



SRI KRISHNA COLLEGE OF ENGINEERING AND TECHNOLOGY

An Autonomous Institution | Approved by AICTE | Affiliated to Anna University | Accredited by NAAC with A++ Grade
Kuniamuthur, Coimbatore – 641008

Phone : (0422)-2678001 (7 Lines) | Email : info@skcet.ac.in | Website : www.skcet.ac.in

Curriculum & Syllabi

Regulation 2022

2024-2028 Batch

**DEPARTMENT OF ELECTRONICS AND
COMMUNICATION ENGINEERING**

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

(Batch 2024-2028)



VISION OF THE INSTITUTION

- To Produce Globally Competitive Engineers with High Ethical Values and Social Responsibilities.



MISSION OF THE INSTITUTION

- To impart the highest quality state-of-the-art technical education by providing impetus to innovation, research, and development and empowering students with entrepreneurship skills.
- To instill ethical values, imbibe a sense of social responsibility, and strive for societal well-being.
- To identify the needs of society and offer sustainable solutions through outreach programs.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING



VISION OF THE DEPARTMENT

- To equip future engineers with high academic knowledge, ethical values, leadership skills and a passion to contribute to the society.



MISSION OF THE DEPARTMENT

- To provide quality and contemporary education in Electronics and Communication Engineering through continuous upgradation of Curriculum and laboratory facilities, industrial collaboration and effective teaching learning process.
- To facilitate research activities and entrepreneurship skills to cope up with the changes in industrial demand and meet the global and societal needs.
- To inculcate professional attitude and ethical values.

I. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)	
PEO 1	Exhibit technical competence in Electronics and Communication Engineering by providing innovative engineering solutions and excel in professional career.
PEO 2	Indulge in problem identification, analysis and formulation to provide technically superior, economically feasible, environmentally compatible and socially acceptable design solutions.
PEO 3	Contribute towards entrepreneurship and research, and exercise leadership through effective communication, teamwork and knowledge upgradation through lifelong learning.

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

	as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

III. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The Graduates of **B.E – ELECTRONICS AND COMMUNICATION ENGINEERING** programme will be able to:

PSO 1	Potential to analyse, design, synthesize and provide technical solutions in the field of VLSI, Embedded Systems and Communication Networks.
PSO 2	Emerge as ethical leaders, excel in research, engage in lifelong learning, pursue entrepreneurship and contribute towards the field of Electronics and Communication Engineering.

IV. MAPPING OF PEOs WITH POs

PEO	POs											
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
1	3	3	3	3	2	2	1	1	1	1	2	2
2	3	3	3	3	3	3	1	1	1	1	2	2
3	1	1	1	1	1	2	3	3	3	3	1	1
	1- low, 2 - medium, 3 - high, '-' - no correlation											

V. MAPPING OF PEOs WITH PSOs

	PSO 1	PSO 2
PEO 1	3	2
PEO 2	2	2
PEO 3	2	3

AUTONOMOUS CURRICULUM AND SYLLABI

Regulations 2022 (Batch 2024-2028)

SEMESTER I								
S.No	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Ext/Int	Cat.	
Theory (Internal 40 Marks & External 60 Marks)								
1	23MA101	Mathematics I	3/1/0	4	4	60/40	BSC	
2	23EC101	Circuit Theory and Electron Devices	3/0/0	3	3	60/40	ESC	
3	23EC202	Digital System Design	3/0/0	3	3	60/40	PCC	
4	23SB101	Engineering Biology	3/0/0	3	3	60/40	BSC	
Theory with Practical (Internal 50 Marks & External 50 Marks)								
5	23CS101	Problem Solving using C++	1/0/4	5	3	50/50	ESC	
6	23IT101	Application Development Practices	1/0/4	5	3	50/50	ESC	
7	23EN101	Oral and Written Communication Skills	2/0/2	4	3	50/50	HSMC	
Practical (Internal 60 Marks & External 40 Marks)								
8	23EC204	Digital System Design Laboratory	0/0/2	2	1	40/60	PCC	
Indian Knowledge System - Blended Learning (Internal 100 Marks)								
9	23TA101	Heritage of Tamils	1/0/0	1	1	60/40	HSMC	
Mandatory Course (Internal 100 Marks)								
10	23MC101	Mandatory Course I: Induction Programme	3 Weeks					MC
TOTAL				30	24			

SEMESTER II							
S.No	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Ext/Int	Cat.
Theory (Internal 40 Marks & External 60 Marks)							
1	23MA205	Differential Equations and Transform Techniques	3/1/0	4	4	60/40	BSC
2	23AS101	Applied Science	4/0/0	4	4	60/40	BSC
3	23EC201	Electronic Circuits	3/0/0	3	3	60/40	PCC
Theory with Practical (Internal 50 Marks & External 50 Marks)							
4	23CD201	Database Management Systems	1/0/4	5	3	50/50	ESC
5	23CY203	Programming in Java	1/0/4	5	3	50/50	ESC
Practical (Internal 60 Marks & External 40 Marks)							
6	23AS102	Applied Science Laboratory	0/0/4	4	2	40/60	BSC
7	23EC203	Circuits Laboratory	0/0/3	3	1.5	40/60	PCC
Indian Knowledge System - Blended Learning							
8	23TA201	Tamils and Technology	1/0/0	1	1	60/40	HSMC

Mandatory Course							
9	23MC102	Mandatory Course II: Environmental Sciences	1/0/0	1	0	0/100	MC
TOTAL				29	21.5		

SEMESTER III							
<u>S.No</u>	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Ext/Int	Cat.
Theory - Blended Learning (Internal 100 Marks)							
1	23GE301	Universal Human Values	3/0/0	3	3	0/100	HSMC
Theory (Internal 40 Marks & External 60 Marks)							
2	23EC301	Signals and Systems	3/1/0	4	4	60/40	PCC
3	23EC304	Analog Communication	3/0/0	3	3	60/40	PCC
4	23EC401	Analog Integrated Circuits	3/0/0	3	3	60/40	PCC
Theory with Practical (Internal 50 Marks & External 50 Marks)							
5	23CSC01	Data Structures	3/0/2	5	4	50/50	PCC
6	23CS302	Python Programming	1/0/4	5	3	50/50	PCC
Practical (Internal 60 Marks & External 40 Marks)							
7	23EC405	Analog Integrated Circuits Laboratory	0/0/3	3	1.5	40/60	PCC
8	23MEC03	Design Thinking and Idea Lab	0/0/2	2	1	40/60	ESC
Spoken Language (Internal 100 marks)							
9	23SLC01	Multilingual Practices	0/0/2	2	1	0/100	SLC
TOTAL				28	23.5		

SEMESTER IV							
<u>S.No</u>	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Ext/Int	Cat.
Theory (Internal 40 Marks & External 60 Marks)							
1	23EC402	Electromagnetic Fields	3/1/0	4	4	60/40	PCC
2	23EC501	Control Engineering	3/1/0	4	4	60/40	PCC
Theory with Practical (Internal 50 Marks & External 50 Marks)							
3	23EC508	Microcontroller and Interfacing	3/0/2	5	4	50/50	PCC
4	23EC505	Digital Signal Processing	3/0/2	5	4	50/50	PCC
5	23EC9XX	Professional Elective-I	3/0/0	3	3	60/40	PEC
6	23EC0XX	Open / Emerging/ Industrial Elective- I	2/0/2	4	3	60/40	OEC
Mandatory Course							
7	23MCXX	Mandatory Course IV	1/0/0	3 Weeks	0	0/100	MC
TOTAL				25	22		

SEMESTER V							
S.No	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Ext/Int	Cat.
Theory (Internal 40 Marks & External 60 Marks)							
1	23EC502	Antenna and Wave Propagation	3/0/0	3	3	60/40	PCC
2	23EC503	Wireless Communication	3/0/0	3	3	60/40	PCC
Theory with Practical (Internal 50 Marks & External 50 Marks)							
3	23EC504	VLSI Design	3/0/2	5	4	50/50	PCC
4	23EC407	Digital Communication	3/0/2	5	4	50/50	PCC
5	23EC506	Computer Networks	2/0/2	4	3	50/50	PCC
6	23CSC02	Machine Learning Techniques	2/0/2	4	3	50/50	PCC
Mini Project (Internal 100 Marks)							
7	23EC406	Capstone Project I (MERN Stack)	0/0/4	4	2	40/60	PROJ
TOTAL				28	22		

SEMESTER VI							
S.No	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Ext/Int	Cat.
Theory - Blended Learning (Internal 100 Marks)							
1	23GEC01	Entrepreneurship and Startups	3/0/0	3	3	0/100	HSMC
Theory (Internal 40 Marks & External 60 Marks)							
2	23EC601	Green communication and Networks	3/0/0	3	3	60/40	PCC
3	23EC9XX	Professional Elective - II	3/0/0	3	3	60/40	PEC
4	23EC0XX	Open / Emerging/ Industrial Elective- II	3/0/0	3	3	60/40	OEC
Theory with Practical (Internal 50 Marks & External 50 Marks)							
5	23EC602	Microwave and Optical Communication	3/0/2	5	4	50/50	PCC
6	23EC604	Embedded systems and connected devices	3/0/2	5	4	50/50	PCC
Mini Project							
7	23EC507	Capstone Project II	0/0/4	4	2	0/100	PROJ
Practical (Internal 60 Marks & External 40 Marks)							
8	23EC603	Prototype Lab	0/0/2	2	1	40/60	PROJ
TOTAL				28	23		

SEMESTER VII							
<u>S.No</u>	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Ext/Int	Cat.
Theory (Internal 40 Marks & External 60 Marks)							
1	23EC0XX	Open / Emerging/ Industrial Elective- III	3/0/0	3	3	60/40	OEC
2	23EC9XX	Professional Elective - III	3/0/0	3	3	60/40	PEC
3	23EC9XX	Professional Elective - IV	3/0/0	3	3	60/40	PEC
4	23EC9XX	Professional Elective - V	3/0/0	3	3	60/40	PEC
5	23EC9XX	Professional Elective - VI	3/0/0	3	3	60/40	PEC
Internship (Internal 100 Marks)							
6	23EC701	Project - I	0/0/6	6	3	0/100	PROJ
7	23EES01	Employability Enhancement Skills (Internship)	28 days		2	0/100	EES
TOTAL				21	20		

SEMESTER VIII							
<u>S.No</u>	Course Code	Course Title	L/T/P	Contact Hrs/Wk	Credits	Ext/Int	Cat.
Project Work							
1	23EC801	Project - II	0/0/24	24	12	40/60	PROJ
TOTAL				24	12		
Total Credits					168		

SCHEME OF CREDIT DISTRIBUTION – SUMMARY											
Sl. No.	Stream	Credits/Semester								C	%
		I	II	III	IV	V	VI	VII	VIII		
1	Humanities & Social Sciences Including Management (HSMC)	4	1	3			3			11	6.55
2	Basic Sciences (BSC)	7	10							17	10.12
3	Engineering Sciences (ESC)	9	6	1						16	9.52
4	Professional Core (PCC)	4	4.5	18.5	16	20	11			74	44.05
5	Professional Electives (PEC)				3		3	12		18	10.71
6	Open/Emerging/ Industry (OEC)				3		3	3		9	5.36
7	Project Work (PROJ)					2	3	3	12	20	11.9
8	Employability Enhancement Skills (EES)							2		2	1.19
9	Mandatory Course (MC) / Spoken Language (SLC)	-	-	1	-	-	-	-	-	1	0.6
Total		24	21.5	23.5	22	22	23	20	12	168	100

STRUCTURE FOR UNDERGRADUATE ENGINEERING PROGRAM			
S. No.	Course Work - Subject Area	AICTE Suggested Credits	SKCET Credits (168)
1.	Humanities and Social Sciences (HS), including Management;	15*	11
2.	Basic Sciences (BS) including Mathematics, Physics, Chemistry, Biology;	23*	17
3.	Engineering Sciences (ES), including Materials, Workshop, Drawing, Basics of Electrical/Electronics/Mechanical/Computer Engineering, Instrumentation;	17*	16
4.	Professional Subjects-Core (PC), relevant to the chosen specialization/branch; (May be split into Hard (no choice) and Soft (with choice), if required	61*	74
5.	Professional Subjects – Electives (PE), relevant to the chosen specialization/ branch;	12*	18
6.	Open Subjects- Electives (OE), from other technical and/or emerging subject areas;	12*	9
7.	Project Work, Seminar and/or Internship in Industry or elsewhere.	20*	22
8.	Mandatory Courses (MC)/ Spoken Language Courses (SLC)	Non-credit	1
Total		160	168
<i>*Minor Variations is allowed as per need of the respective disciplines</i>			

HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT (11 Credits)							
S.No	Course Code	Course Title	L/T/P	Contact Hrs/Wk	C	Ext/Int	Cat.
1.	23TA101	Heritage of Tamils	1/0/0	1	1	60/40	HSMC
2.	23GE301	Universal Human Values	3/0/0	3	3	0/100	HSMC
3.	23EN101	Oral and Written Communication Skills	2/0/2	4	3	50/50	HSMC
4.	23TA201	Tamils and Technology	1/0/0	1	1	60/40	HSMC
5	23GEC01	Entrepreneurship and Startups	3/0/0	3	3	0/100	HSMC

BASIC SCIENCE COURSES (17 Credits)							
S.No	Course Code	Course Title	L/T/P	Contact Hrs/Wk	C	Ext/Int	Cat.
1.	23AS101	Applied Sciences	4/0/0	4	4	60/40	BSC
2.	23MA101	Mathematics I	3/1/0	4	4	60/40	BSC
3.	23SB101	Engineering Biology	3/0/0	3	3	60/40	BSC
4.	23AS102	Applied Sciences Laboratory	0/0/4	4	2	40/60	BSC
5.	23MA205	Differential Equations and Transform Techniques	3/1/0	4	4	60/40	BSC

ENGINEERING SCIENCE COURSES (16 Credits)							
S.No	Course Code	Course Title	L/T/P	Contact Hrs/Wk	C	Ext/Int	Cat.
1.	23EC101	Circuit Theory and Electron Devices	3/0/0	3	3	60/40	ESC
2.	23IT101	Application Development Practices	1/0/4	5	3	50/50	ESC
3.	23CS101	Problem Solving using C++	1/0/4	5	3	50/50	ESC
4.	23CD201	Database Management Systems	1/0/4	5	3	50/50	ESC
5.	23CY203	Programming in Java	1/0/4	5	3	50/50	ESC
6	23MEC03	Design Thinking and Idea Lab	0/0/2	2	1	40/60	ESC

PROFESSIONAL CORE COURSES (73 Credits)							
S. No	Course Code	Course Title	L/T/P	Contact Hrs/Wk	C	Ext/Int	Cat.
1.	23EC201	Electronic Circuits	3/0/0	3	3	60/40	PCC
2.	23EC202	Digital System Design	3/0/0	3	3	60/40	PCC
3.	23EC203	Circuits Laboratory	0/0/3	3	1.5	40/60	PCC
4.	23EC204	Digital System Design Laboratory	0/0/2	2	1	40/60	PCC
5.	23EC301	Signals and Systems	3/1/0	4	4	60/40	PCC

6.	23EC304	Analog Communication	3/0/0	3	3	60/40	PCC
7.	23EC401	Analog Integrated Circuits	3/0/0	3	3	60/40	PCC
8.	23CSC01	Data Structures	3/0/2	5	4	50/50	PCC
9.	23CS302	Python Programming	1/0/4	5	3	50/50	PCC
10.	23EC405	Analog Integrated Circuits Laboratory	0/0/3	3	1.5	40/60	PCC
11.	23EC402	Electromagnetic Fields	3/1/0	4	4	60/40	PCC
12.	23EC501	Control Engineering	3/1/0	4	4	60/40	PCC
13.	23EC407	Digital Communication	3/0/2	5	4	50/50	PCC
14.	23EC505	Digital Signal Processing	3/0/2	5	4	50/50	PCC
15.	23EC502	Antennas and wave propagation	3/0/0	3	3	60/40	PCC
16.	23CSC02	Machine Learning Techniques	2/0/2	4	3	50/50	PCC
17.	23EC503	Wireless Communication	3/0/0	3	3	60/40	PCC
18.	23EC504	VLSI Design	3/0/2	5	4	50/50	PCC
19.	23EC508	Microcontroller and Interfacing	3/0/2	5	4	50/50	PCC
20.	23EC506	Computer Networks	2/0/2	4	3	50/50	PCC
21.	23EC601	Green Communication and Networks	3/0/0	3	3	0/100	PCC
22.	23EC602	Microwave and Optical Communication	3/0/2	5	4	50/50	PCC
23.	23EC604	Embedded Systems and Connected Devices	3/0/2	5	4	50/50	PCC

PROFESSIONAL ELECTIVE COURSES (18 Credits)						
S.No	Course Code	Course Title	L/T/P	Contact hrs./Wk.	C	Ext/Int
ELECTIVE STREAM I – EMBEDDED SYSTEMS						
1.	23EC901	Real-Time Operating Systems and Applications	3/0/0	3	3	60/40
2.	23EC902	Automotive Embedded System	3/0/0	3	3	60/40
3.	23EC903	Hardware-Software Co-Design	3/0/0	3	3	60/40
4.	23EC904	Computational Intelligence	3/0/0	3	3	60/40
5.	23EC905	Embedded System Design using IoT	3/0/0	3	3	60/40
6.	23EC906	Embedded Processors and Architecture	3/0/0	3	3	60/40
7.	23EC907	Embedded Programming	3/0/0	3	3	60/40
8.	23EC908	Industrial IoT	3/0/0	3	3	60/40
9.	23EC909	Embedded Robotics	3/0/0	3	3	60/40
ELECTIVE STREAM II – VLSI						
1.	23EC910	Reconfigurable Architecture	3/0/0	3	3	60/40
2.	23EC911	VLSI Architectures for AI Algorithms	3/0/0	3	3	60/40
3.	23EC912	Low Power VLSI Design	3/0/0	3	3	60/40
4.	23EC913	Testing of VLSI Circuits	3/0/0	3	3	60/40
5.	23EC914	Digital CMOS VLSI Design	3/0/0	3	3	60/40
6.	23EC915	Analog VLSI Design	3/0/0	3	3	60/40
7.	23EC916	System on Chip Design	3/0/0	3	3	60/40
8.	23EC917	ASIC Design	3/0/0	3	3	60/40
9.	23EC918	Design of Semiconductor Memories	3/0/0	3	3	60/40
ELECTIVE STREAM III - NETWORKS, IMAGE AND VIDEO PROCESSING						
1.	23EC919	Network Engineering for IoT and Constrained Devices	3/0/0	3	3	60/40
2.	23EC920	Advanced Computer Network Architectures	3/0/0	3	3	60/40
3.	23EC921	Python Programming for Image and Video Processing	3/0/0	3	3	60/40
4.	23EC922	R Programming for Image and Video Data Analysis	3/0/0	3	3	60/40
5.	23EC923	Digital Image Processing	3/0/0	3	3	60/40
6.	23EC924	Computer Vision Techniques	3/0/0	3	3	60/40
7.	23EC925	Deep Learning for Image and Video Analysis	3/0/0	3	3	60/40
8.	23EC926	Video Analytics and Surveillance Systems	3/0/0	3	3	60/40
9.	23EC927	Network Integration for IoT and Multimedia Applications	3/0/0	3	3	60/40
ELECTIVE STREAM IV – NEXT GENERATION COMMUNICATION SYSTEMS						
1.	23EC928	RF System Design	3/0/0	3	3	60/40
2.	23EC929	Microwave integrated circuits	3/0/0	3	3	60/40
3.	23EC930	CAN and CAN Open Protocols	3/0/0	3	3	60/40
4.	23EC931	Software Defined Networking	3/0/0	3	3	60/40
5.	23EC932	Satellite Communication and GPS	3/0/0	3	3	60/40
6.	23EC933	High Frequency Communication Systems	3/0/0	3	3	60/40
7.	23EC934	Smart Antennas	3/0/0	3	3	60/40

8.	23EC935	Radar Systems	3/0/0	3	3	60/40
9.	23EC936	Wireless Broadband Networks	3/0/0	3	3	60/40
ELECTIVE STREAM V – MICROELECTRONICS, IC DESIGN AND PHOTONICS						
1.	23EC937	Electromagnetic Interference and Compatibility	3/0/0	3	3	60/40
2.	23EC938	Nanophotonics	3/0/0	3	3	60/40
3.	23EC939	SOI Devices Modeling and Simulation	3/0/0	3	3	60/40
4.	23EC940	Modeling of Microelectronic Devices	3/0/0	3	3	60/40
5.	23EC941	IC Design and Technology	3/0/0	3	3	60/40
6.	23EC942	RF Microelectronics	3/0/0	3	3	60/40
7.	23EC943	Photonic Integrated Circuits	3/0/0	3	3	60/40
8.	23EC944	RF and MEMS	3/0/0	3	3	60/40
9.	23EC945	E-Waste Management and Recycling	3/0/0	3	3	60/40
ELECTIVE STREAM VI – SMART SENSOR TECHNOLOGIES AND BIOMEDICAL ENGINEERING						
1.	23EC946	Artificial Intelligence in Healthcare	3/0/0	3	3	60/40
2.	23EC947	Automotive Sensors	3/0/0	3	3	60/40
3.	23EC948	Data Acquisition and Hardware Interfaces	3/0/0	3	3	60/40
4.	23EC949	Flexible and Wearable Sensors	3/0/0	3	3	60/40
5.	23EC950	Medical Sensors and MEMS Technology	3/0/0	3	3	60/40
6.	23EC951	Bio Signal Processing	3/0/0	3	3	60/40
7.	23EC952	Emerging Applications of Biosensors	3/0/0	3	3	60/40
8.	23EC953	Micro Systems & Hybrid Technology	3/0/0	3	3	60/40
9.	23EC954	Medical Robotics	3/0/0	3	3	60/40

OPEN/EMERGING ELECTIVE COURSES (9 Credits)

SL. No.	Course Code	Course Title	L/T/P	Contact hrs./Wk.	C	Ext/Int
1.	23EC001	Principles of Cyber Physical Systems	3/0/0	3	3	60/40
2.	23EC002	Introduction to Raspberry Pi and Arduino	3/0/0	3	3	60/40
3.	23EC003	IT Workshop SCILAB/MATLAB	3/0/0	3	3	60/40
4.	23EC004	Brain Computer Interface and its Applications	3/0/0	3	3	60/40
5.	23EC005	Wireless wearable Sensors	3/0/0	3	3	60/40
6.	23EC006	Organizational Behavior	3/0/0	3	3	60/40
7.	23EC007	Fundamentals of Digital Signal Processing	3/0/0	3	3	60/40
8.	23EC008	Principles of Embedded Systems	3/0/0	3	3	60/40
9.	23EC009	Edge AI and TinyML	3/0/0	3	3	60/40
10.	23EC010	6G and Future Wireless Networks	3/0/0	3	3	60/40
11.	23EC011	Neuromorphic Computing and Design	3/0/0	3	3	60/40

12.	23EC012	Quantum Electronics	3/0/0	3	3	60/40
13	23EC013	Cyber-Physical Systems and Security	3/0/0	3	3	60/40
14	23EC014	Quantum Computing and Information	3/0/0	3	3	60/40

PROJECT WORK (20 Credits)							
SL. No.	Course Code	Course Title	L/T/P	Contact hrs./Wk.	C	Ext/Int	Cat.
1.	25EC506	Capstone Project I - MERN Stack	0 / 0 / 6	6	3	0/100	PROJ
2.	25EC604	Capstone Project II	0 / 0 / 4	4	2	0/100	PROJ
3.	25EC605	Prototype Lab	0 / 0 / 2	2	1	40/60	PROJ
4.	25EC701	Project - I	0 / 0 / 6	6	3	0/100	PROJ
5.	25EC801	Project - II	0 / 0 / 24	24	12	40/60	PROJ

INTERN (2 Credits)							
S.No	Course Code	Course Title	L/T/P	Contact Hrs/Wk	C	Ext/Int	Cat.
1.	23EES01	Employability Enhancement Skills (Internship)		6 weeks	2	0/100	EES

PROFESSIONAL ELECTIVE COURSES: VERTICALS

Vertical I Embedded Systems	Vertical II VLSI	Vertical III Networks, Image And Video Processing	Vertical IV Next Generation Communication Systems	Vertical V Microelectronics, IC Design And Photonics	Vertical VI Smart Sensor Technologies And Biomedical Engineering
Real-Time Operating Systems and Applications	Reconfigurable Architecture	Network Engineering for IoT and Constrained Devices	RF System Design	Electromagnetic Interference and Compatibility	Artificial Intelligence in Healthcare
Automotive Embedded System	VLSI Architectures for AI Algorithms	Advanced Computer Network Architectures	Microwave integrated circuits	Nanophotonics	Automotive Sensors
Hardware-Software Co-Design	Low Power VLSI Design	Python Programming for Image and Video Processing	CAN and CAN Open Protocols	SOI Devices Modeling and Simulation	Data Acquisition and Hardware Interfaces
Computational Intelligence	Testing of VLSI Circuits	R Programming for Image and Video Data Analysis	Software Defined Networking	Modeling of Microelectronic Devices	Flexible and Wearable Sensors
Embedded System Design using IoT	Digital CMOS VLSI Design	Digital Image Processing	Satellite Communication and GPS	IC Design and Technology	Medical Sensors and MEMS Technology
Embedded Processors and Architecture	Analog VLSI Design	Computer Vision Techniques	High Frequency Communication Systems	RF Microelectronics	Bio Signal Processing
Embedded Programming	System on Chip Design	Deep Learning for Image and Video Analysis	Smart Antennas	Photonic Integrated Circuits	Emerging Applications of Biosensors
Industrial IoT	ASIC Design	Video Analytics and Surveillance Systems	Radar Systems	RF and MEMS	Micro Systems & Hybrid Technology
Embedded Robotics	Design of Semiconductor Memories	Network Integration for IoT and Multimedia Applications	Wireless Broadband Networks	E-Waste Management and Recycling	Medical Robotics

MANDATORY COURSES (Non-Credits)/SPOKEN LANGUAGE COURSE							
(Courses conducted either by internal faculty or through MOOCs)							
S.No	Course Code	Course Title	L/T/P	Contact Hrs/Wk	C	Ext/Int	Cat.
1.	23MC101	Induction Programme	3 weeks		0	60/40	OEC
2.	23MC102	Environmental Sciences	1/0/0	1	0	0/100	MC
3.	23MC103	Soft Skills	1/0/0	1	0	0/100	MC
4.	23MC104	Management Organizational Behaviour	1/0/0	1	0	0/100	MC
5.	23MC105	General Aptitude	1/0/0	1	0	0/100	MC
6.	23MC106	Life Skills and Ethics	1/0/0	1	0	0/100	MC
7.	23MC107	Stress Management	1/0/0	1	0	0/100	MC
8.	23MCC03	Indian Constitution	1/0/0	1	0	0/100	MC
9.	23MC109	Essence of Indian Traditional Knowledge	1/0/0	1	0	0/100	MC
10.	23SLC01	Multilingual Practices	0/0/2	2	1	0/100	SLC

VALUE ADDED COURSES (Offered by ECE)			
(Based on student's interest)			
S.No	Course Code	Course Title	C
1.	23VA401	Antenna Design using Ansys HFSS Tool Flow	1
2.	23VA402	Mastering in MATLAB-Math and Optimization	1
3.	23VA403	The Agriculture in Industry 4.0	1
4.	23VA404	Connecting Technologies with Real World	1
5.	23VA405	Arduino Programming model	1
6.	23VA406	PCB Design for Electronic Circuits	1
7.	23VA407	Energy Harvesting and Security Issues in Cognitive Networks	1
8.	23VA408	System Design using IoT	1
9.	23VA409	UAV and UGV Technologies	1
10.	23VA410	Mobile Application Development	1
11.	23VA411	Embedded Software Engineering	1

L: Lecture **T:** Tutorial **P:** Practical **C:** Credit **O:** Outside Class hours **Cat.:** Category

HSMC : Humanities and Social
Sciences including Management

BSC : Basic Science Courses

ESC : Engineering Science Courses

PCC : Professional Core Courses

PEC : Professional Elective Courses

OEC : Open and Emerging Elective Courses

PROJ : Project Work

EES : Employability Enhancement Skills

MC : Mandatory Course

SLC : Spoken Language Course

Definition of Credit:

L – Lecture	1 Hr. Lecture (L) per week	1 credit
T – Tutorial	1 Hr. Tutorial (T) per week	1 credit
P - Practical/Practice (Project and Industry based Courses)	1 Hr. Practical (P) per week	0.5 credit

SEMESTER – III

23GE301	UNIVERSAL HUMAN VALUES (Common to all branches)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence.
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.
5. Helping the students to appreciate the essential complementarities between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity, which are the core aspirations of all human beings.
6. Highlighting plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behaviour and mutually enriching interaction with Nature.

COURSE INTRODUCTION - NEED, BASIC GUIDELINES, CONTENT AND PROCESS FOR VALUE EDUCATION, UNDERSTANDING HARMONY IN THE HUMAN BEING-HARMONY IN MYSELF!

15

Self-evaluation of the students -Pre-test of UHV- Purpose and motivation for the course. Self-exploration –Its content and process- A look at basic Human Aspirations. Understanding Happiness and Prosperity correctly-Understanding the needs of Self ('I') and 'Body'-Understanding the Body as an instrument of 'I'(being the doer, seer and enjoyer)-Understanding the characteristics and activities of 'I' and harmony in 'I' - Understanding the harmony of 'I' with the Body- Social activities – Waste Management - Water Conservation-Soil Pollution - Physical Health and related activities - Lectures by eminent persons- Literary activities.

UNDERSTANDING HARMONY IN THE FAMILY AND SOCIETY- HARMONY IN HUMAN-HUMAN RELATIONSHIP, UNDERSTANDING HARMONY IN THE NATURE AND EXISTENCE- WHOLE EXISTENCE AS COEXISTENCE

15

Understanding values in human relationship - Understanding the harmony in the society (society being an extension of family): - Visualizing a universal harmonious order in society - Understanding the harmony in Nature.-Understanding Existence as Coexistence of mutually Interacting units in all - pervasive space. Holistic perception of harmony at all levels of existence-Buddy program - Relationships – Homesickness - Managing peer pressure - Projects - Socially responsible engineers - Visit to local areas (orphanages, special children) - Physical Activities (games).

IMPLICATIONS OF THE ABOVE HOLISTIC UNDERSTANDING OF HARMONY ON PROFESSIONAL ETHICS

15

Natural acceptance of human values- Definitiveness of Ethical Human Conduct- Basis for Humanistic Education-Humanistic Constitution and Humanistic Universal Order-Competence in professional ethics-Case studies of typical holistic technologies, management models and eco-friendly production systems - Strategy for transition from the present state to Universal Human Order-Sum up: Self-evaluation of the students-Post test of UHV.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to,

- | | | |
|-----|--|------|
| CO1 | Understand and take responsibilities in life and handle problems to attain sustainable solutions while keeping human relationships and human nature in mind. | [U] |
| CO2 | Apply responsibilities towards their commitments (human values, human relationship and human society). | [AP] |
| CO3 | Apply what they have learnt to their own self indifferent day-to-day settings in real life, at least a beginning would be made in this direction. | [AP] |
| CO4 | Analyze ethical and unethical practices, and formulate strategies to actualize a harmonious environment wherever they work. | [AN] |
| CO5 | Understand the harmony in nature and existence, and work out mutually on fulfilling participation in nature. | [U] |

TEXT BOOKS

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010.

REFERENCE BOOKS

1. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
2. The Story of My Experiments with Truth –by Mohandas Karamchand Gandhi
3. India Wins Freedom-Maulana Abdul Kalam Azad.

WEB RESOURCES

1. <https://examupdates.in/professional-ethics-and-human-values/>
2. <http://hvpe1.blogspot.com/2016/06/notes-human-values-and-professional.html>
3. <https://www.yourmorals.org/schwartz.2006.basic%20human%20values.pdf>

ONLINE RESOURCES

1. <https://nptel.ac.in/courses/109/104/109104068/>
2. <https://medium.com/the-mission/the-12-important-life-skills-i-wish-id-learned-in-school-f4593b49445b>
3. <https://www.thebalancecareers.com/life-skills-list-and-examples-4147222>

23EC301	SIGNALS AND SYSTEMS	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES

1. Understanding the fundamental characteristics of signals and systems.
2. Understanding the characterization of LTI systems in time domain.
3. Understanding time domain and frequency domain analysis of Continuous and Discrete systems.
4. Imparting analytical skills to solve problems involving convolution integral and convolution sum.
5. Imparting the knowledge of correlation between signals.

SIGNALS AND SYSTEMS**20**

Signals (discrete / continuous) - Basic signals - Representation of signals, Signal classification, Types of signals, Operations on signals - Time reversal, Scaling, Shifting, Transformation of independent variables. Systems - Classification of systems- Static and dynamic, Linear and non - linear, Time - variant and time - invariant, Causal and non - causal, Stable and unstable, Continuous - time Linear Time Invariant (LTI) systems and Discrete - time Linear Shift Invariant (LSI) systems and its properties

ANALYSIS OF CT SYSTEMS**20**

Continuous - time Fourier transform (CTFT) - Existence, Properties, Inverse Fourier transform, Laplace Transform - Properties, Inverse Laplace transform, Region of convergence, Stability analysis, Relationship between Laplace and Fourier transform. System representation using differential equations - System Analysis using Laplace transform and Fourier transform – Input - output behaviour with periodic and aperiodic convergent inputs - Impulse response and step response - Frequency response, Convolution integral

ANALYSIS OF DT SYSTEMS**20**

Fourier series representation of discrete-time signals - Discrete Time Fourier Transform (DTFT) and its properties – z - transform, Properties, s - plane to z - plane mapping, Inverse z - transform, Region of convergence, Stability analysis, System representation using difference equations - Relationship between Z - transform and DTFT - System Analysis using Z - transform and DTFT - poles and zeros – stability - impulse response and step response - frequency response , convolution sum, Correlation between signals - Autocorrelation and Cross correlation.

TOTAL PERIODS: 60**COURSE OUTCOMES**

Upon completion of the course, students shall have ability to

CO1	Acquire the knowledge of signal, system and its classifications	[R]
CO2	Analyse the spectral characteristics of continuous-time periodic and aperiodic signals using Fourier Transform.	[AN]

CO3	Analyse the response of LTI system using convolution integral and LSI system using convolution.	[AN]
CO4	Analyse system properties based on impulse response and Frequency Response.	[AN]
CO5	Apply Laplace transform for the analysis of continuous-time systems and Z-transform for the analysis of discrete-time signals and systems.	[AP]

TEXT BOOKS

- 1 Allan V. Oppenheim et al, "Signals and Systems", Prentice Hall of India, 2/E, 2015
- 2 Ramakrishna Rao P, "Signals and Systems", McGraw Hill Education, New Delhi, 2/E, 2013.
- 3 Simon Haykin and Barry VanVeen, Signals and systems, 2007, second edition, Wiley, India.

REFERENCE BOOKS

- 1 J. Roberts, "Fundamentals of Signals and Systems", Tata McGraw Hill, 2007.
- 2 B. P. Lathi, "Signal Processing and Linear Systems", Oxford University Press, 1998.
- 3 R.F. Ziemer, W.H. Tranter and D.R. Fannin, "Signals and Systems – Continuous and Discrete", Prentice Hall, 4/E, 1998.

WEB RESOURCES

- 1 <http://www.nptelvideos.in/2012/12/signals-and-system.html>
- 2 <http://freevideolectures.com/Course/3177/Signals-and-Systems>

23EC304	ANALOG COMMUNICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To introduce the fundamental concepts of analog communication systems.
2. To get a deep knowledge about various techniques for analog modulation and demodulation with its noise performance.
3. To provide the knowledge of time and frequency domain representation of angle modulation techniques
4. To familiarize with basic techniques for generating and demodulating angle modulated signals.
5. To understand the properties of random process and concept of sampling

AMPLITUDE MODULATION

20

Introduction: Communication, Elements of an electrical communication system – concept of modulation and demodulation, Modulation : Need for modulation , types-linear and non-linear, Amplitude Modulation : DSBSC, DSBFC, SSB, VSB - Modulation index, Time domain and frequency domain description, Power relations and Bandwidth, single tone modulation, Generation of AM waves – Square law and Switching modulator, Square law and Envelope Detection - DSBSC Generation – Balanced and Ring Modulator, Coherent Detection - SSB Generation – Filter and Phase Shift Method, Coherent Detection - VSB Generation– Filter Method and demodulation, Comparison of different AM techniques, AM transmitter and receiver, Receiver Characteristics, Representation of narrowband noise; receiver model, signal to noise ratio (SNR), noise figure, noise temperature, noise in AM, DSB-SC, SSB-SC.

ANGLE MODULATION

15

Angle Modulation: Introduction, types of angle modulation- FM, PM, Mathematical and phasor representation of FM and PM, Narrow Band and Wide band FM – Modulation index, Spectra, Power relations and Transmission Bandwidth, Relationship between PM and FM, Generation and detection of FM: Direct and Indirect methods, FM to AM conversion , FM Demodulation : Foster Seeley Discriminator - PLL as FM Demodulator, Generation and detection of PM, FM transmitters and receivers, pre-emphasis and de-emphasis, Amplitude limiters, Noise Triangle in Angle Modulation System, Noise in Angle Modulation System

RANDOM PROCESS & SAMPLING

10

Random variables, Random Process, Stationary Processes, Wide Sense Stationary Processes ,Mean, Correlation & Covariance functions, Power Spectral Density, Ergodic Processes, Gaussian Process, Transmission of a Random Process Through a LTI filter, The Quantization Random Process, pulse code modulation(PCM)(Generation, Quantization noise),Differential pulse code modulation Sampling process, sampling theorem for band limited signals. Applications of sampling – pulse amplitude modulation (PAM), pulse width modulation (PWM), pulse position modulation (PPM).

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Understand the principles of AM communication systems	[U]
CO2	Analyze the different analog modulation and demodulation techniques	[AN]
CO3	Analyze the performance of AM systems in the presence of noise.	[AN]
CO4	Understand the various Angle modulation communication systems and their spectral characteristics.	[U]
CO5	Analyze the performance of different angle modulation and demodulation techniques and noise performance of FM systems.	[AN]
CO6	Apply the concepts of Random Process and sampling to the design of Communication systems	[AP]

TEXTBOOKS

1. S. Haykin, Micheal Moher, "Communication Systems", 5th Ed., John Wiley & Sons, 2021.
2. George Kennedy and Bernard Davis, "Electronic Communication systems", 6th Edition, TMH, 2018.
3. John G. Proakis and Masoud Salehi, "Fundamentals of Communication Systems" 2nd edition, Pearson Education, 2014

REFERENCE BOOKS

1. Taub.h and Schilling.D.L, "Principles of Communication Systems", 4th edition, Mc G raw Hill, 2017
2. Wayne Tomasi, "Advanced Electronic Communications Systems", Pearson Education, 6th edition, 2014
3. Rodger E. Ziemer and William H. Tranter "Principles of Communications: Systems, Modulation, and Noise " , 7th edition, Wiley, 2014.

WEB RESOURCES

1. https://onlinecourses.nptel.ac.in/noc25_ee68
2. https://onlinecourses.nptel.ac.in/noc21_ee74
3. <https://www.udemy.com/course/analog-communication>

23EC401	ANALOG INTEGRATED CIRCUITS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To construct the platform for understanding the various functionality of Linear Integrated Circuits.
2. To familiarize the linear and non-linear applications of IC 741 operational amplifiers.
3. To sense the concepts of VCO and PLL with its applications.
4. To interpret the real time signal analysis based on ADC and DAC IC.
5. To impart the knowledge of integrated circuits on Application specific functions.

FUNDAMENTALS OF OP-AMPS AND DIFFERENTIAL CIRCUITS

15

Basic information of Op-Amp, Differential amplifier - Differential amplifier with constant current source–current mirror–Wilson Current Mirror Circuit and Widlar Current Mirror Circuit. Characteristics of Op-Amp–frequency response–stability–OP-AMP design, inverting and non-inverting amplifiers–instrumentation amplifier–integrator and differentiator–voltage-to-current converter–Precision rectifier–Schmitt trigger–waveform generator.

SIGNAL PROCESSING AND CONVERSION CIRCUITS

15

Active Filters: Butterworth filter – LP, HP, BP, BR. Digital -to-analog converters (DAC), Analog-to-Digital converters (ADC). Types of DAC: Weighted resistor, R-2R ladder, Inverted R-2R ladder, Sample and Hold Circuit. Types of ADC: Flash, Counter type, Single slope, dual slope, Successive approximation, Astable and Monostable Multivibrators using 555 Timer.

VOLTAGE REGULATORS AND SPECIAL FUNCTION IC'S

15

VCO, PLL and its applications– Analog Multiplier using Emitter Coupled Transistor Pair - Gilbert Multiplier cell. 723 General Purpose Regulators & L4938 Voltage Regulator–switching regulator–Audio Power Amplifier–Video amplifiers–Opto couplers–Isolation Amplifiers–Fiber optic ICs–AC and DC analysis using circuit simulation using SPICE.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Use the functional blocks of linear integrated circuits and design linear applications using operational amplifiers.	[AP]
CO2	Analyse the characteristics, and application areas of operational amplifiers.	[AN]
CO3	Apply the concepts and applications of Voltage-Controlled Oscillators (VCO) and Phase-Locked Loops (PLL).	[AP]
CO4	Employ the properties of operational amplifiers to design Analog-to-Digital Converters (ADCs) and Digital-to-Analog Converters (DACs) for real-time signal processing.	[AP]
CO5	Apply the principles of integrated circuits to design and implement voltage regulators.	[AP]

TEXT BOOKS

1. D. Roy Choudhury & ShailBala Jain, "Linear IntegratedCircuits",6thEdition, New Age International Publishers, New Delhi, 2022.
2. Sergio Franco, "Design with operational amplifiers and analog integrated circuits", McGraw-Hill, 4thedition, 2016. (Reprint)

REFERENCE BOOKS

1. S.Salivahanan, V S Kanchana Bhaaskaran, "Linear Integrated Circuits", McGraw-Hill, 3rd edition,2023 (Reprint).
2. Michael Jacob J,"Analog Integrated Circuits and Applications", 1st Edition, Prentice Hall of India, New Delhi,2019.

WEB RESOURCES

1. <http://www.electronics-tutorials.ws>
2. <http://www.allaboutcircuits.com>

23CSC01	DATA STRUCTURES	L	T	P	C
		3	0	2	4

Course Objectives:

1. To learn the basics of data structures and linked lists, and implement common sorting techniques.
2. To gain hands-on experience in implementing stacks and queues using arrays and linked lists, and apply them to solve problems like expression evaluation and priority queuing.
3. To understand the usage of binary trees, binary search trees, and searching algorithms for efficient data storage and manipulation.
4. To explore graph representations and traversal techniques, and implement advanced sorting algorithms.
5. To learn hashing techniques and work with advanced data structures

LINKED LIST & STACK**15**

Linked List: Array vs Linked list - Types of linked list - Singly, Doubly and Circular Linked list - Applications of linked list. Stack: Stack Model, Array and Linked list implementation of Stack- Applications of Stack - Infix, Prefix and Postfix expressions - infix to postfix conversion - Expression Evaluation- Balancing Parenthesis.

QUEUE AND TREES**15**

Queue: Queue Model, Array and Linked list implementation of Queue-Priority Queue - Applications of Queue. Trees: Binary Tree - Binary Search Tree - Insertion, Deletion, Traversal- Inorder, Preorder, Postorder, Level order traversal. AVL Tree.

GRAPHS AND HASHING**15**

Graphs: Weighted and Directed graphs - Adjacency matrix and list implementation - Traversal- Breadth First Search & Depth First Search. Hashing: Direct Address Table, Hash function, Collision resolution techniques, Linear Probing, quadratic probing, double hashing. Searching Techniques: Linear Search and Binary Search. Sorting Techniques: Bubble sort, Insertion Sort & Merge Sort

TOTAL PERIODS (Theory):45**List of Lab Experiments:**

1. Implement Singly Linked List operations (Creation, Insertion, Deletion, Traversal)
2. Implement Doubly Linked List operations (Creation, Insertion, Deletion, Traversal)
3. Implement Circular Linked List operations and explore its applications
4. Implement Stack operations using Array and Linked List
5. Evaluate Infix, Prefix, and Postfix Expressions using Stacks
6. Implement Queue operations using Array and Linked List
7. Implement Breadth-First Search (BFS) and Depth-First Search (DFS) on Graphs
8. Implement Binary Tree operations (Creation, Insertion, Deletion) and Tree Traversals
9. Implement Hashing with Collision Resolution Techniques (Linear and Quadratic Probing)

10. Implement Sorting Algorithms (Merge Sort, Quick Sort, and Counting Sort) and evaluate their time complexities

TOTAL PERIODS (Lab): 30

TOTAL PERIODS: 75

COURSE OUTCOMES (COS):

Upon successful completion of this course, students will be able to:

CO1	Analyze the appropriateness of using core data structures like arrays and linked lists to implement efficient algorithms.	[AN]
CO2	Utilize stacks and queues to develop solutions for real-world computational challenges.	[AP]
CO3	Apply binary trees, binary search trees (BSTs), traversal techniques, and searching algorithms to organize and retrieve data efficiently.	[AP]
CO4	Evaluate the effectiveness of various graph algorithms and advanced sorting techniques in solving computational problems.	[AN]
CO5	Design efficient solutions using hashing, searching, and sorting techniques to optimize problem-solving in real-world applications.	[AP]

TEXTBOOKS:

1. Narasimha Karumanchi, "Data Structures and Algorithms Made Easy", 6th Edition, CareerMonk Publications, 2022.
2. Seymour Lipschutz, "Data Structures with C (SIE)", 1st Edition, McGraw Hill Education, 2019.
3. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", 4th Edition, Pearson, 2014.
4. Ellis Horowitz, Sartaj Sahni, and Susan Anderson-Freed, "Fundamentals of Data Structures in C/C++", Second Edition, Silicon Press, 2008.

REFERENCE BOOKS:

1. Reema Thareja, "Data Structures Using C", 3rd Edition, Oxford University Press, 2022.
2. Jean-Paul Tremblay and Paul G. Sorenson, "An Introduction to Data Structures with Applications", 2nd Edition, McGraw-Hill Education, 1984.
3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, "Introduction to Algorithms", 3rd Edition, MIT Press, 2009.
4. Debasis Samanta, "Classic Data Structures", 2nd Edition, PHI Learning, 2009.

WEB REFERENCES:

1. <https://www.khanacademy.org/computing/computer-science/algorithms>
2. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-006-introduction-to-algorithms-spring-2011/>
3. https://www.w3schools.com/dsa/dsa_intro.php
4. <https://techdevguide.withgoogle.com/paths/data-structures-and-algorithms/>

23CS302	PYTHON PROGRAMMING	L	T	P	C
		1	0	4	3

COURSE OBJECTIVES

1. To understand the basics of python programming.
2. To have a basic understanding of functions, modules, and object-oriented programming principles to enable the creation of modular and maintainable code.
3. To gain foundational knowledge of web development, including database management, consuming APIs, and developing web applications using Python web frameworks like Flask or Django.
4. To develop a solution for real-time datasets using tools.

PYTHON FUNDAMENTALS**5**

Python Basics: Syntax, semantics, data types, variables, and operators-Control Flow Statements: if, for, while - **Functions and Modules:** Defining functions, parameters, scope, and working with modules/packages- **Object-Oriented Programming:** Classes, objects, inheritance, polymorphism, encapsulation, abstraction. **Introduction to NumPy and Pandas:** NumPy: Arrays, slicing, indexing, and basic operations - Pandas: DataFrames, Series, and basic data manipulation

ERROR HANDLING, FILE I/O, AND NLP**5**

Error Handling: Using try, except, finally, and custom exceptions - **File I/O:** Reading and writing text, CSV, and JSON files, using context managers - **Data Visualization with Matplotlib:** Line plots, bar charts, scatter plots, and customizations - **Introduction to NLP:** Tokenization, stemming, lemmatization, Using SpaCy or NLTK for part-of-speech tagging and Named Entity Recognition (NER). **Basic preprocessing:** Removing stopwords and normalizing text.

WEB DEVELOPMENT FOUNDATIONS**5**

HTTP and APIs: Basics of HTTP, RESTful API principles, and consuming APIs using Python (requests library) - **Database Integration:** CRUD operations using an ORM (SQLAlchemy) - **Introduction to Web Frameworks:** Flask - Routing, request handling, and response generation - **Advanced Pandas and NumPy:** Data merging, handling missing values, and statistical analysis - **Generative AI Basics:** Overview of GANs, VAEs, and GPT models with Python.

TOTAL PERIODS (Theory): 15

LIST OF EXPERIMENTS

1. Implementation of control flow statements in Python
2. Implementation of functions and modules in Python
3. Implementation of object-oriented programming concepts in Python
4. Implementation of error handling in Python
5. Implementation of file input and output operations in Python
6. Implementation of data visualization using Matplotlib
7. Implementation of Natural Language Processing (NLP) techniques
8. Implementation of API consumption using Python
9. Implementation of CRUD operations using SQLAlchemy
10. Implementation of Flask-based REST API.

TOTAL PERIODS (Lab): 60

TOTAL PERIODS: 75

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply Python programming fundamentals, including syntax, control flow, functions, modules, and object-oriented concepts.	[AP]
CO2	Demonstrate the ability to manipulate data using NumPy and Pandas for data analysis and visualization.	[AP]
CO3	Implement error handling strategies and perform file input/output operations.	[AP]
CO4	Apply data visualization techniques using Matplotlib and utilize NLP methods to analyze and process textual data.	[AP]
CO5	Develop web applications using frameworks and implement CRUD operations with SQLAlchemy for database integration.	[AP]

TEXTBOOKS

1. Magnus Lie Hetland, "Beginning Python: From Novice to Professional", Apress, 2023 Edition.
2. Paul Barry, "Head First Python: A Brain-Friendly Guide", O'Reilly Media, 2024 Edition.
3. David Amos, Dan Bader, Joanna Jablonski, Fletcher Heisler, "Python Basics: A practical introduction to Python 3", Real python Publication, Fourth Edition, 2021.
4. Eric Matthes, "Python Crash Course: A Hands-On, Project-Based Introduction to Programming", No Starch Press, 2nd Edition, 2019.
5. Fabrizio Romano, "Learn Web Development with Python", 1st Edition, Kindle Edition, 2018.

REFERENCE BOOKS

1. Daniel J. Crowley, "Python Machine Learning: A Practical Approach to Building Intelligent Systems", Springer, 2023 Edition.
2. Jake VanderPlas, "Python Data Science Handbook: Essential Tools for Working with Data", O'Reilly Media, 2023 Edition.

3. Joel Grus, "Data Science from Scratch: First Principles with Python", O'Reilly Media, 2nd Edition, 2019.

WEB RESOURCES

1. <https://realpython.com/python-web-applications/>
2. <https://www.python.org/about/gettingstarted/>
3. <https://www.programiz.com/python-programming>
4. <https://www.datacamp.com/community/tutorials/python-statistics-data-science>

23EC405	ANALOG INTEGRATED CIRCUITS LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES

1. To illustrate the working of linear application-based circuits using IC 741.
2. To verify the functionality of Linear application-based circuits using simulation tools.
3. To enumerate the design values of wave form generators and filters for Nonlinear applications.

LIST OF EXPERIMENTS

1. Inverting and Non-inverting Op-amp.
2. Applications of Op-amp (Adder, Subtractor, Adder-Subtractor, Average Amplifier).
3. Integrator and Differentiator using Op-amp.
4. Instrumentation Amplifier using Op-Amp.
5. Waveform generation using Op-Amp.
6. Design of Active filters (LPF, HPF).

Using Multisim/Orcad/Pspice

7. Simulation of Analog to Digital Converter.
8. Simulation of Digital to Analog Converter.
9. Simulation of Multivibrators.
10. Simulation of Wein bridge and RC phase shift oscillator.

TOTAL PERIODS: 30

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Illustrate the diverse applications of operational amplifiers in real-world scenarios.	[U]
CO2	Examine and analyse the characteristic performance of integrator and differentiator circuits.	[AN]
CO3	Illustrate and implement an instrumentation amplifier, then examine and appraise its performance.	[AN]
CO4	Construct and implement a circuit using operational amplifiers to generate waveforms and design active filters.	[AP]
CO5	Classify and simulate ADC, DAC, multivibrators, and oscillators, then compare and appraise the results.	[AN]

TEXT BOOKS

1. D. Roy Choudhury & ShailBala Jain, "Linear IntegratedCircuits",6thEdition, New Age International Publishers, New Delhi, 2022.
2. Sergio Franco, "Design with operational amplifiers and analog integrated circuits", McGraw-Hill, 4thedition, 2016. (Reprint)

REFERENCE BOOKS

1. S. Salivahanan, V S Kanchana Bhaaskaran, "Linear Integrated Circuits", McGraw-Hill, 3rd edition,2023 (Reprint).
2. Michael Jacob J, "Analog Integrated Circuits and Applications", 1st Edition, Prentice Hall of India, New Delhi,2019.

WEB RESOURCES

1. <http://nptel.ac.in/courses/117107094/>
2. <http://www.technologystudent.com/elec1/elecex.htm>

23MEC03	DESIGN THINKING AND IDEA LAB	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES

- 1 To accelerate development of indigenous products in line with the “Make in India” campaign.
- 2 To encourage aspiring engineers to actualize their ideas under one roof.
- 3 To impart multidisciplinary education to all students to promote innovation and product development
- 4 To initiate new ways of creative thinking and enable the students to learn the cycle of Design Thinking process for developing innovative products.
- 5 To promote experiential learning and entrepreneurial skills among the students.

Course contents

DESIGN THINKING

Design Thinking: Definition, Need and Objective, Concepts and Brainstorming, Stages – Empathize, Define, Ideate, Prototype, Test. Practical Examples of Customer Challenges, Alignment of Customer Expectations with Product Design - Feedback, Re-Design and Re-Create.

INTRODUCTION TO TOOLS AND EQUIPMENT

Introduction to Hand Tools and Power Tools - 3-axis CNC routing, basic turning, milling, drilling and grinding operations, Laser cutting, Laser engraving etc.

Basic 2D and 3D designing using CAD tools such as FreeCAD, Sketchup, Prusa Slicer, FlatCAM, Inkspace and OpenBSP - 2D and 3D structures for prototype building using CNC machine - Basic welding and other joining techniques for assembly - Basics of 3D scanning, Point cloud data generation for reverse engineering.

Exposure to PCB prototype fabrication - Familiarity and use of soldering and de-soldering equipment - Usage of Arduino, Raspberry Pi and BeagleBone.

EXPERIMENTAL LEARNING

1. 2D profile cutting of press fit box / casing in acrylic (3 or 6 mm thickness) / polymer / cardboard / MDF (2 mm thickness) board using laser cutter and engraver.
2. Machine 3D geometry on soft material such as soft wood using CNC router.
3. Fabricate products like trusses using cutting and welding tools.
4. 3D printing of scanned geometry using FDM or SLA printer.
5. Designing a suitable PCB layout, fabrication and testing of the circuit.
6. Assemble and disassemble electronic components on a PCB using soldering and de-soldering equipment.
7. Embedded programming using Arduino, Raspberry Pi and BeagleBone.

DESIGN THINKING PROJECT

1. Design and implementation of a capstone project.

TOTAL PERIODS: 30

Course outcomes

Upon completion of the course, students shall have ability to

CO1	Recall the basic concepts of Design Thinking.	[U]
CO2	Utilize the equipment, tools and inventories associated with Design Thinking Laboratory.	[AP]
CO3	Perform fundamental fabrication operation using hand tools, power tools, welding equipment, laser cutter and engraver.	[AP]
CO4	Perform fundamental electrical and electronic circuit design using PCB machine.	[AP]
CO5	Develop innovative products by implementing the design thinking approach	[C]

TEXT BOOKS

1. Veeranna D.K, "Workshop / Manufacturing Practices (with Lab Manual)", AICTE's Prescribed Textbook, Khanna Book Publishing, 1st edition, 2022.
2. E. Balaguruswamy, "Design Thinking: A Beginner's Perspective", McGraw-Hill Education, 1st edition, 2024.
3. Anuja Agarwal, "Design Thinking: A Framework for Applying Design Thinking in Problem Solving", Cengage India, 1st edition, 2024.

REFERENCE BOOKS

1. Lal, D. M., "Design Thinking- Beyond the Sticky Notes", Sage Publications India Pvt. Ltd., 1st edition, 2021.
2. Kaushik Kumar and Muralidhar Kurni, "Design Thinking: A Forefront Insight", CRC Press, 1st edition, 2023.
3. Shalini Rahul Tiwari, "Design Thinking: A Comprehensive Textbook", Wiley India, 1st edition, 2024.

WEB RESOURCES

1. <https://fab-coep.vlabs.ac.in/List%20of%20experiments.html>
2. <https://www.innovationtraining.org/how-to-use-design-thinking-to-design-an-innovation-lab/>
3. <https://www.erdster.co.in/design-thinking-lab.html>
4. <https://www.coursera.org/learn/uva-darden-design-thinking-innovation>

SEMESTER – IV

23EC402	ELECTROMAGNETIC FIELDS	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES

1. To review about co-ordinate systems and to enable the students to understand the concepts of electrostatics
2. To enable the students to understand the concepts of static and vector magnetic fields
3. To understand how electric and magnetic fields affect materials and the relation between the fields under time varying situations.
4. To analyze the principles of propagation of uniform plane waves and emphasize the significance of waveguides.

ELECTROSTATICS

20

Introduction to Co-ordinate System, Gradient, Divergence and Divergence theorem, Curl and Stoke's theorem, Laplacian of a Scalar. Coulomb's law, Electric field, Electric potential, Charge densities – Line, Surface, Volume charge densities, Electric flux, Electric flux density. Electric potential due to dipole - Capacitance Energy density in the electrostatic field. Laplace and Poisson's equations- Applications for Laplace's equation - Capacitance - Parallel Plate- Boundary conditions, Electric current, Current density, Point form of Ohm's law- Case Study: Pacemaker

MAGNETOSTATICS & TIME VARYING FIELD

20

Magnetic field, Biot-Savart's law, Ampere's law, Magnetic vector potential, Magnetic flux density, Definition of Inductance and Inductors-Inductance due to Solenoid and Toroid, Boundary conditions, Time Varying Field-Equation of continuity for time varying fields-Maxwell's equations, Faraday's law and its significance- Case Study: Magnetic Levitation Train

UNIFORM PLANE WAVES & WAVEGUIDES

20

Wave, Wave equation, Wave propagation in space, conducting media and Dielectric loss, travelling waves and standing waves Plane waves at interfaces, Normal incidence, Phase velocity, Group velocity, Index of refraction, Power and energy relations, Poynting theorem Polarizations - Linear, Elliptic and Circular, Characteristics of TE & TM waves – TEM waves, Rectangular Waveguides – Solution of Wave Equations in Rectangular Coordinates, TE/TM mode analysis

TOTAL PERIODS: 60

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Understand the concepts of Electrostatics for various geometries	[U]
CO2	Apply boundary conditions to solve for fields at interface between two different charge medium	[AP]

CO3	Understand the basic Magneto static laws and interpret the nature of magnetic fields	[U]
CO4	Understand the concepts of time varying electric and magnetic fields	[U]
CO5	Apply the concepts of Maxwell's equations in propagation of uniform plane waves and waveguides	[AP]

TEXTBOOKS

1. Sadiku M H, "Principles of Electromagnetics", Oxford University Press Inc., 6th Edition, New Delhi, 2020(Reprint).
2. Eugene I. Nefyodov , Sergey M. Smolskiy, ""Electromagnetic Fields and Waves-Microwave and mm-Wave Engineering with Generalized Macroscopic Electrodynamics", Springer - 2020(Reprint).
3. John D Kraus and Daniel A Fleisch," Electromagnetic with applications", 5th Edition, McGraw-Hill, 2017.

REFERENCE BOOKS

1. Naveen Gupta, "Electromagnetic Field and Waves", New Age International Publishers; First Edition, 2019.
2. William H. Hayt, John A. Buck, "Engineering Electromagnetic", 8th Edition, McGraw-Hill, 2017.
3. Nathan Ida, "Engineering Electromagnetics", Springer (India) Pvt. Ltd. New Delhi,3rd edition,2015.

WEB RESOURCES

1. nptel.ac.in/courses/108104087
2. <http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-630-electromagnetics-fall-2006/>
3. <http://nptel.ac.in/courses/117103065/>
4. <http://nptel.ac.in/video.php?subjectId=108106073>

23EC501	CONTROL ENGINEERING	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES

1. To understand electrical and mechanical systems with its transfer function
2. To provide an adequate knowledge of systems in time domain and steady state error analysis
3. To understand the frequency response and stability of systems
4. To introduce the concept of compensators and design of lag compensator
5. To impart the concept of state variable representation of physical systems.

SYSTEMS MODELLING AND TIME RESPONSE ANALYSIS**20**

Basic elements of control systems - Open and closed loop systems – Transfer function - Mathematical modelling of electrical and mechanical systems – Block diagram reduction techniques – Signal flow graphs. Time response analysis: Time domain specifications – Types of test input, First and Second order system response – Error coefficients – Generalized error series – Steady state error. Controllers: Introduction to P, PI, PD and PID control

FREQUENCY RESPONSE AND STABILITY ANALYSIS**20**

Frequency response - Bode plot - Polar plot - Gain margin and Phase margin. Stability analysis: Concept of stability - Routh Hurwitz criterion - Root locus technique

COMPENSATOR AND STATE VARIABLE ANALYSIS**20**

Compensators: Introduction to Lag, Lead and Lag - Lead networks - Design of Lag compensator using Bode plot. Concept of state variables – State models for linear and time invariant Systems – Solution of state equation - State transition matrix - Jordan canonical form. Concepts of controllability and observability.

TOTAL PERIODS: 60**COURSE OUTCOMES**

Upon completion of the course, students shall have ability to

CO1	Understand the importance of mathematical modelling of systems	[U]
CO2	Analyze the control systems with respect to time domain response and steady state error	[A]
CO3	Analyze the frequency response and examine the stability of systems	[A]
CO4	Analyze lag compensator using Bode plot to meet the desired specifications	[A]
CO5	Construct state space model of a system and test its controllability and observability.	[AP]

TEXTBOOKS

1. I. J. Nagrath & M. Gopal, Control Systems Engineering, 6th Edition, New Age International Publishers, 2017.

2. Richard C. Dorf, Robert H. Bishop, „Modern Control Engineering“, 13th Edition, Pearson Education, New Delhi, 2016.
3. Farid Golnaraghi & Benjamin C. Kuo, Automatic Control systems“, 9th Edition, Wiley, 2014.

REFERENCE BOOKS

1. Norman S. Nise, Control Systems Engineering, Wiley, New Delhi, 2018.
2. Katsuhiko Ogata, Modern Control Engineering, 5th edition, Pearson, New Delhi, 2015.
3. A. Nagoorkani, “Control Systems Engineering”, CBS Publishers, RBA Publications 2021

WEB RESOURCES

1. <http://www.nptel.ac.in/courses/108101037/>
2. <https://www.coursera.org/articles/controls-engineer>
3. <https://www.mathworks.com/help/overview/control-systems.html>

23EC508	MICROCONTROLLER AND INTERFACING	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1. To introduce the basic concept of 8051 microcontroller
2. To study the concepts of Architecture and Assembly language programming of ARM Processor.
3. To enable the student to relate various interfacing devices with microcontrollers.
4. To enable the understanding of Microcontroller Peripherals and their configuration
5. To provide insight on the design of a simple Embedded System for specific Applications

8 BIT MICROCONTROLLER:

15

Introduction to 8051 micro-controller, Architecture, Special Function Registers, Instruction set, Addressing modes, Interrupts, Power down operation, Memory organization, Programming 8051, Micro controller based system designs-LCD – temperature and gas sensors-Stepper motor -RTC-I2C. Memory Interfacing and I/O interfacing -Timer – Keyboard /display

ARM ARCHITECTURE

15

Introduction to Acorn RISC Machine – Architecture Inheritance – LPC2148 Microcontroller Architecture- ARM programming model – ARM Processor Modes and States- - ARM Instruction Set - Types - Data Processing Instructions - Assembly Language Programming ARM Development Tools .

ARM ORGANIZATION AND IMPLEMENTATION

15

ARM 3 Stage and 5 stage Pipeline -- Pipeline in Processor - Pipeline Hazards -GPIO - PLL - Introduction to serial communication - Serial Transmission and Reception using UART

TOTAL PERIODS(Theory): 45

LIST OF EXPERIMENTS

1. Implement addition, subtraction, multiplication, and division for 16-bit numbers using 8051 assembly language. Ensure accurate carry/borrow handling and store the result in bit-addressable memory.
2. Write a program to move a block of data from one memory location to another using 8051. Use loops and indirect addressing for efficient memory handling.
3. Develop a routine to exchange data byte-by-byte between two memory blocks of equal size using the 8051 microcontrollers.
4. Implement a sorting algorithm (e.g., bubble sort) in 8051 to arrange an array of numbers in ascending order.
5. Write an 8051-assembly program to identify the largest number in an array stored in internal RAM.

6. Design a program using conditional CALL and RETURN instructions to execute different subroutines based on input conditions.
7. Interface a stepper motor with the 8051 microcontroller and develop a program to rotate it clockwise and counter-clockwise with speed control.
8. Interface the 8255 PPI with 8051 and demonstrate control of LEDs or switches via parallel port communication
9. Interface an ADC and DAC with 8051 to perform analog signal reading and reconstruction through digital processing.
10. Write a C program to toggle an LED at regular intervals using GPIO control in an ARM microcontroller.
11. Connect a 7-segment display to an ARM microcontroller and display a count from 0 to 9.
12. Interface a 16x2 character LCD with an ARM microcontroller and display a user-defined message or sensor reading.

TOTAL PERIODS (Lab): 30

TOTAL PERIODS: 75

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	To introduce fundamental concepts the internal blocks of 8051 microcontroller	[U]
CO2	To explain the Interface peripheral devices with 8051 microcontrollers	[U]
CO3	Configure the Internal Peripherals of a Microcontroller	[AP]
CO4	Recall the architecture and operation modes of ARM processor.	[R]
CO5	Illustrate the instruction sets of ARM processor	[U]
CO6	Observe the process of ARM 3 and 5 Stage Pipelining	[AN]

TEXTBOOKS

1. Muhammad Ali Mazidi, "The 8051 Microcontroller and Embedded systems", Prentice Hall India, New Delhi, 2016
2. S. Furber, "ARM system On Chip Architecture", Second Edition, Pearson, 2015.
3. LPC2148 User manual, NXP Semiconductor <https://www.nxp.com/docs/en/user-guide/UM10139.pdf>

REFERENCE BOOKS

1. Subrata Ghoshal, "8051 Microcontroller- Internals, Instructions, Programming and Interfacing", Pearson, 2015
2. David Greaves. "Modern System-on-Chip Design on ARM", ARM Eduation Media ,2021
3. Shenouda Dawoud , "Digital System Design - Use of Microcontroller", River publishers,2022

WEB RESOURCES

1. <https://www.elprocus.com/peripherals-interfacing-to-the-microcontroller-8051-in-electronics/>
2. <https://developer.arm.com/products/architecture/cpu-architecture>
3. <http://www.ti.com/microcontrollers/msp430-ultra-low-power-mcus/overview.html>
4. <https://exploreembedded.com>

23EC505	DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES

1. To familiarize the students about Discrete Fourier Transform techniques and its applications in filter design.
2. To allow students to design and analyze digital IIR filters.
3. To enable the students to design and analyze digital FIR filters.
4. To enable students to understand the quantization process and applications of multi rate signal processing.
5. To implement IIR and FIR filter techniques using MATLAB and TMS320C50 Processor.

DISCRETE FOURIER TRANSFORM**15**

Computation of DFT– Properties – Circular convolution – Fast Fourier Transforms (FFT) algorithms – Decimation in Time algorithm – Decimation in Frequency algorithms – Filtering long data sequences - overlap save and overlap add method.

DESIGN AND IMPLEMENTATION OF DIGITAL FILTERS**15**

Analog filters – Butterworth and Chebyshev Type I filter – Frequency transformation in analog domain –LPF to HPF / BPF / BSF. Design of IIR filter from analog filter using impulse invariance technique and bilinear transformations – Realization Structures for IIR filter (Direct Form I and II, cascade form and Parallel form). Finite Impulse Response (FIR) filters - Symmetric and Anti symmetric FIR filter – Linear phase FIR filters – Design of Linear phase FIR filters using windowing technique – Rectangular, Hamming and Hanning windows – Frequency Sampling methods - Structures for FIR filter (Direct form, Linear phase structure).

FINITE WORD LENGTH EFFECTS AND APPLICATIONS OF DSP**15**

Representation of numbers – Quantization process – co-efficient quantization error – Input quantization error – Product quantization error –Limit Cycle Oscillations (LCO) - Multi rate signal processing – Decimation – Interpolation – sampling rate conversion by rational factor I/D – Poly phase filter structure. Application of DSP to speech and radar signal processing.

TOTAL PERIODS(Theory): 45**LIST OF EXPERIMENTS****Analysis and simulation using MATLAB software**

1. Computation of DFT using discrete Fourier transform and Matrix method
2. Computation of Linear and circular convolution using DFT
3. Computation of N-Point DFT using DIT and DIF algorithm
4. Design and simulation of FIR filter using various windowing technique
5. Design and simulation of IIR filter using Impulse invariant and Bilinear

- transformation technique
6. Quantization effects in digital filter design
 7. Implementation of Multirate Signal processing- Interpolation and Decimation
 8. Analysis of ECG signal
 9. Analysis of EEG signal

Experiments Using TMS320C50/6713 Processor

10. Implementation of FFT algorithm
11. Implementation of Linear Convolution
12. Implementation of FIR filter

TOTAL PERIODS (Lab): 30

TOTAL PERIODS: 75

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply discrete Fourier transform for the analysis of discrete signals and systems	[AP]
CO2	Design and analyse FIR filters and IIR filter using various techniques	[AN]
CO3	Understand the concepts of quantization effects and the behavioral Changes in filter response	[U]
CO4	Explore the concept of Multi rate digital signal processing and its applications	[U]
CO5	Examine and simulate the discrete time signal using transform and different techniques for design of digital filters.	[AN]

TEXT BOOKS

- 1 John G. Proakis & Dimitris G. Manolakis, Digital Signal Processing, Pearson, 4th Edition, 2021.
- 2 Sanjit K. Mitra, Digital Signal Processing : A Computer- Based Approach, The McGraw-Hill Education, 4th Edition 2019
- 3 Alan V Oppenheim; Ronald W Schafer, Digital Signal Processing, Pearson India, First edition, 2019

REFERENCE BOOKS

- 1 B.P.Lathi, "Principles of Signal Processing and Linear Systems", Cambridge University, 2023
- 2 Emmanuel C. Ifeachor, & Barrie .W. Jervis, "Digital Signal Processing", Second edition, Pearson Education, 2022
- 3 Li Tan, Jean Jiang, Digital Signal Processing: Fundamentals and Applications, 3rd edition, Academic Press, 2019

WEB RESOURCES

- 1 <https://ocw.mit.edu/courses/6-341-discrete-time-signal-processing-spring-2005>
- 2 <https://nptel.ac.in/courses/108/105/108105157/>
- 3 <https://www.edx.org/course/fundamentals-of-digital-signal-processing>

PROFESSIONAL ELECTIVE COURSES (PEC)

23EC901	REAL-TIME OPERATING SYSTEMS AND APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To provide a strong foundation on the principles and architecture of real-time operating systems.
- 2 To explore the design and implementation of processes and inter-process communication.
- 3 To understand synchronization mechanisms including semaphores, message queues, and pipes.
- 4 To study task scheduling and interrupt handling techniques in real-time environments.
- 5 To evaluate the performance and memory management of real-time kernels and systems.
- 6 To enable students to apply RTOS concepts in practical domains such as image processing, VoIP, control systems, and fault-tolerant applications."

ASIC PRINCIPLES OF OPERATING SYSTEMS AND PROCESS SYNCHRONIZATION 15

Basic Principles, Operating System structures, System Calls, Files, Processes, Design and Implementation of processes, Communication between processes, Introduction to Distributed operating system, Distributed scheduling. RTOS Task and Task state, Process Synchronization- Message queues, Mail boxes, pipes, Critical section, Semaphores, Classical synchronization problem, Deadlocks.

REAL-TIME OPERATING SYSTEMS (RTOS) AND SCHEDULING 15

Event Based – Process Based and Graph based Models, Real Time Languages, RTOS Tasks, RT scheduling, Interrupt processing, Synchronization, Control Blocks, Memory Requirements. REAL TIME KERNEL: Principles, Design issues, Polled Loop Systems, RTOS Porting to a Target, Comparison and study of various RTOS like QNX, VX works, PSOS, C Executive- Case studies.

APPLICATIONS OF RTOS 15

RTOS for Image Processing, Embedded RTOS for voice over IP, RTOS for fault Tolerant Applications, RTOS for Control Systems.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the basic principles of operating system structures and the role of system calls in process management. | [U] |
| CO2 | Apply process communication and synchronization techniques to manage deadlocks and handle critical sections in real-time systems. | [AP] |
| CO3 | Interpret various real-time system models such as event-based, process-based, and graph-based approaches. | [AP] |
| CO4 | Apply design principles of real-time kernels and compare the features of various RTOS platforms. | [AP] |
| CO5 | Implement real-time operating system concepts in domains like image processing, voice-over-IP, and control systems. | [AP] |

TEXT BOOKS:

- 1 Raj Kamal, "Embedded Systems- Architecture, Programming and Design" Tata McGraw Hill, 2020.

- 2 Herma K., "Real Time Systems – Design for distributed Embedded Applications", Kluwer Academic, 2022.
- 3 Charles Crowley, "Operating Systems-A Design Oriented approach" McGraw Hill 1996.
- 4 Krishna.C.M, Kang, Shin.G, "Real Time Systems", McGraw Hill, 1997.

REFERENCE BOOKS:

- 1 Donald L.Bailey, "An Introduction to Real Time Systems", PHI 1999.
- 2 Mukesh Signal and Shi.N.G "Advanced Concepts in Operating System", McGraw Hill 2001.

WEB RESOURCES:

- 1 <https://www.freertos.org/>
- 2 <chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://runtimerec.com/wp-content/uploads/2024/03/rtos-essentials-ebook.pdf>
- 3 <https://rtos.com>
- 4 <https://developer.arm.com/tools-and-software>
- 5 <https://www.ni.com/en-us/innovations/real-time-operating-systems.html>
- 6 <https://developer.arm.com/architectures/learn-the-architecture/real-time-operating-systems>
- 7 <https://www.freertos.org/>

23EC902	AUTOMOTIVE EMBEDDED SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce the fundamental structure and operational principles of automotive electronic systems.
- 2 To describe the architecture and internal communication protocols used in modern vehicles.
- 3 To expose students to key in-vehicle communication networks such as CAN, LIN, FlexRay, and Automotive Ethernet.
- 4 To impart knowledge of fault tolerance, functional safety, and efficient data exchange in automotive networks.
- 5 To provide foundational understanding of software modelling and testing methodologies for embedded automotive applications.
- 6 To equip students with the ability to use modelling languages such as SysML and ADL for systematic design and analysis of automotive embedded systems.

AUTOMOTIVE EMBEDDED SYSTEMS AND ARCHITECTURES**15**

Automotive Systems Overview: Powertrain, Chassis, Body, Telematics, HMI, Safety, Diagnostics, In-Vehicle Networks, and Protocols, Operating Systems, Middleware, and AUTOSAR: Layered Architecture (BSW, RTE), Models, Templates, Exchange Formats, Fail-Safe, Intelligent Automotive Systems, and Automated Road Vehicles.

IN-VEHICLE COMMUNICATION AND NETWORKING TECHNOLOGIES**15**

Embedded Automotive Communication: Point-to-Point vs Multiplexed Systems, Event-Triggered vs Time-Triggered Communication. Automotive Networks Overview: Types, Low-Cost & High-Reliability Networks, Flex Ray & CAN (including Fault Tolerance, Clock Synchronization). Dependable CAN Networks: Features, Limitations, Data Consistency Challenges, Fault-Tolerant Architectures (TTCAN, Flex CAN).

AUTOMOTIVE SOFTWARE DEVELOPMENT, VERIFICATION, AND TESTING**15**

Embedded Software Development: Basic Concepts, Feature Modelling, and Reuse, Modular Automotive Software Architecture, Automotive Software Analysis Languages: SysML and ADL for Automotive Systems, Testing and Verification of Automotive Systems: Dynamic, Functional, Structural, and Model-Based Testing, Test Planning and Execution: Exemplary Case Study on Battery Management System (BMS) Communication Network for EVs, Overview of MISRA C and functional safety (ISO 26262) in software development

TOTAL PERIODS: 45**COURSE OUTCOMES**

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the basic architecture and electronic components of automotive embedded systems. | [U] |
| CO2 | Understand the system frameworks like AUTOSAR and emerging trends in automotive technologies. | [U] |
| CO3 | Understand the structure and functionalities of in-vehicle communication protocols such as CAN, LIN, FlexRay, and Ethernet. | [U] |
| CO4 | Apply strategies for fault tolerance, synchronization, and efficient data exchange in automotive communication systems. | [AP] |
| CO5 | Apply testing methods to evaluate the safety, reliability, and performance of automotive embedded systems | [AP] |

TEXT BOOKS:

- 1 Nicolas Navet, Francoise Simonot-Lion, Automotive Embedded Systems Handbook, CRC Press, 2017.
- 2 William Ribbens, Understanding Automotive Electronics, 8th Edition, Butterworth-Heinemann, 2017.
- 3 Kirsten Matheus and Thomas Königseder, Automotive Ethernet: The Definitive Guide, Cambridge University Press, 2021.
- 4 Konrad Etschberger, "Controller Area Network (CAN): Basics, Protocols, Chips and Applications", IXXAT Automation, 2021

REFERENCE BOOKS:

- 1 Konrad Etschberger, Controller Area Network (CAN): Basics, Protocols, Chips and Applications, IXXAT Automation, 2001.
- 2 Wolfgang Kreutzer, Learning Automotive Embedded Systems Programming with ARM Cortex and CAN, Apress, 2020.

WEB RESOURCES:

- 1 <https://www.autosar.org/>
- 2 https://www.vector.com/vi_can_basics_en.html
- 3 https://www.godaddy.com/forsale/flexray.com?utm_source=TDFS_BINNS2&utm_medium=parkedpages&utm_campaign=x_corp_tdfsbinns2_base&traffic_type=TDFS_BINNS2&traffic_id=binns2&
- 4 <https://www.nxp.com/design>
- 5 <https://www.ptc.com/en/technologies/application-lifecycle-anagement/automotive-embedded-software>
- 6 <https://www.coursera.org/learn/automotive-embedded-systems>
- 7 <https://nptel.ac.in/courses/108/105/108105057>

23EC903	HARDWARE-SOFTWARE CO-DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To explain the role of hardware–software co-design in optimizing embedded systems for performance, power, and cost.
- 2 To describe state-oriented, dataflow, and event-driven modeling techniques for embedded system applications.
- 3 To identify the trade-offs involved in hardware/software partitioning using classical and machine learning–driven algorithms.
- 4 To design hardware accelerators using High-Level Synthesis (HLS) and software components using RTOS-aware synthesis tools.
- 5 To validate timing, power, and area metrics in embedded system design space exploration.
- 6 To apply co-design concepts in real-world scenarios such as RISC-V SoCs and Edge AI deployments.

SYSTEM SPECIFICATION & MODELS OF COMPUTATION

15

Co-Design: Need, Performance, power, and cost tradeoffs - Models of Computation (MoCs): State-oriented (FSMs), Data-oriented, Event-driven, Heterogeneous - Modern Extensions: Real-time constraints - Security-aware modeling

HW/SW PARTITIONING & OPTIMIZATION

15

Partitioning Fundamentals: Granularity (task-level, instruction-level) - Partitioning Techniques: Kernighan-Lin, GCLP, ML-driven partitioning - Real-time scheduling: static vs. dynamic - Co-Synthesis: Hardware Synthesis: C-to-RTL concepts, RISC-V custom extensions - Software Synthesis: RTOS-aware code generation (FreeRTOS, Zephyr) - Interface Synthesis: AXI, SPI, I2C protocol implementation

EMBEDDED SYSTEM VERIFICATION & DEPLOYMENT

15

Estimation & Optimization: Metrics - Timing, power, area (HW); memory, WCET (SW) - Energy-optimal design for battery-operated embedded systems - Co-Verification: Simulation: Transaction-Level Modeling (TLM) vs. Cycle-Accurate - Formal Verification: Model checking for safety-critical systems - Case Studies: RISC-V SoCs: Custom ISA for embedded applications - Edge AI: Deploying TinyML on microcontrollers

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- CO1 Describe the system-level design principles and models of computation used in embedded systems [U]
- CO2 Analyze the trade-offs involving performance, power, and security in hardware-software co-design [AN]
- CO3 Apply partitioning and optimization strategies in embedded system design using formal techniques [AP]
- CO4 Analyze hardware/software synthesis methodologies using RISC-V and RTOS-aware architectures [AN]
- CO5 Demonstrate co-verification, estimation, and deployment techniques using case studies like TinyML [AP]

TEXT BOOKS:

- 1 Felice Balarin, Massimiliano Chiodo, Paolo Giusto, Harry Hsieh, Attila Jurecska, Luciano Lavagno, Claudio Passerone, Alberto Sangiovanni-Vincentelli, Ellen Sentovich, Kei Suzuki, Bassam Tabbara, "Hardware-Software Co-Design of Embedded Systems: The POLIS Approach", 2013
- 2 Peter Marwedel, "Embedded System Design", 4th Edition, Springer, 2021.
- 3 Giovanni De Micheli and Rolf Ernst, "Reading in Hardware/Software Co-Design", Morgan Kaufmann, 2020 Reprin
- 4 Raj Kamal, "Embedded Systems: Architecture, Programming and Design", 3rd Edition, McGraw Hill Education, 2021

REFERENCE BOOKS:

- 1 Russell John Rickford, Bernd Kleinjohann, "Design and Analysis of Distributed Embedded Systems", Springer, 2002,
- 2 Achim Rettberg, Mauro C Zanella, Franz J Rammig, "From Specification to Embedded Systems Application", Springer, 2005,

WEB RESOURCES:

- 1 <https://ieeexplore.ieee.org/document/8448578>
- 2 <https://riscv.org/specifications/ratified/>
- 3 <https://www.iso.org/standard/68383.html>
- 4 <https://riscv.org>
- 5 <https://www.oreilly.com/library/view/tinymt/9781492052036/>
- 6 <https://ocw.mit.edu/courses/6-858-computer-systems-security-fall-2014/>
- 7 <https://www.coursera.org/learn/introduction-embedded-systems>

23EC904	COMPUTATIONAL INTELLIGENCE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce the concepts of Soft Computing and highlight how they differ from traditional computational approaches.
- 2 To study the basics of Fuzzy Logic and its applications in decision-making systems.
- 3 To understand and apply Fuzzy Inference Systems for modeling real-world problems.
- 4 To explain the structure, learning methods, and applications of Artificial Neural Networks.
- 5 To explore Unsupervised Learning and advanced Neural Network models.
- 6 To integrate fuzzy logic and neural networks into control systems and embedded applications.

FUNDAMENTALS OF SOFT COMPUTING AND FUZZY LOGIC

15

Classical Sets and Fuzzy Sets — Basics of Fuzzy Sets and Membership Functions — Set Operations: Union, Intersection, Complement — Fuzzy Relations — Fuzzification and Defuzzification — Fuzzy If-Then Rules — Rule-Based Systems: Knowledge Base, Data Base, Rule Base, and Decision-Making Logic — Fuzzy Logic Controllers: Mamdani Architecture and Sugeno-Takagi Architecture.

FOUNDATIONS AND ARCHITECTURES OF NEURAL NETWORKS

15

Biological Neurons and their Artificial Models — Neuron Modeling — Basic Learning Mechanisms and Learning Factors influencing Neural Networks — Single Layer Networks and Multi-Layer Feed Forward Networks — Supervised Learning Models: Perceptron, Adaline, Multi-Layer Neural Networks, Backpropagation Algorithm, Radial Basis Function (RBF) Networks, and Functional Link Artificial Neural Networks (FLANN) — Unsupervised Learning Models: Competitive Learning Networks, Kohonen Self-Organizing Maps (SOM), and Hopfield Networks.

EVOLUTIONARY COMPUTATION AND OPTIMIZATION TECHNIQUES

15

Adaptive neuro-fuzzy inference systems (ANFIS), coactive neuro-fuzzy modelling, and neuro-fuzzy control. case studies: smart temperature control, handwritten digit recognition, and fault detection in industrial machines. Implementation challenges and integration of fuzzy logic and neural networks in embedded controllers

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Explain the basic principles of fuzzy sets, membership functions, and fuzzy operations | [U] |
| CO2 | Apply fuzzy logic control techniques in rule-based decision-making systems | [U] |
| CO3 | Describe neural architectures, learning algorithms, and network models for pattern recognition | [U] |
| CO4 | Analyze and design supervised and unsupervised neural networks. | [AN] |
| CO5 | Implement and evaluate neuro-fuzzy systems for real-time applications like control and classification | [AP] |

TEXT BOOKS:

- 1 Jacek M. Zurada, Introduction to Artificial Neural Systems, Jaico Publishing House, New Delhi, 2006.
- 2 John Yen, Reza Langari, Fuzzy logic Intelligence, control and Information, Pearson Education, 2011.
- 3 H.J. Zimmerman, Fuzzy Set Theory-and its Applications, Kluwer Academic Publishers, New Delhi 2014.
- 4 B. Kosko, Neural Networks and Fuzzy Systems, Prentice Hall of India Ltd., New Delhi 2009.

REFERENCE BOOKS:

- 1 B. Yagnanarayanan, Artificial Neural Networks, Prentice Hall of India Ltd., New Delhi 2012.
- 2 G.J. Klir and T.A. Folger, Fuzzy Sets, Uncertainty and Information, Prentice-Hall of India Ltd., 2015

WEB RESOURCES:

- 1 <https://towardsdatascience.com>
- 2 <https://link.springer.com/series/7092>
- 3 <https://www.sciencedirect.com/topics/computer-science/evolutionary-algorithm>
- 4 <https://www.fuzzytech.com>
- 5 <https://www.coursera.org/learn/fuzzy-logic>
- 6 <https://nptel.ac.in/courses/106105173>
- 7 <https://www.udemy.com/course/artificial-neural-networks-for-beginners/>

23EC905	EMBEDDED SYSTEM DESIGN USING IoT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To Understand the fundamental concepts of embedded system design.
- 2 Ability to Explain the architecture and working of microcontrollers used in embedded systems
- 3 To Develop programming skills for embedded hardware interfacing.
- 4 To Understand the basics of IoT and its integration with embedded system
- 5 Enable the students to Apply IoT protocols and cloud services to build real-time applications
- 6 To Understand the security challenges and testing techniques for embedded IoT systems.

FUNDAMENTALS OF EMBEDDED SYSTEM DESIGN

15

Introduction to Embedded Systems-Embedded System Architecture: Hardware and Software Components-Input/Output Devices, Memory Systems-Embedded C Programming Fundamentals-Basics of Real-Time Operating Systems (RTOS)-Design Methodology for-Embedded Systems-Development Tools: Compilers, Debuggers, IDEs

IoT INTEGRATION WITH EMBEDDED SYSTEMS

15

Introduction to Internet of Things (IoT)-Embedded Platforms for IoT (ESP32, Raspberry Pi, Arduino)-Sensor and Actuator Interfacing Techniques-IoT Communication Technologies: WiFi, BLE, Zigbee, LoRaWAN-Networking Protocols: MQTT, CoAP, HTTP-Cloud Platforms for IoT (AWS IoT, Google Cloud IoT, Thingspeak, Blynk)-Edge Computing and Local Data Processing Basics-Power Management for IoT Devices

SECURITY, TESTING AND APPLICATIONS OF EMBEDDED IoT SYSTEMS

15

Security in IoT Embedded Systems: Encryption, Authentication, Secure Boot-Firmware Updates and Over-The-Air (OTA) Mechanisms-Testing Techniques: Unit Testing, Integration Testing, System Testing-Debugging Embedded IoT Systems-Case Studies and Applications: Smart Homes-Smart Agriculture- Healthcare-Industrial IoT (IIoT) Systems

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Describe the architecture, components, and characteristics of embedded systems. | [U] |
| CO2 | Develop basic embedded C programs to interface input/output devices with microcontrollers. | [U] |
| CO3 | Interface sensors, actuators, and communication modules with embedded hardware for IoT applications. | [AP] |
| CO4 | Implement IoT protocols and send/receive data between embedded systems and cloud platforms | [AN] |
| CO5 | Apply security mechanisms to ensure safe communication and firmware updates in IoT systems | [AP] |

Text Books:

- 1 Raj Kamal," Embedded Systems: Architecture, Programming and Design" McGraw Hill Education, 2020
- 2 Perry Lea, "Internet of Things for Architects", 1st edition, Packt Publishing, 2018
- 3 Raj Kamal," INTERNET OF THINGS Architecture and Design Principles," McGraw Hill Education, 2022
- 4 Rajkumar Buyya, Amir Vahid Dastjerdi," Internet of Things: Principles and Paradigm", Morgan Kaufmann (Elsevier), 2020 (2nd Edition)

Reference Books:

- 1 Raj Kamal, "Internet of Things: Architecture and Design Principles", McGraw-Hill Education, 2021
- 2 Simone Cirani, Gianluigi Ferrari, Marco Picone, Marco Picone, "Internet of Things_ Architectures, Protocols and Standards" Wiley, 2019

Web References:

- 1 <https://www.tescaglobal.com/embedded-system-design/>
- 2 <https://www.ibm.com/internet-of-things>
- 3 <https://www.edx.org/course/embedded-systems-programming>
- 4 <https://www.iotforall.com/iot-security-challenges>
- 5 <https://create.arduino.cc/projecthub>
- 6 <https://projects.raspberrypi.org/en/projects?software%5B%5D=python>
- 7 <https://www.postscapes.com/internet-of-things-platforms/>

23EC906	EMBEDDED PROCESSORS AND ARCHITECTURE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 Understand the fundamental architecture and features of the Cortex-M processor family
- 2 Gain knowledge about the programming model of the Cortex-M processor, including memory systems, registers, and exceptions
- 3 Develop proficiency in programming assembly language for Cortex-M processors.
- 4 Learn how to handle interrupts and exceptions, optimizing system performance and power consumption
- 5 Acquire skills in embedded system development, including system initialization, memory management, and real-time operating systems (RTOS)
- 6 Interface with various peripherals (e.g., UART, ADC/DAC, SD cards) and manage I/O operations for embedded systems

INTRODUCTION TO CORTEX-M PROCESSOR ARCHITECTURE

15

Cortex-M Processor Family: Overview and Advantages -Cortex-M3 and Cortex-M4 Processors: Block diagram and architectural details-Programmer's Model: Registers, Program Status, and Memory Systems-Exceptions and Interrupts: Basic concepts and interrupt handling-Assembly Language for Cortex-M: Syntax, instruction set, and barrel shifter-Memory System: Connecting the processor to memory and peripherals.

CORTEX-M PROCESSOR FEATURES AND INTERRUPT MANAGEMENT

15

Exceptions and Interrupts: Types, management, and NVIC (Nested Vector Interrupt Controller)-Interrupt and Exception Handling: Priority, vector table, latency, fault exceptions-Low Power Features: Techniques for reducing power consumption-Support: Shadowed stack pointer, context switching, SVC exception, PendSV exception-Exception and Interrupt Optimization: Strategies for improving interrupt handling.

EMBEDDED SYSTEM DEVELOPMENT AND PERIPHERAL INTERFACING

15

UART Interface, Debugging hardware with Target board, SSI Interface, Analog I/O, A/D converter interfacing, Communication system with Ethernet. Memory Management, Dynamic Memory Allocation in Embedded Systems, Fixed-Size Memory Management in Embedded Systems, Blocking vs. Non-Blocking Memory Functions, An Outside-In Approach to Decomposing Applications

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Describe the architecture and core features of Cortex-M processors (Cortex-M3 and Cortex-M4). | [U] |
| CO2 | Explain the programming model of Cortex-M processors, including memory systems, registers, and interrupts | [U] |
| CO3 | Analyze and implement interrupt and exception handling techniques for efficient system management. | [AN] |
| CO4 | Develop embedded systems with RTOS concepts, managing task scheduling and context switching. | [AP] |
| CO5 | Interface peripherals with Cortex-M processors and implement I/O operations | [AP] |

Text Books:

- 1 Rajkamal, 'Embedded system-Architecture, Programming, Design', TMH, 2020
- 2 The Definitive Guide to the ARM Cortex-M3, Joseph Yiu, econd Edition, Elsevier Inc.2013
- 3 Arnold. S. Berger, "Embedded Systems Design -An introduction to Processes, Tools and Techniques", Easwer Press 2001
- 4 C. M. Krishna and K. G. Shin, Real-Time Systems, McGraw-Hill 2E,2010

Reference Books:

- 1 Lyla B Das," Embedded Systems-An Integrated Approach",Pearson, 2024
- 2 Jonathan Valvano, "Embedded Systems: Introduction to ARM Cortex-M Microcontrollers", 5th Edition, 2022, CreateSpace

Web References:

- 1 <https://www.st.com/en/microcontrollers-microprocessors/stm32-32-bit-arm-cortex-mcus.html>
- 2 <https://www.tinymt.org/>
- 3 <https://www.embedded.com/>
- 4 <https://www.nxp.com/docs/en/application-note/AN10216.pdf>
- 5 <https://www.coursera.org/learn/introduction-embedded-systems>
- 6 www.circuitstoday.com/embedded-systems-an-introduction
- 7 <https://www.codrey.com/embedded-systems/embedded-systems-introduction/>

23EC907	EMBEDDED PROGRAMMING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To understand the low-level concepts of programming such as memory layout, pointer usage, and bit manipulation in C.
- 2 To learn how C language features and file handling are used in embedded systems
- 3 To introduce students to Linux command-line tools and basic shell scripting techniques used in embedded development.
- 4 To provide hands-on experience with real-time programming using POSIX threads and kernel timing tools
- 5 To explain how device drivers interact with hardware through kernel modules and file operations
- 6 To introduce debugging techniques, interrupt handling, and driver development using a mini project on virtual sensors

INTRODUCTION TO PROGRAMMING

15

Low-Level Concepts: CPU registers, stack vs heap - Memory layout: .text, .data, .bss sections - Pointers & addresses: Pointer arithmetic, void pointers - Bit manipulation: Masking, shifting, bitfields - High-Level Abstraction: Functions vs macros, Structures/Unions: Memory alignment, padding, File I/O: Text vs binary modes, Basic data structures: Arrays vs linked lists - C for Embedded: volatile keyword (hardware registers) - const & static (ROM vs RAM usage) - Cross-compilation intro (host vs target).

EMBEDDED LINUX & SHELL SCRIPTING

15

Linux CLI for Embedded: Basic commands, Pipes/redirection: Log filtering (dmesg | grep error), Process control: ps, kill, nice, systemd - Shell Scripting for Embedded: Looping, Conditionals, Pattern matching: sed/awk - Practical use case: Write a build script for a kernel module - Real-Time Programming: POSIX threads, RT priorities, cyclictst.

LINUX DEVICE DRIVERS & KERNEL PROGRAMMING

15

Linux System Overview for Drivers: Kernel space vs User space, Device Driver basics - File operations: open(), read(), write(), ioctl() - copy_to_user, copy_from_user for User-Kernel Data Exchange - Interrupt Handling - Introduction to IRQs - Kernel Debugging and Performance: checking memory leaks, race conditions - Case Study: Mini Application — Virtual Sensor Driver Project.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the use of pointers, structures, file operations, and optimization techniques in embedded C programming. | [U] |
| CO2 | Use Linux CLI commands and scripting techniques to automate tasks and manage embedded Linux systems. | [AP] |
| CO3 | Implement real-time multi-threaded applications considering task scheduling and priority management on Linux-based systems. | [AP] |
| CO4 | Compute and test Linux character device drivers to enable communication between user-space applications and kernel modules. | [AP] |
| CO5 | Apply debugging and tracing techniques to optimize kernel modules and analyze performance in embedded Linux systems. | [AP] |

Text Books:

- 1 Michael Barr, Anthony Massa, "Programming Embedded System with C and GNU
- 2 Development Tools" O'Reilly Media, 2006.
- 3 Neil Mathew, Richard stones, "Beginning Linux Programming" 3rd Edition, Wrox – Wiley Publishing.2004
- 4 C Programming language Brian W. Kernighan, Dennis Ritchie.2012

Reference Books:

- 1 Advanced Linux Programming by Mark Mitchell, Jeffrey Oldham, and Alex Samuel.,2005
- 2 Linux Device Drivers by Alessandro Rubini, Elsevier 2005

Web References:

- 1 <https://embeddedartistry.com/>
- 2 <https://linuxcommand.org/>
- 3 <https://kernelnewbies.org/KernelDebuggingTips>
- 4 https://elinux.org/Main_Page
- 5 <https://archive.nptel.ac.in/courses/106/105/106105159/>
- 6 <https://www.coursera.org/specializations/embedded-software-development-with-c>
- 7 <https://www.coursera.org/learn/introduction-embedded-systems>

23EC908	INDUSTRIAL IoT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce the fundamental principles of Industrial IoT and relevance to Industry 4.0
- 2 To help students learn about key technologies and communication methods used in IIoT systems
- 3 To explain how IIoT systems are built using different layers like sensors, processing units, and communication networks
- 4 To explore various industrial IoT platforms and understand how they are used in real-world industries.
- 5 To learn how industrial data is collected and analyzed using tools like big data and machine learning.
- 6 To understand the importance of security in IIoT systems and explore methods to protect them.

FUNDAMENTALS OF IIOT AND INDUSTRY 4.0

15

Introduction to Industrial IoT (IIoT), Elements of an IoT Ecosystem: Technology Drivers, Business Drivers, Typical IIoT Applications and Trends, IoT Hardware Platforms Overview (Microcontrollers, Embedded PCs), M2M Communication, Web of Things (WoT), Internet and Web Layering Concepts, Business Aspects of IoT and IIoT, REST Architecture and Challenges of IoT, Role of IoT and IIoT in Industry 4.0 Revolutions.

INDUSTRIAL IIOT SYSTEMS

15

IIoT-Introduction, Digital Twin, Industrial IoT: Business Model and Reference Architecture: IIoT Business Models, Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication, IIoT Networking, Edge Computing in IIoT, IoT Platforms for Industrial Applications: Overview of AWS IoT, Azure IoT Hub, PTC ThingWorx, OPC UA: Secure data exchange standards for industrial systems.

IIOT ANALYTICS & IOT SECURITY

15

Big Data Analytics and Software Defined Networks, Machine Learning and Data Science, Julia Programming, Data Management with Hadoop, Industrial IoT: Security and Fog Computing – Cloud Computing in IIoT, Fog Computing in IIoT, Security in IIoT. Zero Trust Security Model for IIoT, TinyML: Machine Learning on Edge Devices, Blockchain for Securing IIoT Devices.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Describe the ecosystem, hardware platforms, and protocols used in IIoT. | [U] |
| CO2 | Explain the layered architecture and reference models of Industrial IoT system | [U] |
| CO3 | Analyze key IIoT platforms such as AWS, Azure, and ThingWorx and their industrial applications. | [AN] |
| CO4 | Apply IIoT architecture and networking concepts | [AP] |
| CO5 | Design secure, scalable IIoT systems using Fog/Cloud/TinyML/Blockchain principles | [AP] |

Text Books:

- 1 M. Kranz, "Building the Internet of Things: Implement New Business Models,

Disrupt Competitors, Transform Your Industry", Wiley, 2017.

2 S. Bhattacharjee and S. Kak, "Practical Industrial Internet of Things Security: A Practitioner's Guide to Securing Connected Industries", Apress, 2020.

3 P. Lea, "Internet of Things for Architects: Architecting IoT solutions by implementing sensors, communication infrastructure, edge computing, analytics, and security", Packt Publishing, 2018.

4 K. Schwab, "The Fourth Industrial Revolution", Crown Business, 2016.

Reference Books:

1 B. Sinclair, "IoT Inc.: How Your Company Can Use the Internet of Things to Win in the Outcome Economy", International Society of Automation (ISA), 2017.

2 J. Biron and J. Follett, "Foundational Elements of an IoT Solution", O'Reilly Media, 2016. 7. Keysight Technologies, "The Internet of Things: Enabling Technologies and Solutions for Design and Test, Application Note", 2016.

Web References:

1 <https://www.iotforall.com>

2 <https://www.cisco.com/c/en/us/solutions/internet-of-things/overview.html>

3 <https://www.iiconsortium.org/>

4 <https://www.iiot-world.com/>

23EC909	EMBEDDED ROBOTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To Understand the fundamental concepts, history, laws, and the need for robotics,
- 2 To Develop knowledge of different types of robot joints, links, wrist mechanisms, end effectors, and the role of microcontrollers in robotic systems.
- 3 To understand the mathematical modeling of robot and homogeneous transformations in 2D/3D space
- 4 To develop basic knowledge of control strategies and sensor integration in robotic manipulators and autonomous systems
- 5 To Acquire knowledge about the application of computer vision and pattern recognition techniques in robotic systems.
- 6 To Gain exposure to real-world robotic vision applications through case studies and basic image processing

INTRODUCTION TO ROBOTICS

15

Basics of Robotics: Definition, Basic Concepts, Need for Robots - History of Robotics - Laws of Robotics (Asimov's Laws) - Anatomy and Specifications of Robots - Robot Configurations: Cartesian, Cylindrical, Polar, Articulate Robots - Robot Wrist Mechanisms - Robot Joints and Links – Types and Characteristics - End Effectors: Classifications, Types of Mechanical Actuation - Basics of Gripper Design - Introduction to Microcontrollers in Robotics: Architectures, Addressing modes and Instruction sets.

ROBOT KINEMATICS AND CONTROL SYSTEMS

15

Robot Kinematics: Direct and Inverse Kinematics - Robot Trajectories - 2D and 3D Transformations: Scaling, Rotation, Translation - Homogeneous transformations - Control of Robot Manipulators - Point-to-Point Control - Continuous Path Control - Basics of Robot Programming - Robot Sensors: Touch, Tactile, Proximity, Range, Force, Light, Pressure Sensors - Basics of Machine Vision and Artificial Intelligence.

ROBOT VISION AND APPLICATIONS

15

Robot Vision Applications: Pattern Recognition - Embedded Systems in Robotics - Computer Vision in Robotics - Case Studies: Automated Navigation Guidance, Vision-based Depalletizing, Line Tracking, Automatic Part Recognition - Image Processing for Robotics - Basic Techniques using MATLAB/OPENCV

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand the different robot configurations, joint types, wrist mechanisms, and the basics of end effectors and microcontroller integration. | [U] |
| CO2 | Solve problems related to direct and inverse kinematics, homogeneous transformations, and robot trajectory planning. | [AP] |
| CO3 | Implement basic robot control strategies and demonstrate an understanding of robotic sensors and introductory programming techniques. | [AP] |
| CO4 | Apply computer vision techniques and pattern recognition methods to simple robotic tasks. | [AP] |
| CO5 | Analyze and evaluate vision-based robotic applications through case studies and perform basic image processing operations. | [AN] |

Text Books:

- 1 Dr. Jisu Elsa Jacob, Manjunath N, Robotics Simplified: An Illustrative Guide to Learn Fundamentals of Robotics, Including Kinematics, Motion Control, and Trajectory Planning, Paperback, 2022
- 2 John J. Craig, "Introduction to Robotics: Mechanics and Control", Fourth Edition, Pearson, 2022.
- 3 S. B. Niku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd., (2024)
- 4 N.P. Bali and Manish Goyal, A textbook of Engineering Mathematics, Laxmi Publications, New Delhi, 10th edition, 2020.

Reference Books:

- 1 Anis Koubaa, "Robot Operating System (ROS) The Complete Reference", First Volume, Springer, 2024
- 2 Richard D. Klafter, Thomas A. Chmielewski, Robotic Engineering: An Integrated Approach, 2nd Edition, PHI, 2018

Web References:

- 1 <https://wiki.ros.org/ROS/Tutorials>
- 2 <https://www.arm.com/products/silicon-ip-cpu/cortex-m/cortex-m4>
- 3 <https://www.robotshop.com/blog/en>
- 4 <https://www.mathworks.com/solutions/robotics.html>

23EC910	RECONFIGURABLE ARCHITECTURE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 The student shall develop an overview and deeper insight into the research and development that is underway to meet future needs of flexible processors
- 2 To learn the concepts of implementation, synthesis and placement of modules in reconfigurable architectures
- 3 To understand the communication techniques and System on Programmable Chip for reconfigurable architectures
- 4 To learn the process of reconfiguration management
- 5 To familiarize the applications of reconfigurable architectures
- 6 To explore real-world case studies and performance optimization strategies in reconfigurable systems.

IMPLEMENTATION, SYNTHESIS AND PLACEMENT

15

General purpose computing – domain specific processors – Application Specific Processors – reconfigurable computing – fields of application – evolution of reconfigurable systems – simple Programmable Logic Devices – Complex Programmable Logic Devices – Field Programmable Gate Arrays – coarse grained reconfigurable devices- Integration – FPGA design flow – logic synthesis – LUT based technology mapping – modeling – temporal partitioning algorithms – offline and online temporal placement – managing device's free and occupied spaces.

COMMUNICATION TECHNIQUES AND RECONFIGURATION MANAGEMENT IN SoPCs

15

Direct communication – communication over third party – bus-based communication – circuit switching – Network on Chip – dynamic Network on Chip – System on a Programmable Chip – adaptive multi-processing on chip- Reconfiguration – configuration architectures – managing the reconfiguration process – reducing configuration transfer time – configuration security.

REAL-WORLD APPLICATIONS OF FPGA AND RECONFIGURABLE ARCHITECTURES

15

FPGA based parallel pattern matching – low power FPGA based architecture for microphone arrays in Wireless Sensor Networks – exploiting partial reconfiguration on a dynamic coarse grained reconfigurable architecture – parallel pipelined OFDM baseband modulator with dynamic frequency scaling for 5G systems.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Interpret the different architecture principles relevant to reconfigurable computing systems | [U] |
| CO2 | Illustrate the necessary trade-offs to meet the area, power and timing criteria of reconfigurable systems | [AP] |
| CO3 | Infer the algorithms related to placement and partitioning | [AN] |
| CO4 | Illustrate the communication techniques and system on programmable chip for reconfigurable architectures | [AP] |
| CO5 | Apply the principles of Network and System on a Programmable Chip | [AP] |

Text Books:

- 1 Francesca Palumbo “Applied Reconfigurable Computing: Architectures, Tools, and Applications”, Springer 2023
- 2 Nikoloas Voros Et Al. “Applied Reconfigurable Computing: Architectures, Tools and Applications” Springer, 2018.
- 3 Christophe Bobda, “Introduction to Reconfigurable Computing: Architectures, Algorithms and Applications”, Springer 2007.
- 4 Koen Bertels, João M.P. Cardoso, Stamatias Vassiliadis, “Reconfigurable Computing: Architectures and Applications”, Springer 2006.

Reference Books:

- 1 Scott Hauck and Andre Dehon, “Reconfigurable Computing: The Theory and Practice of FPGA Based Computation”, Elsevier 2008
- 2 M. Gokhale and P. Graham, “Reconfigurable Computing: Accelerating Computation with Field-Programmable Gate Arrays”, Springer, 2005

Web References:

- 1 <https://www.xilinx.com>
- 2 <https://www.intel.com/content/www/us/en/products/details/fpga.html>
- 3 <https://www.mentor.com>

23EC911	VLSI ARCHITECTURES FOR AI ALGORITHMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To enable students to understand the basic concepts of VLSI architectures used in AI and machine learning.
- 2 To teach techniques like parallelism, pipelining, and memory organization used in AI hardware.
- 3 To explain different VLSI design methods for building efficient AI systems.
- 4 To introduce hardware structures like systolic arrays and neural network accelerators used in deep learning.
- 5 To provide an understanding of how hardware and software work together in AI-based VLSI systems.
- 6 To expose students to the latest industry trends and research in AI hardware.

FUNDAMENTALS OF VLSI FOR AI

15

Overview of AI and Machine Learning Algorithms: Matrix operations, CNNs, RNNs- Computational characteristics of AI workloads- Basics of VLSI design: Area, Power, Speed trade-offs- Arithmetic units for AI: Adders, Multipliers, MAC units.

ARCHITECTURES AND ACCELERATORS

15

Dataflow architectures: SIMD, MIMD- Systolic arrays and applications in matrix multiplications - Hardware implementation of Neural Networks: Fixed-point vs Floating-point processing- Memory-centric architectures for AI: Buffer design, Memory Hierarchy for AI.

EMERGING TRENDS IN AI HARDWARE

15

AI-specific ASICs and SoCs: TPU, Eyeriss - FPGA-based AI acceleration- Low-power AI designs and energy-efficient computing- Hardware/Software Co-design for AI systems.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand and model AI algorithms suitable for VLSI hardware realization. | [U] |
| CO2 | Infer the specialized VLSI architectures for efficient AI algorithm execution. | [AN] |
| CO3 | Apply parallel and pipelined data path architectures like systolic arrays. | [AP] |
| CO4 | Infer various design trade-offs including performance, power, and area for AI hardware. | [AN] |
| CO5 | Analyze cutting-edge AI accelerators and co-design methods for future AI-based VLSI solutions. | [AN] |

Text Books:

- 1 Sze, Vivienne, Efficient Processing of Deep Neural Networks: A Tutorial and Survey, Morgan & Claypool Publishers, 2020.
- 2 Mead, Carver and Conway, Lynn, Introduction to VLSI Systems, Addison-Wesley, 1980.
- 3 Bell, Alexander; Horowitz, Mark, Compiling Algorithms for Heterogeneous Systems, Morgan & Claypool Publishers, 2018.

Reference Books:

- 1 Chen, Yu-Hsin; Yang, Tien-Ju; Sze, Vivienne, *Eyeriss: A Spatial Architecture for Energy-Efficient Dataflow for Convolutional Neural Networks*, Springer, 2020.
- 2 Murmann, Boris, *Mixed-Signal Circuits for Machine Learning Applications*, Springer, 2019.
- 3 Hennessy, John L. and Patterson, David A., *Computer Architecture: A Quantitative Approach*, 6th Edition, Morgan Kaufmann, 2024.

Web References:

- 1 <https://energy.mit.edu/research/ai-hardware/>
- 2 <https://cloud.google.com/tpu/docs/tpus>
- 3 <https://vlsi.stanford.edu/>
- 4 <https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=92>

23EC912	LOW POWER VLSI DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To enable students to understand the fundamental principles and key sources of power dissipation in CMOS circuits.
- 2 To facilitate students in analyzing and designing low-power VLSI systems across different abstraction levels.
- 3 To introduce synthesis and optimization methods for low-power digital and memory circuit design.
- 4 To explain the challenges of low-voltage CMOS design and approaches to reduce leakage power.
- 5 To develop student competency in designing energy-efficient VLSI architectures at device, circuit and system levels.
- 6 To expose students to current research directions and industry practices in low-power VLSI design methodologies.

POWER DISSIPATION MECHANISMS AND LOW-POWER CIRCUIT DESIGN 15

Sources of power dissipation – Physics of power dissipation in MOSFET devices: The MIS structure, long channel MOSFET, Submicron MOSFET, gate induced drain leakage– Power dissipation in CMOS: short circuit dissipation, dynamic dissipation, load capacitance– Low power VLSI design: Limits – principles of low power design. Transistor and Gate Sizing: Sizing an Inverter Chain, Transistor and Gate Sizing for Dynamic Power Reduction, Transistor Sizing for Leakage Power Reduction - Network Restructuring and Reorganization: Transistor Network Restructuring, Transistor Network Partitioning and Reorganization - Special Latches and Flip-flops: Self-gating Flip-flop, Varieties of Boolean Functions, Adjustable Device Threshold Voltage

LOW-POWER SYNTHESIS AND SRAM ARCHITECTURE OPTIMIZATION 15

Behavioral Level Transforms, Logic Level Optimization for Low power, Circuit Level Optimization. Organization of a static RAM, MOS Static RAM Memory cell, Banked organization of SRAMs, reducing voltage swings on bit lines, reducing power in write driver circuits, reducing power in sense amplifier circuits, method for achieving low core voltages from a single supply.

DESIGN AND TEST OF LOW VOLTAGE CMOS CIRCUITS 15

Circuit Design style, Leakage current in deep submicrometer transistors, Deep submicrometer device design issues, Low voltage circuit design techniques, Designing deep submicrometer ics with elevated intrinsic leakage, multiple supply voltages.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Analyze various sources of power consumption in CMOS technologies. | [AN] |
| CO2 | Apply effective design strategies to minimize both dynamic and static power dissipation in VLSI circuits. | [AP] |
| CO3 | Understand low-power SRAM architectures and memory optimization techniques. | [U] |
| CO4 | Illustrate low-voltage CMOS design techniques suitable for submicron technologies. | [U] |

CO5 Analyze recent innovations, industrial practices, and methodologies for low- power VLSI design. [AN]

Text Books:

- 1 Narang, Dipankar, *Low-Power CMOS VLSI Design: A Comprehensive Guide*, CRC Press, 2023.
- 2 Rabaey, Jan M., *Low Power Design Essentials*, Springer, 2017.
- 3 Roy, Kaushik and Prasad, Sharat C., *Low Power CMOS VLSI Circuit Design*, Wiley-Interscience, 2000.

Reference Books:

- 1 **Murmann, Boris**, *Mixed-Signal Circuits for Machine Learning Applications*, Springer, 2019.
- 2 **Chandrakasan, Anantha P.; Bowhill, William J.; Fox, Frank**, *Design of High-Performance Microprocessor Circuits*, Wiley-Blackwell, 2001.
- 3 **Chandrakasan, Anantha P.; Brodersen, Robert W.**, *Low-Power CMOS Design*, IEEE Press, 1995.

Web References:

- 1 <https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=92>
- 2 <https://pages.hmc.edu/harris/cmosvlsi/4e/index.html>
- 3 <https://www.islped.org/2025/>
- 4 <https://www.edaboard.com/forums/low-power-design.45/>

23EC913	TESTING OF VLSI CIRCUITS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To enable students to understand the fundamentals of VLSI circuit testing and the various fault models used in industry.
- 2 To impart knowledge of effective test generation techniques for both combinational and sequential circuits.
- 3 To introduce design-for-testability (DFT) concepts and built-in self-test (BIST) methodologies for reliable circuit testing.
- 4 To expose students to memory and embedded system testing algorithms.
- 5 To familiarize students with fault diagnosis techniques and self-checking logic designs.
- 6 To equip students with knowledge on system-level diagnosis and approaches for achieving fault tolerance in VLSI systems.

FUNDAMENTALS OF VLSI TESTING AND FAULT MODELING

15

Introduction to Testing - Faults in digital circuits - Modeling of faults - Logical Fault Models - Fault detection - Fault location - Fault dominance - Logic Simulation - Types of simulation - Delay models - Gate level Event-driven simulation. Test generation for combinational logic circuits - Testable combinational logic circuit design - Test generation for sequential circuits - design of testable sequential circuits.

DESIGN FOR TESTABILITY AND BUILT-IN SELF-TEST TECHNIQUES

15

Design for Testability - Ad-hoc design - Generic scan-based design - Classical scan-based design – System level DFT approaches. Built-In Self-Test - Test pattern generation for BIST - Circular BIST - BIST Architectures - Testable Memory Design - Test algorithms - Test generation for Embedded RAMs.

FAULT DIAGNOSIS AND SELF-CHECKING MECHANISMS

15

Level Diagnosis - Diagnosis by UUT reduction - Fault Diagnosis for Combinational Circuits - Self-checking design - System Level Diagnosis.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Identify various types of faults in digital circuits and understand fault modeling techniques. | [U] |
| CO2 | Infer test patterns for combinational and sequential circuits to ensure fault coverage. | [AN] |
| CO3 | Apply design for testability techniques and understand scan-based design methodologies. | [AP] |
| CO4 | Discuss the built-in self-test (BIST) architectures for complex VLSI circuits and memories | [U] |
| CO5 | Analyze and perform fault diagnosis and self-checking design at the system level. | [AN] |

Text Books:

- 1 M. Abramovici, M.A. Breuer, and A.D. Friedman, Digital Systems and Testable Design, Jaico Publishing House, 2021.
- 2 Bushnell, M. L.; Agrawal, V. D., Essentials of Electronic Testing for Digital,

Memory and Mixed-Signal VLSI Circuits, Springer, 2006.

Reference Books:

- 1 P.K. Lala, "Digital Circuit Testing and Testability", Academic Press, 2002.
- 2 A.L. Crouch, Design for Test for Digital IC's and Embedded Core Systems, Prentice Hall International, 1999.

Web References:

- 1 <https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=43>
- 2 <https://www.itctestweek.org/>
- 3 <https://www.edaboard.com/forums/ic-design-and-test.8/>
- 4 <https://www.crhc.illinois.edu/>

23EC914	DIGITAL CMOS VLSI DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To enable students to understand the basic behavior of MOSFETs and CMOS inverters.
- 2 To illustrate how secondary effects impact power, delay, and energy in CMOS circuits.
- 3 To equip students with the ability to design combinational and sequential logic circuits using CMOS techniques.
- 4 To facilitate analysis of timing and performance in static and dynamic sequential circuits.
- 5 To develop student proficiency in designing arithmetic units and memory blocks like adders, multipliers, and SRAM.
- 6 To introduce students to the use of Hardware Description Languages (HDL) for digital circuit modeling and synthesis.

MOS TRANSISTOR PRINCIPLES AND CMOS INVERTER

15

MOSFET Transistor Characteristic under Static and Dynamic Conditions, MOS Transistor Secondary Effects, CMOS Inverter - Static Characteristic, Dynamic Characteristic, Power, Energy, and Energy Delay parameters.

COMBINATIONAL AND SEQUENTIAL CIRCUITS

15

Static CMOS Design – Complementary CMOS, Ratioed Logic, Pass-Transistor Logic. Dynamic CMOS Design – Dynamic Logic: Basic Principles, Speed and Power Dissipation of Dynamic Logic, Issues in Dynamic Design, Cascading Dynamic Gates- Timing metrics for sequential circuits, Static Latches and Registers, Dynamic Latches and Registers, Pipelines, Pulse and sense amplifier-based Registers, Non-Bistable Sequential Circuits.

ARITHMETIC BUILDING BLOCKS AND MEMORY ARCHITECTURES

15

Data path circuits, Architectures for Adders, Multipliers, Shifters, Speed and Area Tradeoffs, Array Subsystems: SRAM, DRAM, ROM. Introduction, Power distribution, Input/Output, Clock, Hardware Description Languages, Verilog HDL: Behavioral modeling, Structural gate modeling, Switch modeling, Basic constructs, FSM, High-level synthesis.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Explain the static and dynamic behavior of MOSFET transistors and CMOS inverters. | [U] |
| CO2 | Analyze the influence of secondary effects on CMOS inverter performance metrics like power and delay. | [AN] |
| CO3 | Design combinational and sequential circuits using CMOS static and dynamic logic techniques. | [AP] |
| CO4 | Evaluate the performance and timing issues in sequential circuits like latches, registers, and pipelines. | [AN] |
| CO5 | Demonstrate the modeling of digital circuits using Verilog HDL and describe memory subsystem architectures. | [AP] |

Text Books:

- 1 Jan M Rabaey, Anantha Chandrakasan, B Nikolic, Digital Integrated Circuits: A Design Perspective, Second Edition, 2023, Prentice Hall of India.
- 2 Niel H.E. Weste, David Harris, Ayan Banerjee, CMOS VLSI Design- A circuits and Systems Perspective, Third Edition, 2013, Pearson education.

- 3 Chris Spear, Systemverilog for Verification, Springer, 2006.
- 4 Wayne Wolf, Modern VLSI Design, PHI Learning Private Limited, New Delhi, 2011.

Reference Books:

- 1 Douglas A. Pucknell, Kamran Eshraghian, Basic VLSI Design, Third Edition, Prentice Hall of India, 2005.
- 2 Chris Spear, SystemVerilog for Verification: A Guide to Learning the Testbench Language Features, Springer, 2006.

Web References:

- 1 <https://www.coursera.org/learn/vlsi-cad>
- 2 <https://nptel.ac.in/courses/117106092>
- 3 <https://www.eetimes.com/tag/vlsi/>
- 4 <https://www.ece.ucsb.edu/Faculty/rodriuez/VLSI/>

23EC915	ANALOG VLSI DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To enable students to understand the fundamentals of MOS device physics and analog circuit building blocks.
- 2 To guide students in analyzing various noise sources and designing effective analog filters.
- 3 To facilitate the evaluation of data converters with respect to their performance parameters and architectures.
- 4 To equip students with strategies for testing and validating analog VLSI circuits.
- 5 To introduce analog VLSI systems applied to vision and sensory applications.
- 6 To develop the ability to design and test analog VLSI systems for specialized and emerging applications.

MOS DEVICE PHYSICS AND BASIC ANALOG CIRCUITS

15

MOS Device Models: Small Signal Models, Basic CMOS circuits, Gain stages. – BICMOS Technology: Fabrication and design rules. – Passive IC Components: Capacitor and resistor. – Analog Circuits and Amplifiers: Current mirrors, Voltage references, Comparators. – Amplifiers: Inverting and differential amplifiers. – Op-Amps: Two-stage op-amps (BJT and CMOS), Folded cascode op-amp, Instrumentation amplifier.

NOISE, FILTERS, AND DATA CONVERTERS

15

Noise and Filters: Noise spectrum, Thermal and Flicker noise, Noise bandwidth, Noise figure. – Filters: Low pass, High pass, Band pass filters, Phase Locked Loops (PLL). – D/A and A/D Converters: Ideal converters, Quantization noise, Performance limitations. – D/A Converters: Current scaling, Charge scaling, Serial D/A converters. – A/D Converters: Serial and Parallel A/D converters.

ANALOG VLSI TESTING AND SYSTEMS

15

Fault Modelling and Simulation – Built-In Self Test (BIST) Techniques – Analog VLSI for Vision: System design issues, Integrated Image Acquisition, Smoothing and Segmentation Focal Plane Processor.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand MOS device models and basic analog building blocks | [U] |
| CO2 | Analyze the performance of current mirrors, differential pairs, and gain stages. | [AN] |
| CO3 | Apply design principles to develop multistage amplifiers with specified gain and bandwidth. | [AP] |
| CO4 | Analyze frequency response and stability considerations in feedback amplifier circuits. | [AN] |
| CO5 | Design analog circuits such as op-amps, comparators, and oscillators, and analyze their performance. | [AP] |

Text Books:

- 1 Behzad Razavi, Design of Analog CMOS Integrated Circuits, 2nd Edition, 2020.
- 2 Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, 3rd

- Edition, 2012.
- 3 Adel S. Sedra and Kenneth C. Smith, Microelectronic Circuits, 7th Edition, 2014.
 - 4 Tony Chan Carusone, David A. Johns, Kenneth W. Martin, Analog Integrated Circuit Design, 2nd Edition, 2012.

Reference Books:

- 1 Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer, Analysis and Design of Analog Integrated Circuits, 5th Edition, 2009.
- 2 R. Jacob Baker, CMOS: Circuit Design, Layout, and Simulation, 3rd Edition, 2010.

Web References:

- 1 www.students.aiu.edu/submissions/profiles/resources/onlineBook/C6p9V6_CMO_S_Analog_Circuit_Design.pdf
- 2 www.analog.com/en/resources/analog-dialogue/articles/understanding-and-eliminating-1-f-noise.html
- 3 www.mpflynnngroup.com/uploads/7/3/4/9/73490609/08307411.pdf
- 4 eprints.soton.ac.uk/464497/1/822168.pdf

23EC916	SYSTEM ON CHIP DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To explain the principles of low-power design and the impact of resistive and inductive interconnects on delay in VLSI systems.
- 2 To develop the ability to design efficient combinational and sequential logic networks.
- 3 To impart knowledge on power optimization techniques for combinational and sequential logic circuits.
- 4 To introduce testing strategies for logic networks and methods to validate the functionality of sequential systems.
- 5 To enable the design of FPGA and PLA architectures and provide insights into floor planning methodologies for system design.
- 6 To explore on-chip communication architectures and apply low-power design techniques for efficient System-on-Chip (SoC) implementation.

LOGIC GATES

15

Combinational Logic Functions. Static Complementary Gates. Switch Logic. Alternative Gate Circuits. Low-Power Gates. Delay Through Resistive Interconnect. Delay Through Inductive Interconnect.

COMBINATIONAL AND SEQUENTIAL LOGIC NETWORKS

15

Standard Cell-Based Layout. Simulation. Combinational Network Delay. Logic and interconnect Design. Power Optimization. Switch Logic Networks. Combinational Logic Testing. Latches and Flip-Flops. Sequential Systems and Clocking Disciplines. Sequential System Design. Power Optimization. Design Validation. Sequential Testing.

SUBSYSTEM DESIGN AND FLOORPLANNING

15

Introduction. Subsystem Design Principles. Combinational Shifters. Adders. ALUs. Multipliers. High-Density Memory. Field Programmable Gate Arrays. Programmable Logic Arrays. References Problems. Floor-planning Methods – Block Placement & Channel Definition, Global Routing, switchbox Routing.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Explain the principles of logic gate design, including low-power techniques and delay effects in interconnects. | [U] |
| CO2 | Design combinational and sequential logic networks with attention to layout, delay, and power optimization. | [AP] |
| CO3 | Analyze the performance, timing, and validation strategies of sequential systems and logic testing. | [AN] |
| CO4 | Develop arithmetic and memory subsystems such as shifters, adders, ALUs, and high-density memories. | [AP] |
| CO5 | Apply floorplanning techniques including block placement, global routing, and switchbox routing in subsystem design. | [AP] |

Text Books:

- 1 Hubert Kaeslin, *Digital Integrated Circuit Design: From VLSI Architectures to CMOS Fabrication*, 2nd Edition, Cambridge University Press, 2018.
- 2 Mohammad Ismail and Terri S. Fiez, *Analog VLSI: Signal and Information*

Processing, 2nd Edition, Springer, 2022.

Reference Books:

- 1 Yuan Xie, *Design Automation of High-Level Synthesis: From Algorithm to Chip*, Springer, 2020.
- 2 Sudeep Pasricha and Nikil Dutt, *On-Chip Communication Architectures: System on Chip Interconnect*, 2nd Edition, Morgan Kaufmann, 2018.
- 3 Peter Wilson, *Design Recipes for FPGAs: Using Verilog and VHDL*, 3rd Edition, Newnes (Elsevier), 2022.

Web References:

- 1 <https://www.allaboutcircuits.com/technical-articles/introduction-to-digital-circuits>
- 2 <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-111-introduction-to-digital-systems-fall-2006/>
- 3 <https://www.edaplayground.com/>
- 4 <https://www.vlsiencyclopedia.com/2021/02/floorplanning-in-vlsi-design.html>

23EC917	ASIC DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To help students understand the different types of ASICs and programmable technologies like Antifuse, SRAM, EPROM, and EEPROM.
- 2 To explain the VLSI design flow and the role of logic cells, I/O cells, and interconnects in programmable ASICs.
- 3 To enable students to apply partitioning and floorplanning techniques for optimizing speed, area, and power in ASIC designs.
- 4 To guide students in analyzing system-level trade-offs for low-power and asynchronous design.
- 5 To introduce the SoC design flow and compare platform-based and IP-based SoC design methods.
- 6 To explain on-chip communication methods and low-power techniques used in efficient SoC design.

OVERVIEW OF ASIC AND PLD

15

Types of ASICs – VLSI Design flow – Programmable ASICs: Antifuse, SRAM, EPROM, EEPROM-based ASICs – Programmable ASIC logic cells and I/O cells – Programmable interconnects – Latest trends in Programmable Devices: Modern SRAM-based FPGAs (Xilinx UltraScale+), Flash-based CPLDs (Lattice MachXO3) – Soft-core processors (MicroBlaze) – Embedded system integration using IP cores and on-chip communication interfaces.

ASIC PHYSICAL DESIGN

15

Trade off issues at System Level: Optimization with regard to speed, area and power, asynchronous and low power system design. ASIC physical design issues, System Partitioning, Power Dissipation, Partitioning Methods. ASIC floor planning, Placement and Routing.

SYSTEM ON CHIP DESIGN

15

System-On-Chip Design - SoC Design Flow, Platform-based and IP based SoC Designs, Basic Concepts of Bus-Based Communication Architectures, On-Chip Communication Architecture Standards, Low-Power SoC Design High performance algorithms for ASICs/ SoCs as case studies – Canonic Signed Digit Arithmetic.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Demonstrate the complete VLSI tool-flow and illustrate the internal architecture of FPGAs. | [AP] |
| CO2 | Analyze critical issues in ASIC design, including technology selection, design flow management, verification, debugging, and testing | [AN] |
| CO3 | Explain core algorithms used in ASIC construction, such as partitioning, placement, and routing. | [U] |
| CO4 | Understand the fundamentals of System on Chip (SoC) design and describe on-chip communication protocols such as AMBA and AXI. | [U] |
| CO5 | Apply high-performance algorithms and optimization strategies in ASIC and SoC design scenarios. | [AP] |

Text Books:

- 1 Michael J. S. Smith, *Application-Specific Integrated Circuits*, Addison-Wesley, 2021.
- 2 Vaibbhav Taraate, *ASIC Design and Synthesis: RTL Design Using Verilog*, Springer, 2021.

Reference Books:

- 1 David J. Greaves, *Modern System-on-Chip Design on Arm*, Arm Education, 2020.
- 2 Veena S. Chakravarthi and Shivananda R. Koteswar, *System on Chip (SoC) Architecture: A Practical Approach*, Springer, 2023.
- 3 Khaled Salah Mohamed, *Heterogeneous SoC Design and Verification*, Springer, 2024.

Web References:

- 1 <https://www.ansys.com/en-in/simulation-topics/what-is-asic-design>
- 2 <https://teamvlsi.com/2020/05/asic-design-flow-overview-v1.html>
- 3 <https://anysilicon.com/asic-design-flow-ultimate-guide/>
- 4 <https://personal.utdallas.edu/~zhoud/Lecture3.pdf>

23EC918	DESIGN OF SEMICONDUCTOR MEMORIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce the fundamental concepts, classifications, and working principles of semiconductor memory technologies.
- 2 To enable students to understand the architecture and operation of SRAM, DRAM, ROM, and Flash memories.
- 3 To familiarize students with peripheral circuit components such as sense amplifiers, decoders, and address buffers in memory design.
- 4 To expose students to testing techniques, fault models, and reliability considerations in memory systems.
- 5 To explore emerging memory technologies and their relevance in embedded and SoC applications.
- 6 To bridge the gap between academic memory designs and industry-standard interface protocols and use cases.

FUNDAMENTALS OF SEMICONDUCTOR MEMORIES

15

Classification of Memories: Volatile and Non-Volatile Memories – SRAM: 6T, 8T Cells – DRAM: 1T-1C, 3T Cells – ROM, PROM, EPROM, EEPROM – Flash Memory Basics – Timing Parameters (tRC, tRCD, tCAS, tWR) – Access Time, Cycle Time, Bandwidth – Memory Hierarchy: Registers to Secondary Storage.

MEMORY DESIGN AND PERIPHERAL CIRCUITS

15

Memory Array Design: Word Line and Bit Line – Sense Amplifiers – Column Selectors – Row Decoders – Address Buffers – Power and Area Optimization – Redundancy: Row and Column Spares – Built-In Self-Test (BIST) Architectures – Fault Modeling: Stuck-at, Coupling, Transition Faults – Reliability Issues: Soft Errors, Retention Failures.

ADVANCED AND EMERGING MEMORIES

15

Flash Memory Scaling – FRAM – MRAM – PCM – ReRAM – High Bandwidth Memory (HBM) – 3D Memory Architecture – Embedded Memories in SoCs – Memory IP Core Integration – Interface Standards: DDR4, LPDDR5 – Case Studies: Cache Memory, Scratchpad Memory, SoC Memory Subsystem.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Classify and explain the various types of semiconductor memories and their timing characteristics. | [U] |
| CO2 | Design memory arrays and peripheral circuits considering power, area, and performance trade-offs. | [AP] |
| CO3 | Apply fault models and analyze testability using BIST and redundancy techniques. | [AN] |
| CO4 | Explain the operation and use cases of emerging memory technologies in embedded systems. | [U] |
| CO5 | Apply interface standards and evaluate memory hierarchy in real-world SoC memory subsystems. | [AP] |

Text Books:

- 1 Ashok K. Sharma, Semiconductor Memories: Technology, Testing and Reliability, Wiley-IEEE Press, 2nd Edition, 2022.

- 2 Kiyoo Itoh, VLSI Memory Chip Design, Springer (Advanced Microelectronics Ser.), Softcover reprint 1st Edition, 2010.

Reference Books:

- 1 Betty Prince, *Emerging Memories: Technologies and Trends*, Springer, Softcover reprint of 1st Edition, 2013.
- 2 Betty Prince, *High Performance Memories: New Architecture DRAMs and SRAMs – Evolution and Function*, Wiley-IEEE Press, Revised Edition, 1996.
- 3 Rino Micheloni et al., *Inside NAND Flash Memories*, Springer, 1st Edition, 2010.

Web References:

- 1 <https://nptel.ac.in/courses/117106114>
- 2 <https://www.ee.iitb.ac.in/course/~dek/DE/>
- 3 <https://nptel.ac.in/courses/117106058>
- 4 <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-004-computation-structures-spring-2017/pages/unit-4-memory/>

23EC919	NETWORK ENGINEERING FOR IOT AND CONSTRAINED DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce key concepts in IoT-specific network design.
- 2 To explain communication models for constrained devices.
- 3 To illustrate networking standards such as 6LoWPAN, CoAP, and MQTT.
- 4 To design efficient protocols suitable for low-power and lossy networks.
- 5 To explore integration techniques for cloud and edge computing.
- 6 To analyze case studies on smart city, industrial IoT networks.

IOT NETWORKING MODELS AND REQUIREMENTS

15

Internet of Things concepts and design patterns - Communication models: Request/Response, Publish/Subscribe, Event-driven architectures - Constrained Application Protocol (CoAP) design - Network architecture layers for IoT - Power optimization techniques for networking - Challenges in bandwidth-limited and latency-sensitive environments - IPv6 addressing for constrained networks - 6LoWPAN and IPv6 compression techniques - Ubiquitous computing and device connectivity - Role of Gateways in IoT architecture - Smart city and healthcare networking models - Introduction to Software-Defined Networking (SDN) for IoT - Basics of Fog and Edge Computing networking.

PROTOCOLS AND TECHNOLOGIES FOR CONSTRAINED DEVICES

15

6LoWPAN adaptation layer and routing concepts - RPL (Routing Protocol for Low-Power and Lossy Networks) working principles - CoAP and MQTT for constrained environments - Wireless standards: ZigBee, LoRa, Wi-Fi, BLE, NB-IoT, LTE-M - Data encapsulation and protocol stack optimization - Medium Access Control (MAC) issues in IoT - Energy-efficient scheduling and duty-cycling techniques - IoT network security: TLS, DTLS, lightweight cryptography - Secure data transfer mechanisms for low-power devices - Protocol bridging and interoperability challenges - IoT device discovery and registration - Network slicing concepts in 5G for IoT - Emerging protocols: QUIC and SCHC (Static Context Header Compression).

IOT CLOUD AND EDGE INTEGRATION

15

Architecture of Cloud-IoT integration - Edge Computing concepts and architecture for IoT - Data aggregation and data filtering at the edge - MQTT over Websockets and Edge analytics - Real-time streaming protocols for IoT - Application layer protocols comparison: CoAP, MQTT, HTTP - Virtualization technologies in IoT (Docker, Kubernetes) - Managing large-scale IoT networks - Fault tolerance and load balancing strategies - Cloud platforms: AWS IoT Core, Azure IoT Hub, Google Cloud IoT - Edge platform examples: Azure IoT Edge, AWS Greengrass - Industrial case study: Smart Manufacturing Networks - Smart Home case study: Networking Design and Optimization.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Understand the principles of IoT network architectures and protocols.	[U]
CO2	Apply suitable network models for constrained environments.	[AP]
CO3	Design solutions for real-world IoT networking challenges.	[AP]
CO4	Integrate IoT networks with cloud/edge computing infrastructures.	[AP]
CO5	Evaluate and optimize performance of IoT networks.	[AN]

Text Books:

- 1 Daniel Minoli, Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications, Wiley, 2013.
- 2 Peter Waher, Learning Internet of Things, Packt Publishing, 2015.

Reference Books:

- 1 Olivier Hersent, David Boswarthick, and Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley, 2012.
- 2 Adrian McEwen, Designing the Internet of Things, Wiley, 2013.
- 3 Rajkumar Buyya and Satish Narayanan Srirama, Fog and Edge Computing – Principles and Paradigms, Wiley, 2019.

Web References:

- 1 <https://www.iotforall.com>
- 2 <https://openwsn.atlassian.net/wiki>
- 3 <https://www.postscapes.com/internet-of-things-protocols/>
- 4 <https://iotagenda.techtarget.com/definition/IoT-network>

23EC920	ADVANCED COMPUTER NETWORK ARCHITECTURES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To help students understand the evolution of network architectures and networking models.
- 2 To enable learners to analyze emerging networking paradigms such as Software Defined Networking (SDN) and Network Function Virtualization (NFV).
- 3 To introduce high-speed networking technologies and performance-enhancing protocols.
- 4 To provide a strong foundation in network security frameworks, including common threats and mitigation techniques.
- 5 To familiarize students with the architecture and functionality of data centers, cloud networking, and edge computing systems.
- 6 To develop the ability to design and evaluate scalable, secure, and efficient network architectures.

EVOLUTION OF COMPUTER NETWORK ARCHITECTURES

15

Review of OSI and TCP/IP reference models Network - Ethernet and VLAN architectures - IP addressing (IPv4/IPv6) and subnetting - Routing protocols: OSPF, BGP, EIGRP - MPLS architecture and traffic engineering - QoS models: IntServ and DiffServ - Virtual LANs (VLANs) and Virtual Private Networks (VPNs) - IP Multicast Routing Architectures - Data center topologies: Spine-Leaf, Fat-tree architecture - Challenges in traditional networking.

MODERN NETWORKING PARADIGMS AND TECHNOLOGIES

15

Software Defined Networking (SDN) principles – Open Flow protocol and controllers (ONOS, Open Daylight) - Network Function Virtualization (NFV) architecture - Service Function Chaining - Edge Computing architectures - IoT networking integration with SDN/NFV - Traffic engineering with SDN - Cloud Networking: Virtual Private Cloud (VPC), Direct Connect – Micro segmentation and network security using SDN - 5G network slicing and architecture - SD-WAN architectures and protocols.

SECURITY, CLOUD AND DATA CENTER NETWORK ARCHITECTURES

15

Data center network designs - Public, Private and Hybrid cloud networking models - Virtualization in networking: Hypervisors and VNFs - Cloud-native networking (AWS, Azure, GCP) - Load balancing and application delivery networks - Zero Trust Network Architecture (ZTNA) – Cyber-security principles in modern networks - DDoS mitigation architectures - Multi-cloud network architecture designs - Case studies on real-world cloud networks.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand traditional and modern network architecture models. | [U] |
| CO2 | Analyze software-defined networking and network function virtualization. | [AN] |
| CO3 | Explore emerging high-speed networking protocols and techniques. | [U] |
| CO4 | Implement secure, scalable cloud and data center networking solutions. | [AP] |
| CO5 | Design next-generation network architectures for real-world applications. | [AP] |

Text Books:

- 1 William Stallings, *Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud*, Addison-Wesley, 2015.

- 2 Thomas D. Nadeau, Ken Gray, *SDN: Software Defined Networks*, O'Reilly, 2013.
- 3 James F. Kurose, Keith W. Ross, *Computer Networking: A Top-Down Approach*, Pearson, 2021.

Reference Books:

- 1 Behrouz A. Forouzan, *Data Communications and Networking*, McGraw Hill, 2017.
- 2 Tim Szigeti, Christina Hattingh, *QoS Design Best Practices for IP Networks*, Cisco Press, 2004.
- 3 Rajkumar Buyya, *Cloud Computing: Principles and Paradigms*, Wiley, 2011.

Web References:

- 1 <https://opennetworking.org/>
- 2 <https://www.sdxcentral.com/>
- 3 <https://www.networkcomputing.com/>
- 4 <https://www.cisco.com/c/en/us/solutions/cloud/what-is-cloud-networking.html>

23EC921	PYTHON PROGRAMMING FOR IMAGE AND VIDEO PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To enable students to develop a strong foundation in Python programming relevant to image and video processing.
- 2 To introduce the fundamental concepts of image and video data, and train students in using Python libraries such as OpenCV and Pillow for image processing.
- 3 To help students understand and apply various image enhancement and manipulation techniques including contrast adjustment, noise removal, and sharpening.
- 4 To guide students in using filtering, histogram equalization, and morphological operations for practical image enhancement applications.
- 5 To train students in feature extraction methods and segmentation techniques for detecting and analyzing objects within images.
- 6 To provide an introduction to video processing principles, emphasizing moving object detection, motion tracking, and frame-based analysis.

PYTHON AND IMAGING

15

Python, Python IDLE, Arithmetic Operators, Values and types, Variables, Expressions and Statements, Lists, Dictionaries, Tuples, Array, Functions – Function calls, Math Functions, Function types, Concept of local and global, Conditionals, Iteration and Recursion, Modules & Packages. Image, Image Acquisition, Color Images and Video. Python libraries for Image processing (NumPy, SciPy, scikit-image, PIL (Pillow), OpenCV, scikit-learn, SimpleITK, and Matplotlib)

IMAGE MANIPULATION AND ENHANCEMENT

15

Image I/O and display, Image types and file formats, Basic image manipulations, Image Enhancement - Point-wise intensity transformations – pixel transformation, Histogram processing, Linear & Non-linear noise smoothing, Image Enhancement, Edge detection, Image pyramids, Morphological Image Processing.

IMAGE & VIDEO PROCESSING APPLICATION

15

Extracting Image Features - Harris Corner Detector, Blob detectors (LoG, DoG, and DoH). Image Segmentation - Hough transform, Thresholding and Otsu's segmentation, Edges-based/region-based segmentation. Video processing - Moving Object Detection and Tracking.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Apply core Python programming constructs (variables, functions, modules) to solve image and video-related computational problems. | [AP] |
| CO2 | Demonstrate the ability to load, manipulate, and visualize digital images using Python libraries such as NumPy, OpenCV, and PIL. | [AP] |
| CO3 | Implement image enhancement techniques including intensity transformations, filtering, and histogram operations. | [AP] |
| CO4 | Apply morphological operations, edge detection, and segmentation methods to prepare images for feature extraction and analysis. | [AP] |
| CO5 | Develop basic video processing applications for moving object detection and tracking using Python. | [AP] |

Text Books:

- 1 Allen B. Downey, 'Think Python – How to think like a computer scientist', O'Reilly Media, Inc., Second Edition, 2015.
- 2 Sandipan Dey, 'Hands-On Image Processing with Python', Packt Publishing, 2018.
- 3 Kenneth Dawson-Howe, 'A Practical Introduction to Computer Vision with OpenCV', John Wiley & Sons Ltd, First edition, 2014.

Reference Books:

- 1 Adrian Rosebrock, 'Practical Python and OpenCV: An Introductory, Example Driven Guide to Image Processing and Computer Vision', Pyimagesearch, Third edition, 2016.
- 2 Prateek Joshi, 'OpenCV with Python By Example', Packt Publishing, 2015..

Web References:

- 1 <https://www.python.org/>
- 2 <https://www.w3schools.com/python/>
- 3 https://www.w3schools.com/python/python_intro.asp
- 4 <https://developers.google.com/edu/python>

Online Resources:

- 1 https://onlinecourses.nptel.ac.in/noc25_cs69/preview
- 2 https://onlinecourses.swayam2.ac.in/nou25_cs08/preview
- 3 https://onlinecourses.swayam2.ac.in/cec25_ma18/preview
- 4 https://onlinecourses.nptel.ac.in/noc25_ee13/preview

23EC922	R PROGRAMMING FOR IMAGE AND VIDEO DATA ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To impart fundamental programming knowledge in R.
- 2 To familiarize students with R-based libraries and basics of image and image acquisition.
- 3 To enable students to understand various spatial and frequency domain techniques for image enhancement, restoration, and filtering.
- 4 To develop proficiency in implementing morphological and fuzzy-based operations for advanced image transformations
- 5 To introduce advanced concepts such as color image processing, wavelets, compression, segmentation, and object recognition.
- 6 To familiarize students with R for multiresolution analysis and feature extraction.

R AND IMAGING

15

R, RStudio, Arithmetic Operators, Vectors, Character Strings, Matrices and Arrays, Lists, Data Frames, Classes, Functions, Factors and Tables, R programming structures, Input/Output, file handling, packages. Image, Image Acquisition, Color Images and Video. Python libraries for Image processing (ggplot2, dplyr, tidyr, caret, shiny, imager, forecast, randomForest, gdalUtils, raster, RStoolbox, rgdal, mapview, gridExtra, and terra).

SPATIAL AND FREQUENCY OPERATIONS

15

Intensity Transformations and Spatial Filtering, Spatial Enhancement Method, Fuzzy Techniques for Intensity Transformations and Spatial Filtering, Image Restoration and Reconstruction, Morphological Image Processing, Filtering in the Frequency Domain.

ADVANCED IMAGE PROCESSING APPLICATIONS

15

Color Image Processing, Wavelets and Multiresolution Processing, Image Compression, Image Segmentation, Image Representation and Description, Object Recognition.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Apply R programming constructs and basic functions for data manipulation and image/video input-output operations. | [AP] |
| CO2 | Utilize R libraries such as imager, terra, and raster to acquire, visualize, and preprocess image and video data. | [AP] |
| CO3 | Implement image enhancement and restoration techniques including intensity transformations, filtering, and fuzzy logic methods using R. | [AP] |
| CO4 | Analyze morphological operations and frequency domain filtering techniques for efficient image processing tasks. | [AN] |
| CO5 | Design segmentation and object recognition workflows incorporating advanced techniques like wavelet transform, color image analysis, and compression using R. | [AP] |

Text Books:

- 1 Norman Matloff, 'The Art of R Programming', No Starch Press, 2011.
- 2 Rafael C. Gonzalez, Richard E. Woods, 'Digital Image Processing', Pearson Education, Third Edition.

Reference Books:

- 1 Winston Chang, 'R Graphics Cookbook', O'Reilly, First edition, 2012.
- 2 Marcelo de Carvalho Alves, Luciana Sanches, 'Remote Sensing and Digital Image Processing with R - Lab Manual', CRC Press, First Edition, 2024.
- 3 Alejandro C. Frery, Talita Perciano, 'Introduction to Image Processing Using R', Springer.

Web References:

- 1 <https://www.r-project.org/>
- 2 <https://www.w3schools.com/r/>
- 3 <https://www.coursera.org/learn/r-programming>
- 4 <https://www.geeksforgeeks.org/r-programming-language-introduction/>

23EC923	DIGITAL IMAGE PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce fundamental concepts of digital image processing.
- 2 To explore image enhancement, restoration, and compression techniques.
- 3 To analyze image segmentation and morphological processing methods.
- 4 To apply transforms and feature extraction for image understanding.
- 5 To develop solutions for real-world image processing applications
- 6 To introduce fundamental concepts of digital image processing.

FUNDAMENTALS AND IMAGE ENHANCEMENT

15

Introduction to digital image processing - Image formation and sensing - Image sampling and quantization - Basic intensity transformation functions - Histogram processing - Spatial filtering (smoothing, sharpening) - Frequency domain filtering - Introduction to Fourier Transform - Discrete Cosine Transform (DCT).

IMAGE RESTORATION, SEGMENTATION, AND COMPRESSION

15

Noise models - Restoration techniques (inverse filtering, Wiener filtering) - Edge detection techniques (Sobel, Prewitt, Canny) - Thresholding and region-based segmentation - Morphological image processing (dilation, erosion, opening, closing) - Basics of compression - JPEG, JPEG2000 standards - Wavelet-based compression.

ADVANCED TOPICS AND APPLICATIONS

15

Feature extraction: edges, corners, blobs - Image classification basics - Pattern recognition methods - Motion detection - 3D imaging basics - Case study: Medical imaging - Case study: Satellite image processing - Industrial project: Defect detection in manufacturing.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand basic operations and models in digital image processing. | [U] |
| CO2 | Apply enhancement and filtering techniques in spatial and frequency domains. | [AP] |
| CO3 | Perform image segmentation and morphological transformations. | [AP] |
| CO4 | Utilize transforms and feature extraction for object recognition. | [AN] |
| CO5 | Design image processing systems for industrial and research applications. | [AN] |

Text Books:

- 1 Rafael C. Gonzalez and Richard E. Woods, *Digital Image Processing*, Pearson, 4th Edition, 2018.
- 2 Anil K. Jain, *Fundamentals of Digital Image Processing*, Prentice Hall, 1989.

Reference Books:

- 1 Bernd Jähne, *Digital Image Processing*, Springer, 6th Edition, 2005.
- 2 William K. Pratt, *Digital Image Processing: PIKS Scientific Inside*, Wiley-Interscience, 2007.
- 3 Milan Sonka, Vaclav Hlavac, and Roger Boyle, *Image Processing, Analysis, and Machine Vision*, Cengage Learning, 2014.

Web References:

- 1 <https://www.imageprocessingplace.com/>
- 2 <https://homepages.inf.ed.ac.uk/rbf/HIPR2/>
- 3 <https://nptel.ac.in/courses/117105079>

23EC924	COMPUTER VISION TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce basic concepts and techniques in computer vision.
- 2 To explore methods for feature extraction, matching, and object detection.
- 3 To apply image segmentation and 3D vision techniques.
- 4 To understand machine learning models for vision applications.
- 5 To develop end-to-end vision-based systems for practical use cases.
- 6 To introduce basic concepts and techniques in computer vision.

INTRODUCTION TO COMPUTER VISION AND FEATURE EXTRACTION 15

Computer vision overview - Camera models and imaging geometry - Color models and image formation - Edge detection (Sobel, Canny) - Keypoint detection (Harris Corner Detector) - Feature extraction and matching (SIFT, SURF, ORB) - Optical flow basics - Applications in tracking and motion analysis.

OBJECT DETECTION, SEGMENTATION, AND 3D VISION 15

Object detection techniques: Haar cascades, HOG + SVM - Semantic segmentation and instance segmentation basics - Mean-Shift and Graph Cut segmentation - 3D vision: Stereo imaging and disparity maps - Structure from Motion (SfM) concepts - Depth estimation using stereo vision - Application: 3D reconstruction from images.

MACHINE LEARNING AND DEEP LEARNING FOR VISION 15

Introduction to supervised and unsupervised learning - CNN basics for vision - Transfer learning for vision tasks - Object detection frameworks: YOLO, SSD, Faster-RCNN - Model evaluation techniques - Applications: Face detection, pose estimation, gesture recognition - Mini-project: Building a real-time object recognition app.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Understand fundamental principles of computer vision.	[U]
CO2	Apply feature detection, extraction, and matching techniques.	[AP]
CO3	Perform image segmentation and object recognition.	[AP]
CO4	Develop 3D reconstruction and depth estimation solutions.	[AP]
CO5	Implement machine learning models for vision applications.	[AP]

Text Books:

- 1 Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2nd Edition, 2022.
- 2 Simon J. D. Prince, *Computer Vision: Models, Learning, and Inference*, Cambridge University Press, 2012.
- 3 Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2nd Edition, 2022.

Reference Books:

- 1 Forsyth and Ponce, *Computer Vision: A Modern Approach*, Pearson, 2nd Edition, 2011.
- 2 Adrian Kaehler and Gary Bradski, *Learning OpenCV 4*, O'Reilly Media, 2019.
- 3 Ian Goodfellow, Yoshua Bengio, and Aaron Courville, *Deep Learning*, MIT Press, 2016.

Web References:

- 1 <https://opencv.org/>
- 2 <https://scikit-image.org/>
- 3 <https://docs.tensorflow.org/>

23EC925	DEEP LEARNING FOR IMAGE AND VIDEO ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce deep learning foundations for image and video data analysis.
- 2 To explore neural network architectures including CNNs and RNNs.
- 3 To develop deep learning models for object detection and segmentation.
- 4 To analyze video sequences using advanced deep learning techniques.
- 5 To apply deep learning solutions to real-world multimedia applications.
- 6 To introduce deep learning foundations for image and video data analysis.

FUNDAMENTALS OF DEEP LEARNING FOR VISUAL DATA

15

Introduction to deep learning - Neural network basics - Loss functions and optimization techniques - Introduction to convolutional neural networks (CNNs) - CNN architecture: convolution, pooling, fully connected layers - Training deep networks - Data augmentation techniques for images.

DEEP ARCHITECTURES FOR IMAGE AND VIDEO TASKS

15

Popular CNN models: AlexNet, VGGNet, ResNet - Transfer learning and fine-tuning - Object detection frameworks: R-CNN, Fast R-CNN, Faster R-CNN, YOLO, SSD - Semantic segmentation networks: U-Net, Mask R-CNN - Action recognition in videos - 3D convolutional neural networks - Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks for video sequence modeling.

ADVANCED TOPICS AND APPLICATIONS

15

Attention mechanisms and Vision Transformers (ViT) - Generative Adversarial Networks (GANs) for image synthesis - Deepfake detection - Video captioning using deep learning - Deployment of deep learning models on mobile and embedded platforms - Industrial case studies: autonomous driving, medical imaging, surveillance systems.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand deep learning principles and architectures for image and video analysis. | [U] |
| CO2 | Implement convolutional neural networks (CNNs) for visual tasks. | [AP] |
| CO3 | Apply recurrent and 3D CNN models for video analysis. | [AP] |
| CO4 | Utilize advanced models for object detection and segmentation. | [AP] |
| CO5 | Design and deploy end-to-end deep learning systems for real-world multimedia problems. | [AP] |

Text Books:

- 1 Ian Goodfellow, Yoshua Bengio, and Aaron Courville, *Deep Learning*, MIT Press, 2016.
- 2 François Chollet, *Deep Learning with Python*, Manning Publications, 2nd Edition, 2021.

Reference Books:

- 1 Aurelien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly, 2022.
- 2 Rajalingappaa Shanmugamani, *Deep Learning for Computer Vision*, Packt Publishing, 2018.
- 3 Joseph Redmon and Santosh Divvala, *YOLO Object Detection Papers*, arXiv preprints.

Web References:

- 1 <https://keras.io/>
- 2 <https://pytorch.org/>
- 3 <https://tensorflow.org/>

23EC926	VIDEO ANALYTICS AND SURVEILLANCE SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce fundamental concepts of video analytics and surveillance.
- 2 To explore techniques for video preprocessing and event detection.
- 3 To develop algorithms for tracking, behavior analysis, and anomaly detection.
- 4 To understand architectures of smart surveillance systems.
- 5 To apply machine learning and deep learning techniques for video analytics.
- 6 To introduce fundamental concepts of video analytics and surveillance.

FUNDAMENTALS OF VIDEO ANALYTICS

15

Introduction to video surveillance systems - Basics of video acquisition and formats - Frame differencing and background subtraction - Motion detection techniques - Object tracking: Kalman filter, Meanshift, Camshift - Visual surveillance and scene understanding - Challenges in surveillance: occlusion, illumination changes.

BEHAVIOR ANALYSIS AND EVENT DETECTION

15

Action recognition techniques - Spatio-temporal feature extraction - Event detection in crowded scenes - Abnormal behavior detection - Multi-object tracking - Group activity recognition - Applications: Traffic monitoring, Retail analytics, Public safety surveillance - Datasets for video surveillance research.

INTELLIGENT SURVEILLANCE SYSTEMS

15

Deep learning for video analytics: CNN, RNN, 3D CNN models - Person re-identification (Re-ID) - Face detection and recognition in surveillance - Edge-based video processing - Cloud-based video analytics platforms - Privacy issues and ethical considerations in surveillance - Industrial case study: Smart city surveillance systems.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Understand core concepts and challenges in video analytics.	[U]
CO2	Apply preprocessing and feature extraction techniques for video data.	[AP]
CO3	Design algorithms for tracking, behavior recognition, and anomaly detection.	[AP]
CO4	Develop intelligent surveillance systems using modern frameworks.	[AP]
CO5	Analyze real-world scenarios and implement smart video analytics solutions.	[AN]

Text Books:

- 1 Maheshkumar H. Kolekar, *Intelligent Video Surveillance Systems*, Wiley, 2018.
- 2 Yunqian Ma and Gang Qian, *Intelligent Video Surveillance: Systems and Technology*, CRC Press, 2009.

Reference Books:

- 1 Borko Furht, *Handbook of Video Databases: Design and Applications*, CRC Press, 2003.
- 2 Amine Nait-ali, *Advanced Biosignal Processing for Video Surveillance*, Springer, 2019.
- 3 Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2nd Edition, 2022.

Web References:

- 1 <https://openvinotoolkit.org/>
- 2 <https://opencv.org/>
- 3 <https://www.analyticsvidhya.com/>

23EC927	NETWORK INTEGRATION FOR IOT AND MULTIMEDIA APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To enable students to understand the fundamental architecture and protocols governing IoT and multimedia networks.
- 2 To introduce integration techniques for combining heterogeneous network systems effectively.
- 3 To guide students in developing robust communication frameworks that support seamless IoT and multimedia application delivery.
- 4 To help students address key challenges related to Quality of Service (QoS), security, and interoperability in integrated networks.
- 5 To train students in the design, deployment, and management of real-world network solutions involving IoT and multimedia convergence.
- 6 To provide insights into evolving standards and practices in unified network architectures supporting modern connected applications.

NETWORKING BASICS FOR IOT AND MULTIMEDIA 15

Overview of IoT and multimedia network requirements - Heterogeneous network models - Communication protocols: MQTT, CoAP, HTTP, RTP - Streaming protocols for multimedia: RTSP, HLS - Wireless technologies for IoT and multimedia: Wi-Fi, LoRa, 5G - Quality of Service (QoS) metrics - Delay, jitter, packet loss, and throughput considerations.

INTEGRATION ARCHITECTURES AND PROTOCOLS 15

Edge computing and fog networking for IoT-multimedia applications - Cross-domain communication challenges - Protocol conversion and gateways - Service orchestration in heterogeneous environments - Resource allocation strategies - Network slicing in 5G for IoT/multimedia - Case study: Smart city communication infrastructure.

SECURITY, QOS, AND APPLICATIONS 15

Security and privacy challenges in integrated networks - Lightweight encryption for IoT and multimedia - End-to-end QoS provisioning - Adaptive streaming and dynamic bandwidth management - IoT-multimedia fusion platforms: AWS IoT Core, Azure IoT Hub with Media Services - Case studies: Remote healthcare, Industrial monitoring, Smart transportation.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Understand the networking fundamentals for IoT and multimedia integration.	[U]
CO2	Analyze different communication protocols for heterogeneous systems.	[AN]
CO3	Design frameworks ensuring quality of service and security.	[AP]
CO4	Implement network solutions that integrate IoT and multimedia services.	[AP]
CO5	Evaluate real-world applications and case studies of integrated systems.	[AN]

Text Books:

- 1 Zaigham Mahmood, *IoT Applications, Security Threats, and Countermeasures*, Springer, 2022.
- 2 K. Chatterjee, *Multimedia Communications: Applications, Networks, Protocols and Standards*, Elsevier, 2020.

Reference Books:

- 1 F. Hu, *Security and Privacy in Internet of Things (IoTs)*, CRC Press, 2016.
- 2 Adrian Farrel, *The Internet and Its Protocols: A Comparative Approach*, Morgan Kaufmann, 2004.
- 3 Rajkumar Buyya, *Fog and Edge Computing: Principles and Paradigms*, Wiley, 2019.

Web References:

- 1 <https://iotagenda.techtarget.com/>
- 2 <https://www.mediastreamingacademy.com/>
- 3 <https://aws.amazon.com/iot/>

23EC928	RF SYSTEM DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce students to the fundamental concepts and key principles of RF circuit design.
- 2 To enable students to differentiate between various RF filters and resonator structures, and to guide them in their design.
- 3 To teach students to design and analyze RF active components, highlighting their influence on circuit behavior.
- 4 To provide students with the skills to design, match, and bias RF transistor amplifiers for diverse applications.
- 5 To explain the operation and design considerations of RF oscillators and frequency synthesizers.
- 6 To help students understand the working principles and practical applications of RF mixers used for frequency translation.

RF FUNDAMENTALS AND RF FILTER DESIGN

15

Importance of RF Frequency Design, RF behaviour of Passive Components, Chip Components and Circuit Board Considerations, Basic Resonator and Filter Design, Filter Implementation- coupled filter.

IMPEDANCE MATCHING AND RF TRANSISTOR AMPLIFIER DESIGNS

15

High electron mobility transistors, matching and biasing networks – impedance matching using discrete components, microstripline matching networks, amplifier – classes of operation and biasing networks. Characteristics of Amplifiers, Amplifier Power Relations, Stability Considerations, Constant Gain and VSWR Circles, Low noise Amplifier-Single ended and Differential LNAs.

RF OSCILLATORS AND MIXERS

15

Basic Oscillator Model, High Frequency Oscillator Configurations – Fixed Frequency Oscillator, Dielectric Resonator Oscillator, Basics Concepts of Mixer and Frequency domain Considerations, Single balanced and double balanced mixers–subsampling mixers.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand the behavior and characteristics of RF passive and chip components in RF circuit applications. | [U] |
| CO2 | Analyze and design RF resonators, coupled filters, and mixer circuits used in frequency-selective and translation applications. | [AN] |
| CO3 | Apply impedance matching techniques and biasing methods in the design of RF transistor-based circuits. | [AP] |
| CO4 | Analyze the stability, gain characteristics, and noise performance of RF amplifiers, including low noise amplifier (LNA) design. | [AN] |
| CO5 | Apply the principles and configurations of RF oscillator and frequency synthesizer design for communication systems. | [AP] |

Text Books:

- 1 Reinhold Ludwig, Gene Bogdanov, "RF circuit design, theory and applications", Pearson Asia Education, 2nd edition, 2009.
- 2 Joseph. J. Carr, "Secrets of RF Circuit Design ", McGraw Hill Publishers, Third Edition, 2000.

Reference Books:

- 1 Mathew M. Radmanesh, "Radio Frequency & Microwave Electronics", Pearson Education Asia, Second Edition, 2002
- 2 Ulrich L. Rohde and David P. NewKirk, "RF / Microwave Circuit Design", John Wiley & Sons USA, 2000.

Web References:

- 1 <https://www.ti.com/lit/an/snoa529a/snoa529a.pdf>
- 2 <https://www.electronics-tutorials.ws/oscillator/oscillators.html>

23EC929	MICROWAVE INTEGRATED CIRCUITS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To facilitate students, understand planar transmission line structures and various microwave integrated circuit (MIC) technologies.
- 2 To guide students in the design of basic lumped and quasi-lumped microwave passive components.
- 3 To enable students to analyze and design different types of microwave resonators.
- 4 To train students in developing microwave filters using both lumped and distributed design approaches.
- 5 To teach students how to design microwave amplifiers and oscillators to meet specific performance criteria.
- 6 To expose students to fabrication techniques used in MIC and monolithic microwave integrated circuit (MMIC) technologies.

PLANAR TRANSMISSION AND PASSIVE MICROWAVE COMPONENTS

15

Types of MICs and their technology; Microstrip lines, strip lines, slotted lines, co-planar waveguides, coupled lines and SIW. Losses in microstrip transmission lines, Lumped microstrip components: Design of microstrip and chip inductors, capacitors, resistors, Quasi lumped microstrip elements: Open and short-circuited stubs (quarter wavelength, half wavelength). Interdigital capacitors, Approximate analysis.

MICROWAVE RESONATORS AND FILTER DESIGN

15

Analysis and Design of Quarter & Half wave length resonators, Ring resonators, Patch resonators and Slot resonators. Band pass filter: Insertion loss method, Conversion from low pass to band pass, Design of band pass filter using lumped elements, distributed elements, impedance inverters and coupled line filters.

MICROWAVE ACTIVE DEVICES AND MIC/MMIC FABRICATION

15

Single stage amplifier design, Design of low noise amplifiers, Conditions for oscillations, one port oscillator, two port oscillator (Transistor oscillators), Characteristics of mixer, Single ended diode mixer, Single ended FET mixer. Hybrid MICs, Configuration, Dielectric substances, thick and thin film technology, Printed Circuit Board (PCB) Technology, Fabrication process of MMIC.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Apply the concepts of planar transmission lines and passive microwave components in MIC design. | [AP] |
| CO2 | Apply the principles of microwave resonators in analysing and designing resonant circuits. | [AP] |
| CO3 | Design microwave filters using lumped and distributed techniques with impedance inverters and coupled line structures. | [AP] |
| CO4 | Analyze the performance characteristics of microwave amplifiers and oscillators based on key parameters. | [AN] |
| CO5 | Understand fabrication processes for MICs and MMICs using modern technologies and materials. | [U] |

Text Books:

- 1 TC Edwards, MB Steer, "Foundations for Microstrip Circuit Design", 4th Edition, John Wiley, 2022.
- 2 D. M. Pozar, "Microwave Engineering", 4th Edition, John Wiley, 2020.
- 3 Ali A Behagi, "RF and Microwave Circuit Design: A Design Approach using ADS", 1st Edition, Techno Search, 2021.

Reference Books:

- 1 G Gonzalez, "Microwave Transistor Amplifiers", 2nd Edition, PHI Inc., 2021.
- 2 Bharathi Bhat, Shiban K. Koul, "Stripline-Like Transmission Lines for Microwave Integrated Circuits", Blackie Academic & Professional, 2017.
- 3 Hoffman R.K., "Hand Book of Microwave Integrated Circuits", Artech House, Boston, 2019.

Web References:

- 1 <https://www.microwaves101.com/encyclopedias/microwave-integrated-circuits>
- 2 <https://resources.system-analysis.cadence.com/blog/msa2021-monolithic-and-hybrid-microwave-integrated-circuits-whats-the-difference>

23EC930	CAN AND CAN OPEN PROTOCOLS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To facilitate students, understand the basic concepts and significance of CAN and LIN protocols in automotive communication systems.
- 2 To guide students in studying vehicle network architecture and CAN frame structures for effective in-vehicle communication design.
- 3 To facilitate learning about data integrity in CAN, focusing on frame formats, bus arbitration, error detection mechanisms, and fault management.
- 4 To provide an overview of satellite communication fundamentals, including key subsystems, modulation techniques, multiplexing, and multiple access methods.
- 5 To enable students to analyze the functioning of the physical and data link layers within CAN bus systems.
- 6 To train students in designing, simulating, and troubleshooting CAN-based communication networks for real-world applications.

INTRODUCTION TO CAN AND LIN PROTOCOL

15

Introduction to the Controller Area Network (CAN) & LIN protocol, Overview of Reasons for the development of Controller Area Network (CAN) & LIN, Comparison of Controller Area Network (CAN) with other serial communication protocols, Controller Area Network (CAN) vehicle network Architecture, Features of Controller Area Network (CAN) protocol, Frame formats of Controller Area Network (CAN).

DATA INTEGRITY AND ARBITRATION IN CAN

15

Satellite subsystems - Attitude and orbit control electronics - Telemetry and tracking Power subsystems - Communication subsystems - Satellite antennas - Reliability and redundancy- Frequency modulation techniques. Modulation and Multiplexing -Multiple access techniques – FDMA, TDMA, CDMA, SDMA, ALOHA and its types – Onboard processing- Satellite switched TDMA – Spread spectrum transmission and reception for satellite networks.

PHYSICAL AND DATA LINK LAYER CONCEPTS IN CAN COMMUNICATION

15

Differential voltage concept in Controller Area Network (CAN), Controller Area Network (CAN) node interfacing levels, Controller Area Network (CAN) transceivers, Controller Area Network (CAN) physical layer: CAN nodes, CAN Bus voltage levels and node interfacing techniques, CAN bit timings and baud rate settings, Controller Area Network (CAN) data link layer: CAN Bus arbitration, CAN Bus Fault Confinement.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the concepts of CAN and LIN protocols and compare them with other serial communication standards. | [U] |
| CO2 | Analyze the architecture and frame structures of CAN protocol used in automotive communication systems. | [AN] |
| CO3 | Analyze the CAN communication process including arbitration, frame types, error detection, and fault confinement techniques. | [AN] |
| CO4 | Understand satellite communication subsystems, modulation schemes, multiplexing, and multiple access techniques applicable to space-based networks. | [U] |
| CO5 | Apply CAN protocol concepts to design reliable in-vehicle communication | [U] |

systems, focusing on bit timing, transceiver interfacing, and node communication.

Text Books:

- 1 Forouzan, B. A. (2007). *Data Communications and Networking (4th ed.)*. New York, NY: McGraw-Hill.
- 2 Pratt, T., Bostian, C. W., & Allnutt, J. (2003). *Satellite Communications (2nd ed.)*. Hoboken, NJ: Wiley.
- 3 Matheus, K., & Königseder, T. (2015). *Automotive Ethernet: The Definitive Guide*. Cambridge, MA: Cambridge University Press.

Reference Books:

- 1 Maral, G., & Bousquet, M. (2009). *Satellite Communications Systems: Systems, Techniques and Technology (6th ed.)*. Chichester, UK: Wiley.
- 2 Di Natale, M., Zeng, H., Giusto, P., & Ghosal, A. (2012). *Understanding and Using the Controller Area Network Communication Protocol*. New York, NY: Springer.
- 3 Etschberger, K. (2001). *Controller Area Network: Basics, Protocols, Chips and Applications*. Munich, Germany: IXXAT Automation GmbH.

Web References:

- 1 <https://www.bosch-semiconductors.com/can/>
- 2 <https://www.lin-subbus.org/>
- 3 <https://www.vector.com/int/en/know-how/can/can-overview/>

23EC931	SOFTWARE DEFINED NETWORKING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To help students understand the principles of traditional networking, identify its limitations, and recognize the motivation for adopting Software Defined Networks (SDN).
- 2 To guide students in analyzing the fundamental concepts and planar architecture of SDN.
- 3 To provide insights into the flexibility and design of multilevel pipeline processing within SDN environments.
- 4 To examine the interaction between the SDN controller and data plane, with emphasis on flow table matching and packet processing.
- 5 To train students in configuring SDN switches, designing networks by managing flow entries, and interpreting packet behavior through practical tools.
- 6 To help students understand the principles of traditional networking, identify its limitations, and recognize the motivation for adopting Software Defined Networks (SDN).

INTRODUCTION TO TRADITIONAL NETWORKS AND SDN

15

Traditional networks, Control Plane, Data Plane and Management Plane, Flow table, Limitations of traditional networks- Need for simplification, lowering operating costs, Single flow table, Flexibility issues, Proprietary protocols and Destination based forwarding, Forces. Software defined networks, SDN Planes-Data-plane, Control Plane, Application Plane, OpenFlow, Open Network Foundation, Protocol-Encryption, Northbound & Southbound API, Multi-level flow table and pipeline processing, Group table, Meter table-Meter bands, OpenFlow version- 1.0,1.1,1.2,1.3

SDN MESSAGES AND TABLE MATCHING

15

Messages-Controller-Switch, Packet-In, Packet-Out, Flow-Mod, Flow-Removed, Port-Status and Error Messages, Symmetric & Asynchronous messages Counters, OpenFlow Port Concepts & Configuration, Table matching in SDN, Network Automation using SDN Controllers and Integration with Network Virtualization Tools.

MININET EMULATOR, SDN APPLICATIONS AND USE-CASES

15

Introduction to Mininet, Custom topologies of OpenFlow and Legacy Networks, Flow table manipulation-Adding & Deleting Flow entries, Packet Dissection via Wireshark, SDN Controllers-Ryu, POX, Floodlight, SDN Applications, SDN Use Cases, SDN in the Data Center and WAN, SDN-Open Source and its Features.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand the architecture and limitations of traditional networks and explain the motivation for transitioning to Software Defined Networking (SDN). | [U] |
| CO2 | Analyze the structure and functioning of SDN planes—Data, Control, and Application—and evaluate the role of OpenFlow and related standards. | [AN] |
| CO3 | Apply SDN principles to solve performance-related problems in areas such as routing and traffic engineering optimization. | [AP] |
| CO4 | Demonstrate the configuration and use of OpenFlow components including flow tables, meter tables, and group tables within SDN environments. | [AP] |
| CO5 | Analyze real-world SDN applications such as data center networking, WAN optimization, and virtualization by configuring flow entries and interpreting packet behavior. | [AN] |

Text Books:

- 1 Nadeau, Thomas D., and Ken Gray. SDN: Software Defined Networks: an authoritative review of network programmability technologies. " O'Reilly Media, Inc.", 2013.
- 2 Chuck Black and Paul Goransson, "Software Defined Networks: A Comprehensive Approach", Morgan Kaufman.
- 3 Coker, Oswald, and Siamak Azodolmolky. Software-defined Networking with OpenFlow: Deliver Innovative Business Solutions. Packt Publishing Ltd, 2017.

Reference Books:

- 1 Goransson, Paul, Chuck Black, and Timothy Culver. Software Defined Networks: A Comprehensive Approach. 2nd ed., Morgan Kaufmann, 2016.
- 2 Hu, Fei. Network Innovation through OpenFlow and SDN: Principles and Design. CRC Press, 2014.
- 3 Blaise, Pascal, and Doug Marschke. SDN and OpenFlow for Beginners with Hands-on Labs. Leanpub, 2015.

Web References:

- 1 <https://opennetworking.org>
- 2 <http://mininet.org>
- 3 <https://www.openvswitch.org>

23EC932	SATELLITE COMMUNICATIONS AND GPS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To understand the fundamental concepts of satellite communication.
- 2 To analyse the principles and components of satellite launch systems
- 3 To provide a detailed understanding of navigation - both inertial and by navigation satellites.
- 4 To examine digital transmission techniques and multiple access methods
- 5 To analyse typical challenges of satellite-based GPS systems.
- 6 To analyse modern satellite applications

ORBITAL MECHANICS & LAUNCHERS

15

Overview of satellite communication - Orbital mechanics - Equations of the orbit - Kepler's laws of planetary motion - Orbital elements - Look angle determination - Orbital perturbation and determination Launches and launch vehicles- Launch vehicle selection factors - Satellite positioning into geostationary orbit - Orbital effects in communication systems performance - Doppler shift -Range variations - Solar eclipse and sun transit outage.

DESIGN ELEMENTS OF COMMUNICATION SATELLITE & DIGITAL TRANSMISSION

15

Satellite subsystems - Attitude and orbit control electronics - Telemetry and tracking Power subsystems - Communication subsystems - Satellite antennas - Reliability and redundancy- Frequency modulation techniques. Modulation and Multiplexing -Multiple access techniques – FDMA, TDMA, CDMA, SDMA, ALOHA and its types – Onboard processing- Satellite switched TDMA – Spread spectrum transmission and reception for satellite networks.

SATELLITE LINK DESIGN & DIRECT BROADCAST SATELLITE GPS

15

Transmission theory – System noise temperature and G/T Ratio- Noise figure and noise temperature- Calculation of system noise temperature – G/T ratio for earth stations - Link budgets - Uplink and downlink budget calculations - Error control for digital satellite links. DBS Satellite Systems: DVB-S2X Standards -System Design for High-Throughput Applications, Antenna Considerations, Modulation Scheme Considerations, Error Coding Considerations, Remote Sensing Application, Navigation Satellite Systems GPS-Position Calculations and Accuracy, Navigation Messages, Receiver Design- IRNSS.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand the concepts of satellite orbits, launch vehicles, and satellite classifications. | [U] |
| CO2 | Analyze the design and functioning of various satellite subsystems and their role in overall system performance. | [AN] |
| CO3 | Analyze satellite-based navigation systems and services, including their architecture and operational principles. | [AN] |
| CO4 | Understand digital transmission techniques and evaluate the influence of key parameters on satellite link design. | [U] |
| CO5 | Apply satellite communication systems in real-world applications such as broadcasting, remote sensing, and navigation. | [AP] |

Text Books:

- 1 Maral, G., & Bousquet, M. (2009). Satellite Communications Systems: Systems, Techniques and Technology (6th ed.). Chichester, UK: Wiley.
- 2 Pratt, C.W. Boastian and Jeremy Allnutt "Satellite Communication", 2018, 2nd edition, John Wiley and Sons, Bangalore, India.
- 3 G. Maral, M. Bousquet, Z. Sun, "Satellite Communications Systems: Systems, Techniques and Technology", 2020 (6th Edition), John Willy and sons, New York.

Reference Books:

- 1 D.Roddy, "Satellite Communications", 2011, 4th edition (sixth reprint), Tata McGraw Hill, New York.
- 2 Anil K. Maini, Varsha Agrawal, "Satellite Communications", 2018, Wiley India Pvt. Ltd, New Delhi, India
- 3 Hofmann-Wellenhof, B., Lichtenegger, H., & Wasle, E. (2008). Global Navigation Satellite Systems: Insights Into GPS, GLONASS, Galileo, Compass, and Others. New York, USA: Springer.

Web References:

- 1 <https://solarsystem.nasa.gov/basics/>
- 2 <https://www.itu.int/en/ITU-R/space/Pages/default.aspx>
- 3 <https://www.gps.gov/>

23EC933	HIGH FREQUENCY COMMUNICATION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To understand the characteristics of millimeter wave propagation in various environments.
- 2 To explore antenna arrays and beamforming techniques for mmWave communication.
- 3 To study light propagation and loss mechanisms in optical fibers.
- 4 To understand the design principles of fiber optic communication systems and networks.
- 5 To examine the and applications of free-space optical communication.
- 6 To identify hybrid optical communication techniques used in modern wireless and wired systems.

MILLIMETER WAVE PROPAGATION AND COMMUNICATION

15

Radio Wave Propagation for mmWave, Large-Scale and small-scale Propagation Effects of mmwaves, Outdoor Channel Models, Indoor Channel Models, Vehicle-to-Vehicle Models, Spatial Characterization of Multipath and Beam Combining. Adaptive Antenna Arrays — Beam Steering and Beamforming, ESPRIT and MUSIC, Emerging Applications of mmWave Communications.

FIBER OPTIC COMMUNICATION

15

Transmission Characteristics of Fibres: Attenuation, material absorption and scattering loss, bending loss, intra-modal and inter-modal dispersion in step and graded fibres, FOC System description and design considerations, Analog & Digital broadband transmission.

OPTICAL NETWORKS AND FREE-SPACE COMMUNICATION SYSTEMS

15

Principles of WDM, DWDM, telecommunications & broadband application, wavelength-routed networks - SONET/SDH, MUX. Propagation of light in unguided media, LASER beam characteristics, atmospheric effects on optical signals, FSO transceiver design, Point-to-Point FSO systems, point-to-point with transponder nodes, Hybrid FSO and RF, FSO applications, LIDAR.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- CO1 Understand millimeter wave propagation models in outdoor, indoor, and vehicular environments. [U]
- CO2 Apply beamforming and direction-finding techniques in mmWave communication systems. [AP]
- CO3 Analyze fiber optic transmission characteristics including dispersion and attenuation. [AN]
- CO4 Apply system design considerations for fiber optic networks and multiplexing technologies. [AP]
- CO5 Understand the working of free-space optical communication systems under various conditions. [U]

Text Books:

- 1 Theodore S. Rappaport, Robert W. Heath, Robert C. Daniels, and James N. Murdock, "Millimeter Wave Wireless Communications", Prentice Hall of India, 2021.
- 2 Gerd Keiser, "Fiber Optic Communications", Springer, 1st Edition, 2021.
- 3 John M. Senior, "Optical Fiber Communication", PHI/Pearson, 2020.

Reference Books:

- 1 Stamatios V. Kartalopoulos, "Free Space Optical Networks for Ultra-Broad Band Services", John Wiley & Sons, Inc., 3rd Edition, 2020.
- 2 Rajiv Ramaswami, Kumar Sivarajan and Galen Sasaki, "Optical Networks: A Practical Perspective", Morgan Kaufman Publishers, 5th Edition, 2021.
- 3 Agrawal G, "Fiber optic Communication Systems", John Wiley and Sons, 2019.

Web References:

- 1 https://www.rohde-schwarz.com/uk/solutions/aerospace-and-defense/sea/naval-systems/communications-systems/hf-communications_255935.html
- 2 <https://www.afcea.org/signal-media/high-frequency-communications-features-highs-and-lows>
- 3 <https://dst.gov.in/new-model-improving-high-frequency-radio-communications-crucial-during-natural-disasters>

23EC934	SMART ANTENNAS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To gain knowledge in smart antenna radiation properties
- 2 To analyze various narrow band signal processing techniques.
- 3 To analyze various algorithms in estimating solution converges to optimal solution
- 4 To acquire knowledge in broad band signal processing in time domain and frequency domain
- 5 To enable students to understand and analyze direction of arrival estimation techniques
- 6 To explore the application of massive MIMO, flexible antennas and reconfigurable intelligent surfaces in advanced 5G and 6G wireless communication systems

INTRODUCTION TO SMART ANTENNAS

15

Antenna gain, wavelength, Directivity, beamwidth, phased array antenna, power pattern, beam steering, degree of freedom, optimal antenna, adaptive antennas, smart antenna – key benefits of smart antenna technology, wide band smart antennas, Digital radio receiver techniques and software radio for smart antennas, Narrow Band Processing: Signal model conventional beamformer, null steering beamformer, optimal beam former. Flexible /wearable antennas, Reconfigurable antennas/ Reconfigurable Intelligent surfaces(6G applications), Massive MIMO 5G Antennas.

ADAPTIVE PROCESSING AND BROADBAND PROCESSING

15

Sample matrix inversion algorithm, unconstrained LMS algorithm, Gradient Estimate, Recursive Least Mean Square (RLS) Algorithm, normalized LMS algorithm, Constrained LMS algorithm, Neural network Approach. Tapped delay line structure, Digital beam forming, Broad band processing using DFT method.

DIRECTION OF ARRIVAL ESTIMATION METHODS

15

Spectral estimation methods, linear prediction method, Maximum entropy method, Maximum likelihood method, Eigen structure methods, Conventional DOA Estimation Methods, Conventional Beam forming Method, Capon's Minimum Variance Method, MUSIC Algorithm, ESPRIT Algorithm, Uniqueness of DOA Estimates.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the fundamental antenna parameters and their influence on the performance of wireless communication systems. | [U] |
| CO2 | Analyze smart antenna technologies and design antenna systems for advanced and emerging wireless applications. | [AN] |
| CO3 | Analyze adaptive filtering algorithms used in beamforming and direction of arrival (DOA) estimation. | [AN] |
| CO4 | Design optimized beamforming strategies tailored for real-world wireless communication scenarios. | [AP] |
| CO5 | Compare conventional and advanced DOA estimation techniques to evaluate and enhance smart antenna performance. | [AN] |

Text Books:

- 1 Lal Chand Godara, "Smart Antennas" 1st edition, CRC press, 2004.
- 2 Balanis, "Antenna Theory", 4th edition, John Wiley and Sons, 2016.
- 3 R. S. Elliot, "Antenna Theory and Design", revised edition, Wiley-IEEE Press, 2003.
- 4 Constantine A. Balanis & Panayiotis I. Ioannides, "Introduction to Smart Antennas", Morgan & Claypool Publishers' series-2007.

Reference Books:

- 1 T.S Rappaport, "Smart Antennas Adaptive Arrays Algorithms and Wireless Position Location", IEEE press 1998, PTR – PH publishers 1999.
- 2 Robert A.Monzingo, R.L.Haupt, T.W. Miller, "Introduction to Adaptive Arrays",Yesdee Publishing Pvt.Ltd.,Reprint, 2012.
- 3 Frank B.Gross,"Smart Antennas for wireless Communications", 1st edition, Mcgraw Hill, 2005.

Web References:

- 1 https://www.researchgate.net/publication/220696124_Introduction_to_Smart_Antennas
- 2 <https://www.ieeeaps.org/ieee-tap/for-readers/special-issues/special-issue-on-adaptive-antennas>
- 3 <https://www.mdpi.com/1424-8220/20/10/2753>

23EC935	RADAR SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To understand the fundamental principles and operating parameters of radar systems.
- 2 To explore the radar signal characteristics, performance metrics, and range-related concepts.
- 3 To study the architecture and functions of radar subsystems and signal processing techniques.
- 4 To analyze the behaviour and design of various amplifiers and switching components in radar TRMs.
- 5 To examine different radar types, their applications, and methods for signal detection in noise.
- 6 To familiarize with stealth technologies and radar cross section reduction techniques.

RADAR FUNDAMENTALS AND SYSTEM PARAMETERS

15

Radar principles and Doppler Effect, Radar frequency bands and block diagram, Radar range equation and cross section, Radar clutter and scattering types, transmit pulse width, PRF, baud length, range resolution, Coherent and incoherent integration, Detectability, SNR, bandwidth, transmit power, Pulse compression techniques.

RADAR SUBSYSTEMS AND SIGNAL CHAIN

15

Transmit and Receive Module (TRM): block schematic, Timing and signal generation, gain and phase control, Design of amplifiers (power, low-noise, solid-state), TR switches, circulators, blanking switches, band-pass filters, Digital receiver and signal processing flow, Clutter removal, spectral cleaning, velocity and range-SNR computation, Spectral moment computation, auto/cross correlation, Imaging methods: Capon and Maximum Entropy.

RADAR TYPES AND STEALTH TECHNOLOGIES

15

Overview of Radar Types: CW and Frequency Modulated Radar, MTI and Pulse Doppler Radar, Tracking Radar, Detection of Radar Signals in Noise, Airborne Radar, Space borne Radar, Synthesis aperture radar, SHAR and MST radar. Principles of stealth technology, Radar cross section (RCS) reduction techniques, RF absorbers and stealth countermeasures.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Outlines the principles of radar operation, Doppler effect, and key system parameters. | [U] |
| CO2 | Compute radar range parameters, resolution, and signal-to-noise characteristics. | [AP] |
| CO3 | Identify and describe the roles of radar subsystems including TRMs and amplifiers. | [U] |
| CO4 | Analyze radar signal processing methods such as clutter removal and spectral analysis. | [AN] |
| CO5 | Compare and differentiate radar types and describe techniques used in stealth technology. | [AN] |

Text Books:

- 1 Merrill Skolnik, "Introduction to Radar Systems", 3rd Edition, McGraw-Hill, USA, 2017.

- 2 Habibur Rahman, "Fundamental Principles of Radar", CRC Press, Taylor & Francis Group, USA, 2019.
- 3 G.S.N. Raju, "Radar Engineering and Fundamentals of Navigational Aids", DreamTech Press (Wiley distribution), New Delhi, India, 2019.

Reference Books:

- 1 Merrill Skolnik, "Radar Handbook", 3rd Edition, McGraw-Hill, USA, 2018.
- 2 A.K. Sen and A.B. Battacharya, "Radar Systems and Radar Aids to Navigation", Khanna Publications, 2019.
- 3 Mark A Richards, James A Scheer and William A Holm Yesdee, "Principles of Modern Radar: Basic Principles", Scitech Publishing Inc, 1st Edition, 2019.

Web References:

- 1 <https://www.noaa.gov/jetstream/doppler/how-radar-works>
- 2 <https://www.mistralsolutions.com/blog/a-comprehensive-guide-on-radar-systems/>
- 3 https://www.tutorialspoint.com/radar_systems/radar_systems_overview.htm

23EC936	WIRELESS BROADBAND NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To understand the technical, economic and service advantages of next generation networks.
- 2 To analyze the basic architecture of a next generation network (NGN) with reference.
- 3 To understand and compare different methods of delivering connection-oriented services over Next Generation Networks (NGN).
- 4 To explore the role of Multimedia Sub-System (IMS), network attachment and admission control functions.
- 5 To design and simulate routing mechanisms to meet desired Quality of Service (QoS) in NGNs.
- 6 To compare various NGN virtual network services (VPNs, VLANs, VPLS) and understand their real-world applications.

WIRELESS PROTOCOLS

15

Review of cellular standards, migration and advancement of GSM architecture and CDMA architecture, WLAN – IEEE 802.11 and HIPERLAN, Bluetooth, Mobile network layer-Fundamentals of Mobile IP, data forwarding procedures in mobile IP, IPv4, IPv6, IP mobility management, IP addressing - DHCP, Mobile transport layer-Traditional TCP, congestion control, slow start, fast recovery/fast retransmission, classical TCP improvements- Indirect TCP, snooping TCP, Mobile TCP.

MANAGING WIRELESS NETWORKS AND TESTING

15

Managing Wireless Broadband Operations Management of LMDS Systems and their Application, Principles of operations Management, LMDS Versus Other Access technologies, Applications, Testing Wireless Satellite Networks and Fixed Wireless Broadband Networks.

LAYER-LEVEL FUNCTIONS

15

Characteristics of wireless channels - downlink physical layer, uplink physical layer, MAC scheme - frame structure, resource structure, mapping, synchronization, reference signals and channel estimation, SC-FDMA, interference cancellation –Comp, Carrier aggregation, Services - multimedia broadcast/multicast, location-based services.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand the latest technologies and wireless components involved in broadband communication systems. | [U] |
| CO2 | Compare and evaluate various techniques and technologies essential for the development of broadband and next-generation networks (NGNs). | [AN] |
| CO3 | Analyze recent advancements in wireless communication and assess the role of next-generation Internet protocols in broadband networks. | [AN] |
| CO4 | Design efficient routing mechanisms to ensure Quality of Service (QoS) in broadband communication systems. | [AP] |
| CO5 | Compare and analyze NGN-based virtual network services and apply them in the context of real-time broadband applications. | [AN] |

Text Books:

- 1 Kaveh Pahlavan, "Principles of wireless networks", Prentice-Hall of India, 2002.
- 2 John R Vacca, Wireless Broadband Networks Handbook, Tata McGraw Hill, 2001.
- 3 John R. Vacca, "Wireless Broadband Networks Handbook 3G, LMDS and Wireless Internet" Tata McGraw-Hill, 2001.

Reference Books:

- 1 William Stallings, ISDN and Broadband ISDN with Frame and ATM, Pearson 6th edition, 2002.
- 2 Robert C Newman, Broadband Communications, Prentice Hall, 2001.
- 3 William Stallings, Data and Computer Communications, Pearson 10th edition, 2013.

Web References:

- 1 <https://www.mona.uwi.edu/physics/physics/courses/eIng3050/wireless-broadband-networks>
- 2 www.techplayon.com/lte-a-lte

23EC937	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To Introduce the fundamental concepts of EMI and EMC, including their sources and effects on electronic systems.
- 2 To Understand coupling mechanisms and mitigation techniques to ensure system compatibility.
- 3 To Familiarize with international EMC standards and testing procedures.
- 4 To Develop skills to design electronic systems with EMC considerations.
- 5 To Introduce the fundamental concepts of EMI and EMC, including their sources and effects on electronic systems.
- 6 To Understand coupling mechanisms and mitigation techniques to ensure system compatibility.

FUNDAMENTALS OF EMI/EMC

15

Introduction to Electromagnetic Environment -Sources and Types of EMI: Natural sources- Natural sources- Review of Maxwell's equations for EMC- Plane wave concepts, radiation, and field behavior- Reflection, refraction, absorption related to EMC- Narrowband vs. broadband interference- Continuous wave vs. impulsive noise- Effects on communication and control systems -Impact of EMI and EMC Requirements :Reliability issues-Regulatory needs (overview)-Introduction to basic protection techniques

COUPLING MECHANISMS AND MITIGATION TECHNIQUES

15

Coupling paths and mechanisms: Conducted coupling-Radiative coupling-Ground loop coupling-Coupling via supply networks-Common mode vs Differential mode coupling-Cable-related emissions and coupling phenomena-Transient sources and Automotive transients-**Categorization of EMI:** Emission, Susceptibility, Transients, Crosstalk-Shielding and Signal Integrity Issues-**EMI Mitigation Techniques :Shielding Techniques:** LF (Low Frequency) Magnetic shielding-Apertures and Shielding Effectiveness- Choice of Materials for H-field, E-field, and Free-space field shielding- Gasketing and sealing techniques-PCB level shielding methods. Grounding Techniques

STANDARDS, REGULATIONS, EMI TEST METHODS AND BIO-EFFECTS

15

Standards and Regulations: Need for EMI/EMC Standards-International and National Standards- EMI Standardization for different domain- **EMI Test Methods and Instrumentation:** Fundamental considerations for EMI testing-Shielding Effectiveness Test methods-Open-field and Semi-Anechoic Chamber Tests -TEM cells for Immunity Tests- Shielded chambers and anechoic chambers-Test equipment: EMI Test receivers- Spectrum analyzers- Wave simulators- Coupling networks (EMI coupling via cables)-Line Impedance Stabilization Networks (LISN)- Feedthrough capacitors, Current probes, and Antennas-Basics of Biological Effects of EM Waves

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|-----|
| CO1 | Understand the basic concepts of electromagnetic interference (EMI) and electromagnetic compatibility (EMC). | [U] |
| CO2 | Understand the causes of conducted and radiated EMI emissions and describe the susceptibility of systems. | [U] |

CO3	Identify different coupling mechanisms in EMI such as common mode, differential mode, and ground loop coupling.	[U]
CO4	Apply shielding and grounding techniques for minimizing EMI effects in electronic systems.	[AP]
CO5	Apply EMI testing procedures using standard test methods and basic EMI measurement instruments.	[AP]

Text Books:

- 1 William Duff G., & Donald White R. J, "Series on Electromagnetic Interference and Compatibility", Vol. 5, EMI Prediction and Analysis Technique – 1972.
- 2 V.P. Kodali, "Engineering Electromagnetic Compatibility", 2nd Edition, Wiley India, 2001.
- 3 Henry W. Ott, "Electromagnetic Compatibility Engineering", 1st Edition, Wiley, 2009.
- 4 Clayton R. Paul, "Introduction to Electromagnetic Compatibility", 2nd Edition, Wiley, 2006.
- 5 William R. Paul, "Electromagnetics for Engineers: With Applications to EMC", Wiley, 2001.
- 6 Rajeev Bansal, "Engineering Electromagnetic Fields and Waves", CRC Press, 2012.

Reference Books:

- 1 Clayton R. Paul, "Analysis of Multiconductor Transmission Lines", 2nd Edition, Wiley-Interscience, 2008.
- 2 Henry W. Ott, "Noise Reduction Techniques in Electronic Systems", 2nd Edition, Wiley, 1988.
- 3 David Morgan, "A Handbook for EMC Testing and Measurement", IET (Institution of Engineering and Technology), 1994.
- 4 Reinaldo Perez, "Electromagnetic Compatibility Handbook", 1st Edition, CRC Press, 1995.
- 5 Bernhard Keiser, "Principles of Electromagnetic Compatibility", 3rd Edition, Artech House, 1987.

Web References:

- 1 <https://apps.dtic.mil/sti/tr/pdf/ADA018980.pdf>
- 2 <https://nvlpubs.nist.gov/nistpubs/Legacy/TN/nbstechnicalnote1099.pdf>
- 3 <https://interpro.wisc.edu/courses/emc-and-best-practices/>
- 4 <https://www.ansys.com/en-in/applications/emi-emc>

23EC938	NANOPHOTONICS	L	T	P	C
		83	0	0	3

COURSE OBJECTIVES

- 1 To introduce the fundamentals of photonics and nanophotonics, focusing on how light behaves at the nanoscale.
- 2 To understand the interaction of electromagnetic waves with nanostructures and study optical properties of materials at the nanoscale.
- 3 To explain basic phenomena such as surface plasmons, LSPR, and quantum dots, and their significance in nanophotonics.
- 4 To study nanophotonic structures like photonic crystals, metamaterials, and metasurfaces.
- 5 To explore nanofabrication and characterization techniques, including electron beam lithography, nanoimprint lithography, NSOM, SEM, AFM, and TEM.
- 6 To discuss plasmonic circuits, emerging applications, and research trends in nanophotonics, especially in communication, sensing, and imaging.

FUNDAMENTALS OF NANOPHOTONICS

15

Introduction to Photonics and Nanophotonics - Light confinement and guiding at nanoscale- Interaction of electromagnetic waves with nanostructures- Optical properties of materials at nanoscale- Surface Plasmons: Principles and basic phenomena- Localized Surface Plasmon Resonance (LSPR)- Quantum Dots: Emission and absorption properties.

NANOPHOTONIC STRUCTURES AND FABRICATION

15

Photonic Crystals: Concepts, bandgap formation, and applications- Metamaterials and negative refractive index- Plasmonic nanostructures and metasurfaces- Nanofabrication techniques: Electron Beam Lithography, Nanoimprint Lithography, Self-Assembly- Near-field optical microscopy (NSOM)- Characterization methods: SEM, AFM, TEM for nanophotonic devices.

PLASMONICS AND EMERGING TRENDS IN NANOPHOTONICS

15

Introduction to Plasmonics-Fundamentals of Surface Plasmon-Polaritons-Plasmonic Wave Equations-Design of Plasmonic Photonic Circuits-Contemporary Issues in Nanophotonics-Recent Advances and Research Trends-Applications of Nanophotonics in Communication, Sensing, and Imaging-Future directions and challenges.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand the behavior of light in photonics and nanophotonics, including concepts like surface plasmons and quantum dots at the nanoscale. | [U] |
| CO2 | Understand the working principles of photonic crystals, metamaterials, and metasurfaces, and identify their practical applications. | [U] |
| CO3 | Understand various nanofabrication techniques and testing methods employed in nanophotonic device development. | [U] |
| CO4 | Model the propagation of surface plasmons and explain their role in the design of nanoscale photonic circuits. | [U] |
| CO5 | Apply nanophotonic concepts to real-world applications such as communication, sensing, and imaging, and relate them to emerging research trends. | [AP] |

Text Books:

- 1 Paras N. Prasad, "Nanophotonics", Wiley-Interscience, 2004.
- 2 John D. Joannopoulos, Steven G. Johnson, Joshua N. Winn, and Robert D. Meade, Photonic Crystals: Molding the Flow of Light Publisher: Princeton University Press, 2008
- 3 Lukas Novotny & Bert Hecht Principles of Nano-Optics, Cambridge University Press, 2006.

Reference Books:

- 1 Motoichi Ohtsu, Kiyoshi Kobayashi, Tadashi Kawazoe, Takashi Yatsui, Makoto Naruse, Principles of Nanophotonics, CRC Press, Taylor & Francis Group, 2008.
- 2 J. R. Lakowicz, Principle of Fluorescence Spectroscopy, third Edition, Kluwer Academic Publisher, Newyork, 2007
- 3 Stefan A. Maier *Plasmonics: Fundamentals and Applications, Springer, 2007.*

Web References:

- 1 <https://spie.org>
- 2 <https://www.optica.org>
- 3 <https://www.nano.gov>
- 4 <https://www.nature.com/nnano/>

23EC939	SOI DEVICES MODELING AND SIMULATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 Explain the fundamental principles and fabrication techniques of Silicon-On-Insulator (SOI) devices.
- 2 Analyze the electrical characteristics and modeling approaches of SOI devices.
- 3 Interpret simulation results and evaluate the application of SOI devices in advanced semiconductor technologies.

INTRODUCTION TO SOI DEVICES

15

Basics of SOI Technology: Motivation, History, and Evolution - Comparison of SOI and Bulk CMOS - Types of SOI structures: PDSOI (Partially Depleted) vs. FDSOI (Fully Depleted) - Fabrication Techniques: SIMOX (Separation by IMplanted OXYgen), Smart-Cut, BESOI, ELTRAN, and others Thermal and mechanical properties of SOI wafers- Interface states, Buried Oxide (BOX) characteristics.

ELECTRICAL CHARACTERISTICS AND DEVICE MODELING

15

I-V and C-V Characteristics of SOI MOSFETs - Threshold voltage models for PDSOI and FDSOI - Short-channel effects (SCEs) in SOI devices: DIBL, Punch-through, GIDL - Floating body effects: Hysteresis, Kink Effect - Self-heating effects and Thermal modelling - Back-gate biasing and body-contact schemes - Analytical Models vs. Compact Models for SOI MOSFETs.

SIMULATION TECHNIQUES AND APPLICATIONS

15

Basics of TCAD simulation for SOI devices - Setup of 2D/3D simulations: Device structure definition, meshing, and boundary conditions - Calibration of simulation models with experimental data - Simulation of short-channel effects and body effects - Introduction to circuit-level modeling with SOI devices (BSIM-SOI models) - Applications of SOI Technology in RF, High-Speed Digital, and Low-Power Circuits - Emerging trends: UTB (Ultra-Thin Body) SOI, FD-SOI in advanced nodes.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the fundamental concepts, structure, and advantages of SOI devices compared to bulk CMOS technology. | [U] |
| CO2 | Understand various fabrication techniques and process flows used for partially and fully depleted SOI structures. | [U] |
| CO3 | Understand the electrical behavior of SOI MOSFETs and identify performance benefits and challenges such as short-channel and floating body effects. | [U] |
| CO4 | Apply suitable device modeling techniques to analyze parasitic effects and non-idealities in SOI devices. | [AP] |
| CO5 | Apply compact modeling approaches to evaluate circuit-level performance in SOI-based digital and analog circuit applications. | [AP] |

Text Books:

- 1 J.-P. Colinge, "Silicon-on-Insulator Technology: Materials to VLSI", 3rd Edition, Springer, 2004
- 2 Yannis Tsvividis, "Operation and Modeling of the MOS Transistor", 3rd Edition, Oxford University Press, 2011.

- 3 Y. Taur and T. H. Ning, "Fundamentals of Modern VLSI Devices", 2nd Edition, Cambridge University Press, 2013.

Reference Books:

- 1 David Esseni, Pierpaolo Palestri, Luca Selmi, "*Nanoscale MOS Transistors: Semi-Classical Transport and Applications*", Cambridge University Press, 2011.
- 2 H.-S. P. Wong, "*Technology and Design of SOI Devices*", Wiley-IEEE Press, 2009.

Web References:

- 1 <https://ieeexplore.ieee.org/>
- 2 <https://www.sciencedirect.com/>
- 3 <https://www.synopsys.com/>

23EC940	MODELING OF MICROELECTRONIC DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce the fundamental concepts of semiconductor physics, including charge carriers, band theory, and junction behavior.
- 2 To explain the characteristics and operation of metal-semiconductor and p-n junctions under various biasing conditions.
- 3 To understand the working principles of MOS capacitors and MOSFETs, focusing on threshold voltage and I-V characteristics.
- 4 To apply knowledge of device physics to analyze short-channel effects and scaling challenges in advanced MOSFET technologies.
- 5 To provide an overview of numerical simulation techniques and the structure of TCAD tools used in device modeling.
- 6 To develop the ability to use TCAD simulations for evaluating and optimizing semiconductor devices such as MOSFETs and SOI structures.

SEMICONDUCTOR ELECTRONICS AND METAL-SEMICONDUCTOR CONTACTS 15

Semiconductor Electronics – Physics of Semiconductor Materials – Band Model of Solids – Thermal-Equilibrium Statistics – Carriers in Semiconductors – Drift Velocity, Mobility, and Scattering – Drift & Diffusion Current – Device: Hall-Effect Metal-Semiconductor Contacts and P-N Junctions – Metal-Semiconductor Junctions: Current-Voltage Characteristics, Surface Effects – The pn Junction: Step Junction, Linearly Graded Junction, Heterojunctions – Reverse-Biased p-n Junctions and Breakdown Mechanism – Generation and Recombination.

FIELD-EFFECT TRANSISTORS (MOSFETS) AND DEVICE MODELING 15

Field-Effect Transistors (MOSFETs): MOS capacitor – oxide & interface charge – basic MOSFET I-V behaviour – threshold voltage & body-effect – complementary MOSFETs (CMOS) – velocity saturation – channel-length modulation – leakage currents – sub-threshold conduction

Short-Channel Effects & Device Modeling: limitations of long-channel models – mobility degradation – hot-carrier effects – threshold-voltage adjustment techniques – gate-coupling effects – overview of FDSOI & multi-gate MOSFETs – key challenges to scaling.

NUMERICAL SIMULATION AND TCAD TOOLS 15

Basic Concepts of Simulations – Grids – Device Simulation and Challenges – Importance of Semiconductor Device Simulators – Key Elements of Physical Device Simulation – Historical Development of Physical Device Modeling. Introduction to TCAD Simulation Tool – Examples of TCAD Simulations: MOSFETs and SOI – Application of TCAD in Modern Semiconductor Design.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|-----|
| CO1 | Understand basic semiconductor physics, including carrier transport mechanisms, energy band models, and p-n junction behavior. | [U] |
| CO2 | Understand the characteristics and operation of metal-semiconductor junctions, p-n junctions, and MOS structures under various biasing conditions. | [U] |
| CO3 | Interpret the behavior of MOS capacitors and MOSFETs, including threshold voltage, current-voltage characteristics, and their dependence on device | [U] |

- parameters.
- CO4 Apply theoretical concepts to analyze short-channel effects and scaling issues in advanced MOSFET technologies. [AP]
- CO5 Use TCAD tools to simulate and evaluate semiconductor devices such as MOSFETs and SOI structures for design optimization. [AP]

Text Books:

- 1 S. M. Sze and M.K. Lee, "Semiconductor devices- Physics and Technology", 3rd Edition, John Wiley & Sons, 2012
- 2 Dragica Vasileska, Stephen M. Goodnick," Computational Electronics: Semiclassical and Quantum Device Modeling and Simulation" CRC Press,2017.
- 3 Shunri Oda, David Ferry," Silicon Nanoelectronics" CRC Press, 2006.

Reference Books:

- 1 S. M. Sze and Kwok K. Ng, "Physics of Semiconductor Devices" John Wiley & Sons, 3rd Edition, 2002.
- 2 Ben G. Steetman and Sanjay Banerjee, "Solid State Electronic Devices", Prentice Hall, 6th Edition, 2005
- 3 Robert F. Pierret, "Semiconductor Device Fundamentals", Addison-Wesley Publishing, 1996.

Web References:

- 1 [https://eng.libretexts.org/Bookshelves/Materials_Science/Supplemental_Modules_\(Materials_Science\)/Semiconductors/Metal-Semiconductors_Contacts](https://eng.libretexts.org/Bookshelves/Materials_Science/Supplemental_Modules_(Materials_Science)/Semiconductors/Metal-Semiconductors_Contacts)
- 2 <https://web.iitd.ac.in/~bkrishna/MLL738/Lecture16.pdf>
- 3 <https://www.sciencedirect.com/topics/engineering/metal-oxide-semiconductor-field-effect-transistor>
- 4 <https://www.sciencedirect.com/science/article/abs/pii/S0168900215009614>

23EC941	IC DESIGN AND TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce the fundamentals of analog VLSI and understand mixed-signal design challenges in CMOS technologies.
- 2 To study MOS transistor modeling, small-signal parameters, and their impact on analog circuit design.
- 3 To design and analyze basic CMOS analog building blocks like current mirrors, differential amplifiers, and operational amplifiers.
- 4 To understand the working principles of frequency synthesizers, phase-locked loops, and nonlinear analog blocks such as comparators and charge-pumps.
- 5 To explore data converter basics, analog layout considerations, and low-power circuit design techniques
- 6 To introduce the fundamentals of analog VLSI and understand mixed-signal design challenges in CMOS technologies.

FUNDAMENTALS OF ANALOG VLSI AND CMOS CIRCUIT BUILDING BLOCKS 15

Introduction to Analog VLSI and mixed-signal issues in CMOS technologies – Basic MOS models and their extensions – SPICE models for MOSFETs – Frequency-dependent parasitic parameters in MOS devices – Basic MNOS/CMOS gain stages – Cascade and Cascode amplifier circuits – Frequency response of analog circuits – Stability issues in amplifier design – Noise sources in analog amplifiers and their impact.

ANALOG CMOS BLOCKS AND OPERATIONAL AMPLIFIERS 15

CMOS analog functional blocks: Current sources and voltage references – Design of Differential Amplifiers – Design of Operational Amplifiers (OPAMPs) – Frequency synthesizers: Design basics – Phase-Locked Loops (PLLs): Components and applications – Non-linear analog blocks: Comparators, Charge-pump circuits, Multipliers – Basics of data converters (ADC/DAC fundamentals).

ADVANCED TOPICS: TESTING, LAYOUT, LOW POWER, AND RF INTRODUCTION 15

Analog testing strategies for mixed-signal circuits – Layout issues unique to analog and mixed-signal ICs – Techniques for minimizing mismatch and parasitic effects in layout – Low voltage and low power design considerations – Challenges in scaling analog circuits for low power operation – Introduction to RF electronics and RF circuit behavior at high frequencies.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand fundamental principles of analog and mixed-signal circuit design in CMOS technologies. | [U] |
| CO2 | Understand MOS device models, frequency-dependent parameters, and their impact on analog circuit performance. | [U] |
| CO3 | Apply the logic to build the CMOS analog building blocks like current sources, voltage references, differential amplifiers, and operational amplifiers. | [AP] |
| CO4 | Understand the working and design considerations of frequency synthesizers, PLLs, and basic data converters. | [U] |
| CO5 | Apply layout techniques and testing strategies for robust mixed-signal circuit design. | [AP] |

Text Books:

- 1 B. Razavi, Design of Analog CMOS Integrated Circuits, McGraw Hill 2001
- 2 P. E. Allen and D. R. Holberg, CMOS Analog Circuit Design, 2nd edition, Oxford University Press, 1997
- 3 B. Razavi, RF Microelectronics, Prentice-Hall, 1998.

Reference Books:

- 1 R. Jacob Baker, CMOS Circuit Design, Layout, and Simulation, IEEE Press, 1997.
- 2 P. R. Gray and R. G. Meyer, Analysis and design of Analog Integrated circuits 4th Edition, Wiley Student Edition, 2001.
- 3 D. A. Johns and K. Martin, Analog Integrated Circuit Design, Wiley Student Edition, 2002

Web References:

- 1 https://community.cadence.com/cadence_blogs_8/b/cic/posts/from-concept-to-reality-understanding-the-cadence-analog-ic-design-flow
- 2 https://www.cadence.com/en_US/home/training/all-courses/86404.html
- 3 <https://www.allaboutcircuits.com/technical-articles/introduction-to-analog-ic-design/>
- 4 https://onlinecourses.nptel.ac.in/noc23_ee142/preview

23EC942	RF MICROELECTRONICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce the fundamental principles and components used in RF circuit design, including RLC networks and integrated passive devices.
- 2 To explain supply-independent biasing techniques such as Bandgap Voltage Reference and Constant-gm biasing used in RF IC design.
- 3 To describe feedback systems and various types of noise in RF circuits, and analyze how noise affects circuit performance.
- 4 To develop an understanding of high-frequency amplifier design, including LNAs and power amplifiers, focusing on design trade-offs and performance optimization.
- 5 To provide knowledge of oscillator design, phase-locked loops (PLLs), and mixer architectures used in RF signal generation and processing.
- 6 To analyze the complete RF transceiver system architecture and apply concepts through a practical case study or design example.

FUNDAMENTALS OF RF CIRCUIT DESIGN AND NOISE ANALYSIS

15

Fundamental concepts in RF circuit design - Basic concepts in RF design - Passive RLC networks - Characteristics of passive IC components such as resistors, capacitors, and inductors - Techniques for supply-independent biasing including Bandgap Voltage Reference and Constant-gm Biasing - Feedback systems: Desensitivity, Stability, Errors, and Compensation methods - Noise in RF circuits: Thermal noise, Shot noise, Flicker noise, Popcorn noise - Analysis of noise behavior in devices and its impact on RF performance.

RF AMPLIFIERS, LOW NOISE AMPLIFIERS (LNA), AND POWER AMPLIFIERS

15

High-frequency amplifier design and optimization - Bandwidth enhancement techniques using zeros - Shunt-series amplifiers - Tuned amplifiers and cascaded amplifier structures - Low Noise Amplifier (LNA) design principles: Power Match and Noise Match topologies - Linearity and large-signal performance in LNA designs - RF Power Amplifiers: Design and characteristics of Class A, Class B, Class C, and Class AB amplifiers - Trade-offs between linearity, efficiency, and power output - Real-world considerations in amplifier design for RF circuits.

OSCILLATORS, PLLS, MIXERS, AND TRANSCEIVER ARCHITECTURES

15

Generation and control of RF signals - RF Oscillators: Tuned oscillators, Negative resistance oscillators, and Phase Noise analysis - Phase-Locked Loops (PLLs): Design of phase detectors, loop filters, and frequency synthesizers - Mixer fundamentals: Non-linear behaviour, linearization of mixers, and various mixer architectures - Transceiver architectures: Overview and analysis of modern RF transceiver design - Practical case study example illustrating the design of a complete RF transceiver.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand the fundamentals of RF circuits, including passive components, biasing techniques, and noise behavior. | [U] |
| CO2 | Analyze and design biasing and feedback networks in RF systems with emphasis on noise performance. | [AN] |
| CO3 | Understand the design of Low Noise Amplifiers (LNA), focusing on bandwidth, impedance matching, linearity, and noise figure. | [U] |

- CO4 Understand and compare different RF power amplifier classes (A, B, AB, C) with respect to efficiency, linearity, and performance trade-offs. [U]
- CO5 Describe the principles of RF oscillators, mixers, and PLLs, and apply system-level concepts in transceiver design. [AP]

Text Books:

- 1 Behzad Razavi, "RF Microelectronics", 2nd Edition, Pearson Education, Saddle River, New Jersey, USA, 2012.
- 2 John W. Rogers, Calvin Plett, "Radio Frequency Integrated Circuit Design", 2nd Edition, Norwood, Massachusetts, USA, 2010.
- 3 Charles E. Free, Colin S. Aitchison, "RF and Microwave Circuit Design" Wiley 2021.

Reference Books:

- 1 B. Razavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw-Hill, 2002.
- 2 Sorin Voinigescu, "High Frequency Integrated Circuits", Cambridge University Press.
- 3 Reinhold Ludwig, Gene Bogdanov, "RF Circuit Design Theory and Applications", Pearson Education

Web References:

- 1 <https://www.allaboutcircuits.com/textbook/radio-frequency-analysis-design/rf-principles-components/passive-components-in-rf-circuits/>
- 2 <https://rahsoft.com/2021/05/10/different-types-of-noise-in-rf-devices/>
- 3 <https://www.analog.com/en/resources/technical-articles/choosing-a-lownoise-amplifier.html>
- 4 <https://www.rfwireless-world.com/tutorials/rf-measurements/rf-mixer-basics>

23EC943	PHOTONIC INTEGRATED CIRCUITS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 Understand the development of optical communication systems and explain the key benefits of integrated optics in modern photonic circuits.
- 2 Identify and analyze guided modes (TE/TM) in various planar waveguide structures
- 3 Explain the structure and operation of passive and active photonic devices
- 4 Describe the working principles of advanced integrated photonic components
- 5 List and compare different material platforms used in PIC fabrication
- 6 Explain and apply characterization techniques for integrated photonic devices

FUNDAMENTALS OF GUIDED WAVE OPTICS

15

Brief history of optical communication – Advantages of integrated-optics configurations – Guided TE and TM modes in symmetric and anti-symmetric planar waveguides – Step-index versus graded-index slab waveguides – Strip and channel waveguides – Beam Propagation Method (BPM) for field profiling.

PASSIVE & ACTIVE PIC DEVICES

15

Directional couplers and their use as power splitters – Y-junctions and basic on-chip optical switches – Mach–Zehnder interferometer structures – Integrated modulators and on-chip filters – A/D converters in PICs – Mode splitters and arrayed waveguide gratings (AWGs) – Acousto-optic waveguide devices – Nanophotonic elements: metal/dielectric plasmonic waveguides, surface-plasmon modes, and waveguide polarizers.

MATERIALS, FABRICATION & CHARACTERIZATION

15

Photonic-material platforms: glass, lithium niobate, silicon, III–V compound semiconductors – Fabrication techniques: lithography, thin-film deposition, etching for integrated waveguides – Device characterization: prism coupling, grating couplers, tapered-fiber coupling – Nonlinear effects in integrated waveguides (Kerr, two-photon absorption, etc.) – Applications of on-chip nonlinear optics

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|-----|
| CO1 | Describe the principles of guided wave optics and analyze guided modes in planar, strip, and channel waveguides. | [U] |
| CO2 | Distinguish between TE and TM modes in symmetric and asymmetric waveguide structures using Beam Propagation Method (BPM). | [U] |
| CO3 | Understand the operation of passive and active photonic integrated circuit components such as directional couplers, Mach–Zehnder interferometers, and modulators. | [U] |
| CO4 | Understand the functions of advanced photonic components including waveguide filters, arrayed waveguide gratings (AWGs), and plasmonic devices. | [U] |
| CO5 | Describe the material platforms, fabrication methods, and characterization techniques used in integrated photonic device development. | [U] |

Text Books:

- 1 José Capmany and Daniel Pérez, Photonic Integrated Circuits, Oxford University Press, 2020
- 2 C. R. Pollock and M Lipson, Integrated photonics, Kluwer Pub, 2003.
- 3 H Nishihara, M Haruna and T Suhara, Optical Integrated Circuits; McGraw-Hill Book Company, New York, 1989.

Reference Books:

- 1 K. Okamoto, Fundamentals of Optical waveguides, Academic Press, 2006.
- 2 A Ghatak and K Thyagarajan, Optical Electronics, Cambridge University Press, 1989.
- 3 T. Tamir, Guided wave opto-electronics, Springer Verlag, 1990

Web References:

- 1 <https://www.sciencedirect.com/topics/physics-and-astronomy/guided-wave-optics>
- 2 <https://ebin.pub/fundamentals-of-optical-waveguides.html>
- 3 <https://www.opticsjournal.net/Articles/OJ4bdca8c5d0ec8a24/FullText>
- 4 https://www.researchgate.net/publication/266865363_Silicon-based_Photonic_Devices_Design_Fabrication_and_Characterization

23EC944	RF AND MEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce RF MEMS fundamentals, mechanical modeling, materials, fabrication, and MEMS switch design.
- 2 To understand MEMS-based inductors, capacitors, filters, and phase shifters with modeling and fabrication aspects.
- 3 To study RF MEMS interconnects, transmission lines, antennas, and micromachining techniques for performance improvement.
- 4 To learn RF MEMS packaging methods, material selection, integration strategies, and reliability considerations.

RF MEMS DEVICES, FABRICATION AND SWITCHING MECHANISMS 15

RF MEMS for microwave applications – overview of MEMS technology and fabrication – mechanical modeling of MEMS devices – key MEMS materials and their fabrication techniques – MEMS switches: introduction and applications in RF systems – capacitive shunt and series switches with physical description, circuit models, and electromagnetic modeling – fabrication and packaging techniques for MEMS switches – design considerations for high-performance MEMS switching elements.

MEMS PASSIVE COMPONENTS, FILTERS, AND PHASE SHIFTERS 15

MEMS passives and tunable components – MEMS inductors: micromachined inductor structures, impact of layout on performance, modeling and design challenges for on-chip planar inductors – MEMS capacitors: gap-tuning and area-tuning capacitor concepts – dielectric-tunable capacitors for frequency agile RF circuits – RF MEMS filters: mechanical filter modeling, micromachined resonator filters, surface-acoustic-wave (SAW) filters, and millimeter-wave micromachined filters – phase shifters: MEMS-based and ferroelectric implementations, device types and their limitations.

RF MEMS INTERCONNECTS, ANTENNAS, AND PACKAGING TECHNIQUES 15

RF MEMS interconnects, antennas, and packaging – micromachined transmission lines: design, loss mechanisms, coplanar transmission line structures, and micromachined waveguide components – micromachined antennas: key design parameters, micromachining techniques to boost performance, and reconfigurable antenna approaches – integration and packaging of RF MEMS: the role of MEMS packages, various package types, module-level packaging strategies, choice of packaging materials, and reliability considerations in RF environments.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Identify various types of RF MEMS devices, fabrication methods and packaging standard. | [U] |
| CO2 | Design MEMS inductors and tunable capacitors using micromachine techniques. | [U] |
| CO3 | Model MEMS filters and Phase shifters for various types of RF applications. | [U] |
| CO4 | Design and analyze Micro machined Transmission lines and Antennas for wireless applications. | [AP] |
| CO5 | Analyze the reliability and design related issues in MEMS structures. | [AP] |

Text Books:

- 1 RF MEMS and their Applications, Vijay K. Varadan, Wiley-India,2011.
- 2 RF MEMS: Theory, Design, and Technology, Gabriel M. Rebeiz, Wiley, 2003.

Reference Books:

- 1 An Introduction to Microelectromechanical Systems Engineering, NadimMaluf, Artech House,2000. .
- 2 RF MEMS Circuit Design for Wireless Communications, De LosSantosH J, Artech House, 1999

Web References:

- 1 https://en.wikipedia.org/wiki/Radio-frequency_microelectromechanical_system
- 2 <https://eepower.com/technical-articles/rf-mems-switches-types-working-principle-and-applications/>
- 3 <https://www.mems-exchange.org/MEMS/>

23EC945	E-WASTE MANAGEMENT AND RECYCLING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To understand the sources, generation, and characteristics of e-waste and plastic waste from industrial and commercial activities.
- 2 To study national and international regulatory frameworks and policy initiatives on e-waste and plastic waste management.
- 3 To explore sustainable design strategies, circular economy approaches, and eco-friendly practices for managing electronic and plastic waste.
- 4 To analyze advanced technologies for recycling and recovery, including nanotechnology, biotechnological, and smart system applications.
- 5 To introduce digital innovations like IoT, blockchain, and AI for efficient and transparent waste management systems.
- 6 To familiarize with global case studies, industry collaborations, and future trends in sustainable waste management.

CONCEPTS, CHALLENGES AND REGULATORY FRAMEWORK

15

Introduction to E-Waste and Plastic Waste: Sources, generation, and characteristics from industrial and commercial activities – Current trends and challenges in e-waste and plastic waste management – Waste management practices: onsite handling, storage, collection, and transfer– E-Waste Processing Alternatives: Mechanical, thermal, chemical, and biological routes – Overview of E-Waste Management Rules and Plastic Waste Management Rules (2016) and subsequent amendments – International regulations and agreements on e-waste management– Policy development and implementation strategies – Extended Producer Responsibility (EPR) programs and their global impact.

SUSTAINABLE DESIGN, CIRCULAR ECONOMY, AND ADVANCED RECYCLING TECHNOLOGIES

15

Circular Economy Approaches for E-Waste Recycling – Sustainable design strategies for electronic products – Eco-design principles and Life Cycle Assessment (LCA) for electronics – Green procurement policies and eco-labeling initiatives – Innovative recycling processes for complex e-waste streams – Nanotechnology applications in e-waste recovery – Biotechnological solutions for e-waste valorization – Sustainable processing and recovery approaches for plastics and e-waste.

DIGITAL TRANSFORMATION, SMART SYSTEMS, AND FUTURE TRENDS

15

Big Data Analytics and Artificial Intelligence applications in e-waste management – Blockchain technology for traceability and transparency in waste streams – Internet of Things (IoT) for smart e-waste management systems – Case Studies: Successful global models in e-waste management – Industry collaborations and public-private partnerships for sustainable waste handling – Lessons learned from global practices – Future directions in advanced e-waste and plastic waste management

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Understand the fundamental concepts of e-waste and plastic waste generation, characteristics, and classification.	[U]
CO2	Explain the regulatory frameworks, international agreements, and national policies governing e-waste and plastic waste management.	[U]
CO3	Apply circular economy principles, sustainable design strategies, and eco-	[AP]

	labeling techniques to enhance waste management practices.	
CO4	Understand the various advanced recycling and recovery technologies including nanotechnology and biotechnology for valorization of e-waste.	[U]
CO5	Apply emerging technologies like IoT, AI, and Blockchain for developing smart and traceable waste management systems.	[AP]

Text Books:

- 1 Electronic Waste Management Rules 2016, Govt. of India, available online at CPCB website.
- 2 MSW Management Rules 2016, Govt. of India, available online at CPCB website

Reference Books:

- 1 Ravi Agarwal, "*Waste of a Nation: Social Inequalities and Global Growth of Electronic Waste*", Harvard University Press, 2018.
- 2 Kahhat, Ramzy, et al., "*E-Waste Management: From Waste to Resource*" (UNEP), Routledge, 2012.
- 3 Kumar, Sunil, et al., "*Electronic Waste Management: Approaches, Technology, and Trends*", CRC Press, 2021.
- 4 Vishnupriya Singh, "*Plastic Waste and Its Management*", AkiNik Publications, 2020.
- 5 R. Rajagopalan, "*Environmental Studies: From Crisis to Cure*", 3rd Edition, Oxford University Press, 2016. (Includes E-waste and Plastic Waste chapters)
- 6 R. Widmer, H. Oswald-Krapf, D. Sinha-Khetriwal, M. Schnellmann, "*Global Perspectives on E-Waste*", Environmental Impact Assessment Review, Elsevier, 2005.

Web References:

- 1 <https://wasteaid.org/wp-content/uploads/2022/06/Handbook-of-E-waste-management.pdf>
- 2 <https://greene.gov.in/wp-content/uploads/2018/01/E-waste-Vol-I-Inventory-Assessment-Manual.pdf>
- 3 https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf
- 4 https://www.teriin.org/sites/default/files/files/White_paper_E-wasteEPR.pdf

23EC946	ARTIFICIAL INTELLIGENCE IN HEALTHCARE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To learn the fundamental concepts, principles, and history of Artificial Intelligence.
- 2 To Identify and summarize appropriate search algorithms for solving medical-related problems.
- 3 To apply behavioral logic models to effectively represent and solve structured problems.
- 4 To differentiate various AI problem-solving techniques and apply them to real-world scenarios.
- 5 To analyze and evaluate the development and impact of AI applications in healthcare for societal benefits.
- 6 To Design and develop simple intelligent systems for medical diagnosis using AI techniques.

FOUNDATIONS OF ARTIFICIAL INTELLIGENCE AND PROBLEM-SOLVING TECHNIQUES

15

Introduction to Artificial Intelligence, AI Approach to Healthcare Problem-Solving, Problem-Solving Methods in AI, Constraint-Based Problem Solving, Backtracking Search Algorithms, Applications of CSPs in Healthcare (Case Studies)

AI LEARNING METHODS AND KNOWLEDGE REPRESENTATION

15

Learning methods in AI, Rule-based systems, Decision tree learning, Reinforcement learning, Application of AI in medical diagnosis. Knowledge representation techniques, First Order Predicate Logic (FOPL), Prolog programming, Unification, Forward and backward chaining, Resolution. Ontological engineering, Categories and objects, Events and mental objects, reasoning systems for categories, Default reasoning. Case studies on AI applications in healthcare.

INTELLIGENT AGENTS AND MEDICAL APPLICATIONS OF AI

15

Architecture of intelligent agents, Agent communication, negotiation, and argumentation, Trust and reputation in multi-agent systems, Biomedical applications AI in blood pressure control, Speech recognition systems, Robotic control for surgical applications, Hardware, perception, planning, and moving image guidance in medical AI.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand the fundamental concepts of Artificial Intelligence and its relevance in solving healthcare problems. | [U] |
| CO2 | Apply appropriate search algorithms and behavioral logic to model medical diagnostic problems. | [AP] |
| CO3 | Differentiate and apply AI problem-solving techniques to various healthcare scenarios. | [AP] |
| CO4 | Develop simple intelligent systems for medical diagnosis and healthcare decision support. | [AP] |
| CO5 | Analyze the development and impact of AI applications for solving real-world healthcare problems. | [AN] |

Text Books:

- 1 M. Tim Jones, "Artificial Intelligence: A Systems Approach ", Jones and Bartlett Publishers, Inc.; First Edition, 2015 Reprint. ISBN-13: 978-9380298139.
- 2 Nils J. Nilsson, "The Quest for Artificial Intelligence", Cambridge University Press, 2009. ISBN-13: 978- 0521122931

Reference Books:

- 1 William F. Clocksin and, Christopher S. Mellish, "Programming in Prolog: Using the ISO Standard", Fifth Edition, Springer, 2012 Reprint. ISBN 978-3-642-55481-0, DOI 10.1007/978- 3-642-5548.
- 2 Ian Millington, John Funge, "Artificial intelligence for Games", Second edition, Morgan Kaufmann Publishers, CRC Press, 2012, ISBN: 978-0-12-374731-0.
- 3 S. Russell and P. Norvig, "Artificial Intelligence: A Modern Approach", Prentice Hall, Third Edition, 2016. ISBN-1537600311, 97-81537600314.
- 4 David L. Poole and Alan K. Mackworth, "Artificial Intelligence: Foundations of Computational Agents", Cambridge University Press, 2010. ISBN-13: 978-0521519007.

Web References:

- 1 <https://nptel.ac.in/courses/106102220>
- 2 <https://www.youtube.com/watch?v=t2G6u8GgUYE>

23EC947	AUTOMOTIVE SENSORS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce the basic principles and types of sensors used in automotive systems.
- 2 To understand the operational characteristics and applications of various automotive sensors.
- 3 To analyze the role of sensors in engine management, safety, and emission control systems.
- 4 To develop diagnostic skills related to sensor faults and understand their impact on vehicle systems.
- 5 To explore advancements in automotive sensor technologies for intelligent and autonomous vehicles.
- 6

FUNDAMENTALS AND TYPES OF AUTOMOTIVE SENSORS

15

Introduction to automotive sensors: purpose and applications, Sensor characteristics: sensitivity, accuracy, resolution, ranges. Classification: active/passive, contact/non-contact sensors. Overview of engine sensors: crankshaft, camshaft, knock, temperature, and pressure sensors (MAP, TPMS). AI Approach to Healthcare Problem-Solving, Problem-Solving Methods in AI, Constraint-Based Problem Solving, Backtracking Search Algorithms, Applications of CSPs in Healthcare (Case Studies)

SENSOR APPLICATIONS IN AUTOMOTIVE SYSTEMS

15

Sensor applications in emission control (oxygen sensors, NOx sensors, PM sensors). Safety and comfort sensors: wheel speed, airbag impact, rain, light, parking sensors. Working of MAF, TPS, detonation sensors for fuel injection and ignition control. Introduction to OBD systems and sensor data fault diagnosis.

ADVANCED AUTOMOTIVE SENSOR TECHNOLOGIES

15

Introduction to smart sensors and MEMS in automotive, Use of Lidar, Radar, and Ultrasonic sensors for ADAS and autonomous vehicles, Sensor fusion and predictive maintenance using sensor data, emerging trends: wireless sensors, IoT applications, and case studies on modern automotive sensors.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the fundamental principles, classifications, and characteristics of sensors used in automotive systems. | [U] |
| CO2 | Apply knowledge of sensor behavior to evaluate performance in engine management, emission control, and vehicle diagnostics. | [AP] |
| CO3 | Diagnose common sensor faults and analyze their impact on overall vehicle operation. | [AP] |
| CO4 | Apply sensor technologies in enhancing automotive safety, comfort, and driver-assist features. | [AP] |
| CO5 | Analyze recent advancements and emerging trends in automotive sensor technologies and their applications. | [AN] |

Text Books:

- 1 Robert Bosch GmbH, "Automotive Electrics and Automotive Electronics", 5th Edition, Springer Vieweg, 2014.
- 2 William Ribbens, "Understanding Automotive Electronics", 8th Edition, Butterworth-Heinemann, 2017.

Reference Books:

- 1 Tom Denton, "Automobile Electrical and Electronic Systems", 5th Edition, Routledge, 2017.
- 2 Thomas Gillespie, "Fundamentals of Vehicle Dynamics", SAE International, 1992.

Web References:

- 1 <https://archive.nptel.ac.in/courses/107/106/107106088/>
- 2 <https://archive.nptel.ac.in/courses/108/108/108108147/>
- 3 <https://www.youtube.com/watch?v=ECDVNAmcKFE>

23EC948	DATA ACQUISITION AND HARDWARE INTERFACES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce students to the fundamental concepts of power supplies, amplifiers, and signal conditioning in automotive sensor systems.
- 2 To familiarize students with the operation and characteristics of various automotive sensors and their signal processing techniques.
- 3 To teach students the principles of signal conversion and communication standards such as RS232, S485, SPI, I2C, and CAN in automotive applications.
- 4 To enable students to design and implement data acquisition systems for multi-channel automotive sensor networks.
- 5 To equip students with the skills to interface automotive sensors with microcontrollers and develop real-time data transmission systems.
- 6 To help students identify, diagnose, and rectify faults in automotive sensor systems, ensuring optimal performance and reliability in automotive applications.

POWER SUPPLIES, FILTERS & SIGNAL CONDITIONING 15

Overview of amplifiers: Instrumentation, isolation, chopper, low drift, lock-in, electrometer, and trans-impedance amplifiers, Introduction to modulation, filters, and voltage regulators: constant voltage, constant current, DC-DC converters, SMPS, Signal conditioning for resistive sensors, reactive variation sensors, and self-generating sensors; Error budget analysis.

SIGNAL CONVERSION, COMMUNICATION & DATA ACQUISITION 15

Basic signal conversion methods: RS232, S485, and IEEE488 interface standards. Distributed vs. stand-alone data loggers, methods of frequency-to-code conversion, and indirect counting. Data acquisition systems: time-division and space-division-channelling, error protection in multi-channel systems, and data transmission techniques.

SERIAL COMMUNICATION & INTERFACING 15

Serial data communication protocols: SPI, I2C, and CAN, Implementation examples on 8051-based microcontrollers, interfacing techniques for memory, LVDT, RPM meters, and digital thermometers.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the basic principles of power supplies and signal conditioning circuits used in automotive sensor systems. | [U] |
| CO2 | Apply knowledge of data acquisition systems to implement sensor networks in automotive applications. | [AP] |
| CO3 | Apply serial communication protocols such as RS232, RS485, SPI, I ² C, and CAN for efficient automotive data exchange. | [AP] |
| CO4 | Design and develop microcontroller-based interfaces for integrating sensors in automotive systems. | [AP] |
| CO5 | Analyze and troubleshoot sensor system faults to ensure real-time data transmission and accurate signal processing. | [AN] |

Text Books:

- 1 Automotive Technician Training, Tom Denton, Taylor and Francis, New York, 2015.
- 2 Automobile Electrical and Electronic Systems: Automotive Technology - Vehicle Maintenance and Repair, Tom Denton, Fourth Edition, Elsevier, New York, 2015.
- 3 Advanced Automotive Fault Diagnosis: Automotive Technology - Vehicle Maintenance and Repair, Tom Denton, Third Edition, Elsevier, New York, 2012.

Reference Books:

- 1 Automotive Electrical and Electronic Systems, Tom Denton, Fourth Edition, Elsevier, New York, 2015.
- 2 Microcontroller Interfacing for Automotive Applications, William H. Collins, Wiley, 2018.

Web References:

- 1 <http://www.digimat.in/nptel/courses/video/108105088/L07>
- 2 <https://www.youtube.com/watch?v=WwQSfk6SSSo>

23EC949	FLEXIBLE AND WEARABLE SENSORS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To understand the basics for the need of Wearable Devices
- 2 To understand the operation of wearable devices and mobile sensing
- 3 To learn how to use software programs to perform varying and complex tasks
- 4 To expand upon the knowledge learned and apply it to solve real world problems
- 5 To apply the wearable algorithms for developing wearable sensing

INTRODUCTION TO WEARABLE'S

15

Fundamentals-wearable sensing technology, Social Aspects of Wear ability, Adoption of Innovation and Aesthetic Change, On-Body Interaction, Wearable Haptics, Categories of Wearable Haptic and Tactile Display, wearable Sensorimotor Enhancer, Wearable Bio and Chemical Sensors, Wearable Inertial Sensors and Their Applications, Cameras in wearable devices, Applications in safety and security, navigation.

WEARABLE WIRELESS SENSORS

15

Overview of various wireless wearable sensors, Accelerometer, gyroscope, magnetometer, Smartphone orientation and heading detection, Health monitoring and fitness tracking, Wrist-worn wearable's, gesture and remote interaction, Sensor fusion in body-area networks, Application of Optical Heart Rate Monitoring, Measurement of Energy Expenditure by Body-worn Heat-flow Sensor, Biomechanical Sensing, Non-Invasive Sweat Monitoring by Textile Sensors, Smart Fabrics and Interactive Textile Platforms for Remote Monitoring, Physical Activity Body Sensor Technology.

FUTURE TRENDS OF WEARABLE SENSING ELEMENTS

15

Channel Models for On-Body Communications, Establishment in Wireless Body Area Networks, Wearable Sensors for the Monitoring of Physical and Physiological Changes in Daily Life, Wearing Sensors Inside and Outside of the Human Body for the Early Detection of Diseases, Wearable and Non-Invasive Assistive Technologies, Wireless Tracking of Tongue Motion, Detection and Characterization of Food Intake by Wearable, future trends in wearable and implantable sensor technology :CASE STUDY: Wearable Event Device, Google Glass, Apple Watch.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the principles, categories, and social implications of wearable sensing technologies and their interaction modalities. | [U] |
| CO2 | Analyze various wearable wireless sensors, their placement, applications in health monitoring, and the role of sensor fusion in body-area networks. | [AN] |
| CO3 | Apply sensor integration techniques for real-time monitoring using smart fabrics, body-worn devices, and non-invasive textile sensors. | [AP] |
| CO4 | Evaluate the effectiveness of wearable sensing systems in tracking physiological and biomechanical parameters for health and fitness applications. | [AN] |
| CO5 | Analyze emerging trends in wearable and implantable sensor technologies through relevant case studies and real-world applications. | [AN] |

Text Books:

- 1 Edward Sazonov, Michael R. Neuman "Wearable Sensors: Fundamentals, Implementation and Applications", 7th Edition, Academic Press/Elsevier, 2020.
- 2 Woodrow Barfield "Fundamentals of Wearable Computers and Augmented Reality", 2nd Edition, CRC Press, 2015.
- 3 Annalisa Bonfiglio, Danilo De Rossi, "Wearable Monitoring Systems", Springer Publishers, 4th Edition, 2014.

Reference Books:

- 1 Micheal, Katina "Wearable Technologies: Concepts, Methodologies, Tools, and Applications" 2nd Edition, IGI Global Engineering Publishers, 2018.
- 2 Omesh Tickoo, Ravi Iyer "Making Sense of Sensors: End-to-End Algorithms and Infrastructure Design", 2nd Edition, Apress Publishers, 2017.
- 3 Kate Hartman, "Make: Wearable Electronics: Design, Prototype and wear your own interactive garments", 3rd Edition, Maker Media, 2015.
- 4 Guang Zhong Yang, "Body Sensor Networks", 4th Edition, Springer Publisher, 2016.

Web References:

- 1 <https://www.sciencedirect.com/science/book/9780124186620>
- 2 <https://pdfs.semanticscholar.org/.../4331017b99da992456c4a6e9b98bd2d54a41.pdf>
- 3 <https://www.elsevier.com/books/wearable-sensors/sazonov/978-0-12-418662-0>

23EC950	MEDICAL SENSORS AND MEMS TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 Understand the fundamental concepts of medical sensors and their classifications.
- 2 Explain the working principles and applications of various medical sensors.
- 3 Apply modelling techniques to simulate the behaviour of piezoelectric MEMS devices and capacitive MEMS gyroscopes.
- 4 Assess the impact of packaging, testing, and calibration on MEMS device performance and reliability, and the selection of materials for MEMS applications
- 5 Find the tools to design and development of sensors for the medical applications
- 6 Analyse the integration of machine learning techniques in sensor design through case studies.

MEDICAL SENSORS

15

Introduction to medical sensors - Classification of Sensors: Sensors for Pressure Measurement- Sensors for Motion and Force Measurement - Sensors for Flow Measurement - Temperature Measurement - Sensors for speed, torque, vibration - smart sensors, design of interface system. Artificial intelligence in medical sensor technology.

MATERIAL FOR MEMS AND NEMS

15

RF- MEMS- Modeling of Piezoelectric MEMS, Interface Circuits for Capacitive MEMS Gyroscope, Advanced MEMS Technologies for Tactile Sensing and Actuation, Packaging, test and calibration of MEMS, Dielectrics for Use in MEMS Applications, Piezoelectric Thin Films for MEMS Applications, future of smart structures and MEMS leading to NEMS.

SOFTWARE TOOLS

15

Introduction to software tools: COMSOL Multiphysics, ANSYS, MATLAB, and Lumerical FDTD for sensor design and simulation - Modeling and design using MatLab - Design of sensors: pressure sensor, temperature sensor, motion sensor, MatLab - Machine learning tools in design and analysis, case study using medical sensors.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the classification, working principles, and interface design of medical sensors for measuring physiological parameters. | [U] |
| CO2 | Analyze the material properties, modeling techniques, and circuit interfaces used in MEMS and NEMS devices for biomedical applications. | [AN] |
| CO3 | Apply knowledge of MEMS fabrication, packaging, and calibration techniques in the design of smart sensor systems. | [AP] |
| CO4 | Utilize simulation tools like COMSOL, ANSYS, MATLAB, and Lumerical FDTD to model and design various biomedical sensors. | [AP] |
| CO5 | Evaluate sensor performance through simulations and apply machine learning techniques in sensor analysis using case studies. | [AN] |

Text Books:

- 1 Vikas Choudhary, Krzysztof Iniewski, "MEMS: Fundamental Technology and Applications", CRC Press, UK, 2017.
- 2 John G. Webster, "Medical Instrumentation: Application and Design", Wiley, 2020.
- 3 Holly Moore "MATLAB for Engineers", Pearson Education Inc, 2022.

Reference Books:

- 1 Octavian Adrian Postolache and Subhas Chandra Mukhopadhyay, "Sensors for Everyday Life: Healthcare Settings (Smart Sensors, Measurement and Instrumentation)", CRC Press, 2017.
- 2 Albert Folch, "Introduction to Bio MEMS", CRC Press, 2012.
- 3 Mohammad Ilyas, Imad Mahgoub, "Handbook of Sensor Networks Compact Wireless and Wired Sensing Systems" CRC Press, USA. 2005.

Web References:

- 1 <https://nptel.ac.in/courses/108105064>
- 2 <https://pmc.ncbi.nlm.nih.gov/articles/PMC4435109/>
- 3 <https://www.mathworks.com/solutions/medical-devices.html>

23EC951	BIO SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To facilitate students to understand and apply various methods for analyzing biomedical signal characteristics.
- 2 To make students able to analyse mathematical methods of biomedical signal and image processing.
- 3 To make students able to design time domain filters for noise and artifact removal from biomedical signals.
- 4 To make students able to design frequency domain filters for noise and artifact removal from biomedical signals.
- 5 To motivate students to explore alternative techniques of analyzing biomedical signals in time and frequency domain.

INTRODUCTION TO BIOMEDICAL SIGNALS

15

Action Potential and Its Generation, Origin and Waveform Characteristics of Basic Biomedical Signals like: Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Phonocardiogram (PCG), Electroneurogram (ENG), Event-Related Potentials (ERPS), Electrogastrogram (EGG), Objectives & Difficulties in Biomedical Signal Analysis, Computer-Aided Diagnosis.

REMOVAL OF NOISE AND ARTIFACTS FROM BIOMEDICAL SIGNAL

15

Random and Structured Noise, Physiological Interference, Stationary and Nonstationary Processes, Advanced Denoising Methods: Wavelet denoising, Independent Component Analysis (ICA) and Principal Component Analysis (PCA) for artifact removal, EEG Artifact Removal - Eye blink, muscle artifacts, movement artifacts.

EEG SIGNAL PROCESSING AND EVENT DETECTION IN BIOMEDICAL SIGNAL

15

EEG recording systems, Time and Frequency Domain Analysis of EEG, Feature Extraction from EEG, Seizures, Sleep stages, K-complexes, Machine learning-based detection (SVM, Random Forest, KNN), Future of EEG signal processing: AI and hybrid models.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the fundamental concepts of biosignal and biomedical image processing, including key mathematical methods. | [U] |
| CO2 | Compare and contrast various noise analysis techniques used in biomedical signal and image processing. | [AN] |
| CO3 | Analyze the adaptability and integration of biomedical signal and image processing techniques into medical devices. | [AN] |
| CO4 | Apply signal representation and processing methods to EEG data for diverse biomedical applications. | [AP] |
| CO5 | Develop algorithms to detect physiological events from biomedical signals and images. | [AN] |

Text Books:

- 1 Rangayyan, R.M., 2015. Biomedical signal analysis (Vol. 33). John Wiley & Sons
- 2 Reddy, D.C., 2005. Biomedical signal processing: principles and techniques. McGraw-Hill
- 3 Saeid Sanei and J.A. Chambers, 2007, " EEG Signal Processing" Wiley

Reference Books:

- 1 Tompkins, W.J., 1993. Biomedical digital signal processing. Editorial Prentice Hall
- 2 Sörnmo, L. and Laguna, P., 2005. Bioelectrical signal processing in cardiac and neurological applications (Vol. 8). Academic Press
- 3 Nilanjan Dey, Amira Ashour, Fuqian Shi, "Practical Guide for Biomedical Signal Analysis Using Machine Learning Techniques", Academic Press.

Web References:

- 1 https://onlinecourses.nptel.ac.in/noc20_ee41/preview
- 2 <https://www.coursera.org/courses?query=signal%20processing>
- 3 <https://www.mathworks.com/help/wavelet/gs/wavelet-applications-in-biosignals.html>

23EC952	EMERGING APPLICATIONS OF BIOSENSORS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To learn the Fundamentals of biosensors.
- 2 To acquaint the student with design and construction of biosensors.
- 3 To expose recent advances in application of biosensors in health, environment, and agriculture.
- 4 To differentiate types of transducers with their characteristics.
- 5 To know the use of different nanomaterials in biosensors.

INTRODUCTION TO BIOSENSORS

15

Introduction to biosensor, General components of biosensor, Biomolecules in biosensors such as enzyme, DNA, antigen antibody, protein, Classification of biosensors based on principle: amperometric, potentiometric biosensors, optical, acoustic, piezoelectric, and calorimetric biosensors, scope of biosensors and its limitations.

APPLICATIONS OF BIOSENSORS IN HEALTH, ENVIRONMENT AND AGRICULTURE

15

Biosensors and diabetes management, Micro fabricated biosensors and point-of-care diagnostics systems, Non-invasive biosensors in clinical analysis; Surface plasmon resonance and evanescent wave biosensors, Biosensor in cancer and HIV early diagnosis, Detection of crop diseases, pathogens in plants, Detection of soil nutrients, pesticide and its residual detection.

TRANSDUCERS AND NANOMATERIALS IN BIOSENSORS

15

Types of Transducers; Fiber Optic, ECL, Surface Plasmon Resonance, Electro chemical; FET, Impedance, Piezoelectric; Cantilever, Nano Materials in biosensors; Carbon based Nano Material, Metal oxide and nano particle, Quantumdots, Role of nano material in Signal Amplifications, Detection and Transducer Fabrication.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|--|------|
| CO1 | Understand the fundamental components of biosensors and the role of biomolecules in sensing mechanisms. | [U] |
| CO2 | Classify and differentiate various types of biosensors and transducers based on their operating principles and physiochemical characteristics. | [AN] |
| CO3 | Apply biosensing techniques in diverse domains including healthcare, environmental monitoring, and agriculture. | [AP] |
| CO4 | Analyze the integration of biosensors with nanomaterials and biomaterials for advanced sensing applications. | [AN] |
| CO5 | Examine the role of biosensors in signal amplification, detection mechanisms, and transducer fabrication. | [AN] |

Text Books:

- 1 Jeong-Yeol Yoon, Introduction to Biosensors, Springer-Verlag New York Ed., 2016
- 2 Mohammed Zourob, Recognition Receptors in Biosens; Publisher: Springer-Verlag New York Ed., 2010
- 3 B. D. Ratner, A. S. Hoffman, F. J. Schoen and J. E. Lemons, Biomaterials Science: An Introduction to Materials and Medicine, 3rd Edition, Academic Press, 2012.
- 4 Zhang X. ZuH. Wang J. Electrochemical Sensors, Biosensors and their Biomedical applications. Elsevier Science and Technology Books, 2018.

Reference Books:

- 1 Zvi Liron, Novel Approaches in Biosensors and Rapid Diagnostic Assays; Publisher: Springer US Ed., 2001.
- 2 J. B. Park and J. D. Bronzino, Biomaterials: Principles and Applications, CRC Press, 2002.
- 3 Pierre R. C, and Loïc J.B, Biosensor Principles and Applications, CRC Press, 2019.

Web References:

- 1 https://onlinecourses.nptel.ac.in/noc20_ph13/preview
- 2 <https://nptel.ac.in/courses/102101054>
- 3 <https://www.youtube.com/watch?v=kQ6CY1qpGjY>

23EC953	MICRO SYSTEMS & HYBRID TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To introduce the fundamental concepts of microsystem design.
- 2 To provide comprehensive understanding of various micromachining techniques.
- 3 To acquaint the students with various materials and material properties for microsystem designing.
- 4 To expose to various scaling effects of Microsystems.
- 5 Enhancing the basics of thick film and hybrid technologies for sensor development.

INTRODUCTION TO MICROSYSTEMS & MICROMACHINING TECHNOLOGIES 15

Microsystems, Miniaturization, Benefits of Microsystems, Microsystems products, Evolution of Micro fabrication and Applications, Micro actuators, Design of Micro accelerometers, Overview of silicon processes techniques, Photolithography, Ion Implantation, Diffusion, Chemical Vapor Deposition, Physical vapor Deposition, Epitaxy, Etching, Bulk micromachining, Surface Micromachining, LIGA and other techniques.

MATERIALS & SCALING EFFECTS FOR MICROSYSTEMS 15

Silicon compounds, Silicon Piezo resistors, Gallium Arsenide, Quartz, Piezoelectric materials, Polymers, Shape Memory Alloys, ferroelectric and rheological materials, Scaling, Scaling laws, Scaling in Geometry, Scaling in Rigid body dynamics, Scaling in Electromagnetic, Electrostatic, magnetic, optical and Thermal domains. Scaling in Fluid mechanics.

HYBRID TECHNOLOGY 15

Thick-film and hybrid technology in sensor production. Basic materials, components, manufacturing Screen manufacturing, Screen printing, Parameters, Comparison: thick- vs. thin film technology Structure dimensions, Assembly and packaging Surface mount technology (SMT) Active and passive devices (SMD), Connection technologies, Packaging.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

- | | | |
|-----|---|------|
| CO1 | Understand the fundamental concepts and background of microsystems and their applications. | [U] |
| CO2 | Apply knowledge of micromachining techniques and material selection for microsystem design. | [AP] |
| CO3 | Determine the impact of scaling laws in the miniaturization of devices. | [AP] |
| CO4 | Analyze the use of thick film and hybrid technologies in the development of sensors. | [AN] |
| CO5 | Evaluate microsystem packaging techniques by analyzing performance parameters and integration challenges. | [AN] |

Text Books:

- 1 G.K.Ananthasuresh, K J Vinoy, S Gopalakrishnan, KN Bhatt, V K Aatre," Micro and smart systems", 1 st ed., Wiley, New York, 2012.
- 2 Tai-Ran Hsu, "MEMS & Microsystem, Design and Manufacture", 1 st ed., McGraw Hill India, New Delhi, 2017.
- 3 Wolfgang Menz, Jürgen Mohr, Oliver Paul, "Microsystem Technology", 2 nd ed., Wiley, New York, 2011.

Reference Books:

- 1 Banks H.T. Smith R.C. and Wang Y.Smart, 'Material Structures – Modeling, Estimation and Control', 1st ed., John Wiley & Sons, NewYork, 2011.
- 2 Massood Tabib – Arar, 'Microactuators – Electrical, Magnetic Thermal, Optical, Mechanical, Chemical and Smart structures', 1 st ed., Kluwer Academic publishers, New York, 2014.
- 3 Marc Madau, Fundamentals of Microfabrication Science of Miniaturization, CRC Press, 2002.

Web References:

- 1 <https://benthamsience.com/public/journals/micro-and-nanosystems>
- 2 https://www.ikts.fraunhofer.de/en/departments/electronics_microsystems_biomedicine/hybrid_micro_systems.html
- 3 <https://archive.nptel.ac.in/courses/117/105/117105082/>

23EC954	MEDICAL ROBOTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- 1 To impart basic understanding of robotics.
- 2 To provide knowledge on the application of robotics in the field of health care.
- 3 To overview the sensor requirements for localization and tracking in medical applications.
- XA4 To understand the design aspects of medical robots.
- 5 To comprehend on the application of robotics in the field of healthcare.

INTRODUCTION TO ROBOTS

15

Introduction to robots: Robots as mechanical devices, Classification of robotic manipulators, Robotic systems: Accuracy and repeatability, Wrists and end-effectors, Mathematical modelling of robots, Symbolic representation of robots, The configuration space, The state space, The workspace common kinematic arrangements of manipulators, Forward kinematics, Inverse kinematics, Velocity kinematics.

CONTROL MODES, LOCALIZATION AND TRACKING

15

Medical robots: Robots for navigation, Movement replication, Robots for imaging, Rehabilitation and prosthetics, Describing spatial positioned orientation, Standardizing kinematic analysis, Computing joint angles, Quaternions, Robot kinematics, Three-joint robot, Six-joint robot, Position sensors requirements, Tracking, Mechanical linkages, Optical - Sound based, Electromagnetic - Impedance-based, In-bore MRI tracking.

DESIGN & APPLICATIONS OF ROBOTS IN MEDICAL CARE

15

Assistive robots, types of assistive robots - case studies, Characterization of gestures to the design of robots, Design methodologies, Technological choices, Security, Application of medical robots: The learning curve of robot, Assisted laparoscopic surgery, Haptic feedback in robotic heart surgery, Robotic applications in neurosurgery, Miniature robotic guidance for spine surgery.

TOTAL PERIODS: 45

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

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|-----|---|------|
| CO1 | Understand the different types of robotic systems and their relevance to medical applications. | [U] |
| CO2 | Design kinematic models for specified robotic systems used in medical environments. | [AP] |
| CO3 | Analyze the design methodology, sensor integration, and technological choices in medical robot development. | [AN] |
| CO4 | Evaluate localization and tracking techniques using various sensors in medical robotic systems. | [AN] |
| CO5 | Summarize the role and impact of surgical robotics across different clinical procedures. | [U] |

Text Books:

- 1 AchimSchweikard, Floris Ernst, "Medical Robotics", Springer, 2015.
- 2 Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, "Robot Modeling and Control", Wiley Publishers, 2006.
- 3 VanjaBozovic, Medical Robotics, Springer, 2008.

Reference Books:

- 1 Paula Gomes, "Medical robotics- Minimally Invasive surgery", Woodhead, 2012.
- 2 Jocelyne Troccaz, "Medical Robotics", Wiley, 2013.
- 3 Daniel Faust, "Medical Robots", Rosen Publishers, 2016.

Web References:

- 1 <https://r2surgical.com/blogs/news/how-much-is-a-new-surgical-robot>
- 2 <https://web.stanford.edu/class/me328/lectures/lecture1-intro.pdf>
- 3 <https://youtu.be/rYWJdZ5qg6M>