system, Direct to Home Satellite Systems		
UNIT-V	**MODERN WIRELESS COMMUNICATION SYSTEMS**	**9**
Introduction to Modern Wireless Communication Systems, Second generation cellular networks, third generation wireless networks, fourth generation, fifth generation wireless technologies Wireless in local loop, wireless local area networks, Bluetooth, and Personal Area networks. Case Studies – Verizon's 5G ultra-wideband Network, Ericsson's 5G Collaboration with Telstra.		
		Total Contact Hours: 45

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

- Describe about microwave radio communications and frequency modulated microwave radio systems.
- Demonstrate digitized video and Digital Video Broadcasting
- Analyze about different modulation techniques and to understand Digital TV Transmission
- Describe about the satellite obits, Satellite Sub systems and its applications
- Analyze the generation of wireless communication systems and its case studies

Suggested Activities:

- Oral Presentation on the types of microwave repeaters and their applications
- Flipped classroom on implementation of Digital TV
- Survey on various Display techniques
- Activity Based Learning on Satellite Systems
- Group Projects on Implementation of small module to analyse performance of wireless technologies like Wi-Fi, Bluetooth, or Zigbee in a specific scenario, presenting their findings and recommendations.

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):

1. Dennis Roody, Satellite communication, 4/e, McGraw Hill, 2006.
2. Herve Benoit, Digital Television Satellite, Cable, Terrestrial, IPTV, Mobile TV in the DVB Framework, 3/e, Focal Press, Elsevier, 2008
3. Simon Haykin, Michael Mohar, Modern wireless communication, Pearson Education, 2008
4. Theodore S. Rappaport: Wireless communication principles and practice,2/e, Pearson Education, 1990

Reference Book(s) / Web links:

1. "Microwave Engineering" by David M. Pozar, 4th edition, John wiley& Sons, Inc
2. Mishra, Wireless communications and Networks, McGraw Hill, 2/e, 2013.
3. W.C.Y.Lee, Mobile Cellular Telecommunication, McGraw Hill, 2010.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23B13.1	3	3	3	3	2	1	1	2	1	1	1	1	3	3	3
EC23B13.2	3	3	2	3	2	1	1	1	1	1	1	1	2	3	3
EC23B13.3	3	3	3	3	2	1	1	1	1	1	1	1	2	3	3
EC23B13.4	3	3	2	3	2	1	1	2	1	1	1	1	3	2	2
EC23B13.5	3	3	3	2	2	2	1	2	1	2	1	1	3	2	2
Average	**3**	**3**	**2.6**	**2.8**	**2**	**1.2**	**1**	**1.6**	**1**	**1.2**	**1**	**1**	**2.6**	**2.6**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23B14	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	PE	3	0	0	3

Objectives:

- To understand the basics of EMI.
- To acquire knowledge on EMI coupling principles.
- To learn various EMI control techniques.
- To acquaint with solution methods for EMC PCB.
- To become familiar with various EMI measurement techniques.

UNIT-I	**EMI/EMC CONCEPTS**	**9**
EMI-EMC definitions, Sources and victim of EMI-Conducted and Radiated EMI Emission and Susceptibility-Transient EMI, ESD-Radiation Hazards.		
UNIT-II	**EMI COUPLING PRINCIPLES**	**9**
Conducted, radiated and transient coupling-Common ground impedance coupling-Common mode and ground loop coupling-Differential mode coupling- Near field cable to cable coupling, crosstalk- Field to cable coupling-Power mains and Power supply coupling.		
UNIT-III	**EMI CONTROL TECHNIQUES**	**9**
Shielding- Shielding Material-Shielding integrity at discontinuities, Filtering- Characteristics of Filters-Impedance and Lumped element filters-Telephone line filter, Power line filter design, Filter installation and Evaluation, Grounding-Measurement of Ground resistance-system grounding for EMI/EMC- Cable shielded grounding, Bonding, Isolation transformer, Transient suppressors, EMI gaskets.		
UNIT-IV	**EMC DESIGN OF PCB**	**9**
Component selection and mounting; PCB trace impedance- Routing- Cross talk control, Power distribution decoupling-Zoning- Grounding- VIAs connection-Terminations.		
UNIT-V	**EMI MEASUREMENTS AND STANDARDS**	**9**
Open area test site- TEM cell- EMI test shielded chamber and shielded ferrite lined anechoic chamber- EMI Rx and spectrum analyzer-Civilian standards- CISPR, FCC, IEC, EN; Military standards- MIL461E/462. Frequency assignment –spectrum conversation.		
		Total Contact Hours: 45

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

- Identify the various types and mechanisms of EMI
- Analyze the EMI with various ways of coupling
- Control EMI using various techniques
- Construct printed circuit boards with minimum interference
- Demonstrate their acquired knowledge in EMI measurements and various standards

Suggested Activities:

- Problem solving sessions
- Flipped classroom -
- Activity Based Learning
- Implementation of small module

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):

1. W.PrasadKodali,V.P.Kodali,"Engineering EMC Principles, Measurements, Technologies and Computer Models", Second edition, Wiley, 2001.
2. Clayton R. Paul, "Introduction to Electromagnetic Compatibility", Second edition, John Wiley Publications, 2006.

Reference Book(s) / Web links:

1. Henry W. Ott., "Noise Reduction Techniques in Electronic Systems", A Wiley Inter Science Publications, John Wiley and Sons, New York,1988.
2. Bemhard Keiser, "Principles of Electromagnetic Compatibility", Third edition, Artech house, Norwood, 1986.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23B14.1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EC23B14.2	3	3	3	3	2	3	3	2	3	3	2	2	3	2	3
EC23B14.3	3	3	3	3	3	2	3	3	2	2	3	3	3	3	2
EC23B14.4	3	3	3	3	2	3	3	2	3	3	3	3	2	3	3
EC23B14.5	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3
Average	**3**	**3**	**3**	**3**	**2.6**	**2.8**	**3**	**2.6**	**2.8**	**2.8**	**2.6**	**2.8**	**2.8**	**2.8**	**3**

Course Code	Course Title	Category	L	T	P	C
EC23B15	MILLIMETER WAVE COMMUNICATION	PE	3	0	0	3

Objectives: The student should be made
• To understand the fundamentals of millimeter wave propagation
• To understand the fundamentals of millimeter wave devices and circuits.
• To study the various components of millimeter wave communications system.
• To understand the principles of millimeter wave MIMO systems.
• To know the antenna design at millimeter wave frequencies.

UNIT-I	MILLIMETER WAVE PROPAGATION	9
Millimeter wave characteristics- millimeter wave wireless, implementation challenges, Radio wave propagation for mm wave: Large scale propagation channel effects, small scale channel effects, Outdoor and Indoor channel models, Emerging applications of millimeter wave communications.		
UNIT-II	**MM WAVE DEVICES AND CIRCUITS**	**9**
Millimeter wave generation and amplification: Peniotrons, Ubitrons, Gyrotrons and Free electron lasers. Analog mm wave components: Amplifiers, Mixers, VCO, PLL. Metrics for analog mm wave devices, Consumption factor theory.		
UNIT-III	**MM WAVE COMMUNICATION SYSTEMS**	**9**
Modulations for millimeter wave communications: OOK, PSK, FSK, QAM, OFDM, Millimeter wave link budget, Transceiver architecture, Transceiver without mixer, Receiver without Oscillator, Millimeter wave design considerations.		
UNIT-IV	**MM WAVE MIMO SYSTEMS**	**9**
Massive MIMO Communications, Spatial diversity of Antenna Arrays, Multiple Antennas, Multiple Transceivers, Noise coupling in MIMO system, Potential benefits for mm wave systems, Dynamic spatial, frequency and modulation allocation.		
UNIT-V	**ALGORITHMS AND PHY LAYER DESIGN FOR MM WAVE SYSTEMS**	**9**
Antenna beamwidth, polarization, advanced beam steering and beamforming-Analog, digital and Hybrid, mm wave design consideration, single-carrier frequency domain equalization, Device to Device communications over 5G systems.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Familiar in the basic concepts of Millimeter wave devices and circuits
• Analyze the Millimeter wave devices for various applications
• Describe the Millimeter wave communication systems
• Formulate Millimeter wave MIMO system.
• Design antenna for Millimeter wave frequencies

Suggested Activities:

- Problem solving sessions- Millimeter wave propagation
- Flipped classroom - Modulation
- Seminar-D2D communication

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):
1. K.C.Huang, Z.Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March2011.
2. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 2014.
3. Xiang,W; Zheng,K; Shen,X.S; "5G Mobile Communications", Springer, 2016.

Reference Book(s) / Web links:
1. Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications", Springer, 2016.
2. Sergey M. Smolskiy Author, Leonid A. Belov and Victor N. Kochemasov, "Handbook of RF, Microwave, and Millimeter-Wave Components", Artech House Microwave Library, 2012.
3. https://onlinecourses.nptel.ac.in/noc21_ee102/announcements?force=true

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23B15.1	3	3	3	3	2	2	1	2	1	1	1	1	3	3	1
EC23B15.2	3	3	3	3	1	1	1	2	1	1	1	1	3	3	1
EC23B15.3	3	3	3	3	2	2	1	2	2	1	1	2	3	3	2
EC23B15.4	3	3	3	3	2	2	1	2	2	1	1	3	3	3	2
EC23B15.5	3	3	3	3	2	2	2	2	3	1	2	3	3	3	2
Average	**3**	**3**	**3**	**3**	**1.8**	**1.8**	**1.2**	**2**	**1.8**	**1**	**1.2**	**2**	**3**	**3**	**1.6**

Course Code	Course Title	Category	L	T	P	C
EC23B16	ADVANCED ANTENNA TECHNOLOGIES	PE	3	0	0	3

Objectives:

- To impart knowledge on microstrip patch antenna and various techniques for polarization
- To be able to learn the design considerations of smart antennas
- To explore knowledge on the antenna for wearable devices
- To enrich the knowledge about the reconfigurable antenna and antenna measurements
- To deal with neural network and its use in antenna design

UNIT-I	MICROSTRIP ANTENNAS: ANALYSIS, DESIGN AND APPLICATIONS	9

Technical background, Analysis and design - Analysis techniques - Transmission-line circuit model, Multimode cavity model, Moment method, FDTD method, FEM. Design methodology - Patch element design, Array configuration design. Feed/excitation methods, Dual-polarization and Circular-polarization techniques, Broadband and Dual-band techniques, Antenna miniaturization techniques.

UNIT-II	SMART ANTENNAS	9

Smart antennas - Beam-forming basics, Analog beamforming, Digital beamforming, Smart antenna method, Smart antenna algorithms – Adaptive beamforming, Direction finding methods, Smart antenna advantages, Smart antenna implementation and system issues, MIMO systems.

UNIT-III	ANTENENA FOR WEARABLE DEVICES	9

Wireless body area networks, Antenna design requirements for wireless BAN/PAN, Modelling and characterization of wearable antennas, WBAN radio channel characterization and effect of wearable antennas. Case study – A compact wearable antenna for healthcare sensors.

UNIT-IV	RECONFIGURABLE ANTENNAS AND ANTENNA MEASUREMENTS	9

Design consideration and recent development, Frequency reconfigurable antennas - Frequency reconfigurable slot loaded microstrip patch antenna, Frequency reconfigurable E shaped patch antenna. Pattern reconfigurable antennas - Pattern reconfigurable fractal patch antenna, Pattern reconfigurable leaky-wave antenna. Multi-reconfigurable antenna.

Antenna measurement - Microwave absorbing material, Instrumentation, Impedance measurements, Current measurements, Polarization measurements.

UNIT-V	NEURAL NETWORKS FOR ANTENNAS	9

Neural network concepts, Neural network model development, Other neural network models used for antenna modeling, A typical example – equilateral triangular microstrip antenna, Antenna applications – Horn antenna analysis and synthesis, Aperture antenna shape prediction, Microstrip antenna analysis and design, reconfigurable antenna analysis and design. Issues of using NN for antenna problems, Disadvantages of using NN.

Total Contact Hours:45

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

- Design a patch antenna for the given specification and constraint
- Analyze and address the issues related to smart antenna
- Appreciate the motivation and the necessity of antenna for wearable devices
- Describe various reconfiguration methods and able to measure the radiation parameters of antenna
- Apply the neural network principles in the design of antennas

Suggested Activities:

- Problem solving sessions
- Flipped classroom
- Seminar and implementation of small module

Suggested Evaluation Methods:

- Assignment
- Quizzes

Text Book(s):

1. Constantine A. Balanis, "Modern antenna handbook" John Wiley & Sons, Inc., Publication, 2008. (Unit 1,2,4,5)
2. Zhi Ning Chen, "Antennas for portable devices", John Wiley & Sons Inc., 2007. (Unit 3)
3. Eng Hock Lim, "Compact multifunctional antennas for wireless systems", John Wiley & Sons Inc., 2012. (Unit 4)

Reference Book(s) / Web links:

1. Krauss.J.D, "Antennas", II edition, John Wiley and sons, New York, 1997.
2. W.L.Stutzman and G.A.Thiele, "Antenna Theory and Design", 2nd Edition, John Wiley & Sons Inc., 1998.
3. S.Drabowitch e.al, "Modern Antennas", 2nd Edition Springer science business Media, Inc.2005.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23B16.1	3	3	3	2	3	2	2	2	2	2	2	2	3	3	2
EC23B16.2	3	3	2	2	2	2	1	2	2	2	2	2	3	3	2
EC23B16.3	3	2	2	2	2	2	1	2	2	2	2	2	3	3	2
EC23B16.4	3	2	2	2	2	2	1	2	2	2	2	2	3	3	2
EC23B16.5	3	3	2	2	2	2	1	2	2	2	2	2	3	3	2
Average	**3**	**2.6**	**2.2**	**2**	**2.2**	**2**	**1.2**	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**2**

Course Code	Course Title	Category	L	T	P	C
EC23B17	RF Circuit Design and RADAR Engineering	PE	3	0	0	3

Objectives:

- To inculcate understanding of the basics required for filter, design and implement filter using distributed elements.
- To design the oscillator and matching network for RF system.
- To understand the basics of mixers and frequency multiplier.
- To deal with the design of small signal and large signal microwave amplifier.
- To obtain basic knowledge on microwave RADAR engineering.

UNIT-I	**RF FILTERS**	**8**
RF behavior of passive components – High frequency resistors, High frequency capacitors, High frequency inductors. Tchebyscheff filter – Normalized Tchebyscheff tables, Low pass filter design, High pass filter, Band pass filter, Band stopfilter. Filter implementation using distributed elements.		
UNIT-II	**OSCILLATORS AND MATCHING NETWORK**	**9**
High frequency oscillator configuration – Adding a positive feedback element to initiate oscillations, Design of fixed frequency lumped element oscillator, Dielectric resonator oscillators. Impedance matching using discrete components – T and Pi Matching Network. Problem solving using Smith chart.		
UNIT-III	**MIXERS AND FREQUENCY MULTIPLIERS**	**8**
Basic characteristics of mixer – Basic concepts, Frequency domain considerations, Single-ended mixer design, Single-balanced mixer, Double-balanced mixer. Frequency multiplier – Reactive diode multiplier, Resistive diode multipliers, Transistor multipliers, Frequency doubler design.		
UNIT-IV	**AMPLIFIER DESIGN**	**11**
Design of amplifier for specific gain – Constant gain circles, Design of amplifier for optimum noise figure, Design of amplifier for constant VSWR circles. Design broadband amplifiers –Broadband design using mismatch techniques, Design of feedback amplifiers, Design of Class A power amplifiers.		
UNIT-V	**RADAR SYSTEMS**	**9**
Introduction, Simple RADAR, Free space RADAR range equation, Maximum unambiguous range, Pulsed RADAR system, RADAR receivers, Line pulse modulator, Doppler effect, CW Doppler RADAR, Radio navigational aids.		
		Total Contact Hours: 45

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

- Implement RF filters for real-time applications.
- Design high frequency oscillator and matching network.
- Explain the functions of mixers and frequency multipliers for RF circuits.
- Analyze and design the RF transistor amplifier.
- Distinguish and explain the working of pulsed and Doppler RADAR systems.

Suggested Activities:

- Problem solving sessions
- Flipped classroom
- Implementation of small module

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes

Text Book(s):
1. Reinhold Ludwig and Gene Bogdanov, “RF Circuit Design: Theory and Applications”, Pearson Education Inc., 2011.
2. David M. Pozar, “Microwave Engineering”, Wiley India (P) Ltd, New Delhi, 2008.
3. M.Kulkarni, "Microwave and RADAR Engineering”, Umesh Publications, Fourth edition.

Reference Book(s) / Web links:
1. E.Da.Silva, “High Frequency And Microwave Engineering”, Butterworth Heinmann publications, Oxford, 2001.
2. Byron Edde, “Radar principles, Technology, Applications” Pearson Publications, 2009.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23B17.1	3	3	3	3	1	2	1	2	2	2	2	2	3	3	2
EC23B17.2	3	3	3	3	1	2	1	2	2	2	2	2	3	3	2
EC23B17.3	3	3	2	2	1	2	1	1	2	2	1	2	2	2	2
EC23B17.4	3	3	3	3	1	2	1	2	2	2	2	2	3	3	2
EC23B17.5	3	2	2	2	1	2	1	1	2	1	1	2	2	2	2
Average	**3**	**2.8**	**2.6**	**2.6**	**1**	**2**	**1**	**1.6**	**2**	**1.8**	**1.6**	**2**	**2.6**	**2.6**	**2**

Course Code	Course Title	Category	L	T	P	C
EC23B18	5G PHYSICAL LAYER TECHNOLOGIES	PE	3	0	0	3

Objectives:

- To explore the architecture of 5G.
- To understand the 5G modulation and multiple access schemes.
- To identify the various 5G channel models.
- To explore power optimization algorithms.
- To give the exposure on the concept of MIMO and other research areas in 5G.

UNIT-I	**EVOLUTION OF 5G NETWORKS**	**9**
Introduction to 5G, vision and challenges- eMBB, MTC- Physical architecture and 5G deployment- 5G spectrum- 5G New Radio (NR)- air interface of 5G, radio access- Ultra dense network architecture and technologies for 5G		
UNIT-II	**RADIO ACCESS TECHNOLOGIES IN 5G**	**9**
Universal filtered OFDM- Non-orthogonal multiple access (NOMA), system model, user selection and optimal power allocation - Sparse code multiple access (SCMA), Interleave division multiple access (IDMA).		
UNIT-III	**5G WIRELESS CHANNEL MODELS**	**9**
Channel model requirements- Propagation scenarios-METIS channel models- Map based model, Stochastic model, Interference management- mobility management		
UNIT-IV	**POWER OPTIMIZATION ALGORITHMS**	**9**
Introduction to Power optimization – One dimensional, Multi- dimensional- Multi objective optimization- Convex optimization- Ant Colony- Genetic algorithms- Fuzzy logic- Heuristic algorithms.		
UNIT-V	**5G RESEARCH AREAS**	**9**
Massive MIMO- Hybrid Beamforming for interference clustering and user grouping- D2D communications in 5G- Coordinated multipoint transmissions, Cognitive radio based on 5G, Dynamic spectrum sharing- Security features in 5G networks.		
		Total Contact Hours: 45

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

- Comprehend the significance of 5G technology.
- Characterize the different 5G candidate waveforms and multiple access schemes.
- Analyse the various 5G channel models
- Apply the suitable power allocation and optimization algorithms.
- Analyse MIMO techniques and explore other research areas in 5G.

Suggested Activities:

- Problem solving sessions
- MATLAB Simulation

Suggested Evaluation Methods:

- Continuous assessment test
- Assignment problems
- Quizzes and class test
- Discussion in classroom

Text Book(s):
1. Afif Osseiran, Jose.F.Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.
2. Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications", Springer, 2016.
3. Stephen Rommer , "5G Core Networks: Powering Digitization", Academic Press, 2019.
4. SaroVelrajan, "An Introduction to 5G Wireless Networks: Technology, Concepts and Use cases. First Edition, 2020.
5. Suvra Sekhar Das and Ramjee Prasad , "Evolution of Air Interface Towards 5G Radio Access Technology and Performance Analysis", River Publishers, 2018.

Reference Book(s) / Web links:
1. Saad Z Asif, "5G Mobile Communication, Concepts and Challenges", CRC Press
2. Thomas L. Marzetta, Erik G. Larsson, Hong Yang, Hien Quoc Ngo, " Fundamentals of Massive MIMO", Cambridge University press, 2018.
3. Jyrki. T.. J. Penttinen, "5G Simplified: ABCs of Advanced Mobile Communications".
4. Wan Lee Anthony, "5G System Design: An end to end perspective, Springer publications, 2019.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23B18.1	3	3	3	2	3	1	1	1	1	1	1	1	3	3	1
EC23B18.2	3	3	3	2	3	2	1	1	1	1	1	1	3	3	1
EC23B18.3	3	3	3	2	3	2	1	2	1	1	1	2	3	3	1
EC23B18.4	3	3	3	2	3	2	1	1	1	1	1	1	3	3	1
EC23B18.5	3	3	3	3	3	3	2	2	3	2	2	2	3	3	2
Average	**3**	**3**	**3**	**2.2**	**3**	**2**	**1.2**	**1.4**	**1.4**	**1.2**	**1.2**	**1.4**	**3**	**3**	**1.2**

VERTICAL 3 – SEMICONDUCTOR AND VLSI DESIGN

Course Code	Course Title	Category	L	T	P	C
EC23C11	SYSTEM ON CHIP AND FPGA TESTING	PE	3	0	0	3

Objectives:
• Systematic overview on architecture optimization techniques
• Analyse with different simulation modes
• Role of graph theory on synthesis
• Design the Internal architectures of FPGA's
• Programming ASIC design software and Low-Level Design Entry

UNIT-I	**ASIC Design**	**9**
ASICS OF ASICS AND ASIC LIBRARY DESIGN Types of ASICs - Design flow - CMOS transistors CMOS Design rules - Combinational Logic Cell – Sequential logic cell - Data path logic cell - Transistors as Resistors - Transistor Parasitic Capacitance- Logical effort –Library cell design - Library architecture Overview of ASIC types, design strategies, CISC, RISC and NISC approaches for SOC architectural issues and its impact on SoC design methodologies, Application Specific Instruction Processor (ASIP) concepts.		
UNIT-II	**PROGRAMMABLE ASICS, LOGIC CELLS AND I/O CELLS**	**9**
Anti-fuse - static RAM - EPROM and EEPROM technology - PREP benchmarks - Actel ACT - Xilinx LCA –Altera FLEX - Altera MAX DC & AC inputs and outputs - Clock & Power inputs - Xilinx I/O blocks. Design systems - Logic Synthesis - Half gate ASIC -Schematic entry, Low level design language - PLA tools -EDIF- CFI design representation.		
UNIT-III	**SIMULATION and SYNTHESIS AND OPTIMIZATION**	**9**
Simulation Different simulation modes, behavioral, functional, static timing, gate level, switch level, transistor/circuit simulation, design of verification vectors, Low power FPGA, Reconfigurable systems, SoC related modeling of data path design and control logic, Minimization of interconnects impact, clock tree design issues. **Synthesis And Optimization** Role and Concept of graph theory and its relevance to synthesizable constructs, Walks, trails paths, connectivity, components, mapping/visualization, nodal and admittance graph. Technology independent and technology dependent approaches for synthesis, optimization constraints, HDL coding techniques for minimization of power consumption.		
UNIT-IV	**PHYSICAL DESIGN OF ASIC**	**9**
System partition - FPGA partitioning - partitioning methods - floor planning - placement - physical design flow – global routing - detailed routing - special routing - circuit extraction - DRC.		
UNIT-V	**FPGA ARCHITECTURES, SIMULATION AND TESTING**	**9**
FPGA Architectures. SRAM-Based FPGAs. Permanently Programmed FPGAs. Chip I/O, Types of simulation -boundary scan test - Fault simulation - Automatic Test Pattern Generation, Introduction to JTAG.		
		Total Contact Hours: 45

Course Outcomes: On completion of the course, students will be able to
• Analyze the ASIP concepts Identify and formulate a given problem in the framework of SoC based design approaches.
• Design SoC based system for engineering applications
• Analyze the passive elements for ASIC design
• Analyze the characteristics of Programmable ASIC I/O cells
• Analyze the synthesis part on different logic structures
• Test the Integrated Circuit using various procedures

Suggested Activities:

- Ice breaker
- Just A Minute
- Ship wreck
- Hot seat
- Vocabulary building
- Chinese whispers
- Case study

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Book(s):

1. Hubert Kaeslin, “Digital Integrated Circuit Design: From VLSI Architectures to CMOS Fabrication”, Cambridge University Press, 2008.
2. B. Al Hashimi, “System on chip-Next generation electronics”, The IET, 2006.
3. Rochit Rajsuman, “System-on- a-chip: Design and test”, Advantest America R & D center, 2000.
4. Hubert Kaeslin, “Digital Integrated Circuit Design: From VLSI Architectures to CMOS Fabrication”, Cambridge University Press, 2008. 2. B. Al Hashimi, “System on chip-Next generation electronics”, The IET, 2006 3. Rochit Rajsuman, “System-on- a-chip: Design and test”, Advantest America R & D center, 2000
5. M.J.S .Smith, "Application - Specific Integrated Circuits ", Pearson Education, 2013.

Reference Book(s) / Web links:

1. Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English With Answers 2nd Edition by Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor).
2. Reading Development and Difficulties By Kate Cain.
3. FPGA-Based System Design, Wayne Wolf, Published by Prentice Hall, 2004 .
4. Jose E. France, Yannis Tsividis, " Design of Analog - Digital VLSI Circuits for Telecommunication and Signal Processing ", Prentice Hall, 1994.
5. https://www.cerc.utexas.edu/~jaa/soc/lectures/1-2.pdf
6. https://www.cl.cam.ac.uk/teaching/1516/SysOnChip/materials.d/socdam-notes00.pdf
7. https://nptel.ac.in/courses/108102045/10

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23C11.1	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C11.2	3	3	3	1	3	3	3	1	-	3	3	3	3	3	3
EC23C11.3	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C11.4	2	2	2	2	2	2	2	1	1	3	2	2	2	2	2
EC23C11.5	2	2	2	1	2	2	2	1	1	3	2	2	2	2	2
Average	**2.6**	**2.2**	**2.2**	**1.2**	**2.6**	**2.6**	**2.6**	**1**	**1**	**3**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23C12	PHYSICAL DESIGN AUTOMATION	PE	3	0	0	3

Objectives:

- To understand relation between automation algorithms and constraints posed by VLSI technology.
- To understand the concepts of Physical Design Process
- To design area efficient logics by employing different routing algorithms and shape functions.
- To familiarize the concept of field programmable gate arrays, its design flow & its applications in various areas and MCM.
- To simulate and synthesis different combinational and sequential logics

UNIT-I	VLSI PHYSICAL DESIGN AUTOMATION	9

VLSI Design Cycle, New Trends in VLSI Design Cycle, Physical Design Cycle, New Trends in Physical Design Cycle, Design Styles, System Packaging Styles.

UNIT-II	PARTITIONING, FLOOR PLANNING, PIN ASSIGNMENT AND PLACEMENT	9

Partitioning – Problem formulation, Classification of Partitioning algorithms, Kernighan-Lin Algorithm, Simulated Annealing. Floor Planning – Problem formulation, Classification of floor planning algorithms, constraint based floor planning, Rectangular Dualization, Pin Assignment – Problem formulation, Classification of pin assignment algorithms, General and channel Pin assignments. Placement – Problem formulation, Classification of placement algorithms, Partitioning based placement algorithms.

UNIT-III	FLOOR PLANNING AND ROUTING	9

Floor planning concepts. Shape functions and floor planning sizing. Local routing. Area routing. Channel routing, global routing and its algorithms, Over the cell routing and via minimization, Clock and power routing.

UNIT-IV	PHYSICAL DESIGN AUTOMATION OF FPGAs AND MCMs	9

FPGA Technologies, Physical Design cycle for FPGAs, Partitioning, Routing – Routing Algorithm for the Non-Segmented model, Routing Algorithms for the Segmented Model; Introduction to MCM Technologies, MCM Physical Design Cycle.

UNIT-V	SIMULATION AND SYNTHESIS	9

Simulation: Gate level and switch level modeling and simulation. Introduction to combinational logic synthesis: ROBDD principles, implementation, construction and manipulation. Two level logic synthesis. High-level synthesis: hardware model for high level synthesis. Internal representation of input algorithms. Allocation, assignment and scheduling. Scheduling algorithms. Aspects of assignment. High level transformations.

Total Contact Hours: 45

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

- Implement automation process for VLSI System design.
- Adopt algorithms to meet critical design parameters.
- Identify the concepts of Physical Design Process such as partitioning, Floor planning, Placement and Routing.
- Develop and enhance the existing algorithms and computational techniques for physical design process of VLSI systems.
- Develop various simulation and synthesis methods for physical design.

Suggested Activities:

- Video lecture
- PPT
- Role Play
- Quizzes
- VLAB

Suggested Evaluation Methods:

- MCQ
- Assignment

Text Book(s):

1. S.H.Gerez, "Algorithms for VLSI Design Automation", John Wiley 1999
2. N.A.Sherwani, Algorithms for VLSI Physical Design Automation, (3/e), Kluwer,1999.

Reference Book(s) / Web links:

1. N.A.Sherwani , Algorithms for VLSI Physical Design Automation, (3/e), Kluwer,1999.
2. M.Sarrafzadeh, Introduction to VLSI Physical Design, McGraw Hill (IE), 1996
3. VLSI Physical Design Automation-Theory and Practice by Sadiq M Sait, Habib Youssef, World Scientific.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23C12.1	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C12.2	3	3	3	1	3	3	3	1	-	3	3	3	3	3	3
EC23C12.3	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C12.4	2	2	2	2	2	2	2	1	1	3	2	2	2	2	2
EC23C12.5	2	2	2	1	2	2	2	1	1	3	2	2	2	2	2
Average	**2.6**	**2.2**	**2.2**	**1.2**	**2.6**	**2.6**	**2.6**	**1**	**1**	**3**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23C13	DIGITAL IC DESIGN	PE	3	0	0	3

Objectives:
• To design CMOS inverters with specified noise margin and propagation delay
• To implement efficient techniques at circuit level for improving power and speed of digital circuits.
• To understand the timing concepts in latch and flip-flops.
• To study interconnect and clocking issues
• To design semiconductor memories to improve access times and power consumption

UNIT-I	**CMOS INVERTER**	**9**
Introduction to MOS transistor, V-I Characteristics, Electrical Parameters, Static behavior, Switching Threshold, Noise Margins, Robustness revisited, Dynamic behavior: Computing the capacitances, Propagation delay, Propagation delay from a design perspective, Power, Energy and energy delay.		
UNIT-II	**COMBINATIONAL LOGIC DESIGN**	**9**
Introduction, Static CMOS Design: Complementary CMOS, Ratioed logic, Pass transistor logic dynamic CMOS Design: Dynamic logic, Speed and power dissipation of dynamic logic, Signal integrity issues in Dynamic design, Cascading dynamic gates.		
UNIT-III	**SEQUENTIAL LOGIC DESIGN**	**9**
Introduction, Static latches and registers: The Bi-stability principle, Multiplexer based latches, Master-slave edge-Triggered register, Low-voltage static latches, Static SR Flip-flop, Dynamic latches and registers, Dynamic transmission, Gate Edge - triggered registers, CMOS NORA-CMOS True single - Phase clocked register (TSPCER).		
UNIT-IV	**INTERCONNECTS AND TIMING ISSUES**	**9**
Resistive, Capacitive and Inductive Parasitics - Computation of R, L and C for given inter-connects - Buffer Chains - Timing classification of digital systems - Synchronous Design - Origins of Clock Skew/Jitter and impact on Performance - Clock Distribution Techniques - Latch based clocking - Synchronizers and Arbiters -Clock Synthesis and Synchronization using a Phase-Locked Loop.		
UNIT-V	**DIGITAL INTEGRATED SYSTEM BUILDING BLOCKS**	**9**
Introduction, Adders, Multipliers, Shifters, Memories, ROM, RAM, Internal structure, ROM 2 D Structure, Power dissipation in memories, SRAM, DRAM.		
		Total Contact Hours: 45

Course Outcomes: On completion of the course, students will be able to
• Design the CMOS inverter with optimized power, area and timing
• Identify the critical path of a combinational circuit
• Build elementary sequential circuits like latches, flip flops and registers- Static and Dynamic
• Estimate the wire parasitics
• Design Integrated System building blocks

Suggested Activities:

- Video lecture
- PPT
- Role Play
- Quizzes
- VLAB

Suggested Evaluation Methods:

- MCQ
- Assignment

Text Book(s):
1. Jan M. Rabaey, Anantha Chadrakasan, Borivoje Nikolic, Digital Integrated Circuits: A Design Perspective, PHI, Second Edition, 2016.
2. Neil.H, E.Weste, David Harris, Ayan Banerjee, CMOS VLSI Design: A Circuit and Systems Perspective, Pearson Education, Fourth Edition, 2011.

Reference Book(s) / Web links:
1. Sung-Mo Kang, Yusuf Leblebici, CMOS Digital Integrated Circuits - Analysis and Design, McGraw-Hill, Fourth Edition, 2014.
2. Ken Martin, Digital Integrated Circuit Design, Oxford University Press, 1st edition, 1999.
3. Jan M. Rabaey, "Digital Integrated Circuits" Pearson Education, 2003.
4. Kamran Ehraghian, Dauglas A. Pucknell and Sholeh Eshraghiam, "Essentials of VLSI Circuits and Systems" – PHI, EEE, 2005 Edition.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23C13.1	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C13.2	3	3	3	1	3	3	3	1	-	3	3	3	3	3	3
EC23C13.3	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C13.4	2	2	2	2	2	2	2	1	1	3	2	2	2	2	2
EC23C13.5	2	2	2	1	2	2	2	1	1	3	2	2	2	2	2
Average	**2.6**	**2.2**	**2.2**	**1.2**	**2.6**	**2.6**	**2.6**	**1**	**1**	**3**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23C14	FUNCTIONAL VERIFICATION OF SOCs	PE	3	0	0	3

Objectives:

- Today, VLSI chips are entire "system-on-chip" designs, which include processors, memories, peripheral controllers, and connectivity sub-systems. The course aims to provide an appreciation for the motivation behind SoC design, the challenges of SoC design, and the overall SoC design flow.

UNIT-I	**SOC Design Concept**	**9**
Introduction: Driving Forces for SoC - Components of SoC - Design flow of SoC Hardware/Software nature of SoC - Design Trade-offs - SoC Applications System-level Design: Processor selection-Concepts in Processor Architecture: Instruction set architecture (ISA), elements in Instruction Handing-Robust processors: Vector processor, VLIW, Superscalar, CISC, RISC—Processor evolution: Soft and Firm processors, Custom Designed processors- on-chip memory.		
UNIT-II	**SOC Interconnection**	**9**
On-chip Buses: basic architecture, topologies, arbitration and protocols, Bus standards: AMBA, Core Connect, Wishbone, Avalon - Network-on chip: Architecture topologies-switching strategies - routing algorithms flow control, Quality-of-Service- Reconfigurability in communication architectures.		
UNIT-III	**SOC IP based system design**	**9**
Introduction to IP Based design, Types of IP, IP across design hierarchy, IP life cycle, Creating and using IP - Technical concerns on IP reuse – IP integration - IP evaluation on FPGA prototypes.		
UNIT-IV	**SOC implementation**	**9**
Study of processor IP, Memory IP, wrapper Design - Real-time operating system (RTOS), Peripheral interface and components, High-density FPGAs - EDA tools used for SOC design.		
UNIT-V	**SOC testing**	**9**
Manufacturing test of SoC: Core layer, system layer, application layer-P1500 Wrapper Standardization- SoC Test Automation (STAT).		
		Total Contact Hours: 45

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

- Analyze the ASIP concepts Identify and formulate a given problem in the framework of SoC based design approaches.
- Design SoC based system for engineering applications
- Analyze the passive elements for ASIC design
- Analyze the characteristics of Programmable ASIC I/O cells
- Analyze the synthesis part on different logic structures
- Test the Integrated Circuit using various procedures

Suggested Activities:

- Ice breaker
- Just A Minute
- Ship wreck
- Hot seat
- Vocabulary building
- Chinese whispers
- Case study

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Book(s):

1. Michael J.Flynn, Wayne Luk, "Computer system Design: Systemon-Chip", Wiley-India, 2012.
2. Sudeep Pasricha, Nikil Dutt, "On Chip Communication Architectures: System on Chip Interconnect", Morgan Kaufmann Publishers, 2008.
3. Sudeep Pasricha, Nikil Dutt, "On Chip Communication Architectures: System on Chip Interconnect", Morgan Kaufmann Publishers, 2008.
4. Patrick Schaumont "A Practical Introduction to Hardware/Software Co-design", 2nd Edition, Springer, 2012.

Reference Book(s) / Web links:

1. Zainalabedin Navabi., "Embedded Core Design with FPGAs" , McGraw-Hill Electronic Engineering,
2. https://www.cerc.utexas.edu/~jaa/soc/lectures/1-2.pdf
3. https://www.cl.cam.ac.uk/teaching/1516/SysOnChip/materials.d/socdam-notes00.pdf
4. https://nptel.ac.in/courses/108102045/10

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23C14.1	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C14.2	3	3	3	1	3	3	3	1	-	3	3	3	3	3	3
EC23C14.3	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C14.4	2	2	2	2	2	2	2	1	1	3	2	2	2	2	2
EC23C14.5	2	2	2	1	2	2	2	1	1	3	2	2	2	2	2
Average	**2.6**	**2.2**	**2.2**	**1.2**	**2.6**	**2.6**	**2.6**	**1**	**1**	**3**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23C15	COMPUTER SYSTEM ARCHITECTURE	PE	3	0	0	3

Objectives:
• To provide knowledge on overview of IAS computer function and addressing modes
• Hardware and software implementation of arithmetic unit to solve addition, subtraction, multiplication and division.
• To provide knowledge of memory technologies, interfacing techniques and sub system devices.

UNIT-I	INTRODUCTION TO COMPUTER ARCHITECTURE	9
Functional blocks of a computer: CPU, memory, input-output subsystems, control unit. Instruction set architecture of a CPU: Registers, instruction execution cycle, RTL interpretation of instructions, addressing modes, instruction set. Outlining instruction sets of some common CPUs.		
UNIT-II	**COMPUTER ARITHMETIC**	**9**
Integer addition and subtraction, ripple carry adder, carry look-ahead adder, etc. multiplication – shift-and add, Booth multiplier, carry save multiplier, etc. Division restoring and non-restoring techniques, floating point arithmetic, IEEE 754 format.		
UNIT-III	**DATA REPRESENTATION**	**9**
Signed number representation, fixed and floating-point representations, character representation.		
UNIT-IV	**CPU CONTROL UNIT DESIGN AND MEMORY ORGANIZATION**	**9**
Hardwired and micro-programmed design approaches, design of a simple hypothetical CPU. Memory system design: Semiconductor memory technologies, memory organization, Memory interleaving, concept of hierarchical memory organization, cache memory, cache size vs. block size, mapping functions, replacement algorithms, write policies.		
UNIT-V	**PERIPHERAL DEVICES AND CONTEMPORARY ISSUES**	**9**
Input-output subsystems, I/O device interface, I/O transfers – program controlled, interrupt driven and DMA, privileged and non-privileged instructions, software interrupts and exceptions. Programs and processes – role of interrupts in process state transitions, I/O device interfaces – SCII, USB, Guest lecture by Industry Experts or R&D organization		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Provide fundamentals on machine instructions and addressing modes.
• Comprehend the various algorithms for computer arithmetic.
• Analyse the performance of various memory modules in memory hierarchy.
• Analyse the performance of various memory modules in memory hierarchy.
• Outline the evaluation of memory organization.

Suggested Activities:

- Arithmetic Logic Unit
- Memory Design
- CPU Design
- Combinational Multipliers
- Case study

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Book(s):

1. M. M. Mano, Computer System Architecture, 3rd ed., Prentice Hall of India, 1993.
2. David A. Patterson and John L. Hennessy, Computer Organization and Design: The Hardware/Software Interface, 4th Edition, Elsevier, 2012.
3. Carl Hamacher, Zvonko Vranesic, Safwat Zaky, Naraig Manjikian, Computer Organization and Embedded Systems, McGraw-Hill Publishing, 2011.

Reference Book(s) / Web links:

1. John P. Hayes, Computer Architecture and Organization, McGraw-Hill, 1998
2. William Stallings, Computer Organization and Architecture: Designing for Performance, 8th Edition, Prentice Hall, 2006.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23C15.1	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C15.2	3	3	3	1	3	3	3	1	-	3	3	3	3	3	3
EC23C15.3	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C15.4	2	2	2	2	2	2	2	1	1	3	2	2	2	2	2
EC23C15.5	2	2	2	1	2	2	2	1	1	3	2	2	2	2	2
Average	**2.6**	**2.2**	**2.2**	**1.2**	**2.6**	**2.6**	**2.6**	**1**	**1**	**3**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23C16	SEMICONDUCTOR PACKAGING	PE	3	0	0	3

Objectives:

- To give an introduction to semiconductor packaging
- To comprehend various chip packages
- To design PWB using CAD tools with thermal considerations
- To test PWB using various methods.
- To introduce the concept of advanced packaging

UNIT-I	**SEMICONDUCTOR PACKAGING OVERVIEW**	**9**
History of semiconductors, Products and levels of packaging, Definition of PWB, Semiconductor and Process flowchart Basics, Wafer fabrication, inspection and testing, Wafer packaging, Packaging evolution; Chip connection choices, Wire bonding, TAB and flip chip.		
UNIT-II	**CHIP PACKAGES**	**9**
Single chip packages or modules (SCM), Commonly used packages and advanced packages; Materials in packages; Thermal mismatch in packages; Multichip modules (MCM)-types; System-in-package (SIP); Packaging road maps, Hybrid circuits.		
UNIT- III	**CAD PWB AND THERMAL CONSIDERATIONS**	**9**
Printed Circuit Board- Anatomy, CAD tools for PCB design, Standard fabrication, Micro via Boards. Board Assembly-Surface Mount Technology, Through Hole Technology, Process Control and Design challenges. Thermal Management, Heat transfer fundamentals, Thermal conductivity and resistance, Conduction, convection and radiation – Cooling requirements		
UNIT-IV	**TESTING**	**9**
Reliability, Basic concepts, Environmental interactions. Thermal mismatch and fatigue – failures – thermo mechanically induced –electrically induced – chemically induced. Electrical Testing: System level electrical testing, Interconnection tests, Active Circuit Testing, Design for Testability		
UNIT-V	**ADVANCED PACKAGING**	**9**
Kinds of advanced packaging, groups of advanced packaging, 2D Fan out(chip First) IC integration, 2D flipchip IC chip integration, PoP, SiP and heterogeneous integration, 2D Fan out (chip Last) IC integration. System in Package(SiP)-Introduction, SoC(system on chip), System in Package, Intention of SiP, Actual applications of SiP, SMT, Flip chip technology.		
Total Contact Hours: 45 Periods		

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

- Understand the Semiconductor packaging overview
- Familiarize the various chip packages
- Design PWB using CAD tool
- Interpret the testing methods for PWB
- Comprehend the advanced packaging techniques

Suggested Activities:

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):

- Rao R. Tummala, "Fundamentals of Microsystems Packaging", McGraw Hill, NY, 2001.

Reference Book(s) / Web links:

- Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000.
- Tummala, Rao R, Microelectronics packaging handbook, McGraw Hill, 2008.
- William D. Brown, "Advanced Electronic Packaging", IEEE Press, 1999.
- Bosshart, Printed Circuit Boards Design and Technology, TataMcGraw Hill, 1988.
- R.S.Khandpur, Printed Circuit Board, Tata McGraw Hill, 2005.
- Michael L. Bushnell &Vishwani D. Agrawal, Essentials of Electronic Testing for Digital, memory & Mixed signal VLSI Circuits‖, Kluwer Academic Publishers, 2000.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23C16.1	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C16.2	3	3	3	1	3	3	3	1	-	3	3	3	3	3	3
EC23C16.3	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C16.4	2	2	2	2	2	2	2	1	1	3	2	2	2	2	2
EC23C16.5	2	2	2	1	2	2	2	1	1	3	2	2	2	2	2
Average	**2.6**	**2.2**	**2.2**	**1.2**	**2.6**	**2.6**	**2.6**	**1**	**1**	**3**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23C17	VLSI TESTING AND TESTABILITY	PE	3	0	0	3

Objectives:
• To preface VLSI testing and to model various faults.
• To simulate faults and to generate test patterns for combinational and sequential circuits.
• To design and to implement scan based testing
• To cognize BIST methods for testability
• To perform Fault diagnosis

UNIT-I	**INTRODUCTION TO TESTING**	**9**
Introduction- VLSI testing process and test equipment-Challenges in VLSI testing- History of VLSI test technology-Functional Vs structural testing- Fault models-relationship among fault models		
UNIT-II	**LOGIC AND FAULT SIMULATION AND TEST GENERATION**	**9**
Simulation for design verification and test evaluation- Modeling circuits for simulation- Algorithms for True value and fault simulation- test generation-ATPG algorithm for combinational and sequential circuits- testability measures -Scoap controllability and observability		
UNIT- III	**SCAN CELL DESIGN AND TESTING**	**9**
Design for testability basics-Scan cell design-Scan architecture-Scan design-Partial scan design-Variations of Scan.		
UNIT-IV	**BUILT-IN SELF-TEST**	**9**
BIST design rules- Test pattern generation-Exhaustive, Pseudo-random testing-Pseudo Exhaustive testing- delay fault testing for other test objectives, BIST architecture for circuits.		
UNIT-V	**FAULT DIAGNOSIS**	**9**
Introduction and Basic definitions-Fault models for diagnosis- Generation of vectors for diagnosis-Combinational logic diagnosis-Scan chain diagnosis- Logic BIST diagnosis		
		Total Contact Hours: 45

Course Outcomes: On completion of the course, students will be able to
• Understand the VLSI testing process and model faults.
• Perform Fault Simulation and Logic simulation
• Design and test scan cell
• Understand the design for testabaility
• Do fault diagnosis

Suggested Activities:

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):
1. Z.Navabi, Digital System Test and Testable Design, Springer, 2011.
2. Laung-Terng Wang, Cheng-Wen Wu, and Xia oqing Wen, VLSI Test Principles and Architectures, The Morgan Kaufmann, 2013.
3. Michael L.Bushnell and Vishwani D.Agarwal, "Essentials of Electronic testing for Digital Memory and Mixed-Signal VLSI circuits, Kluwer Academic Publishers, 2017

Reference Book(s) / Web links:
1. M.Abramovici, M.A.Breuer and A.D.Fried man, Digital Systems and Testable Design", Jaico Publishing House.
2. P.K.Lala, "Digital circuits Testing and Testability", Academic Press.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23C17.1	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C17.2	3	3	3	1	3	3	3	1	-	3	3	3	3	3	3
EC23C17.3	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C17.4	2	2	2	2	2	2	2	1	1	3	2	2	2	2	2
EC23C17.5	2	2	2	1	2	2	2	1	1	3	2	2	2	2	2
Average	**2.6**	**2.2**	**2.2**	**1.2**	**2.6**	**2.6**	**2.6**	**1**	**1**	**3**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23C18	COMPUTATIONAL VLSI AND IOT FOR AI	PE	3	0	0	3

Objectives:
• Systematic overview on VLSI computing System
• Understanding Inter-Processor Communication Schemes
• Role of IOT SYSTEM IN VLSI
• Study of Intelligent agents in AI
• Overview of VLSI in IOT based concepts

UNIT-I	FUNDAMENTALS OF VLSI COMPUTING SYSTEMS	9
Review of Types of Parallelism - Instruction Level Parallelism - Thread Level Parallelism - Limits of ILP - Parallel Processing Architectures - Superscalar - VLIW - Scheduling - Techniques - Static and Dynamic Schemes - SIMD Architectures - GPU.		
UNIT-II	**INTER-PROCESSOR COMMUNICATION SCHEMES**	**9**
Inter-Processor Communication Schemes - Bus-Based - Shared Memory - Distributed Memory and Network on Chips - Performance Analysis - Data Parallelism - GPU and GPGPU Applications - Overview of HPC Platforms - CUDA/Hadoop/Mapreduce.		
UNIT-III	**INTRODUCTION TO HETEROGENEOUS COMPUTING**	**9**
Introduction to Markovian/Stochastic Models for Heterogeneous Computing - Operating System - Role of Multi-Cores - Case Study for Heterogeneous Architectures - Case Studies of Data-Intensive Application Platforms - FPGA based Platforms.		
UNIT-IV	**IOT SYSTEM IN VLSI**	**9**
Introduction to IoT - Features - IoT Stack - Technologies and IoT Challenges - Sensors and Hardware for IoT - Protocols. U Model based Approaches - Hardware/Software Partitioning - Computing Paradigms/Platforms - IoT/Cloud Integration.		
UNIT V	**INTELLIGENT AGENTS**	**9**
Introduction to AI – Agents and Environments – concept of rationality – nature of environments – structure of agents. Problem solving agents – search algorithms – uninformed search strategies.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Analyze the ASIP concepts Identify and formulate a given problem in the framework of SoC based design approaches.
• Design SoC based system for engineering applications
• Analyze the passive elements for ASIC design
• Analyze the characteristics of Programmable ASIC I/O cells
• Analyze the synthesis part on different logic structures
• Test the Integrated Circuit using various procedures

Suggested Activities:

- Ice breaker
- Just A Minute
- Ship wreck
- Hot seat
- Vocabulary building
- Chinese whispers
- Case study

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Book(s):

1. Keshap K. Parhi, VLSI Digital Signal Processing Systems, Design and Implementation, John Wiley, 2007
2. J. G. Proakis, & D. G. Manolakis, Digital Signal Processing Principles, Algorithms and Applications, Prentice Hall of India, 2002.
3. Charalampos Doukas, "Building Internet of Things with the Arduino", Create Space, April 2002.
4. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases",

Reference Book(s) / Web links:

1. Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English With Answers 2nd Edition by Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor).
2. Reading Development and Difficulties By Kate Cain
3. FPGA-Based System Design, Wayne Wolf, Published by Prentice Hall, 2004
4. Stuart Russell and Peter Norvig, "Artificial Intelligence – A Modern Approach", Fourth Edition, Pearson Education, 2021
5. https://www.cerc.utexas.edu/~jaa/soc/lectures/1-2.pdf
6. https://www.cl.cam.ac.uk/teaching/1516/SysOnChip/materials.d/socdam-notes00.pdf
7. https://nptel.ac.in/courses/108102045/10

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23C18.1	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C18.2	3	3	3	1	3	3	3	1	-	3	3	3	3	3	3
EC23C18.3	3	2	2	1	3	3	3	1	-	3	3	3	3	3	3
EC23C18.4	2	2	2	2	2	2	2	1	1	3	2	2	2	2	2
EC23C18.5	2	2	2	1	2	2	2	1	1	3	2	2	2	2	2
Average	**2.6**	**2.2**	**2.2**	**1.2**	**2.6**	**2.6**	**2.6**	**1**	**1**	**3**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**

VERTICAL 4 – HIGH SPEED NETWORKS

Course Code	Course Title	Category	L	T	P	C
EC23D11	Wireless Networks	PE	3	0	0	3

Objectives:
• To learn about Wireless networks, protocol stack and standards
• To study about mobile network layer functionalities
• To analyze about mobile transport layer functionalities
• To understand the fundamentals of 3G Services, its protocols and applications
• To discuss about evolution of 4G Networks, its architecture and applications, study the concept of Software defined radio.

UNIT-I	WIRELESS LAN	9
Introduction-WLAN technologies: Infrared, UHF narrowband, spread spectrum -IEEE802.11: System architecture, Protocol architecture, Physical layer, MAC layer, 802.11b, 802.11a – Hiper LAN: WATM, HiperLAN2 – Bluetooth: Architecture, Radio Layer, Baseband layer, Link manager protocol, security - IEEE802.16-WIMAX: Physical layer, MAC.		
UNIT-II	**MOBILE NETWORK LAYER**	**9**
Introduction - Mobile IP: IP packet delivery, Agent discovery, Tunneling and Encapsulation, IPV6Network layer in the internet- Mobile IP session initiation protocol - Mobile ad-hoc network: Routing, Destination sequence distance vector, Dynamic source routing.		
UNIT-III	**MOBILE TRANSPORT LAYER**	**9**
TCP enhancements for wireless protocols - Traditional TCP: Congestion control, fast retransmit/fast recovery, Implications of mobility - Classical TCP improvements: Indirect TCP, Snooping TCP, Mobile TCP, Time out freezing, Selective retransmission, Transaction oriented TCP - TCP over 3G wireless networks.		
UNIT-IV	**WIRELESS WIDE AREA NETWORK**	**9**
Overview of UTMS Terrestrial Radio access network-UMTS core network architecture: 3G-MSC, 3GSGSN, 3G-GGSN, SMS-GMSC/SMS-IWMSC, Firewall, DNS/DHCP-High Speed Downlink Packet Access (HSDPA) - LTE network architecture and protocol.		
UNIT-V	**4G NETWORKS**	**9**
Introduction – 4G vision – 4G features and challenges - Applications of 4G – 4G Technologies: Multicarrier modulation, Smart antenna techniques, OFDM-MIMO systems, Adaptive modulation and coding with time slot scheduler, Software Defined Radio system.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Conversant with the latest 3G/4G and Wi MAX networks and its architecture
• Discuss various layer functionalities in mobile networks.
• Design and implement wireless network environment for any application using latest wireless protocols and standards.
• Implement different type of applications for smart phones and mobile devices with latest network strategies.
• Identify the role of SDR in the next generation networks.

Suggested Activities:

- Flipped classroom –(Unit-I/HiperLAN)
- Survey on 5G Networks

Suggested Evaluation Methods:

- Quizzes–(Unit-II/Mobile IP)
- Class Presentation/Discussion – (Unit-IV/LTE network architecture and protocol)

Text Book(s):

1. Jochen Schiller, "Mobile Communications", Second Edition, Pearson Education 2012.
2. Vijay Garg, "Wireless Communications and networking", First Edition, Elsevier 2007.

Reference Books(s) / Web links:

1. Erik Dahlman, Stefan Parkvall, Johan Skold and Per Beming, "3G Evolution HSPA and LTE for Mobile Broadband", Second Edition, Academic Press, 2008.
2. Anurag Kumar, D.Manjunath, Joy kuri, "Wireless Networking", First Ed., Elsevier 2011
3. Simon Haykin, Michael Moher, David Koilpillai, "Modern Wireless Communications", First Edition, Pearson Education 2013.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23D11.1	2	2	1	1	2	2	2	2	2	2	2	3	3	2	2
EC23D11.2	2	2	1	1	1	2	1	1	1	2	2	2	3	2	1
EC23D11.3	2	2	1	1	1	2	2	1	2	2	2	2	2	2	2
EC23D11.4	2	2	2	1	1	2	1	1	2	2	2	2	3	2	1
EC23D11.5	2	2	2	1	2	3	2	2	2	2	2	3	3	3	2
Average	**2**	**2**	**1.4**	**1**	**1.4**	**2.2**	**1.6**	**1.4**	**1.8**	**2**	**2**	**2.4**	**2.8**	**2.2**	**1.6**

Course Code	Course Title	Category	L	T	P	C
EC23D12	WIRELESS SENSOR NETWORKS	PE	3	0	0	3

Objectives:

- Know the basic knowledge about wireless sensor networks
- Understand the basics of sensor architecture
- Describe the different strategies used to develop MAC and routing protocols for the sensor networks.
- Learn the basic concepts involved in localization and synchronization of WSN.
- Have an exposure to Ad Hoc networks

UNIT-I	**OVERVIEW OF WIRELESS SENSOR NETWORKS**	**9**
Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, Comparison with ad hoc network, Applications of Wireless Sensor Networks.		
UNIT-II	**ARCHITECTURES**	**9**
Single-node Architecture – Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments, Network Architecture – Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts.		
UNIT-III	**NETWORKING SENSORS**	**9**
Physical Layer and Transceiver Design Considerations, MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols and Wakeup Concepts – S-MAC, The Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy-Efficient Routing, Geographic Routing.		
UNIT-IV	**INFRASTRUCTURE ESTABLISHMENT**	**9**
Topology Control, Clustering, Time Synchronization, Localization and Positioning – Properties, Approaches and Mathematical basics for single hop and multi-hop environment, Sensor Tasking and Control.		
UNIT-V	**OVERVIEW OF AD HOC NETWORKS**	**9**
Introduction to Ad hoc networks – Cellular and Ad Hoc wireless networks, Applications of Ad Hoc wireless networks, Issues in designing a Routing Protocols for Ad hoc Wireless Networks, Classification of Routing protocols – Table driven – DSDV, On demand- Dynamic Source Routing (DSR)		
		Total Contact Hours: 45

Course Outcomes:

- Know the basics of Wireless Sensor Networks
- Understand the architecture of WSN.
- Apply this knowledge to identify the suitable MAC layer protocol and routing algorithm based on the network and user requirement
- Understand the localization and synchronization of sensor networks.
- Understand the basics of Ad Hoc Networks.

Suggested Activities:

- Flipped classroom –Applications of WSN
- Survey on routing protocols (Unit-V)
- Implementation of small WSN module.

Suggested Evaluation Methods:

- Quizzes – (Unit-2/Architectures)
- Class Presentation/Discussion – (Unit-5/DSDV)

Text Book(s):
1. Holger Karl & Andreas Willig, “Protocols And Architectures for Wireless Sensor Networks”, John Wiley, 2005.
2. Feng Zhao & Leonidas J. Guibas, “Wireless Sensor Networks- An Information Processing Approach”, Elsevier, 2007.
3. Murthy, C. Siva Ram, and B. S. Manoj. Ad hoc wireless networks: Architectures and protocols, portable documents. Pearson education, 2004.

Reference Book(s) / Web links:
1. Kazem Sohraby, Daniel Minoli, &TaiebZnati, “Wireless Sensor Networks Technology, Protocols, And Applications”, John Wiley, 2007.
2. Anna Hac, “Wireless Sensor Network Designs”, John Wiley, 2003.
3. Edgar H. Callaway, Jr. and Edgar H. Callaway, "Wireless Sensor Networks: Architectures and Protocols," CRC Press, August 2003.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23D12.1	3	1	1	1	1	2	1	1	1	2	1	2	3	1	1
EC23D12.2	3	1	1	1	1	2	1	1	1	2	2	2	3	2	1
EC23D12.3	3	2	3	3	2	2	2	1	1	1	3	2	3	3	2
EC23D12.4	3	2	3	3	3	1	2	1	2	1	3	2	3	3	2
EC23D12.5	3	1	1	2	1	1	1	1	1	2	1	2	3	1	1
Average	**3**	**1.4**	**1.8**	**2.0**	**1.6**	**1.6**	**1.4**	**1.0**	**1.2**	**1.6**	**2.0**	**2.0**	**3**	**2**	**1.4**

Course Code	Course Title	Category	L	T	P	C
EC23D13	NETWORK ROUTING ALGORITHMS	PE	3	0	0	3

Objectives:
• To study the principles behind the data transfer mechanisms over the conventional network.
• To understand the data traversal through various cross points (routers) in the network.
• To acquire knowledge about routing algorithms of conventional networks.
• To familiarize with the various types of key routing protocols used in modern computer networks.
• To familiarize with the fundamentals of wavelength routing in optical WDM networks.

UNIT-I	**NETWORK ROUTING**	**9**
An Introduction to Routing algorithms, Functions of Router IP Addressing, Protocol Stack Architecture, Network Topology and Management architectures, PSTN, Communication Technologies, Network Protocol Analyzer.		
UNIT-II	**ROUTING ALGORITHMS: SHORTEST PATH AND WIDEST PATH**	**9**
Bellman Ford algorithm and distance vector approach, Dijikstra's algorithm, Comparison of Bellman Ford algorithm and Dijikstra's algorithm, shortest and widest path computation, k-shortest path algorithms, Routing Protocols: Framework and Principles.		
UNIT-III	**ROUTING IN IP NETWORKS**	**9**
IP Routing and Distance Vector Protocol Family, Routers, Networks, and Routing information Basics, RIP v1,v2 – IGRP – EIGRP, OSPF and integrated IS-IS, IP Traffic Engineering, BGP, Internet Routing Architectures.		
UNIT-IV	**ROUTING IN WIRELESS NETWORKS**	**9**
Internet based mobile ad-hoc networking, Destination sequenced Distance Vector (DSDV), Dynamic source Routing (DSR), Ad-hoc on demand Distance Vector (AODV), Temporarily Ordered Routing algorithm (TORA).		
UNIT-V	**ROUTING IN OPTICAL WDM NETWORKS**	**9**
Classification of RWA algorithms, RWA algorithms, Fairness and Admission Control, Distributed Control Protocols, Permanent Routing and Wavelength Requirements, Wavelength Rerouting Benefits and Issues, Light path Migration, Rerouting Schemes, Algorithms- AG, MWPG.		
Total Contact Hours: 45		

Course Outcomes:
• Ability to understand the data transfer mechanisms over the conventional network.
• Foster ability to select the optimal routing algorithm for any given network based on path distance.
• Acquired knowledge about routing in IP networks.
• Ability to manifest the skills in applying suitable routing technique for wireless networks.
• Demonstrate the ability to understand the features of routing in WDM networks.

Suggested Activities:

- Flipped classroom –(Unit-II/Comparison of Bellman Ford algorithm and Dijikstra's algorithm)
- Survey on various Routing Algorithms

Suggested Evaluation Methods:

- Quizzes – (Unit-III/ Internet Routing Architectures)
- Class Presentation/Discussion – (Unit-I/PSTN)

Text Book(s):
1. D.Medhi and K.Ramasamy, Network Routing: Algorithms, Protocols and Architectures, Morgan
2. Kaufmann Publishers, First Edition 2007.
3. Steen Strub M, Routing in Communication networks, Prentice Hall International, 1995.

Reference Book(s) / Web links:
1. Internetworking Technologies Handbook, Inc. Cisco Systems, ILSG Cisco.
2. William Stallings, _ High speed networks and Internets Performance and Quality of Service‘, II Edition, Pearson Education Asia, Reprint India 2002.
3. M. Steen Strub, _ Routing in Communication network, Prentice –Hall International, Newyork, 1995.
4. S. Keshav, An engineering approach to computer networking Addison Wesley 1999.
5. William Stallings, High speed Networks TCP/IP and ATM Design Principles, Prentice- Hall, New York, 1995.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23D13.1	3	3	3	2	3	3	2	1	2	3	3	3	3	3	2
EC23D13.2	3	3	3	3	3	3	2	1	2	3	3	3	3	3	2
EC23D13.3	3	2	2	2	3	2	2	1	2	2	2	2	3	3	2
EC23D13.4	3	3	3	3	3	3	2	1	2	3	3	3	3	3	2
EC23D13.5	3	3	2	3	3	3	3	1	2	3	3	3	3	3	3
Average	**3.0**	**2.8**	**2.6**	**2.6**	**3.0**	**2.8**	**2.2**	**1.0**	**2.0**	**2.8**	**2.8**	**2.8**	**3.0**	**3.0**	**2.2**

Course Code	Course Title	Category	L	T	P	C
EC23D14	MULTIMEDIA COMPRESSION AND NETWORKING	PE	3	0	0	3

Objectives:
• Study basics components of multimedia.
• Analyse the characteristics of text and image data.
• Distinguish various compression schemes for voice and video.
• Measure the performance of multimedia networking.
• Evaluate Voice over IP technology.

UNIT-I	BASICS OF MULTIMEDIA COMPONENTS	9
Introduction - Multimedia skills - Multimedia components and their characteristics - Text, sound, images, graphics, animation, video, hardware.		
UNIT-II	**TEXT AND IMAGE COMPRESSION**	**9**
Compression principles-source encoders and destination encoders-lossless and lossy compression-entropy encoding – source encoding -text compression –static Huffman coding dynamic coding – arithmetic coding –Lempel Ziv-Welch Compression-image compression.		
UNIT-III	**AUDIO AND VIDEO COMPRESSION**	**9**
Audio compression–DPCM-Adaptive DPCM –adaptive predictive coding-linear Predictive coding-code excited LPC-perpetual coding Video compression –principles-H.261-H.263-MPEG 1, 2, and 4.		
UNIT-IV	**MULTIMEDIA NETWORKING**	**9**
Multimedia networking -Applications-streamed stored and audio-making - Best Effort service-protocols for real time interactive Applications-distributing multimedia-beyond best effort service-secluding and policing Mechanisms-integrated services-differentiated Services-RSVP.		
UNIT-V	**VOIP TECHNOLOGY**	**9**
Basics of IP transport, VoIP challenges, H.323/ SIP –Network Architecture, Protocols, Call establishment and release, VoIP and SS7, Quality of Service- CODEC Methods- VOIP applicability		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Understand various multimedia components.
• Compare the various compression techniques for text and image data.
• Explore the compressions and decompressions of multimedia content.
• Assess the quality of service provided by multimedia networking.
• Examine VOIP challenges and its technologies.

Suggested Activities:
• Flipped Classroom –(Unit-III/DPCM And Adaptive DPCM)

Suggested Evaluation Methods:
• Assignment problems – (Unit-II/Huffman coding and arithmetic coding)

Text Book(s):
1. Fred Halshall "Multimedia communication - Applications, Networks, Protocols and Standards", First edition, Pearson Education, 2007.
2. Tay Vaughan, "Multimedia: Making It Work", 7/e, TMH, 2007.

Reference Book(s) / Web links:
1. Kurose and W.Ross “Computer Networking: A Top Down Approach”, 6 edition, Pearson Education, 2013.
2. Marcus Goncalves “Voice over IP Networks”, Mc Graw hill, 1999.
3. KR. Rao, Z S Bojkovic, D A Milovanovic, “Multimedia Communication Systems: Techniques, Standards and Networks”, Pearson Education India, 2007.
4. R. Steimnetz, K. Nahrstedt, “Multimedia Computing, Communications and Applications”, Pearson Education, First edition, 1995.
5. Ranjan Parekh, “Principles of Multimedia”, 2 edition, TMH, 2012.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23D14.1	3	3	1	3	2	2	2	-	2	2	2	2	3	3	2
EC23D14.2	3	2	2	2	1	2	2	-	2	1	2	2	3	3	2
EC23D14.3	3	2	2	2	1	2	1	3	2	1	1	2	2	3	3
EC23D14.4	3	2	2	2	1	2	2	2	2	1	1	2	2	2	2
EC23D14.5	3	2	1	3	1	1	1	-	2	-	1	2	3	2	2
Average	**3**	**2.2**	**1.6**	**2.4**	**1.2**	**1.8**	**1.6**	**1**	**2**	**1**	**1.4**	**2**	**2.6**	**2.6**	**2.2**

Course Code	Course Title	Category	L	T	P	C
EC23D15	INTERNETWORKING MULTIMEDIA	PE	3	0	0	3

Objectives:
• To discuss the various multimedia standards
• To understand the different broadband technologies
• To analyze the transport protocols and its applications
• To study various multimedia communication standards
• To analyze multimedia across Wireless Network

UNIT-I	MULTIMEDIA NETWORKING	9
Digital Sound, Video and Graphics – Basic Multimedia Networking – Multimedia Characteristics – Evolution of Internet Services Model – Network Requirements for Audio/ Video Transform – Multimedia Coding and Compression for Text, Image Audio and Video.		
UNIT-II	**BROADBAND NETWORK TECHNOLOGY**	**9**
Broadband Services – ATM and IP, IPV6, High Speed Switching – Resource Reservation, Buffer Management – Traffic Shaping – Caching – Scheduling and Policing, Throughput, Delay and Jitter Performance – Storage and Media Services – Voice and Video Over IP – MPEG–2 over ATM/IP – Indexing Synchronization of Requests – Recording and Remote Control.		
UNIT-III	**RELIABLE TRANSPORT PROTOCOL AND APPLICATIONS**	**9**
Multicast over Shared Media Network – Multicast Routing and Addressing – Scaling Multicast and NBMA Networks – Reliable Transport Protocols – TCP Adaptation Algorithm – RTP, RTCP – MIME – Peer–to–Peer Computing – Shared Application – Video Conferencing, Centralized and Distributed Conference Control – Distributed Virtual Reality – Light Weight Session Philosophy		
UNIT-IV	**MULTIMEDIA COMMUNICATION STANDARDS**	**9**
Objective of MPEG-4 Video Transport across Internet, MPEG – 7 Standard – Functionalities and Systems of MPEG–7, MPEG–21 Multimedia Framework Architecture – Content Representation – Content Management and Usage – Intellectual Property Management – Audio Visual System – H322: Guaranteed QOS LAN Systems.		
UNIT-V	**MULTIMEDIA COMMUNICATION ACROSS NETWORKS**	**9**
Packet Audio/Video in The Network Environment –Video Transport across Generic Networks – Layered Video Coding– Error Resilient Video Coding Techniques – Scalable Rate Control – Streaming Video Across Internet – Multimedia Transport Across ATM Networks and IP Network – Multimedia Across Wireless Networks.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Apply various communication standards in multimedia communication
• Utilize different networks for multimedia communication
• Understand Broadband Network technology
• Improve different protocols for efficient communication.
• Address various multimedia communication standards

Suggested Activities:
• Flipped classroom –(Unit-III/TCP Protocol)

Suggested Evaluation Methods:

- Quizzes–(Unit-IV/MPEG Standards)
- Class Presentation/Discussion – (Unit-V/ATM Networks)

Text Book(s):

1. B O Szuprowicz, "Multimedia Networking", McGraw Hill, Newyork, 1995.
2. K R Rao, Zoran S, Bojkovic and Dragorad A, Milovanovic "Multimedia communication systems", PHI, 2003.

Reference Book(s) / Web links:

1. Jon Crowcroft, Mark Handley, Ian Wakeman "Internetworking Multimedia" Harcourt, Singapore, 1998.
2. Tay Vaughan, "Multimedia Making it to work", 4th edition Tata McGraw Hill, NewDelhi, 2000.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23D15.1	3	3	3	2	3	3	2	1	2	3	3	3	3	3	2
EC23D15.2	3	3	3	3	3	3	2	1	2	3	3	3	3	3	2
EC23D15.3	3	2	2	2	3	2	2	1	2	2	2	2	3	3	2
EC23D15.4	3	3	3	3	3	3	2	1	2	3	3	3	3	3	2
EC23D15.5	3	3	2	3	3	3	3	1	2	3	3	3	3	3	3
Average	**3.0**	**2.8**	**2.6**	**2.6**	**3.0**	**2.8**	**2.2**	**1.0**	**2.0**	**2.8**	**2.8**	**2.8**	**3.0**	**3.0**	**2.2**

Course Code	Course Title	Category	L	T	P	C
EC23D16	PRINCIPLES OF CRYPTOGRAPHY AND NETWORK SECURITY	PE	3	0	0	3

Objectives:

- Learn basics of encryption and modern cryptography.
- Understand methods of public key encryption.
- Learn authentication and hash functions.
- Know the Techniques of system level securities.
- Have knowledge on current trends on wireless security.

UNIT-I	**INTRODUCTION**	**9**

Services, Mechanisms and attacks-the OSI security architecture-Network security model-Classical Encryption techniques Symmetric cipher model, substitution techniques, transposition techniques, steganography. Finite Fields: Groups, Rings, Fields-Modular arithmetic-Euclid's Algorithm-Finite fields. Number Theory: Fermat's and Euler's Theorem- Chinese Remainder Theorem.

UNIT-II	**BLOCK CIPHERS & PUBLIC KEY CRYPTOGRAPHY**	**9**

Data Encryption Standard-Block cipher principles-block cipher modes of operation-Advanced Encryption Standard (AES)-Triple DES. Public key cryptography: Principles of public key cryptosystems-The RSA algorithm-Key management-Attacks on RSA - Diffie Hellman Key exchange.

UNIT-III	**HASH FUNCTIONS AND DIGITAL SIGNATURES**	**9**

Application of Hash Functions – Two simple Hash Functions-Requirements and Security – Hash Function based Cipher Block Chaining – Secure Hash Algorithm (SHA), Message Authentication Codes – Requirements and Security of MACs, HMAC– Digital Signatures and Authentication Protocols – Digital Signature Standards.

UNIT-IV	**SECURITY PRACTICE & SYSTEM SECURITY**	**9**

Authentication applications – Kerberos – X.509 Authentication services – Internet Firewalls for Trusted System: Roles of Firewalls – Firewall related terminology- Types of Firewalls – Firewall designs – SET for E-Commerce Transactions. Intruder – Intrusion detection system – Virus and related threats – Countermeasures – Firewalls design principles – Trusted systems – Practical implementation of cryptography and security

UNIT-V	**E-MAIL, IP, WEB & WIRELESS LAN SECURITY**	**9**

E-mail Security: Security Services for E-mail-attacks possible through E-mail - establishing keys privacy-authentication of the source-Message Integrity-Nonrepudiation-Pretty Good Privacy-S/MIME. IPSecurity: Overview of IPSec - IP and IPv6-Authentication Header-Encapsulation Security Payload (ESP)-Internet Key Exchange (Phases of IKE, ISAKMP/IKE Encoding). Web Security: SSL/TLS Basic Protocol-computing the keys- client authentication-Wireless LAN Security: Wi-Fi Protected Access (WPA)

Total Contact Hours: 45

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

- The methods of conventional encryption and modern cryptography.
- The concepts of Public Key Encryption.
- Methodology for Authentication and Hashing.
- Comprehending System Level Securities.
- Perceiving Wireless Security.

Suggested Activities:

- Problem solving sessions – (Unit-I/RSA, AES and DES)
- Flipped classroom – (Unit-III/Digital Signature Standards)
- Implementation of encryption and decryption algorithm using MATLAB

Suggested Evaluation Methods:

- Assignment problems - (Unit-I/RSA, AES and DES)
- Quizzes–(Unit-I & II - encryption and decryption algorithms)
- Class Presentation/Discussion - (Unit-V/E-Mails)

Text Book(s):

1. William Stallings, Cryptography and Network Security-Principles and Practices, Eighth Edition, Pearson Education, 2020.
2. Forouzan, Cryptography and Network Security, Third Edition, Mc Graw Hill India, 2015.
3. Charlie Kaufman, "Network Security Private Communication in Public World" 2nd edition, Prentice Hall of India New Delhi, 2004.

Reference Book(s) / Web links:

1. William Stallings, "Network Security Essentials", 6th edition, Prentice Hall of India New Delhi, 2017.
2. Charlie Kaufman, Radia Perlman and Mike Speciner, "Network Security", Prentice Hall of India, 2002.
3. AtulKahaet, Cryptography and Network Security, Fourth Edition, Tata McGraw-Hill, 2019.
4. Bruce Schneier , Applied Cryptography: Protocols, Algorithms and Source Code in C, Special Edition, Wiley, 2015.
5. JoxeanKoret and Elias Bachaalany, The Antivirus Hackers Handbook, First Edition, Wiley, 2015.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23D16.1	3	3	2	1	1	2	1	1	1	2	1	2	2	1	2
EC23D16.2	3	2	2	1	2	1	1	1	2	2	2	2	2	2	2
EC23D16.3	3	2	2	2	3	1	2	1	2	2	2	2	2	2	2
EC23D16.4	3	2	2	2	3	2	2	2	2	2	2	2	2	2	2
EC23D16.5	3	2	3	3	3	3	3	2	3	2	2	3	3	2	3
Average	**3**	**2.2**	**2.2**	**1.8**	**2.4**	**1.8**	**1.8**	**1.4**	**2**	**2**	**1.8**	**2.2**	**2.2**	**1.8**	**2.2**

Course Code	Course Title	Category	L	T	P	C
EC23D17	SOFTWARE DEFINED NETWORKS	PE	3	0	0	3

Objectives:
• To learn the fundamentals of software defined networks.
• To understand the separation of the data plane and the control plane.
• To learn the concepts of different data centres
• To study about the SDN Programming.
• To study about the various applications of SDN

UNIT-I	**INTRODUCTION**	**9**
History of Software Defined Networking (SDN) – Modern Data Center – Traditional Switch Architecture – Why SDN – Evolution of SDN – How SDN Works – Centralized and Distributed Control and Date Planes.		
UNIT-II	**OPEN FLOW & SDN CONTROLLERS**	**9**
Open Flow Specification – Drawbacks of Open SDN, SDN via APIs, SDN via Hypervisor- Based Overlays – SDN via Opening up the Device – SDN Controllers – General Concepts.		
UNIT-III	**DATA CENTERS**	**9**
Multitenant and Virtualized Multitenant Data Center – SDN Solutions for the Data Center Network – VLANs – EVPN – VxLAN – NVGRE.		
UNIT-IV	**SDN PROGRAMMING**	**9**
Programming SDNs: Northbound Application Programming Interface, Current Languages and Tools, Composition of SDNs – Network Functions Virtualization (NFV) and Software Defined Networks: Concepts, Implementation and Applications.		
UNIT-V	**SDN**	**9**
Juniper SDN Framework – IETF SDN Framework – Open Daylight Controller – Floodlight Controller – Bandwidth Calendaring – Data Center Orchestration.		
		Total Contact Hours: 45

Course Outcomes: On completion of the course, students will be able to
• Analyze the evolution of software defined networks
• Express the various components of SDN and their uses
• Analyze the concepts of data centres
• Explain the use of SDN in the current networking scenario
• Design and develop various applications of SDN

Suggested Activities:

- Survey on SDR.

Suggested Evaluation Methods:

- Quizzes – (Unit-IV/ Software Defined Networks: Concepts, Implementation and Applications)

Text Book(s):

1. Paul Goransson and Chuck Black, ―Software Defined Networks: A Comprehensive Approach, First Edition, Morgan Kaufmann, 2014.
2. Thomas D. Nadeau, Ken Gray, ―SDN: Software Defined Networks, O'Reilly Media, 2013.

Reference Book(s) / Web links:
1. Siamak Azodolmolky, ―Software Defined Networking with Open Flow, Packet Publishing, 2013.
2. Vivek Tiwari, ―SDN and Open Flow for Beginners‖, Amazon Digital Services, Inc., 2013.
3. Fei Hu, Editor, ―Network Innovation through Open Flow and SDN: Principles and Design, CRC Press, 2014.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23D17.1	3	3	1	3	2	2	2	-	2	2	2	2	3	3	2
EC23D17.2	3	2	2	2	1	2	2	-	2	1	2	2	3	3	2
EC23D17.3	3	2	2	2	1	2	1	3	2	1	1	2	2	3	3
EC23D17.4	3	2	2	2	1	2	2	2	2	1	1	2	2	2	2
EC23D17.5	3	2	1	3	1	1	1	-	2	-	1	2	3	2	2
Average	**3**	**2.2**	**1.6**	**2.4**	**1.2**	**1.8**	**1.6**	**1**	**2**	**1**	**1.4**	**2**	**2.6**	**2.6**	**2.2**

Course Code	Course Title	Category	L	T	P	C
EC23D18	HIGH PERFORMANCE COMPUTING FOR CYBER PHYSICAL SYSTEMS	PE	3	0	0	3

Objectives:
• To introduce the concepts of super computers and their applications to grids and clouds
• To learn the scheduling architectures for high performance computing
• To understand the concepts of privacy and security policies
• To analyse the different data execution models involved in cyber physical systems
• To discuss the applications of high performance computing in different domains

UNIT-I	**INTRODUCTION TO SUPERCOMPUTERS**	**9**
Introduction of Super Computers and Grids, Public-Private Supercomputing Grid Partnership Prerequisites and Problems, Introduction to Porting HPC Applications to Grids And Clouds -Applications and the Grid Infrastructure, Grid Programming Models and Environments		
UNIT-II	**SCHEDULING ARCHITECTURES**	**9**
Introduction To Scheduling- Mouldable Job Allocation for Handling Resource Fragmentation in Computational Grid, Introduction to Speculative Scheduling of Parameter Sweep Applications using Job Behaviour Descriptions; Continuous systems modelling; Discrete time system modelling;		
UNIT-III	**PRIVACY & SECURITY FRAMEWORK**	**9**
Introduction To Security - Policy Based Security Framework - Privacy Management in Large Scale Distributed Systems- Integration of The Security Framework's Privacy Management Components, Time Dependent Schrödinger's Wave Equation.		
UNIT-IV	**DATA EXECUTION MODELS**	**9**
Big Data Architectures, Dataflow Model for Cloud Computing Frameworks in Big Data, Related Work-Customizable Design and Processors, Micro Architecture, Computation - Introduction To Electro Migration Alleviation Techniques		
UNIT-V	**EMERGING APPLICATIONS**	**9**
Introduction To Emerging Big Data Application- Parameter Sensitive Analysis - Overview Of Neural Network Accelerators- Architectures Of Hardware Accelerators –FPGA, Modern Storage Accelerator - Parallel Programming Models ASIC, GPU - Middleware Of Neural Networks -		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Understand the concepts of super computers and their applications to grids and clouds
• Analyse the scheduling architectures for high performance computing
• Understand the concepts of privacy and security policies
• Analyse the different data execution models involved in cyber physical systems
• Demonstrate the applications of high performance computing in different domains

Suggested Activities:

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

Suggested Evaluation Methods:

- Quizzes
- Assignments

Text Book(s):

1. Emmanuel Udoh, Cloud grid and High-performance computing Emerging Applications, 1st Edition, IGI Global, 2011.
2. Marilyn wolf "High-Performance Embedded Computing: Applications in Cyber-Physical Systems"
3. Walid M. Taha • Abd-Elhamid M. Taha Johan Thunberg "Cyber-Physical Systems: A Model-Based Approach"
4. Chao Wang, High performance computing for Big Data Methodologies and Applications, 1st Edition, Chapman &Hall Press Publications, 2020.

Reference Book(s) / Web links:

1. F. Pasqualetti, F. Dörfler and F. Bullo "Control Theoretic methods for Cyber Physical Security", in IEEE Control System Magazine, pp. 110-127, Feb. 2015
2. Yilin Mo, Rohan Chabukswar and Bruno Sinopoli "Detecting Integrity Attacks on SCADA Systems" in IEEE Transactions on Control System Technology, Vol. 22, No. 4, 2014.
3. H. Fawzi, P. Tabuada and S. Diggavi, "Secure Estimation and Control for Cyber-Physical Systems Under Adversarial Attacks," in IEEE Transactions on Automatic Control, vol. 59, no. 6, pp. 1454-1467, June 2014.
4. F. Pasqualetti, F. Dörfler and F. Bullo, "Attack Detection and Identification in Cyber-Physical Systems," in IEEE Transactions on Automatic Control, vol. 58, no. 11, pp. 2715-2729, Nov. 2013.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23D18.1	3	3	1	3	2	2	2	-	2	2	2	2	3	3	2
EC23D18.2	3	2	2	2	1	2	2	-	2	1	2	2	3	3	2
EC23D18.3	3	2	2	2	1	2	1	3	2	1	1	2	2	3	3
EC23D18.4	3	2	2	2	1	2	2	2	2	1	1	2	2	2	2
EC23D18.5	3	2	1	3	1	1	1	-	2	-	1	2	3	2	2
Average	**3**	**2.2**	**1.6**	**2.4**	**1.2**	**1.8**	**1.6**	**1**	**2**	**1**	**1.4**	**2**	**2.6**	**2.6**	**2.2**

VERTICAL 5 – MEMS AND IOT

Course Code	Course Title	Category	L	T	P	C
EC23E11	INTRODUCTION TO MEMS	PE	3	0	0	3

Objectives:

- To introduce the fundamental concepts of MEMS & Microsystems
- To gain a fundamental understanding of standard microfabrication techniques
- To understand the fundamental principles behind the operation of MEMS devices/systems
- To apply knowledge of microfabrication techniques and applications to the design and manufacturing of MEMS device or a microsystem
- To acquire knowledge about the challenges in packaging of MEMS devices

UNIT-I	**INTRODUCTION**	**9**
Introduction: Microelectronics and Microsystems, MEMS roadmaps, Materials: Silicon, glass, metals, dielectrics, carbides, silicon dioxide, silicon carbide, silicon nitride, and polycrystalline silicon ; Applications of Microsystems.		
UNIT-II	**MICROMACHINING**	**9**
Bulk micromachining – overview of etching, isotropic and anisotropic etching, etch stop, wet etching, dry etching, comparison of wet and dry etching, Surface micromachining– General description, process, mechanical problems associated with surface micromachining, LIGA process.		
UNIT-III	**MATERIALS AND PROCESSES**	**9**
Structure of silicon and other materials, Polymer for MEMS, Silicon wafer processing, Thin-film deposition- Physical vapor Deposition, Chemical vapour deposition, Lithography - positive and negative photoresists.		
UNIT-IV	**SENSORS AND ACTUATORS**	**9**
Working principles of MEMS Sensors - Biosensors, optical sensors, micro accelerometer, capacitive and piezo resistive pressure sensors and Thermal Sensors, Micro actuators based on thermal forces, piezo electric crystal and electrostatic forces.		
UNIT-V	**MEMS PACKAGING**	**9**
Overview of packaging, packaging design, selection of packaging materials, levels of microsystem packaging, interface in microsystem packaging, essential packaging technologies, assembly of microsystems		
		Total Contact Hours: 45

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

- Understand the MEMS and micro devices, micro systems and their significance.
- Gain knowledge on recent fabrication methods for the design of microsystems.
- Derive the fabrication steps for MEMS devices.
- Understand the working of various sensors and actuators.
- Learn the significance and challenges in MEMS packaging units.

Suggested Activities:

- Case study
- Quiz
- Discussions on recent technologies

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):
1. Tai Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata-McGraw Hill, New Delhi, 2007.
2. Stephen D Senturia, 'Microsystem Design', Springer Publication,1st ed. 2000. Corr. 2nd printing 2004 Edition

Reference Book(s) / Web links:
1. Mark Madou, Fundamentals of Microfabrication, CRC Press, New York, 2002, eBook Published 8th Oct 2018. DOIhttps://doi.org/10.1201/9781482274004.
2. Chang Liu, Foundations of MEMS, Pearson Education India, 2012.
3. Nadim Maluf, Kirt Willams, An Introduction to Microelectromechanical Systems Engineering, Artech House Publishers, London, Second Edition, 2004.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23E11.1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2
EC23E11.2	2	2	1	3	3	2	3	3	3	2	2	2	2	2	2
EC23E11.3	2	2	3	2	3	3	3	3	2	1	2	2	3	2	3
EC23E11.4	2	2	3	3	2	3	3	3	2	2	1	2	2	2	2
EC23E11.5	2	2	3	3	3	2	2	2	1	2	1	2	2	3	2
Average	**2**	**1.8**	**2.4**	**2**	**2**	**2.4**	**2**	**2.6**	**2**	**2.8**	**1.6**	**2**	**2.2**	**2.2**	**2.2**

Course Code	Course Title	Category	L	T	P	C
EC23E12	MEMS AND MICROFLUIDIC TECHNOLOGIES	PE	3	0	0	3

Objectives:

- To train the students in the design aspects of BioMEMS devices and systems
- To understand basic working principle of microfluidic devices
- To gain knowledge on working principle of MEMS sensors
- To understand working principles of microactuators and drug delivery systems
- To create awareness on lab-on-chip and micro total analysis systems

UNIT-I	**FABRICATION OF MEMS DEVICES FOR BIOMEDICAL APPLICATIONS**	**9**
Introduction- The driving force behind biomedical applications - biocompatibility- reliability considerations- regularity considerations of BioMEMS - micro fabrication of microfluidic devices using soft lithography.		
UNIT-II	**MICRO FLUIDIC PRINCIPLES**	**9**
Introduction- Transport processes in microfluidic channels - electro kinetic phenomena- microvalves –micromixers- micro pumps.		
UNIT-III	**SENSOR PRINCIPLES AND MICRO SENSORS**	**9**
Introduction- working principle of sensors- Piezo electric sensors and SAW devices- electrochemical detection- applications in Medicine.		
UNIT-IV	**MICRO ACTUATORS AND DRUG DELIVERY**	**9**
Introduction- actuation methods- micro actuators for microfluidics- equivalent circuit representation - Drug Delivery.		
UNIT-V	**MICRO TOTAL ANALYSIS**	**9**
Lab on Chip- capillary electrophoresis arrays- cell, molecule and particle handling- surface modification- microsphere- cell based bioassay systems - case study: emerging BioMEMS technologies.		
		Total Contact Hours: 45

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

- Realize the MEMS applications in biomedical engineering.
- Understand the microfluidic principles.
- Interpret the applications of sensors in medical engineering.
- Apply the principles of microactuators and drug delivery systems.
- Identify the applications of micrototal analysis.

Suggested Activities:

- Case study
- Quiz
- Presentation

Suggested Evaluation Methods:

- Assignment
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):

1. Steven S. Saliterman, Fundamentals of Bio MEMS and Medical Micro devices, Wiley Interscience, 2006.
2. Albert Folch, “Introduction to BioMEMS ”, CRC Press, Taylor & Francis Group, Florida, 2013.

Reference Book(s) / Web links:
1. Gerald A. Urban, Bio MEMS, Springer, 2006.
2. Wanjun wang, steven A. Soper, Bio-MEMS Technologies and Applications, CRC Press, 2006.
3. Marc J. Madou, Fundametal of Micro fabrication, The Science of Miniaturization, 2nd Edition, 2017, https://doi.org/10.1201/9781482274004.
4. Gregory T. A. Kovacs, Micro machined Transducers Sourcebook, McGraw-Hill, 1998 - Microelectromechanical systems.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23E12.1	3	3	3	-	-	-	-	-	-	-	-	2	3	3	-
EC23E12.2	3	3	2	-	-	-	-	-	-	-	-	2	3	3	-
EC23E12.3	3	3	3	3	-	-	-	-	-	-	-	2	3	3	-
EC23E12.4	3	3	3	3	-	-	-	-	-	-	-	2	3	3	-
EC23E12.5	3	3	3	-	-	-	-	-	-	-	-	2	3	3	-
Average	**3**	**3**	**2.8**	**1.2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**3**	**-**

Course Code	Course Title	Category	L	T	P	C
EC23E13	BIOMEMS	PE	3	0	0	3

Objectives:
• To acquire knowledge on various MEMS fabrication techniques
• To gain a fundamental understanding on MEMS sensors and actuators
• To understand the fundamental working principles behind electrostatic and piezoelectric sensors
• To apply knowledge of microfabrication techniques and analyse the functionality of microfluidic systems.
• To gain knowledge on diverse applications of BioMEMS

UNIT-I	MEMS MATERIALS AND FABRICATION	9
Typical MEMs and Microsystems, materials for MEMS - active substrate materials-Silicon and its compounds, Silicon piezoresistors, Gallium Arsenide, quartz, polymers. Micromachining photolithography, thin film deposition, doping, etching, bulk machining, wafer bonding, LIGA.		
UNIT-II	**PRINCIPLES OF MEMS SENSORS AND ACTUATORS**	**9**
Mechanics for MEMS design- static bending of thin plates, mechanical vibration, thermo mechanics, fracture and thin film mechanics. Mechanical sensors and actuators – beam and cantilever – microplates, strain, pressure and flow measurements, Thermal sensors and actuators- actuators based on thermal expansion, thermal couples, thermal resistors, Shape memory alloys, inertia sensor, flow sensor.		
UNIT-III	**PRINCIPLES OF ELECTROSTATIC, PIEZOELECTRIC SENSORS AND ACTUATORS**	**9**
Parallel plate capacitor, pull in effect, Electrostatic sensors and actuators- Inertia sensor, Pressure sensor, flow sensor, tactile sensor, comb drive , properties of piezoelectric materials, piezoelectric sensor and actuator – inchworm motor, inertia sensor, flow sensor.		
UNIT-IV	**MICROFLUIDIC SYSTEMS**	**9**
Fluid dynamics, continuity equation, momentum equation, equation of motion, laminar flow in circular conduits, fluid flow in microconduits in submicrometer and nanoscale. microscale fluid, expression for liquid flow in a channel, fluid actuation methods, dielectrophoresis, microfluid dispenser, microneedle, micropumps, continuous flow system, micromixers.		
UNIT-V	**APPLICATIONS**	**9**
CAD for MEMS, micro total analysis systems (MicroTAS) detection and measurement methods, microsystem approaches to polymerase chain reaction (PCR), DNA sensor, MEMS based drug delivery, Emerging Bio-MEMS technology: Minimally invasive surgery, Oncology, Tissue Engineering, Biosensors. Case study: Design of MEMS based Infusion Pump.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Describe the various MEMS fabrication techniques
• Outline different types of mechanical and thermal actuators and sensors.
• Explain different types of electrostatic and piezoelectric actuators and sensors.
• Analyze the fluid dynamics in Micro conduits and its applications.
• Illustrate various medical applications of MEMS.

Suggested Activities:

- Case study
- Quiz
- Discussions on recent technologies

Suggested Evaluation Methods:

- Assignment
- Quiz
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):

1. Tai Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw Hill Publishing Company, New Delhi, 2002. (Unit I, II, III & IV). .
2. Wanjun Wang, Stephen A. Soper, "BioMEMs: Technologies and Applications", CRC Press, New York, 2007. (Unit V).

Reference Book(s) / Web links:

1. Mark Madou, Fundamentals of Microfabrication, CRC Press, New York, 2002, eBook Published 8th Oct 2018. DOIhttps://doi.org/10.1201/9781482274004.
2. Chang Liu, Foundations of MEMS, Pearson Education India, 2012
3. NadimMaluf, KirtWillams, An Introduction to Microelectromechanical Systems Engineering Artech House Publishers, London, Second Edition, 2004.
4. Nitaigour Premchand Mahalik, "MEMS", Tata McGraw Hill Publishing Company, New Delhi, 2007.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23E13.1	1	-	3	-	3	-	-	1	-	-	-	-	-	3	-
EC23E13.2	1	-	3	-	3	-	-	1	-	-	-	-	-	3	-
EC23E13.3	1	-	3	-	3	-	-	1	-	-	-	-	-	3	-
EC23E13.4	1	-	3	-	3	-	-	1	-	-	-	-	-	3	-
EC23E13.5	-	-	-	-	-	-	2		-	-	-	1	-		-
Average	**0.8**	**0**	**2.4**	**0**	**2.4**	**0**	**0.4**	**0.8**	**0**	**0**	**0**	**0.2**	**0**	**2.4**	**0**

Course Code	Course Title	Category	L	T	P	C
EC23E14	BIOMATERIAL SCIENCE AND APPLICATIONS	PE	3	0	0	3

Objectives:
• To study the characteristics of biomaterials and their reaction in host environment
• To understand the applications of metals and ceramics as biomaterials
• To study the design of drug delivery using polymeric materials
• To study the different types of soft and hard tissue implants.
• To understand the concept of biocompatibility and the methods of biomaterial testing

UNIT-I	INTRODUCTION TO BIO-MATERIALS	9
Definition and classification of bio-materials, Characterization of biomaterials: mechanical properties, surface properties, viscoelasticity. Host reactions to biomaterials: Inflammation, Wound Healing and Foreign Body Response, Failure mechanisms: corrosion, fracture, degradation of Implanted materials in the biological environment.		
UNIT-II	**APPLICATIONS OF METALLIC AND CERAMIC MATERIALS**	**9**
Metallic implants: Stainless steels, co-based alloys, Ti-based alloys, shape memory alloy, applications. Ceramic implant: bioinert, biodegradable or bio resorbable, bioactive ceramics, applications.		
UNIT-III	**POLYMERIC IMPLANT MATERIALS**	**9**
Polymerization, Polyethylene, Clinical study of synthetic polymers, Bioerodible polymers, Blood compatible polymers, Bioactive polymers, Hydrogels; Methacrylates, Drug incorporation polymer gels, Biomedical application of polymers outside the body and temporary in vivo applications. Case Study: Biodegradable polymers for medicinal applications.		
UNIT-IV	**TISSUE ENGINEERING FOR IMPLANTS**	**9**
Soft tissue replacements, sutures, surgical tapes, adhesive, percutaneous and skin implants, maxillofacial augmentation, vascular grafts, Prosthetic Cardiac Valves, hard tissue replacement Implants, Internal fixation device, joint replacements, dental implants. Case Study: Failure analysis of internal fixation devices.		
UNIT-V	**TESTING AND ASSESSMENT OF BIOMATERIALS**	**9**
Testing of blood- material interactions: blood compatibility and thrombogenicity, In vitro assessment of tissue compatibility: assay methods - direct contact test, agar diffusion test, elution test, clinical use. In vivo assessment of tissue compatibility: mechanical testing, criteria for assessing acceptability of the tissue response. Sterilization of implants: steam sterilization, EtO sterilization, radiation sterilization.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Explain the properties of biomaterials and biomaterial- tissue reaction.
• Identify metals and ceramic implants used for medical applications
• Compare different polymeric materials, their application in drug delivery.
• Outline the concept behind the different tissue engineering and implants.
• Demonstrate various testing and validation techniques on biomaterials.

Suggested Activities:
- Case study
- Quiz
- Presentation

Suggested Evaluation Methods:
- Assignment
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):
1. Sujata V. Bhatt, “Biomaterials”, Second Edition, Narosa Publishing House, 2005.
2. BD Ratner, AS Hoffmann,FJ Schoen, JE Lemmons, “An Introduction to Materials in Medicine” Academic Press, Third Edition, 2013.
3. Park J.B, R.S Lakes “Biomaterials an Introduction”, Springer, 2007.

Reference Book(s) / Web links:
1. Joseph D Bronzino, “Biomedical engineering Fundamentals”, CRC press, Third Edition, 2006.
2. A.C Anand, J F Kennedy, M.Miraftab, S.Rajendran, “Woodhead Medical Textiles and Biomaterials for Healthcare”, Publishing Limited 2006. 3. Andrew F.Von Racum, Handbook of Biomaterials Evaluation: Scientific, Technical and Clinical Testing of Implant Materials, Second Edition, CRC Press, 1998.
4. M.F. Maitz, Applications of synthetic polymers in clinical medicine, Biosurface and Biotribology, Volume 1, Issue 3, 2015, Pages 161-176, ISSN 2405-4518, https://doi.org/10.1016/j.bsbt.2015.08.002
5. Baran, George & Kiani, Mohammad & Samuel, Solomon. (2014). Healthcare and biomedical technology in the 21st century: An introduction for non-science majors. 10.1007/978-1-4614-8541-4.
6. Birringer, R.P., Ganot, G.S. & James, B.A. Failure Analysis of Internal Fixation Medical Devices: Overview and Case Studies. J Fail. Anal. And Preven. 16, 849–857 (2016). https://doi.org/10.1007/s11668-016-0159-1.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23E14.1	3	3	3	-	-	-	-	-	-	-	-	2	3	3	-
EC23E14.2	3	3	2	-	-	-	-	-	-	-	-	2	3	3	-
EC23E14.3	3	3	3	3	-	-	-	-	-	-	-	2	3	3	-
EC23E14.4	3	3	3	3	-	-	-	-	-	-	-	2	3	3	-
EC23E14.5	3	3	3	-	-	-	-	-	-	-	-	2	3	3	-
Average	**3**	**3**	**2.8**	**1.2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**3**	**-**

Course Code	Course Title	Category	L	T	P	C
EC23E15	NANOTECHNOLOGY FOR ENGINEERING APPLICATIONS	PE	3	0	0	3

Objectives:

- To understand the basic scientific concepts underpinning nanoscience
- To understand the multidisciplinary aspects of synthesizing nanomaterials
- To understand the different types of nanomaterials
- To demonstrate specifically the characterization tools used in nanotechnology
- To appreciate the emerging role of nanotechnology in society, the regulatory framework within which it operates and the ethical issues it raises

UNIT-I	INTRODUCTION	9

Scientific revolutions –Time and length scale in structures – Definition of a nanosystem – Dimensionality and size dependent phenomena – Surface to volume ratio. Properties at nanoscale (optical, mechanical, electronic, and magnetic). Definition, objective and goal of Nanotechnology, Importance of Nanoscale, revolution of Nanotechnology.

UNIT-II	NANOFABRICATION TECHNIQUES	9

Nanoparticles through homogeneous and heterogeneous nucleation-Growth controlled by surface and diffusion process-Oswald ripening process - influence of reducing agents. Fabrication methods – Top down processes: Milling, lithographics, Machining process, vapour deposition. Bottom–Up process: Colloidal and Sol – gel methods, electro deposition, Self Assembly.

UNIT-III	NANOMATERIALS	9

Classification based on dimensionality- Quantum Dots, Wells and Wires- Carbon- based nano materials (buckyballs, nanotubes, graphene) – Metal based nano materials (nanogold, nanosilver and metal oxides) - Nanocomposites-Nanopolymers – Nanoglasses –Nano ceramics –Biological nanomaterials. Case Study: Engineered Carbon Nanotube (CNT) and its applications.

UNIT-IV	EXPERIMENTAL TECHNIQUES	9

Characterization – X- ray diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscope (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling microscopy (STM), Scanning probe microscopy (SPM), Optical and Raman Spectroscopy (ORS).

UNIT-V	NANOTECHNOLOGY IN HEALTH CARE	9

Properties of nanocarriers; drug delivery systems used in nanomedicine; Enhanced Permeability and Retention effect; Blood-brain barrier; Active and passive targeting of diseased cells; Nanotechnology in defense - environmental application, Health and environmental impacts of nanotechnology. Case Study: Nano Toxicological Studies.

Total Contact Hours: 45

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

- Gain knowledge on the general principles of physics, chemistry, electronics and biology that play a role on the nanometer scale
- Understand various nanofabrication techniques
- Understand various types of nanomaterials and their applications
- Acquire knowledge on different types of characterization techniques
- Demonstrate the socioeconomic impact of nanotechnology and toxicological issues associated with it.

Suggested Activities:

- Case study
- Quiz
- Discussions on recent technologies

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):

1. Edelstein. A.S. and R.C. Cammearata, eds., "Nanomaterials: Synthesis, Properties and Applications", Institute of Physics Publishing, Bristol and Philadelphia, 1996.
2. John Dinardo. N, "Nanoscale characterization of surfaces & Interfaces", 2nd edition, Weinheim Cambridge, Wiley-VCH, 2000.
3. Bio-Nanotechnology_ Concepts and applications. Madhuri Sharon, Maheshwar Sharon,Sunil Pandey and Goldie Oza, Ane Books Pvt Ltd, 1 edition 2012.

Reference Book(s) / Web links:

1. Nanoscience and technology - Latest research and news | Nature
2. Nanomaterials: a review of synthesis methods, properties, recent progress, and challenges - Materials Advances (RSC Publishing)
3. Alain Nouailhat, 'An Introduction to Nanoscience and Nanotechnology', Wiley 2010.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23E15.1	3	3	3	-	-	-	-	-	-	-	-	1	3	3	-
EC23E15.2	3	3	3	-	-	-	-	-	-	-	-	1	3	3	-
EC23E15.3	3	3	2	2	-	2	-	-	-	-	-	1	3	3	-
EC23E15.4	3	3	3	-	-	-	-	-	-	-	-	1	3	3	-
EC23E15.5	3	3	2	2	-	2	2	2	-	-	-	1	3	3	-
Average	**3**	**3**	**2.6**	**2**	**-**	**2**	**2**	**2**	**-**	**-**	**-**	**1**	**3**	**3**	**-**

Course Code	Course Title	Category	L	T	P	C
EC23E16	SENSOR TECHNOLOGY	PE	3	0	0	3

Objectives:
• To have basic knowledge in transduction principles, sensors and measurement systems
• To understand the fundamental principles behind the operation of sensors
• To gain knowledge on velocity and acceleration measurement methods
• To have basic knowledge in various methods of measurement of physical and electrical parameters
• To provide calibration methods for sensors interface with real time systems

UNIT-I	INTRODUCTION TO MEASUREMENT SYSTEMS	9
General concepts and terminology, measurement systems, sensor classifications: Analog Input and Output, Digital Input and Output, general input-output configuration, methods of correction. Passive Sensors Resistive Sensors: Potentiometers, Resistive Temperature Detectors (RTDs), Thermistors, Light-dependent Resistors (LDRs), Capacitive Sensors: Variable capacitor and Differential capacitor.		
UNIT-II	**SELF-GENERATING SENSORS**	**9**
Thermoelectric Sensors: Thermocouples, Thermo electric effects, Common thermocouples, Practical thermocouple laws, cold junction compensation in thermocouples circuits. piezoelectric Sensors: Piezoelectric effect, piezoelectric materials, applications.		
UNIT-III	**VELOCITY AND ACCELERATION MEASUREMENT**	**9**
Relative velocity – Translational and Rotational velocity measurements – Revolution counters and Timers - Magnetic and Photoelectric pulse counting stroboscopic methods. Accelerometers-different types, Gyroscopes-applications.		
UNIT-IV	**DENSITY, VISCOSITY AND OTHER MEASUREMENTS**	**9**
Units of Viscosity, specific gravity scales used in Petroleum Industries, Different Methods of measuring consistency and Viscosity –Two float viscometer –Industrial consistency meter. Sound-Level Meters, Microphones, Humidity Measurement.		
UNIT-V	**CALIBRATION AND INTERFACING**	**9**
Calibration using Master Sensors, Interfacing of Force, Pressure, Velocity, Acceleration, Flow, Density and Viscosity Sensors, variable frequency drive.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Interpret the working of sensors using various measurement methods.
• Analyse the actuation of sensors using their fundamental working principles.
• Measure the velocity and acceleration of accelerometers and gyroscopes.
• Deploy various measurement methods of physical and electrical parameters.
• Apply knowledge of calibration methods on sensors interfaced with real time systems.

Suggested Activities:
- Case study
- Quiz
- Presentation

Suggested Evaluation Methods:
- Assignment
- Quizes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):
1. Measurement Systems – Applications and Design – by Doeblin E.O., 4/e, McGraw Hill, International, 1990.
2. Principles of Industrial Instrumentation – Patranabis D. TMH. End edition 1997

Reference Book(s) / Web links:
1. Sensor Technology Hand Book – Jon Wilson, Newne 2004.
2. Measurement system: Applications and Design – by E. O. Doeblin, McGraw Hill Publications.
3. Instrument Transducers – An Introduction to their Performance and design – by Herman K.P. Neubrat, Oxford University Press.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23E16.1	3	3	3	-	-	-	-	-	-	-	-	2	3	3	-
EC23E16.2	3	3	2	-	-	-	-	-	-	-	-	2	3	3	-
EC23E16.3	3	3	3	3	-	-	-	-	-	-	-	2	3	3	-
EC23E16.4	3	3	3	3	-	-	-	-	-	-	-	2	3	3	-
EC23E16.5	3	3	3	-	-	-	-	-	-	-	-	2	3	3	-
Average	**3**	**3**	**2.8**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**3**	**-**

Course Code	Course Title	Category	L	T	P	C
EC23E17	IOT COMMUNICATION TECHNOLOGIES	PE	3	0	0	3

Objectives:
• Understand the architecture of Internet of Things and connected world.
• Explore on use of various hardware, communication and sensing technologies to build IoT applications.
• Illustrate the real time IoT applications to make smart world.
• Understand challenges and future trends in IoT.
• Gain knowledge in working principle of IoT physical servers and smart systems.

UNIT-I	FUNDAMENTALS OF COMMUNICATION NETWORKS	9
Data Communication, Networks, Protocols and standards, Line configuration, Topology, Transmission mode, Signaling, RS232 Serial Communication and Manchester encoding, OSI reference model - layers and duties. TCP/IP reference model – layers and duties.		
UNIT-II	**IoT AND M2M**	**9**
Introduction to M2M, difference between IoT and M2M, software defined networking (SDN) and network function virtualization (NFV) for IoT, basics of IoT system management with NETCONFYANG.		
UNIT-III	**IoT PLATFORMS DESIGN METHODOLOGY**	**9**
IoT Architecture: State of the art introduction; Architecture reference model: Introduction, reference model and architecture, IoT reference model. Logical design using Python: Installing Python, Python data types and data structures, control flow, functions, modules, packages, file handling.		
UNIT-IV	**IoT PHYSICAL DEVICES AND ENDPOINTS**	**9**
Introduction to Raspberry Pi interfaces (Serial, SPI, I2C), programming Raspberry PI with Python, other IoT devices.		
UNIT-V	**IoT PHYSICAL SERVERS AND CLOUD OFFERINGS**	**9**
Introduction to cloud storage models and communication APIs, WAMP – AutoBahn for IoT, Xively cloud for IoT, case studies illustrating IoT design – home automation, smart cities, smart environment.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, the students will be able to
• Understand the fundamentals of communication networks.
• Deploy various IoT models build efficient IoT platform
• Identify accurate design methodologies and build IoT platform
• Program Raspberry PI using Python
• Deploy IoT platforms in a real time environment.

Suggested Activities:
- Case study
- Quiz
- Presentation

Suggested Evaluation Methods:
- Assignment
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):
1. Arshdeep Bahga, Vijay Madisetti, ―Internet of Things: A Hands-on-Approach‖, VPT, 1st Edition, 2014.
2. Matt Richardson, Shawn Wallace, ―Getting Started with Raspberry Pi, O'Reilly (SPD), 3rd Edition, 2014.

Reference Book(s) / Web links:
1. Adrian McEwen, Hakim Cassimally, ―Designing the Internet of Things, John Wiley and Sons 2014.
2. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, A press Publications, 1st Edition2013

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23E17.1	3	3	3	3	2	2	2	2	3	2	3	3	3	3	3
EC23E17.2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EC23E17.3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EC23E17.4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EC23E17.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**2.75**	**2.75**	**2.75**	**2.75**	**3**	**2.75**	**3**	**3**	**3**	**3**	**3**

Course Code	Course Title	Category	L	T	P	C
EC23E18	INDUSTRY 4.0 AND IIOT	PE	3	0	0	3

Objectives:
• To understand the basics of Industry 4.0.
• To learn the basics of IIoT.
• To analyze IIOT platform and SDN using big data analytics
• To familiarize and implement safety protocols in Industrial IoT .
• To deploy IIoT in various applications

UNIT-I	**INTRODUCTION**	**9**
Globalization, The Fourth Revolution, LEAN Production Systems; Industry 4.0: Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis.		
UNIT-II	**BASICS OF INDUSTRIAL IoT**	**9**
IIoT- Introduction, Industrial Processes, Industrial Sensing & Actuation; IIoT- Business Models, IIoT Reference Architecture; IIoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication.		
UNIT-III	**INDUSTRIAL IoT-BIG DATA ANALYTICS AND SOFTWARE DEFINED NETWORKS**	**9**
IIoT: Big Data Analytics - Introduction, Machine Learning and Data Science; Software Defined Networks in IIoT; Data Center Networks.		
UNIT-IV	**IIoT SECURITY AND FOG COMPUTING**	**9**
Security in IIoT; Plant Safety and Security (Including AR and VR safety applications), Facility Management, Fog Computing in IIoT.		
UNIT-V	**IIoT APPLICATION**	**9**
Healthcare, Power Plants, Oil, Chemical, Pharmaceutical, Packaging Industries.		
		Total Contact Hours: 45

Course Outcomes: On completion of the course, the students will be able to
• Understand the basics of Industry 4.0.
• Learn the basics of IIoT.
• Analyze IIoT platform and SDN using big data analytics
• Familiarize and implement safety protocols in Industrial IoT.
• Deploy IIoT in various applications

Suggested Activities:

- Problem solving sessions
- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies
- Activity Based Learning
- Implementation of small module

Suggested Evaluation Methods:

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Text Book(s):
1. Arshdeep Bahga, Vijay Madisetti, —Internet of Things: A Hands-on-Approach‖, VPT, 1st Edition, 2014.
2. Honbo Zhou, Internet Of Things In The Cloud A Middleware Perspective, 2013.

Reference Book(s) / Web links:
1. Sudip Misra, Chandana Roy, Anandarup Mukherjee -Introduction to Industrial Internet of Things and Industry 4.0, First Edition 2021.
2. Industrial IoT : Challenges, Design Principles, Applications, and Security | SpringerLink.
3. Alasdair Gilchrist ,Industry 4.0: The Industrial Internet of Things' · 2016.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23E18.1	3	3	3	3	2	2	2	2	3	3	3	3	3	3	3
EC23E18.2	3	3	3	3	2	2	2	2	3	3	3	3	3	3	3
EC23E18.3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EC23E18.4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EC23E18.5	3	3	3	3	2	2	2	2	3	3	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**2.4**	**2.4**	**2.4**	**2.4**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

VERTICAL 6 – SPACE TECHNOLOGIES

Course Code	Course Title	Category	L	T	P	C
EC23F11	SATELLITE COMMUNICATION	PE	3	0	0	3

Objectives:
• To understand the fundamental concepts of frequency allocations, Kepler's laws, satellite different orbits with emphasize on geostationary orbit
• To know different types of losses in satellite communications and how it affects the carrier-to-noise ratio for the uplink, downlink, the combined link and received power at the earth stations.
• To learn different satellite access performance metrics and characteristics with and apply it to some satellite network applications..
• To understand the basics of satellite orbits ,the satellite segment and earth segment
• To understand the applications of satellites

UNIT-I	**COMMUNICATION SATELLITE**	**9**
Orbit and Description: A brief History of Satellite Communication, Satellite Frequency bands, Satellite Systems, Applications, Orbital Period and Velocity, Effects of Orbital inclination, Azimuth and Elevation, Coverage and Slant range, Eclipse, Orbital perturbations , Placement of a Satellite in a Geo-Stationary Orbit.		
UNIT-II	**SATELLITE LINK DESIGN**	**9**
Satellite Sub-Systems: Altitude and orbit control system, TT&C Sub-System, Altitude control Sub-System, Power Systems, Communication Subsystems, Satellite antenna Equipment. Satellite Link: Basic transmission theory, system noise temperature and G/T ratio, Basic Link Analysis, Interference Analysis, Design of satellite links for specified C/N, (with and without frequency Re-use), Link Budget.		
UNIT-III	**SATELLITE ACCESS AND CODING METHODS**	**9**
Modulation and Multiplexing: Voice, Data, Video, Analog – digital transmission system, Digital video Broadcast, multiple access: FDMA, TDMA, CDMA, DAMA Assignment Methods, compression – encryption, Coding Schemes		
UNIT-IV	**EARTH STATION TECHNOLOGY:**	**9**
Transmitters, Receivers, Antennas, Tracking systems, Terrestrial Interface, Power Test methods, Lower Orbit Considerations. Satellite Navigation & Global Positioning Systems: Radio and Satellite Navigation, GPS Position Location principles, GPS Receivers, GPS C/A code accuracy, Differential GPS.		
UNIT-V	**SATELLITE APPLICATIONS**	**9**
INTELSAT Series, INSAT, VSAT, Mobile satellite services: GSM, GPS, INMARSAT, LEO, MEO, Satellite Navigational System. GPS Position Location Principles, Differential GPS, Direct Broadcast satellites (DBS/DTH).		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Describe the satellite orbits and its trajectories with the definitions of parameters associated with it..
• Explain the electronic hardware systems associated with the satellite subsystem and earth station.
• Describe the communication satellites with the focus on national satellite system.
• Compute the satellite link parameters under various propagation conditions with the illustration of multiple access techniques.
• Describe the satellites used for applications in remote sensing, weather forecasting and navigation..

Suggested Activities:

- Industrial visit to ISRO
- Quizzes
- Video lectures

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):

1. Satellite Communications- Timothy Pratt, Charles Bostian and Jeremy Allnutt, WSE, Wiley Publications, 2nd Edition, 2003, John Wiley & Sons.
2. Satellite Communications- Dennis Roddy, 4th Edition,2017 , McGraw Hill
3. Digital Satellite Communications-Tri. T.Ha, 2nd Edition, 1990, Mc. Graw Hill

Reference Book(s) / Web links:

1. Satellite Communication Engineering- Wilbur L. Pritchand, Robert A Nelson and Henri G.Suyderhoud, 2nd Edition, Pearson Publications.
2. Satellite Communications: Design Principles- M. Richharia, 2nd Edition, BS Publications, 2003.
3. Digital Satellite Communications-Tri. T. Ha, 2nd Ed., MGH, 1990.
4. Fundamental of Satellite Communications- K. N Raja Rao, PHI, 2004.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23F11.1	3	3	3	3	2	3	1	1	1	1	1	1	3	3	3
EC23F11.2	3	2	2	3	2	3	1	1	1	1	1	1	3	3	3
EC23F11.3	3	3	3	2	1	3	1	1	1	1	1	1	3	3	3
EC23F11.4	3	3	2	3	2	3	1	1	1	1	1	1	3	3	3
EC23F11.5	3	2	3	2	2	1	1	1	1	1	1	1	3	3	3
Average	**3**	**2.6**	**2.6**	**2.6**	**1.8**	**2.6**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**3**	**3**

Course Code	Course Title	Category	L	T	P	C
EC23F12	RADAR TECHNOLOGIES	PE	3	0	0	3

Objectives:
• To understand the basics of Radar and Radar equation
• To learn the types of Radar
• To gain knowledge about tracking Radar
• To understand the various signal processing in Radar
• To know the subsystems in Radar

UNIT-I	INTRODUCTION TO RADAR EQUATION	9
The Origins of Radar ,Radar principles, Basic Block Diagram, Radar classifications based on Frequencies, Wave form and application, Radar Fundamentals: Detection, Range, velocity, The simple form of the Radar Equation, Pulsed Radar equation, Detection of Signals in Noise- Receiver Noise, Signal-to-Noise Ratio, Probabilities of Detection and False Alarm, Integration of Radar Pulses, Radar Cross Section of Targets, Transmitter Power, Pulse Repetition Frequency, Antenna Parameters, System losses		
UNIT-II	**CW, MTI AND PULSE DOPPLER RADAR**	**9**
CW and Frequency Modulated Radar, Doppler and MTI Radar- Delay Line Cancellers, Staggered Pulse Repetition Frequencies, Doppler Filter Banks, Digital MTI Processing, Moving Target Detector, Limitations to MTI Performance, MTI from a Moving Platform (AMIT), Pulse Doppler Radar.		
UNIT-III	**TRACKING RADAR**	**9**
Tracking with Radar, Monopulse Tracking, Conical Scan, Sequential Lobing, Limitations to Tracking Accuracy, Low-Angle Tracking - Comparison of Trackers, Track while Scan (TWS) Radar- Target prediction, state estimation, Measurement models, alpha – beta tracker, Kalman Filtering, Extended Kalman filtering		
UNIT-IV	**RADAR SIGNAL PROCESSING**	**9**
Radar Signal Processing Fundamentals, Detection strategies, Optimal detection, Threshold detection, Constant False alarm rate detectors, Adaptive CFAR, pulse compression waveforms, compression gain, LFM waveforms matched filtering, radar ambiguity functions, radar resolution, Detection of radar signals in Noise and clutter, detection of non-fluctuating target in noise, Doppler spectrum of fluctuating targets, Range Doppler spectrum of stationary and moving radar..		
UNIT-V	**RADAR TRANSMITTERS AND RECEIVERS**	**9**
Radar Transmitter, Linear Beam Power Tubes, Solid State RF Power Sources, Magnetron, Crossed Field Amplifiers, Other RF Power Sources. The Radar Receiver, Receiver noise power, Super heterodyne Receiver, Duplexers and Receiver Protectors- Radar Displays. Radar Antenna - Reflector Antennas - Electronically Steered Phased Array Antennas – Phase Shifters		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Identify the Radar parameters
• Differentiate various radar types
• Evaluate different tracking and filtering schemes
• Apply signal processing in target detection
• Design Radar transmitter and receiver blocks

Suggested Activities:
• Industrial visit to Airport Authority of India
• Quizzes

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):

1. Habibur Rahman, Fundamental Principles of Radar, CRC press, Taylor and Francis, 2019.
2. M. R. Richards, J. A. Scheer, W. A. Holm, Editors "Principles of Modern Radar, Basic Principles", SciTech Publishing, 2012.

Reference Book(s) / Web links:

1. Nathansan, "Radar design principles-Signal processing and environment", PHI, 2nd Edition, 2007.
2. M.I.Skolnik , "Introduction to Radar Systems", Tata McGraw Hill, 2006.
3. Mark A. Richards, "Fundamentals of Radar Signal Processing", McGraw-Hill, 2005.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23F12.1	3	3	3	2	2	2	-	-	-	-	2	2	3	3	2
EC23F12.2	3	3	3	2	2	2	-	-	-	-	2	2	2	2	2
EC23F12.3	3	3	3	2	2	2	-	-	-	-	2	2	2	2	3
EC23F12.4	3	3	3	2	3	2	-	-	-	-	1	2	2	2	2
EC23F12.5	3	2	2	2	3	2	-	-	-	-	1	2	2	2	2
Average	**3**	**2.8**	**2.8**	**2**	**2.4**	**2**	**-**	**-**	**-**	**-**	**1.6**	**2**	**2.2**	**2.2**	**2.2**

Course Code	Course Title	Category	L	T	P	C
EC23F13	AVIONICS SYSTEMS	PE	3	0	0	3

Objectives:
• To gain knowledge on the needs for avionics for both Civil and military aircraft.
• To understand the avionics architecture and Avionics data bus.
• To understand the various cockpit displays and human interfaces
• To know the concepts of flight control systems FMS and their importance
• To gain the knowledge on different navigation aids and need for certification

UNIT-I	INTRODUCTION TO AVIONICS	9
Basics of Avionics-Basics of Cockpits – Need for Avionics in civil and military aircraft and space systems – Integrated Avionics Architecture –Military and Civil system – Typical avionics System and Sub systems – Design and Technologies – Requirements and Importance of illities of Avionic Systems.		
UNIT-II	**DIGITAL AVIONICS BUS ARCHITECTURE**	**9**
Evolution of Avionics architecture– Avionics Data buses MIL-STD-1553, MIL-STD-1773, ARINC429, ARINC-629, AFDX/ARINC-664, ARINC-818 – Aircraft system Interface		
UNIT-III	**COCKPIT DISPLAYS AND MAN-MACHINE INTERACTION**	**9**
Trends in display technology- CRT, LED, LCD, EL and plasma panel - Touch screen - Direct voice input (DVI) –-Civil cockpit and military cockpit: MFD, MFK, HUD, HDD, HMD, HOTAS – Glass cockpit.		
UNIT-IV	**FLIGHT CONTROL SYSTEMS**	**9**
Introduction to Flight control systems and FMS– Longitudinal control – Lateral Control –Autopilot – Flight planning – Radar Electronic Warfare - Certification-Military and civil aircrafts.		
UNIT-V	**NAVIGATION SYSTEMS**	**9**
Overview of navigation systems - Communication Systems – Radio navigation – Types & Principles – Fundamentals of Inertial Sensors – INS – GNSS -- GPS – Approach and Landing Aids – ILS & MLS – Hybrid Navigation		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Explain the different of Avionics Systems and its need for civil and military aircrafts considering the reliability and safety aspects
• Describe the suitable architecture and data bus based on the requirements
• Compare the different display technologies used in cockpit
• Explain the principles of flight control systems and the importance of FMS
• Demonstrate the communication and navigation techniques used in aircrafts

Suggested Activities:

- Demo on Flight control systems
- Quizzes
- Video Lecture

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):
1. R.P.G. Collinson, “Introduction to Avionics”, Springer Publications, Third Edition, 2011.

Reference Book(s) / Web links:
1. Cary R .Spitzer, “The Avionics Handbook”, CRC Press, 2000.
2. Middleton, D.H. “Avionics Systems”, Longman Scientific and Technical, Longman Group UK Ltd., England, 1989.
3. Spitzer, C.R. “Digital Avionics Systems”, Prentice Hall, Englewood Cliffs, N.J., U.S.A., 1987.
4. Myron Kayton, Walter R. Fried “Avionics Navigation Systems” 2nd Edition, Wiley Publication, 2008.
5. Jim Curren, “Trend in Advanced Avionics”, IOWA State University, 1992.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23F13.1	3	3	3	3	3	2	-	-	-	-	-	3	3	3	3
EC23F13.2	3	2	2	2	2	2	-	-	-	-	-	3	3	3	3
EC23F13.3	3	3	3	3	1	2	-	-	-	-	-	2	3	2	2
EC23F13.4	2	3	2	3	2	1	-	-	-	-	-	2	3	2	2
EC23F13.5	3	3	2	2	2	1	-	-	-	-	-	2	3	2	2
Average	**2.8**	**2.8**	**2.4**	**2.6**	**2**	**1.6**	**-**	**-**	**-**	**-**	**-**	**2.4**	**3**	**2.4**	**2.4**

Course Code	Course Title	Category	L	T	P	C
EC23F14	POSITIONING AND NAVIGATION SYSTEMS	PE	3	0	0	3

Objectives:
• To understand the fundamentals of navigation systems.
• To gain an idea on the inertial navigation systems.
• To acquire knowledge on radio navigation.
• To understand global positioning systems
• To learn GPS Navigational Application

UNIT-I	**NAVIGATION CONCEPTS**	**9**
Fundamentals of navigation systems and Position Fixing – Categories of navigation - Geometric concepts of Navigation – The Earth in inertial space - Different Coordinate Systems – Coordinate Transformation - Euler angle formulations - Direction cosine matrices formulation - Quaternion formulation.		
UNIT-II	**INERTIAL NAVIGATION SYSTEMS**	**9**
Inertial sensors - Gyroscopes -Types - Mechanical - Electromechanical-Optical Gyro -Ring Laser gyro- Fiber optic gyro- Accelerometers – Pendulous type – Force Balance type – MEMs - Basic Principles of Inertial Navigation – Types - Platform and Strap down - Mechanization of INS system - Rate Corrections - Acceleration errors – Schuler Tuning..		
UNIT-III	**RADIO NAVIGATION & AIR TRAFFIC MANAGEMENT**	**9**
Different types of radio navigation- ADF, VOR, DME, TACAN,VORTAC - Doppler – Hyperbolic Navigations – Air Traffic Management – RADAR Surveillance - Airborne Collision Avoidance Systems		
UNIT-IV	**GLOBAL POSITIONING SYSTEM (GPS) FOR NAVIGATION**	**9**
Overview of GPS, Reference systems. Satellite orbits, Signal structure, Geometric dilution of precision (GDOP), or Position dilution of precision (PDOP), Satellite ephemeris, Satellite clock, Ionospheric group delay. Tropospheric group delay, Multipath errors and Receiver measurement errors.		
UNIT-V	**GPS NAVIGATIONAL APPLICATION**	**9**
General applications of GPS, DGPS, Marine. Air and Land Navigation, Surveying, Mapping and Geographical information systems, Military and Space.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Describe the advanced concepts of Positioning and Navigation systems and exposure on various Navigation systems
• Explain about Gyroscopes and accelerometers and Inertial Navigation systems and its types and Mechanisation
• Describe the different Radio Navigation aids and its usage for civil and military aircrafts and satellites
• Explain the Satellite Navigation – GPS and its usage in aircraft and spacecraft applications
• Analyze the hybrid navigation systems and relative navigation in a spacecraft.

Suggested Activities:

- Quizzes
- Video Lecture
- Industrial visit

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):
1. Myron Kyton, Walfred Fried, 'Avionics Navigation Systems', John Wiley & Sons, 2nd edition,1997.
2. Nagaraja, N.S. "Elements of Electronic Navigation", Tata McGraw-Hill Pub. Co., New Delhi, 2nd edition, 1975.
3. Parkinson. BW. Spilker, "Global Positioning System Theory and Applications", Progress in Astronautics, Vol. I and II, 1996.

Reference Book(s) / Web links:
1. George M Siouris, 'Aerospace Avionics System; A Modern Synthesis', Academic Press Inc., 1993.
2. Albert Helfrick, 'Practical Aircraft Electronic Systems', Prentice Hall Education, Career & Technology, 1995.
3. Albert D. Helfrick, 'Modern Aviation Electronics', Second Edition, Prentice Hall Career & Technology, 1994.
4. Paul. D. Groves. 'Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems', Artech House, 2013.
5. Maxwell Noton, "Spacecraft navigation and guidance", Springer (London, New York), 1998.
6. Hoffman. B., Wellenhof. H. Lichtenegger and J. Collins, "GPS Theory and Practice", Springer Verlang Wien New York, 1992.
7. Elliot D. Kaplan, "Understanding GPS Principles and Applications", Artech House. Inc., 1996.
8. Lieck Alfred, "GPS Satellite Surveying", John Wiley, 1990.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23F14.1	3	3	3	3	2	2	-	-	-	-	-	2	3	2	2
EC23F14.2	3	2	2	3	2	2	-	-	-	-	-	2	3	2	2
EC23F14.3	3	3	3	2	2	2	-	-	-	-	-	2	2	2	3
EC23F14.4	3	3	2	3	2	2	-	-	-	-	-	2	2	2	3
EC23F14.5	3	3	3	2	2	2	-	-	-	-	-	2	2	2	2
Average	**3**	**2.8**	**2.6**	**2.6**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**2**	**2.4**	**2**	**2.4**

Course Code	Course Title	Category	L	T	P	C
EC23F15	FUNDAMENTALS OF REMOTE SENSING	PE	3	0	0	3

Objectives:
• To familiarize about the basic principles of remote sensing and electromagnetic radiation
• To gain the knowledge about the platforms
• To expose the various types of sensors used for remote sensing
• To gain knowledge about the generation of satellite data products
• To extract useful information from satellite images

UNIT-I	REMOTE SENSING AND ELECTROMAGNETIC RADIATION	9
Definition – components of RS – History of Remote Sensing – Merits and demerits of Data Collation between conventional and remote sensing methods - Electromagnetic Spectrum – Radiation principles - Wave theory, Planck's law, Wien's Displacement Law, Stefan's Boltzmann law, Kirchoff's law – Radiation sources: active & passive – Radiation Quantities.		
UNIT-II	**PLATFORMS**	**9**
Orbit elements – Types of orbits – Motions of planets and satellites – Launch of space vehicle – Orbit perturbations and maneuvers – escape velocity - Types and characteristics of different remote sensing platforms – sun synchronous and geo synchronous satellites.		
UNIT-III	**SENSORS**	**9**
Classification of remote sensors – selection of sensor parameters - resolution concept - Spectral, Radiometric and temporal resolution – Quality of images – imaging mode – photographic camera – opto-mechanical scanners – pushbroom and whiskbroom cameras – Panchromatic, multi spectral , thermal, hyperspectral scanners and microwave sensors – geometric characteristics of scanner imagery –Operational Earth resource satellites - Landsat, SPOT, IRS, WorldView, hyperion and hysis, ERS, ENVISAT, Sentinel.		
UNIT-IV	**DATA RECEPTION AND DATA PRODUCTS**	**9**
Ground segment organization – Data product generation – sources of errors in received data – referencing scheme – data product output medium – Digital products – Super structure, Fast, GeoTIFF, Hierarchical and HDF formats – Indian and International Satellite Data Products – ordering of data.		
UNIT-V	**DATA PRODUCTS AND INTERPRETATION**	**9**
Photographic and digital products – Types, levels and open-source satellite data products – selection and procurement of data – Visual interpretation: basic elements and interpretation keys - Digital interpretation – Concepts of Image rectification, Image enhancement and Image classification.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Describe the concepts and laws related to remote sensing and the principles of electromagnetic radiation.
• Demonstrate various remote sensing platforms
• Analyze the characteristics of different types of remote sensors
• Discuss the reception, product generation, storage and ordering of satellite data
• Describe different image processing techniques and interpretation of satellite data

Suggested Activities:

- Quizzes
- Video lectures

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):

1. Lillesand T.M., and Kiefer,R.W. Remote Sensing and Image interpretation, VI edition of John Wiley & Sons-2015.
2. George Joseph and C Jeganathan, Fundamentals of Remote Sensing, Third Edition Universities Press (India) Private limited, Hyderabad, 2018.

Reference Book(s) / Web links:

1. John R. Jensen, Introductory Digital Image Processing: A Remote Sensing Perspective, 4th Edition, 2017.
2. John A.Richards, Springer – Verlag, Remate Sensing Digital Image Analysis 5th edition, 2013.
3. Paul Curran P.J. Principles of Remote Sensing, ELBS; 1985.
4. George Joseph, Fundamentals of Remote Sensing, Third Edition, Universities Press (India) Pvt Ltd, Hyderabad, 2018.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23F15.1	3	2	2	1	1	2	1	-	-	-	-	1	3	3	2
EC23F15.2	3	2	2	1	1	2	1	-	-	-	-	1	3	3	2
EC23F15.3	3	2	2	1	1	2	1	-	-	-	-	2	3	3	3
EC23F15.4	3	2	2	1	1	2	1	-	-	-	-	2	3	3	3
EC23F15.5	3	2	2	2	1	2	1	-	-	-	-	2	3	3	3
Average	**3**	**2**	**2**	**1.2**	**1**	**2**	**2**	**-**	**-**	**-**	**-**	**1.6**	**3**	**3**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23F16	SPACE MECHANICS	PE	3	0	0	3

Objectives:
• To introduce special needs for manned space missions and pre-calculation of space environment to students.
• To impart the knowledge on basis concepts of space mechanics like Newton's law of gravitation and its applications, reference co-ordinate systems and position vs time relationships of celestial bodies.
• To acquaint students on the methodologies for computation of satellite orbit perturbations
• To elucidate the concepts of space of influence and its purpose in computing interplanetary trajectories to students.
• To impart knowledge of various phases of ballistic trajectories and special features of re-entry phase to students.

UNIT-I	SPACE ENVIRONMENT	9
Peculiarities of space environment and its description– effect of space environment on materials of spacecraft structure and astronauts- manned space missions – effect on satellite life time.		
UNIT-II	**BASIC CONCEPTS AND THE GENERAL N- BODY PROBLEM**	**9**
The solar system – reference frames and coordinate systems – terminology related to the celestial sphere and its associated concepts – Kepler's laws of planetary motion and proof of the laws – Newton's universal law of gravitation - the many body problem - Lagrange-Jacobi identity – the circular restricted three body problem – libration points – the general N-body problem – two body problem – relations between position and time.		
UNIT-III	**SATELLITE INJECTION AND SATELLITE PERTURBATIONS**	**9**
General aspects of satellite injection – satellite orbit transfer – various cases – orbit deviations due to injection errors – special and general perturbations – Cowell's method and Encke's method – method of variations of orbital elements – general perturbations approach.		
UNIT-IV	**INTERPLANETARY TRAJECTORIES**	**9**
Two-dimensional interplanetary trajectories – fast interplanetary trajectories – three dimensional interplanetary trajectories – launch of interplanetary spacecraft – trajectory estimation about the target planet – concept of sphere of influence – Lambert's theorem.		
UNIT-V	**BALLISTIC MISSILE TRAJECTORIES**	**9**
Introduction to ballistic missile trajectories – boost phase – the ballistic phase – trajectory geometry– optimal flights – time of flight – re-entry phase – the position of impact point – influence coefficients.		
		Total Contact Hours: 45

Course Outcomes: On completion of the course, students will be able to
• Discuss the unique features of space environment and its effect on space craft and astronauts.
• Calculate the position of bodies in orbits in terms of their coordinates with respect to time.
• Discuss the insights on the intricate aspects of satellite injectors.
• Determine and compute interplanetary trajectories.
• Describe the important phases of missile trajectories.

Suggested Activities:

- Quizzes
- Video lectures

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):
1. Cornelisse,J.W., “Rocket Propulsion and Space Dynamics”,J.W. Freeman & Co., Ltd, London, 1982.
2. Parker, E.R., “Materials for Missiles and Spacecraft”, Mc.Graw Hill Book Co. Inc., 1982.

Reference Book(s) / Web links:
1. Sutton, G.P., “Rocket Propulsion Elements”, John Wiley & Sons; 8th Edition 2010.
2. Satellite Communications: Design Principles- M. Richharia, 2nd Edition, BS Publications, 2003
3. Digital Satellite Communications-Tri. T. Ha , 2nd Ed.,MGH,1990.
4. Fundamental of Satellite Communications- K. N Raja Rao, PHI, 2004.

PO/PSO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
EC23F16.1	3	2	2	1	1	2	1	-	-	-	-	1	3	3	2
EC23F16.2	3	2	2	1	1	2	1	-	-	-	-	1	3	3	2
EC23F16.3	3	2	2	1	1	2	1	-	-	-	-	2	3	3	3
EC23F16.4	3	2	2	1	1	2	1	-	-	-	-	2	3	3	3
EC23F16.5	3	2	2	2	1	2	1	-	-	-	-	2	3	3	3
Average	**3**	**2**	**2**	**1.2**	**1**	**2**	**1**	**-**	**-**	**-**	**-**	**1.6**	**3**	**3**	**2.6**

Course Code	Course Title	Category	L	T	P	C
EC23F17	ROCKET PROPULSION	PE	3	0	0	3

Objectives:
• To introduce the basic concepts of jet propulsion.
• To make students learn the operating and performance characteristics of ramjet engines.
• To impart knowledge on the needs, various challenges in scramjet combustion and the applications of scramjet to hypersonic vehicle operations.
• To give exposure to the students on the various kinds of propellants and internal ballistics of solid rocket motor.
• To make the students familiarize with the various subsystems of liquid, hybrid rockets and importance aspects of advanced propulsion systems.

UNIT-I	RAMJET PROPULSION	9
Operating principle of ramjet engine – various components of ramjet engines and their efficiencies – modes of inlet operation - Combustion in ramjet engine –- performance characteristics – sample ramjet design calculations – flame stability problems in ramjet combustors –integral ram rockets.		
UNIT-II	**SCRAMJET PROPULSION**	**9**
Introduction to hypersonic air breathing propulsion, hypersonic vehicles and supersonic combustion- need for supersonic combustion for hypersonic propulsion – salient features of scramjet engine and its applications for hypersonic vehicles – problems associated with supersonic combustion – engine/airframe integration aspects of hypersonic vehicles – various types scramjet combustors – fuel injection schemes in scramjet combustors – one dimensional models for supersonic combustion using method of influence coefficients.		
UNIT-III	**SOLID ROCKET MOTOR**	**9**
Type of rockets – specific impulse of a rocket– rocket performance – Real and ideal nozzle - solid propellants– selection criteria of solid propellants – internal ballistics – burning rate - propellant grain design considerations – erosive burning in solid rockets – Igniters – types of igniters.		
UNIT-IV	**LIQUID AND HYBRID ROCKET ENGINES**	**9**
Liquid propellant rockets – selection of liquid propellants – various feed systems for liquid rockets -thrust control in liquid rockets – cooling in liquid rockets and the associated heat transfer problems – advantages of liquid rockets over solid rockets - introduction to hybrid propulsion – advantages and limitations of hybrid propulsion - static testing of rockets and safety considerations.		
UNIT-V	**ADVANCED PROPULSION TECHNIQUES**	**9**
Introduction to nozzleless propulsion and basic concepts - Electric rocket propulsion – Ion propulsion – Nuclear rocket – comparison of performance of these propulsion systems with chemical rocket propulsion systems - Solar sail.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Design model ramjet engines.
• Discuss the supersonic combustion process and their difficulties.
• Describe the internal ballistic properties based on mission requirements.
• Determine operational and performance characteristics of liquid and hybrid rockets.
• Discuss the propulsive systems and their futuristic applications.

Suggested Activities:

- Quizzes
- Video lectures

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):

1. David H. Heiser and David T. Pratt., "Hypersonic Air breathing Propulsion", AIAA Education Series, 1999.
2. Mathur, M.L. and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers & Distributors, Delhi, 2nd edition 2014.

Reference Book(s) / Web links:

1. Martin J. Chiaverini and Kenneth K. Kuo, "Fundamentals of Hybrid Rocket Combustion and Propulsion", Progress in Astronautics and Aeronautics, 2007.
2. Ramamurthi K, "Rocket Propulsion", Macmillian publishers India Ltd, 1st edition, 2010.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23F17.1	3	2	2	1	-	1	-	-	-	-	-	1	3	2	2
EC23F17.2	3	2	2	1	-	1	-	-	-	-	-	1	3	2	2
EC23F17.3	3	2	2	1	-	1	-	-	-	-	-	2	3	2	2
EC23F17.4	3	2	2	2	-	2	-	-	-	-	-	2	3	2	2
EC23F17.5	3	2	2	2	-	2	-	-	-	-	-	2	3	2	2
Average	**3**	**2**	**2**	**1.4**	**-**	**1.4**	**-**	**-**		**-**	**-**	**1.6**	**3**	**2**	**2**

Course Code	Course Title	Category	L	T	P	C
EC23F18	DRONE TECHNOLOGY IN ENGINEERING	PE	3	0	0	3

Objectives:
• To understand the basics of drone concepts
• To learn and understand the fundaments of design, fabrication and programming of drone
• To impart the knowledge of an flying and operation of drone.
• To know about the various applications of drone
• To understand the safety risks and guidelines of fly safely

UNIT-I	INTRODUCTION TO DRONE TECHNOLOGY	9
Drone Concept - Vocabulary Terminology- History of drone - Types of current generation of drones based on their method of propulsion- Drone technology impact on the businesses- Drone business through entrepreneurship- Opportunities/applications for entrepreneurship and employability.		
UNIT-II	**DRONE DESIGN, FABRICATION AND PROGRAMMING**	**9**
Classifications of the UAV -Overview of the main drone parts- Technical characteristics of the parts -Function of the component parts -Assembling a drone- The energy sources- Level of autonomy- Drones configurations -The methods of programming drone- Download program - Install program on computer- Running Programs- Multi rotor stabilization- Flight modes -Wi-Fi connection.		
UNIT-III	**DRONE FLYING AND OPERATION**	**9**
Concept of operation for drone -Flight modes- Operate a small drone in a controlled environment- Drone controls Flight operations –management tool –Sensors-On board storage capacity -Removable storage devices- Linked mobile devices and applications.		
UNIT-IV	**DRONE COMMERCIAL APPLICATIONS**	**9**
Choosing a drone based on the application -Drones in the insurance sector- Drones in delivering mail, parcels and other cargo- Drones in agriculture- Drones in inspection of transmission lines and power distribution -Drones in filming and panoramic picturing.		
UNIT-V	**FUTURE DRONES AND SAFETY**	**9**
The safety risks-Guidelines to fly safely-Specific aviation regulation and standardization- Drone license- Miniaturization of drones- Increasing autonomy of drones -The use of drones in swarms.		
Total Contact Hours: 45		

Course Outcomes: On completion of the course, students will be able to
• Discuss about a various type of drone technology, drone fabrication and programming
• Describe the suitable operating procedures for functioning a drone
• Analyze appropriate sensors and actuators for Drones
• Develop a drone mechanism for specific applications
• Create the programs for various drones

Suggested Activities:

- Quizzes
- Video lectures

Suggested Evaluation Methods:

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):

1. Daniel Tal and John Altschuld, "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation", 2021 John Wiley & Sons, Inc.
2. Terry Kilby and Belinda Kilby, "Make: Getting Started with Drones ", Maker Media, Inc, 2016.

Reference Book(s) / Web links:

1. John Baichtal, "Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs", Que Publishing, 2016.
2. Zavrsnik, "Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance", Springer, 2018.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC23F18.1	3	2	2	1	-	1	-	-	-	-	-	1	3	2	2
EC23F18.2	3	2	2	1	-	1	-	-	-	-	-	1	3	2	2
EC23F18.3	3	2	2	1	-	1	-	-	-	-	-	2	3	2	2
EC23F18.4	3	2	2	2	-	2	-	-	-	-	-	2	3	2	2
EC23F18.5	3	2	2	2	-	2	-	-	-	-	-	2	3	2	2
Average	**3**	**2**	**2**	**1.4**	**-**	**1.4**	**-**	**-**		**-**	**-**	**1.6**	**3**	**2**	**2**