SRI VENKATESWARA COLLEGE OF ENGINEERING

An Autonomous Institution,

Affiliated to Anna University, Chennai

REGULATION 2022

B.E. ELECTRONICS AND COMMUNICATION ENGINEERING

Choice Based Credit System

Curriculum and Syllabi (I – VIII Semester)

SRI VENKATESWARA COLLEGE OF ENGINEERING,

(An Autonomous Institution, Affiliated to Anna University, Chennai – 600025)

B.E., Electronics and Communication Engineering

CURRICULUM AND SYLLABUS

REGULATION – 2022

CHOICE BASED CREDIT SYSTEM

Curriculum Revision No:	00	Board of Studies recommendation date:	19.09.2024 08.04.2024 12.09.2023 10.04.2023 07.10.2022 18.03.2022	Academic Council Approved date:	18.10.2024 09.05.2024 18.10.2023 21.04.2023 08.10.2022 12.04.2022
Salient Points of the revision	01.	The courses "Tamil language and Heritage of Ancient Tamil Society" in Semester I and "Science and Technology in Ancient Tamil Society" in Semester II are introduced as per the recommendations of Anna University/Government of Tamil Nadu.			
	02.	The course “Technical Drawing Laboratory” is introduced in semester II replacing “Engineering Drawing” of R2018. This will enable the students to draw the circuit symbols using free hand sketches and simulation tools.			
	03.	The course “Circuit Theory” is shifted to semester II from semester III of R2018 and introduced as Theory cum Practical Course.			

	04.	The courses of R2018 “Engineering Mathematics III” and “Probability and Random Processes” are replaced with the new course “Transforms and Random Processes” and the same is offered in semester IV.
	05.	The course “Environmental Sciences and Sustainability” is shifted to IV semester. This will help the Lateral entry students to describe the sustainable development for environmental protection.
	06.	The course “Machine Learning” is introduced in semester IV as Theory cum Practical course. This will enable the students to expose the various Machine Learning algorithms and implementation of the same using Python.
	07.	The course “Microcontroller Systems” is introduced as Theory cum Practical course in semester IV.
	08.	The courses “Physical VLSI Design” and “Embedded Systems and IoT Design” are offered as Industry supported courses.
	09.	The professional electives are grouped under 6 verticals based on programme specific domain.
	10.	The course “Next Generation Mobile Networks – 5G” is introduced under Wireless System Engineering vertical.
	11.	EC22074 is renamed as Software Defined Networks in IoT.

SRI VENKATESWARA COLLEGE OF ENGINEERING,

(An Autonomous Institution, Affiliated to Anna University, Chennai – 600025)

REGULATIONS 2022

B.E. ELECTRONICS AND COMMUNICATION ENGINEERING

CHOICE BASED CREDIT SYSTEM

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

I. Create value to organizations as an EMPLOYEE at various levels, by improving the systems and processes using appropriate methods and tools learnt from the programme.

II. Run an organization successfully with good social responsibility as an ENTREPRENEUR, making use of the knowledge and skills acquired from the programme.

III. Contribute to the future by fostering research in the chosen area as an ERUDITE SCHOLAR, based on the motivation derived from the programme.

PROGRAM OUTCOMES (POs)

PO	GRADUATE ATTRIBUTES

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

1. An ability to apply the concepts of Electronics, Communications, Signal processing, VLSI, Control systems etc., in the design and implementation of application oriented engineering systems.
2. An ability to solve complex Electronics and communication Engineering problems, using latest hardware and software tools, along with analytical and managerial skills to arrive appropriate solutions, either independently or in team.

PEO's – PO's & PSO's MAPPING:

POs	PEOs		
	I	II	III
1.	✓		
2.	✓		✓
3.	✓	✓	
4.	✓		✓
5.	✓		
6.		✓	✓
7.		✓	
8.		✓	
9.	✓		✓
10.		✓	
11.		✓	
12.	✓		✓
PSOs			
1.	✓		✓
2.	✓	✓	

SRI VENKATESWARA COLLEGE OF ENGINEERING,

(An Autonomous Institution, Affiliated to Anna University, Chennai – 600025)

REGULATIONS 2022

CHOICE BASED CREDIT SYSTEM

B.E. ELECTRONICS AND COMMUNICATION ENGINEERING

CURRICULUM & SYLLABI FOR SEMESTERS FROM I TO VIII

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY#	PERIODS PER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
1.	IP22151	Induction Programme (Common to all Branches)	-	-	-	-	-	-	-	-
Theory Subjects										
2.	HS22151	Tamil language and Heritage of Ancient Tamil Society (Common to all branches)	HS	1	0	0	1	1	Nil	F
3.	HS22152	Communicative English (Common to all Branches)	HS	3	0	0	3	3	Nil	F
4.	MA22151	Applied Mathematics I (Common to all Branches except MR)	BS	3	1	0	4	4	Nil	F
5.	PH22151	Applied Physics (Common to AD, CS, EE, EC, IT)	BS	3	0	0	3	3	Nil	F
6.	CY22151	Applied Chemistry (Common to AD, CS, EE, EC, IT)	BS	3	0	0	3	3	Nil	F
7.	EE22152	Basic Electrical Engineering	ES	3	0	0	3	3	Nil	F
8.	IT22101	Programming for Problem Solving (Common to IT, AD, CS, EE, EC)	ES	3	0	0	3	3	Nil	F
Practical Subjects										
9.	PH22161	Physics Laboratory (Common to all Branches except BT)	BS	0	0	2	1	2	Nil	F
10.	ME22161	Basic Civil and Mechanical Engineering Laboratory (Common to CE, EE, EC)	ES	0	0	2	1	2	Nil	F
11.	IT22111	Programming for Problem Solving Laboratory (Common to IT, AD, CS, EE, EC)	ES	0	0	3	1.5	3	Nil	F
			Total	**19**	**1**	**7**	**23.5**	**27**	-	-

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY#	PERIODS PER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.	HS22251	Science and Technology in Ancient Tamil Society (Common to all Branches)	HS	2	0	0	2	2	Nil	F
2.	HS22252	Technical English (Common to all Branches)	HS	3	0	0	3	3	Nil	F
3.	MA22251	Applied Mathematics II (Common to all Branches except MR)	BS	3	1	0	4	4	Nil	F
4.	PH22252	Physics of Materials (Common to EE, EC)	BS	3	0	0	3	3	Nil	F
5.	EC22201	Electron Devices	PC	3	0	0	3	3	Nil	F
6.	EC22202	Circuit Theory	PC	3	0	2	4	5	EE22152	F
Practical Subjects										
7.	CY22161	Chemistry Laboratory (Common to all Branches except AD, CS, IT)	BS	0	0	2	1	2	Nil	F
8.	EC22211	Technical Drawing Laboratory	ES	0	0	2	1	2	Nil	F
9.	EC22212	Electron Devices and Electrical Machines Laboratory	PC	0	0	3	1.5	3	Nil	F
			Total	**17**	**1**	**9**	**22.5**	**27**	-	-

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY#	PERIODS PER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.	MA22358	Transform and Random Processes	BS	3	1	0	4	4	Nil	F
2.	EC22301	Object Oriented Programming and Data Structures	ES	3	0	0	3	3	Nil	F
3.	EC22302	Digital System Design	PC	3	0	0	3	3	PH22151	F
4.	EC22303	Electromagnetic Fields and Waves	PC	3	0	0	3	3	Nil	F
5.	EC22304	Electronic Circuits	PC	3	0	0	3	3	EC22201, EC22202	F
6.	EC22305	Signals and Systems	PC	3	0	0	3	3	Nil	F
Practical Subjects										
7.	EC22311	Analog and Digital Circuits Laboratory	PC	0	0	3	1.5	3	Nil	F
8.	EC22312	Object Oriented Programming and Data Structures Laboratory	ES	0	0	3	1.5	3	Nil	F
			Total	**18**	**1**	**6**	**22**	**25**	-	-

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY#	PERIODS PER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.	EC22401	Analog Integrated Circuits and its Applications	PC	3	0	0	3	3	EC22304	F
2.	EC22402	Linear Control Systems	PC	3	0	0	3	3	Nil	F
3.	EC22408	Machine Learning: Theory and Practices	ES	3	0	2	4	5	Nil	F
4.	EC22409	Microcontroller Systems: Theory and Practices	PC	3	0	2	4	5	Nil	F
5.	EC22403	Discrete Time Signal Processing	PC	3	0	0	3	3	EC22305	F
6.	GE22451	Environmental Sciences and Sustainability (Common to all branches)	HS	3	0	0	3	3	Nil	F
Practical Subjects										
7.	EC22411	Analog Integrated Circuits and Simulation Laboratory	PC	0	0	3	1.5	3	Nil	F
8.	EC22412	Discrete Time Signal Processing Laboratory	ES	0	0	3	1.5	3	Nil	F
			Total	**18**	**0**	**10**	**23**	**28**	-	-

SEMESTER V

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY#	PERIODS PER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.	EC22501	Communication Systems	PC	3	1	0	4	4	Nil	F
2.	EC22502	Computer Organization and Design	PC	3	0	0	3	3	Nil	F
3.	EC22503	Communication Networks and Security	PC	3	0	0	3	3	Nil	F
4.	EC22504	Physical VLSI Design (Common to EC, EE)	PC	3	0	0	3	3	EC22302	F
5.	EC22505	Transmission Lines and RF Systems	PC	3	0	0	3	3	EC22303	F
6.	*******	Professional Elective I	PE	3	0	0	3	3	Nil	M
7.	*******	Mandatory Course	MC	2	0	0	0	2	Nil	M
Practical Subjects										
8.	EC22511	Communication Systems Laboratory	PC	0	0	3	1.5	3	Nil	F
9.	EC22512	Communication Networks Laboratory	PC	0	0	3	1.5	3	Nil	F
10.	EC22513	VLSI Design Laboratory	PC	0	0	3	1.5	3	Nil	F
			Total	**20**	**1**	**9**	**23.5**	**30**	-	-

SEMESTER VI

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY#	PERIODS PER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.	EC22601	Antenna and Microwave Engineering	PC	3	1	0	4	4	EC22505	F
2.	EC22602	Embedded Systems and IoT Design	PC	3	0	0	3	3	EC22409	F
3.	EC22603	Wireless Communication	PC	3	0	0	3	3	EC22501	F
4.	*******	Professional Elective II	PE	3	0	0	3	3	Nil	M
5.	*******	Professional Elective III	PE	3	0	0	3	3	Nil	M
6.	*******	Open Elective I	OE	3	0	0	3	3	Nil	M
Practical Subjects										
7.	EC22611	Antenna and Microwave Engineering Laboratory	PC	0	0	4	2	4	Nil	F
8.	EC22612	Embedded Systems and IoT Laboratory	PC	0	0	3	1.5	3	Nil	F
9.	HS22511	Interview and Career Skills Laboratory (Common to all branches except CE)	EEC	0	0	3	2	3	Nil	F
10.	EC22613	Industrial Training/Internship	EEC	0	0	0	2	0	Nil	-
		Total		**18**	**1**	**10**	**26.5**	**29**	-	-

SEMESTER VII

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY#	PERIODS PER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
Theory Subjects										
1.	EC22701	Optical Communication and Networks	PC	3	0	0	3	3	PH22151, PH22252	M
2.	EC22702	Management Principles and Ethical Conduct	MC	3	0	0	3	3	Nil	M
3.	*******	Professional Elective IV	PE	3	0	0	3	3	Nil	M
4.	*******	Professional Elective V	PE	3	0	0	3	3	Nil	M
5.	*******	Professional Elective VI	PE	3	0	0	3	3	Nil	M
6.	*******	Open Elective II	OE	3	0	0	3	3	Nil	M
Practical Subjects										
7.	EC22711	Project Work - Phase I	EEC	0	0	4	2	4	Nil	F
		Total		**18**	**0**	**4**	**20**	**22**	-	-

SEMESTER VIII

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY#	PERIODS PER WEEK				TOTAL Hours	Prerequisite	Position
				L	T	P	C			
Practical Subjects										
1.	EC22811	Project Work - Phase II	EEC	0	0	16	8	16	-	F
		Total		**0**	**0**	**16**	**8**	**16**	-	-

Total Credits: 169

PROFESSIONAL ELECTIVE COURSES: VERTICALS

Vertical 2 **Wireless Systems Engineering**	**Vertical 3** **Antenna and Microwave Technology**	**Vertical 4** **VLSI**	**Vertical 5** **Signal Processing and Data Science**	**Vertical 6** **Embedded System Design and IoT**	**Vertical 7** **Networking and Security**
Cognitive Radio	Antenna Theory and Design	Analog IC Design	Audio Signal Processing	Industry 4.0 and IIoT (Common to EC, ME and MN)	Blockchain and Smart Contract
Emerging Wireless Technologies	Antennas for Wireless Communication Systems	ASIC and FPGA Design	Artificial Intelligence for Signal Processing	IoT Based System Design	Cryptography and Network Security
Free Space Optical Communication	Computational Electromagnetics with EM Simulation	CAD for VLSI Circuits	Biomedical Signal Processing	IoT for Real Time Applications	IoT Security
Intelligent Communication Networks	EMI/EMC Pre Compliance Testing	Low Power IC Design	Biometric Systems	IoT Solutions for Smart Cities	Software Defined Networking in IoT
Mobile Technologies	RADAR and Microwave Engineering	Mixed Signal IC Design and Testing	Data Science and its Applications	Real Time Operating Systems	SDN and NFV Architectures
Multimedia Communication Systems	MICs and RF System Design	SoC Design	Deep Learning for Computer Vision	Robotics and Automation (Common to EC and EE)	Wireless Broadband Networks
Radio over Fibre Systems	Millimeter Wave Antenna Technology	Testing of VLSI Circuits	Image Analysis and Machine Vision	Vehicle Infotainment and Connected Vehicles	Wireless Networks
Satellite Communication Systems	Smart Antenna Systems and Technology	VLSI for Wireless Communication	Soft Computing Techniques and its Applications	Wearable Devices for Healthcare Applications	Wireless Sensor Networks
Next Generation Mobile Networks – 5G	-	-	-	-	-
Mini Project	Mini Project	Mini Project	Mini Project	Mini Project	Mini Project

PROFESSIONAL ELECTIVE COURSES: VERTICALS

VERTICAL 2: WIRELESS SYSTEMS ENGINEERING

Sl. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EC22021	Cognitive Radio	PE	3	3	0	0	3
2.	EC22022	Emerging Wireless Technologies	PE	3	3	0	0	3
3.	EC22023	Free Space Optical Communication	PE	3	3	0	0	3
4.	EC22024	Intelligent Communication Networks	PE	3	3	0	0	3
5.	EC22025	Mobile Technologies	PE	3	3	0	0	3
6.	EC22026	Multimedia Communication Systems	PE	3	3	0	0	3
7.	EC22027	Radio over Fibre Systems	PE	3	3	0	0	3
8.	EC22028	Satellite Communication Systems	PE	3	3	0	0	3
9.	EC22029	Next Generation Mobile Networks – 5G	PE	3	3	0	0	3
PRACTICAL								
10.	EC22020	Mini Project	PE	4	0	0	4	2

VERTICAL 3: ANTENNA AND MICROWAVE TECHNOLOGY

Sl. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EC22031	Antenna Theory and Design	PE	3	3	0	0	3
2.	EC22032	Antennas for Wireless Communication Systems	PE	3	3	0	0	3
3.	EC22033	Computational Electromagnetics with EM Simulation	PE	3	3	0	0	3
4.	EC22034	EMI/EMC Pre Compliance Testing	PE	3	3	0	0	3
5.	EC22035	RADAR and Microwave Engineering	PE	3	3	0	0	3
6.	EC22036	MICs and RF System Design	PE	3	3	0	0	3
7.	EC22037	Millimeter Wave Antenna Technology	PE	3	3	0	0	3
8.	EC22038	Smart Antenna Systems and Technology	PE	3	3	0	0	3
PRACTICAL								
9.	EC22030	Mini Project	PE	4	0	0	4	2

VERTICAL 4: VLSI

Sl. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EC22041	Analog IC Design	PE	3	3	0	0	3
2.	EC22042	ASIC and FPGA Design	PE	3	3	0	0	3
3.	EC22043	CAD for VLSI Circuits	PE	3	3	0	0	3
4.	EC22044	Low Power IC Design	PE	3	3	0	0	3
5.	EC22045	Mixed Signal IC Design and Testing	PE	3	3	0	0	3
6.	EC22046	SoC Design	PE	3	3	0	0	3
7.	EC22047	Testing of VLSI Circuits	PE	3	3	0	0	3
8.	EC22048	VLSI for Wireless Communication	PE	3	3	0	0	3
PRACTICAL								
9.	EC22040	Mini Project	PE	4	0	0	4	2

VERTICAL 5: SIGNAL PROCESSING AND DATA SCIENCE

Sl. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EC22051	Audio Signal Processing	PE	3	3	0	0	3
2.	EC22052	Artificial Intelligence for Signal Processing	PE	3	3	0	0	3
3.	EC22053	Biomedical Signal Processing	PE	3	3	0	0	3
4.	EC22054	Biometric Systems	PE	3	3	0	0	3
5.	EC22055	Data Science and its Applications	PE	3	3	0	0	3
6.	EC22056	Deep Learning for Computer Vision	PE	3	3	0	0	3
7.	EC22057	Image Analysis and Machine Vision	PE	3	3	0	0	3
8.	EC22058	Soft Computing Techniques and its Applications	PE	3	3	0	0	3
PRACTICAL								
9.	EC22050	Mini Project	PE	4	0	0	4	2

VERTICAL 6: EMBEDDED SYSTEM DESIGN AND IOT

Sl. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EC22061	Industry 4.0 and IIoT	PE	3	3	0	0	3
2.	EC22062	IoT Based System Design	PE	3	3	0	0	3
3.	EC22063	IoT for Real Time Applications	PE	3	3	0	0	3
4.	EC22064	IoT Solutions for Smart Cities	PE	3	3	0	0	3
5.	EC22065	Real Time Operating Systems	PE	3	3	0	0	3
6.	EC22066	Robotics and Automation (Common to EC, EE)	PE	3	3	0	0	3
7.	EC22067	Vehicle Infotainment and Connected Vehicles	PE	3	3	0	0	3
8.	EC22068	Wearable Devices for Healthcare Applications	PE	3	3	0	0	3
PRACTICAL								
9.	EC22060	Mini Project	PE	4	0	0	4	2

VERTICAL 7: NETWORKING AND SECURITY

Sl. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EC22071	Blockchain and Smart Contract	PE	3	3	0	0	3
2.	EC22072	Cryptography and Network Security	PE	3	3	0	0	3
3.	EC22073	IoT Security	PE	3	3	0	0	3
4.	EC22074	Software Defined Networking in IoT	PE	3	3	0	0	3
5.	EC22075	SDN and NFV Architectures	PE	3	3	0	0	3
6.	EC22076	Wireless Broadband Networks	PE	3	3	0	0	3
7.	EC22077	Wireless Networks	PE	3	3	0	0	3
8.	EC22078	Wireless Sensor Networks	PE	3	3	0	0	3
PRACTICAL								
9.	EC22070	Mini Project	PE	4	0	0	4	2

SPECIAL ELECTIVE COURSES*

Sl. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	SE22001	Financial Statement Analysis (Common to All branches)	PE	3	3	0	0	3
2.	SE22002	Introduction to Securities Market (Common to All branches)	PE	3	3	0	0	3
3.	SE22003	Option Trading Strategies (Common to All branches)	PE	3	3	0	0	3
4.	SE22004	Corporate Finance (Common to All branches)	PE	3	3	0	0	3
5.	SE22005	Managerial Economics (Common to All branches)	PE	3	3	0	0	3
6.	SE22006	Project Management (Common to All branches)	PE	3	3	0	0	3
7.	SE22007	Mathematics for AI & ML (Common to All branches)	PE	3	3	0	0	3

OPEN ELECTIVE COURSES

Sl. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	OE22701	Autotronics	OE	3	3	0	0	3
2.	OE22702	Biometric System and its Application	OE	3	3	0	0	3
3.	OE22703	Computer Vision and its Application	OE	3	3	0	0	3
4.	OE22704	Consumer Electronics	OE	3	3	0	0	3
5.	OE22705	Embedded Systems and its Application	OE	3	3	0	0	3
6.	OE22706	Fundamentals of Analog and Digital ICs	OE	3	3	0	0	3
7.	OE22707	IoT and Sensing	OE	3	3	0	0	3
8.	OE22708	Fundamentals of Wireless Communication	OE	3	3	0	0	3
9.	OE22709	Introduction to Smart City	OE	3	3	0	0	3
10.	OE22710	Medical Imaging System	OE	3	3	0	0	3
11.	OE22711	Neural Networks and its Application	OE	3	3	0	0	3
12.	OE22712	Robotic Systems	OE	3	3	0	0	3
13.	OE22713	System Design using Microcontrollers	OE	3	3	0	0	3

VALUE ADDED COURSES

Sl. No.	COURSE CODE	COURSE TITLE	CREDIT
1.	VD22701	5G and 6G Antenna Theory and Design	2
2.	VD22702	Artificial Neural Networks	2
3.	VD22703	Deep Learning using Python	2
4.	VD22704	Embedded System Simulation	2
5.	VD22705	Hardware Modeling and Analysis using EDA tool	2
6.	VD22706	MIMO Technologies	2
7.	VD22707	Mixed Signal IC Design	2
8.	VD22708	PCB Design using EDA Tool	2
9.	VD22709	RF Circuit Design – Theory and Simulation using EM Simulation tools	2
10.	VD22710	Simulation of Communication Networks	2
11.	VD22711	Smart IoT Applications	2
12.	VC22001	Basics of Entrepreneurship Development (Common to all branches)	2
13.	VC22002	Advances in Entrepreneurship Development (Common to all branches)	2
14.	VC22003	Communicative German (Common to all branches)	2
15.	VC22004	Communicative Hindi (Common to all branches)	2
16.	VC22005	Communicative Japanese (Common to all branches)	2
17.	VC22006	Design Thinking and Prototyping laboratory (Common to all branches)	2

MANDATORY COURSES*

Sl. No.	COURSE CODE	COURSE TITLE
1.	MC22001	Indian Constitution and Society (Common to all branches)
2.	MC22002	Essence of Indian Traditional Knowledge (Common to all branches)
3.	MC22003	Gender Sensitization (Common to all branches)

GENERAL ELECTIVE COURSES*

Sl. No.	COURSE CODE	COURSE TITLE
1.	GN22001	Introduction to NCC for Engineers (Common to all branches)
2.	GN22002	Yoga and physical culture (Common to all branches)
3.	GN22003	Introduction to Fine arts (Common to all branches)

*Refer to General Curriculum and Syllabus in the college website

Summary:

Subject Area	Credit as per Semester								Total Credit	Percentage
	I	II	III	IV	V	VI	VII	VIII		
Humanities and Social Sciences (HS), courses include Technical English, Engineering Ethics and Human Values, Communication Skills, Environmental Science and Engineering.	4	5		3					**12**	**7.1%**
Management Courses (MC) such as Principles of management, Total Quality Management and Organizational Behaviour etc.							3		**3**	**1.78%**
Basic Sciences (BS) courses include Mathematics, Physics, Chemistry, Biology, etc.	11	8	4						**23**	**13.6%**
Professional Core (PC) courses include the core courses relevant to the chosen specialisation/branch.		8.5	13.5	16	20.5	13.5	3		**75**	**44.38%**
Engineering Sciences (ES) courses include Engineering Practices, Engineering Graphics, Basics of Electrical / Electronics / Mechanical / Computer Engineering / Instrumentation, etc.	8.5	1	4.5	4					**18**	**10.65%**
Professional Elective (PE) courses include the elective courses relevant to the chosen specialisation/branch.					3	6	9		**18**	**10.65%**
Open Elective (OE) courses include the courses from other branches						3	3		**6**	**3.55%**
Employability Enhancement Courses (EEC) include Project Work and/or Internship, Seminar, Professional Practices, Case Study and Industrial/Practical Training.						4	2	8	**14**	**8.28%**
Total Credits	**23.5**	**22.5**	**22**	**23**	**23.5**	**26.5**	**20**	**8**	**169**	**100%**

SEMESTER I

HS22151	தமிழ் மொழியும் தமிழர் மரபும் **TAMIL LANGUAGE AND HERITAGE OF ANCIENT TAMIL SOCIETY** **(Common to all branches)**	**L**	**T**	**P**	**C**
		1	**0**	**0**	**1**

பாடத்தின் நோக்கங்கள்:

1. தமிழ் மொழியின் தோற்றம் பற்றியும், திணை கருத்துக்கள் வாயிலாக வாழ்வியல் முறைகளை பற்றியும் கற்றுக் கொள்வார்கள்.
2. இந்திய தேசிய சுதந்திர இயக்கத்தில் தமிழர்களின் பங்களிப்பு மற்றும் தமிழர்களின் மேலாண்மை முறைகளை பற்றியும் கற்றுக் கொள்வார்கள்.

Course Objectives:

1. They will learn about the origin of the Tamil language and the ways of life through five types of lands.
2. They will also learn about the contribution of Tamils in the Indian National Freedom Movement and the management methods of Tamils.

அலகு 1	**தமிழுக்கும் தொழில்நுட்பக் கல்விக்கும் உள்ள தொடர்பு**	**3**

மொழி மற்றும் பாரம்பரியம்: இந்தியாவில் உள்ள மொழிக் குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழில் செம்மொழி இலக்கியம் - உ.வே.. சாமிநாதய்யர். ஆறுமுகநாவலர் ஆகியோரின் பங்களிப்பு – தொழில் நுட்பக் கல்வியில் தமிழ் மொழியின் முக்கியத்துவம்.

UNIT -1 LANGUAGE AND HERITAGE

Language families in India – Dravidan Languages – Tamil as a Classical language – Classical Literature in Tamil – Contribution of U. Ve. Saminathaiyar. Arumuka Navalar – Importance of Tamil language in technical education.

அலகு 2	**திணை கருத்துக்கள்**	**9**

திணை கருத்துக்கள்: -ஐந்து வகை நிலங்கள், விலங்குகள், கடவுள்கள், தொழில், வாழ்க்கை முறைகள், இசை, நடனம், உணவு முறை, தமிழர்களின் தாவரங்கள் மற்றும் விலங்கினங்கள் – தொல்காப்பியம் மற்றும் சங்க இலக்கியங்களில் இருந்து அகம் மற்றும் புரம் கருத்து – தமிழ் பற்றிய அறம் கருத்து – கல்வி மற்றும் எழுத்தறிவு சங்க காலம் – சங்ககாலத்தின் பண்டைய நகரங்கள் மற்றும் துறைமுகங்கள் – சங்க காலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – சோழர்களின் வெளிநாட்டு வெற்றி.

UNIT -2 THINAI CONCEPTS

Five types of lands, animals, Gods, occupation, life styles, music, dance , food style, Floara and Fauna of Tamils - Agam and puram concept from Tholkappiyam and Sangam Literature – Aram concept of Tamil – Education and Literacy during Sangam Age – Ancient cities and Ports of Sangam Age – Export and Import during Sangam Age - Overseas Conquest of Choloas.

அலகு 3	**தமிழரின் மரபு**	**3**

இந்திய தேசிய சுதந்திர இயக்கம் மற்றும் இந்திய கலாச்சாரத்திற்கு தமிழர்களின் பங்களிப்பு:- சுப்ரமணிய பாரதி, வாஞ்சிநாதன், சுப்பிரமணிய சிவா, வீரபாண்டிய கட்ட பொம்மன், வா..ஊ சிதம்பரம் பிள்ளை, தீரன் சின்னமலை, மருது பாண்டிய சகோதரர்கள், பூலி தேவர், திருப்பூர் குமரன், வீரமங்கை வேலு நாச்சியார் - ,தமிழர் இலக்கியங்களில் மேலாண்மை கருத்துக்கள் (கி. மு. 500 முதல் கி. பி 200 வரை) – அகநானூறு, புறநானூறு, திருக்குறள் ஆகியவற்றில் மேலாண்மைக் கருத்துகள்..

UNIT -3 HERITAGE OF TAMILS

Contribution of Tamils to Indian National Freedom Movement and Indian Culture : Contributions of Subramanya Bharathi, Vanchinathan, Subramaniya Siva, Veerapandiya Kattabomman, V O Chidambaram Pillai, Dheeran Chinnamalai, The Maruthu Pandiyar, Puli Thevar, Tiruppur Kumaran, Veera Mangai Velunachiyar.

பாடநூல்கள்:

1. **பொன். முத்துகுமாரன்** (2002), "தமிழ் மரபு", காந்தளகம், 68, அண்ணா சாலை, சென்னை 600 002
2. **பி. டிஶ்ரீனிவாச ஐயங்கார்** (தமிழக்கமும் திறனாய்வும்) புலவர் கா. கோவிந்தன் (1988), "தமிழர் வரலாறு (முதல் பகுதி)", திருநெல்வேலி தென்னிந்திய சைவ சித்தாந்த நூற்பதிப்பு கழகம் ,154, TTK சாலை, சென்னை 18.
3. **டாக்டர். கே. கே. பிள்ளை** (2009), "தமிழக வரலாறு மக்களும் பண்பாடும்", உலக தமிழாராய்ச்சி நிறுவனம், தரமணி , சென்னை 600113
4. **முனைவர். ச. இராஜேந்திரன்** (2004), "தமிழில் சொல்லாக்கம்", தஞ்சாவூர் தமிழ் பல்கலைக் கழகம் வெளியீடு

பாடநெறி முடிவுகள் : படிப்பை வெற்றிகரமாக முடித்தவுடன் , மாணவர்கள் பின்வருவனவற்றைச் செய்ய முடியும்.

COURSE OUTCOMES : On completion of the course, the student will be able to

பா .வெ . எண் **CO No**	பாடத்திட்டத்தின் வெளிப்பாடு **Course Outcomes**	**RBT* level**
1	மாணவர்கள் தமிழ் மொழித் தோற்றம் பற்றித் தெரிந்து கொள்வார்கள். Students will learn about the origin of the Tamil language	1
2	தமிழர்களின் வாழ்வியல் முறைகளைத் தெரிந்து கொள்வார்கள். They will know the ways of life of Tamils.	2
3	தமிழர்களின் சுதந்திர போராட்ட வீரர்களை பற்றியும், மேலாண்மைகளை பற்றியும் தெரிந்து கொள்வார்கள். They will know about the freedom fighters of Tamils and the management of Tamils	2
1- Weak; 2 - Moderate; 3 - Strong.		

HS22152	COMMUNICATIVE ENGLISH (Common to all Branches)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Enable learners to interact fluently on everyday social contexts.
- Train learners to engage in conversations in an academic/scholarly setting.
- Instil confidence in learners to overcome public speaking barriers.
- Develop learners' ability to take notes and in the process, improve their listening skills
- Enhance learners' reading skill through reading text passages for comprehension and contemplation.
- Improve learners' skills to write on topics of general interest and drafting correspondences for general purposes.

UNIT 1		**9**

Listening - short video clips - conversational scenes form movies, celebrities' speeches /interviews. Speaking - several ways of introducing oneself at several situations, introducing others at several situations, inviting people for several occasions, describing people and their places. Reading - short comprehension passages - making inferences, critical analysis. Writing - completing the incomplete sentences - developing hints from the given information. Grammar - Wh-Questions and Yes or No questions - Parts of speech. Vocabulary development - prefixes - suffixes - articles - countable / uncountable nouns.

UNIT II		**9**

Listening - customer care voice files, short narratives - identifying problems and developing telephone etiquettes. Speaking - speaking over skype/ whatsapp, making business calls, making self-recorded informative videos, inquiring about a concept/activity, describing a concept/activity. Reading - reading the headlines on news magazines - slogans and taglines from advertisements. Writing - free writing - writing - headlines, slogans and taglines individual inspirations. Grammar- conjunctions, idioms, phrases, quotes. Vocabulary development - guessing the meanings of words in different contexts.

UNIT III		**9**

Listening - courtroom scenes from movies, debates and talks from news channels, notes taking. Speaking - language and tone for arguments, discussion, deliberation, contemplation, expressing opinions, reacting to different situations in an alien country. Reading - language used in instruction manuals of household appliances, cookery and other basic instructions. Writing- understanding the structure of texts - use of reference words, discourse markers- coherence, rearranging the jumbled sentences. Grammar - adjectives - degrees of comparison, framing direct and indirect questions. Vocabulary development - concise approach, single word substitution.

UNIT IV		**9**

Listening - Sports commentaries, advertisements with users' criticisms; Speaking - for social causes, for promoting a concept, negotiating and bargaining; Reading - review of a product, movie, movement or a system; Writing - writing for advertisements, selling a product; Grammar – Tenses - Simple Past, Present and Future, Continuous - Past, Present and Future; Vocabulary Development - synonyms, antonyms and phrasal verbs.

UNIT V		**9**

Listening - video lectures, video demonstration of a concept; Speaking – presenting papers/concepts, delivering short speeches, discourses on health, suggesting natural home remedies, cleanliness, civic sense and responsibilities; Reading - columns and articles on home science; Writing - correspondences of requests, basic enquiry/observation and basic complaints; Grammar - modal verbs, perfect tenses - Vocabulary development - collocations.

TOTAL: 45 PERIODS

REFERENCES:

1. Department of English, Anna University, Mindscapes : English for Technologists and Engineers. Orient Black Swan, Chennai, 2017.
2. Downes and Colm, "Cambridge English for Job-hunting", Cambridge University Press, New Delhi, 2008.
3. Murphy and Raymond, "Intermediate English Grammar with Answers", Cambridge University Press, 2000.
4. Thomson, A.J., "Practical English Grammar" Oxford, 1986.

Websites

1. http://www.usingenglish.com
2. http://www.uefap.com3
3. https://owl.english.purdue.edu/owl/
4. www.learnenglishfeelgood.com/esl-printables-worksheets.html

Software

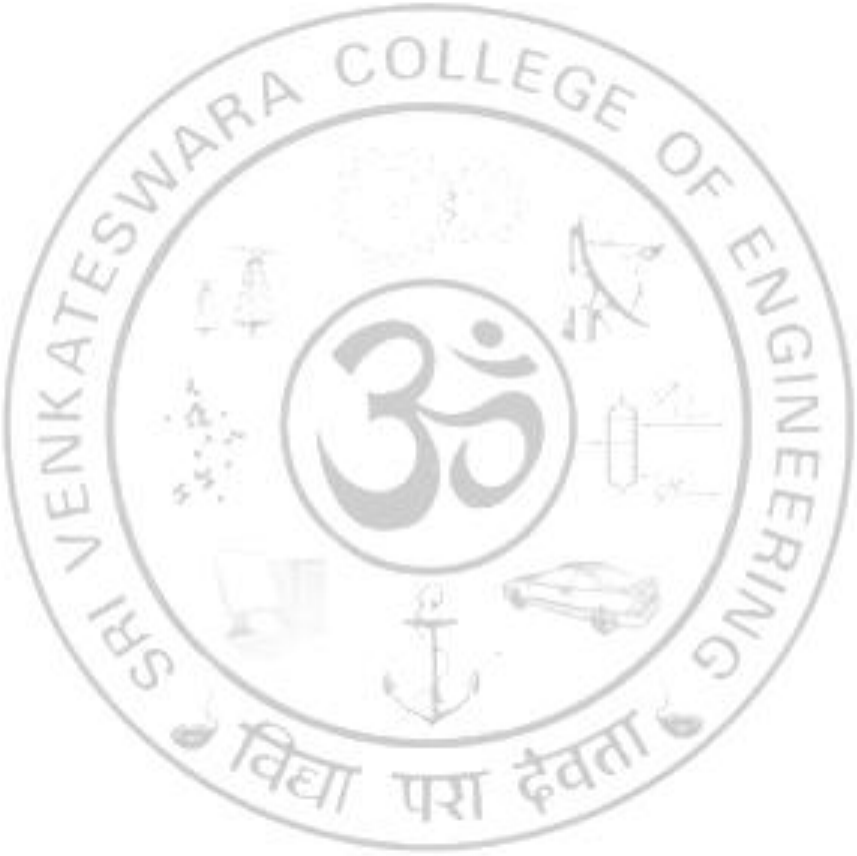
1. Face 2 Face Advance – Cambridge University Press, 2014.
2. English Advance Vocabulary- Cambridge University Press.
3. IELTS test preparation – Cambridge University Press 2017.
4. Official Guide to the TOEFL Test With CD-ROM, 4th Edition.
5. Cambridge Preparation for the TOEFL TEST- Cambridge University Press, 2017.

Course Outcomes: Upon completion of the course, students will be able to:		**RBT* Level**
CO1	Acquire adequate vocabulary for effective communication	3
CO2	Listen to formal and informal communication and read articles and infer meanings from specific contexts from magazines and news papers.	3
CO3	Participate effectively in informal/casual conversations; introduce themselves and their friends and express opinions in English.	4
CO4	Comprehend conversations and short talks delivered in English.	6
CO5	Write short write-ups and personal letters and emails in English	6

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1.	-	-	-	-	-	-	-	-	-	3	-	-	-	-
2.	-	-	-	-	-	-	-	-	-	3	-	-	-	-
3.	-	-	-	-	-	-	-	-	-	3	-	-	-	-
4.	-	-	-	-	-	-	-	-	-	3	-	-	-	-
5.	-	-	-	-	-	-	-	-	-	3	-	-	-	-
1- Weak; 2 - Moderate; 3 - Strong.														



MA22151	APPLIED MATHEMATICS I (Common to all Branches except MR)	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

The Student should be made to:

- Compute eigen values and eigen vectors and use in diagonalization and in classifying real quadratic forms.
- Study differential calculus and its applications to relevant Engineering problems.
- Compute derivatives using the chain rule or total differentials.
- Understand the rotation of two dimensional geometry using definite integrals.
- Acquaint with the Mathematical tools needed in evaluating multiple integrals and their usage.

UNIT 1	MATRICES	(9+3)

Eigen values and Eigen vectors of a real matrix – Characteristic equation – Properties of Eigen values and Eigen vectors – Statement and Applications of Cayley-Hamilton Theorem –Diagonalization of matrices– Reduction of a quadratic form into canonical form by orthogonal transformation-Nature of quadratic forms.

UNIT II	APPLICATION OF DIFFERENTIAL CALCULUS	(9+3)

Curvature and radius of Curvature– Centre curvature – Circle of curvature –Evolutes– Envelopes-Evolute as Envelope of Normals.

UNIT III	DIFFERENTIAL CALCULUS FOR SEVERAL VARIABLES	(9+3)

Limits and Continuity - Partial derivatives – Total derivatives – Differentiation of implicit functions – Jacobians and properties– Taylor's series for functions of two variables – Maxima and Minima of functions of two variables –Lagrange's method of undetermined multipliers.

UNIT IV	APPLICATION OF DEFINTE INTEGRALS	(9+3)

Integration by Parts-Bernoulli's formula for integration- Definite integrals and its Properties- Solids of Revolution- Disk Method- Washer Method- Rotation about both x and y axis and Shell method.

UNIT V	MULTIPLE INTEGRALS	(9+3)

Double integrals in Cartesian and polar coordinates – Change of order of integration – Area enclosed by plane curves - Change of variables in double integrals – Triple integrals – Volume of solids.

TOTAL (L: 45 + T:15): 60 PERIODS

TEXT BOOKS:

1. Erwin Kreyszing, Herbert Kreyszing, Edward Norminton, "Advanced Engineering Mathematics", 10th Edition, John Wiley, (2015)
2. Grewal .B.S, Grewal .J.S "Higher Engineering Mathematics",43rd Edition, Khanna Publications, Delhi, (2015).

REFERENCES:

1. Bali N.P and Manish Goyal, "A Text book of Engineering Mathematics", Nineth Edition, Laxmi Publications Pvt. Ltd., (2014).
2. Glyn James, "Advanced Modern Engineering Mathematics", 4th Edition, Pearson Education, (2016).
3. Ramana B.V, "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company, New Delhi, (2013).

Web Link:

1. https://home.iitk.ac.in/~peeyush/102A/Lecture-notes.pdf
2. 2. https://www.sydney.edu.au/content/dam/students/documents/mathematics-learning-entre/integration-definite-integral.pdf

Course Outcomes: Upon completion of the course, students will be able to:		**RBT* Level**
CO1	Solve the Eigen value problems in matrices.	3
CO2	Apply the basic notion of calculus in Engineering problems and to tackle for different geometries.	3
CO3	Perform calculus for more than one variable and its applications in Engineering problems.	3
CO4	Apply definite integrals for design of three dimensional components.	3
CO5	Evaluate multiple integral in Cartesian and polar coordinates.	3
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO-1**	**PSO-2**
CO1	3	3	3	3	-	-	-	-	-	-	-	3	-	-
CO2	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	3	-	-
CO4	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO5	3	3	2	2	-	-	-	-	-	-	-	3	-	-
1- Weak; 2 - Moderate; 3 - Strong.														

PH22151	APPLIED PHYSICS (Common to AD, CS, EE, EC, IT)	L 3	T 0	P 0	C 3

COURSE OBJECTIVES:

- To enhance the fundamental knowledge in Physics and its applications relevant to various Streams of Engineering and Technology.

UNIT 1	**LASERS AND FIBER OPTICS**	**9**

Lasers: population of energy levels, Einstein's A and B coefficients derivation – resonant cavity, optical amplification (qualitative) – Nd-YAG laser – CO2 Laser – Exceimer Laser – Applications. Fiber optics: principle, numerical aperture and acceptance angle - types of optical fibres (material, refractive index, and mode) – losses associated with optical fibers–Fiber optic communication - fibre optic sensors: pressure and displacement - Endoscope.

UNIT 2	**QUANTUM PHYSICS**	**9**

Black body radiation – Planck's theory (derivation)- deduction of Wien's and Rayleigh Jean's law – Compton effect: theory and experimental verification – wave particle duality – electron diffraction – concept of wave function and its physical significance – Schrödinger's wave equation – time independent and time dependent wave equations – particle in a one-dimensional - three dimensional potential box–Fermi distribution function – Effect of temperature on Fermi Function – Density of energy states – carrier concentration in metals.

UNIT 3	**CRYSTAL PHYSICS**	**9**

Single crystalline, polycrystalline and amorphous materials – single crystals: unit cell, crystal systems, Bravais lattices, directions and planes in a crystal, Miller indices – interplanar distances-coordination number and packing factor for SC, BCC, FCC, HCP and Diamond structure (qualitative) – crystal imperfections: point defects, line defects – Burger vectors, stacking faults.

UNIT 4	**WAVES AND OSCILLATIONS**	**9**

Travelling waves, Wave equation for string, Energy and momentum, Resonance Superposition & Reflection, Standing waves, Harmonic oscillations, Damped harmonic motion- Forced oscillations, amplitude resonance - Expression for Resonant frequency, Electrical analogy of mechanical oscillations, Quality factor and sharpness of resonance, Electrical analogy of mechanical oscillators.

UNIT 5	**ELECTROMAGNETIC WAVES**	**9**

Maxwell's Equations. Vector and Scalar Potentials. Plane waves in Dielectric media. Poynting Theorem and Poynting Vector.- Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, EM Wave Propagation in Unbounded Media, Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant.

Total (L:45): 45 PERIODS

TEXT BOOKS:

1. Gaur R.K., Gupta S.L, "Engineering Physics", Dhanput Publications, 2015.
2. Shatendra Sharma, Jyotsna Sharma, "Engineering Physics", Pearson, 2006.
3. Rajendran V, "Engineering Physics", Tata McGraw Hill, 2009.
4. Arumugam M, "Materials Science", Anuradha Publications, 2015.

REFERENCES:

1. David Halliday, Robert Resnick, Jearl Walker, "Principles of Physics", 10th Edition, Wiley, 2015.
2. Peter Atkins, Julio De Paula, "Physical Chemistry",10th Edition., Oxford University Press, 2014.
3. Arthur Beiser, Shobhit Mahajan, Rai Choudhury S,"Concepts of Modern Physics", 7th Edition, McGraw Hill Education, 2017.
4. Raghavan V, "Materials Science and Engineering", PHI Learning Pvt. Ltd., 2010

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO 1	Apply fundamentals law of optics in different types of LASER and Optic fiber communication.	3
CO 2	Apply the principals of Quantum mechanics to study the properties of Electrons.	3
CO 3	Classify and demonstrate the fundamentals of crystals and their defects in solids.	2
CO 4	Demonstrate a strong fundamental knowledge in wave oscillations.	2
CO 5	Apply Electromagnetic equations for various media.	3

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX:

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	-	3	-	-	2	-	-	2	-	2	-	-
2.	3	2	-	2	-	-	-	-	-	2	-	2	-	-
3.	3	-	-	-	-	-	-	-	-	2	-	2	-	-
4.	3	2	-	-	-	-	-	-	-	2	-	2	-	-
5.	3	2	-	1	-	-	-	-	-	2	-	2	-	-

1- Weak; 2 - Moderate; 3 - Strong.

CY22151	APPLIED CHEMISTRY (Common to AD, CS, EE, EC, IT)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To make the students conversant with basic electrochemistry and batteries.
- To develop an understanding of the laws of photochemistry and basics.
- To acquaint the students with the basics of nanomaterials, their properties and uses.
- To acquire the basic knowledge on sensors which are essential for the software engineers for develop new devices.
- To enable the students to understand the types of instruments for material analysis and their working principle.

UNIT I	**ELECTROCHEMISTRY**	**9**

Electrodes and electrochemical cells – electrode potential, standard electrode potential, single electrode potential and its determination, types of electrodes – calomel, quinhydrone and glass electrode. Nernst equation - Determination of pH of a solution by using quinhydrone and glass electrode. Electrochemical series and its applications. Batteries – Primary (dry cell) and secondary batteries (Lead – acid storage battery and Lithium ion battery) and next generation batteries

UNIT II	**PHOTOCHEMISTRY**	**9**

Laws of photochemistry – Grotthuss-Draper law, Stark–Einstein law and Lambert Beer Law – determination iron by spectrophotometer. Quantum efficiency – Photo processes - internal conversion, inter-system crossing, fluorescence, phosphorescence and photo-sensitization-quenching of fluorescence and its kinetics, Stern-Volmer relationship. Applications of photochemistry.

UNIT III	**NANOCHEMISTRY**	**9**

Basics and scale of nanotechnology, different classes of nanomaterials, Distinction between molecules, nanoparticles and bulk materials; size-dependent properties. Synthesis of nanomaterials, fabrication (lithography) and its applications – Basics of nanophotonics and quantum confined materials (surface plasmon resonance).

UNIT IV	**CHEMICAL SENSOR**	**9**

Sensors, sensor science and technology, types of sensors. Chemical Sensors – characteristics and elements. Electrochemical sensors – voltammetry, potentiometric sensors, amperometric sensors, polarization techniques.

UNIT V	**INSTRUMENTATION TECHNIQUES**	**9**

Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental method - Electromagnetic radiation-UV-visible and IR spectroscopy: principles, instrumentation (Block diagram only) and applications. Separation techniques chromatography: Gas chromatography, liquid chromatography - importance of column technology (packing, capillaries), separation based on increasing number of factor (volatility, solubility, interactions with stationary phase, size)

	TOTAL (L: 45): 45 PERIODS

TEXT BOOKS:

1. Jain P.C. and Monica Jain, "Engineering Chemistry", Dhanpat Rai Publishing Company (P) Ltd., New Delhi, 2010.
2. Dara S.S, Umare S.S, "Engineering Chemistry", S. Chand & Company Ltd., New Delhi 2010
3. B.K.Sharma, "Instrumental Methods of Chemical Analysis", 28th Edition, Goel Publishing House, 2012.
4. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.

REFERENCES:

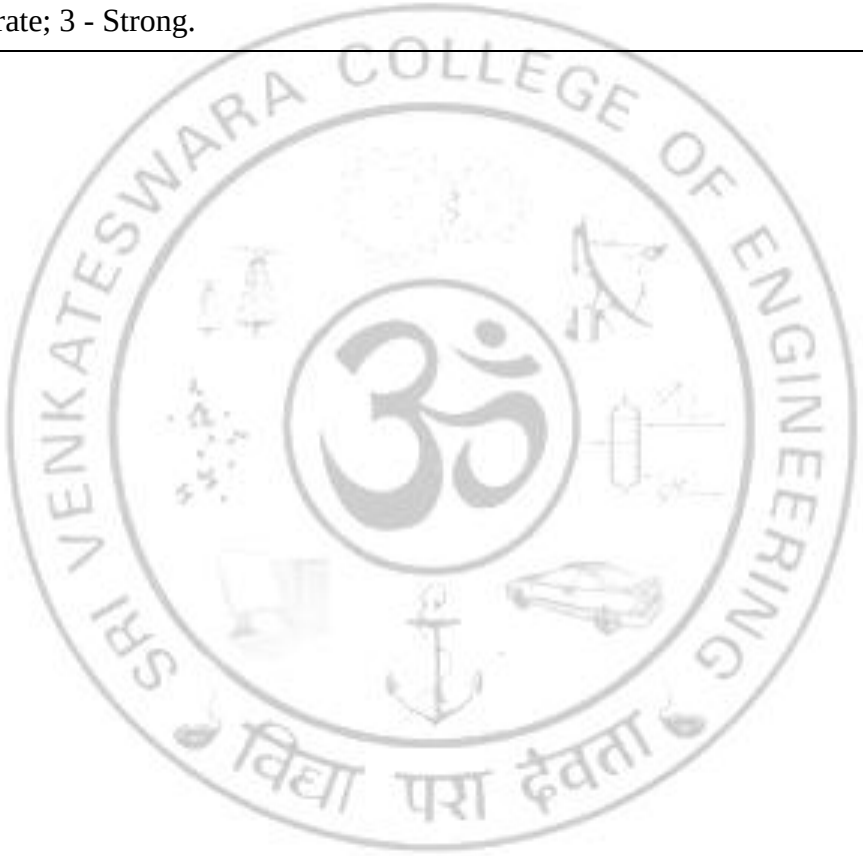
1. Ozin G. A. and Arsenault A. C., "Nanochemistry: A Chemical Approach to Nanomaterials", RSC Publishing, 2005.
2. B.R. Puri, L.R. Sharma, M.S. Pathania., "Principles of Physical Chemistry" Vishal Publishing Company, 2008.
3. John Vetelino, Aravind Reghu, Introduction to Sensors , Taylor & Francis Group, CRC Press, 1st edition, 2010.
4. Peter Gründler, Chemical Sensors, An Introduction for Scientists and Engineers, Springer-Verlag Berlin Heidelberg 2007.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Identify electrochemical cells, corrosion and fundamental aspects of batteries.	2
CO2	Interpret the photochemical reactions and make use of spectroscopic techniques.	2
CO3	Realize the structures, properties and applications of nanoparticles.	2
CO4	Acquire the basic knowledge on chemical sensors to develop an interdisciplinary	2
CO5	Develop theoretical principles of UV-visible and IR spectroscopy and separation techniques.	3

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO-1	PSO-2
CO1	3	3	3	2	-	-	-	-	-	-	-	3	-	-
CO2	3	3	-	-	-	3	3	-	-	-	-	3	-	-
CO3	3	3	3	-	-	3	3	1	-	-	-	3	-	-
CO4	3	3	3	-	1	3	3	-	-	-	-	3	-	-
CO5	3	3	-	2	-	3	3	-	-	-	-	3	-	-
1- Weak; 2 - Moderate; 3 - Strong.														



EE22152	BASIC ELECTRICAL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce basics concepts of electric circuits
- To impart knowledge in types, construction and working of DC machines and transformers.
- To study the working principles of AC machines.
- To introduce the components of low voltage electrical installations and working principles of Power converters.
- To study the different types of measuring instruments.

UNIT I	**BASIC CIRCUITS ANALYSIS**	**9**

Ohm's Law – Kirchoff's laws – DC and AC Circuits – Resistors in series and parallel circuits – Mesh current and node voltage method of analysis for D.C and A.C. circuits – Phasor Diagram – Power, Power Factor and Energy. Network reduction: Voltage and current division rule, Star to delta conversion.

UNIT II	**DC MACHINES AND TRANSFORMER**	**9**

Introduction- ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer. Construction, working, torque-speed characteristic and speed control of separately excited dc motor – Applications.

UNIT III	**AC MACHINES**	**9**

Overview of three phase circuits, Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip Characteristic, Loss components and efficiency, Single-phase induction motor, Working of synchronous generators.

UNIT IV	**ELECTRICAL INSTALLATIONS AND POWER CONVERTERS**	**9**

Components of LT switch gear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB. Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption. DC-DC buck and boost converters, duty ratio control. Introduction to voltage source inverters.

UNIT V	**MEASURING INSTRUMENTS**	**9**

Types of instruments, Construction and working principles of PMMC and moving iron type voltmeters, ammeters and ohm meter. Measurement of frequency. Single phase dynamometer wattmeter, Use of shunts and multipliers (Simple numerical problems on shunts and multipliers). Analog Energy meters, Smart digital Energy meter and Net meter.

TOTAL (L:45): 45 PERIODS

TEXT BOOKS:

1. D.P. Kothari and I.J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 3rd edition 2010.
2. D.C. Kulshreshtha, "Basic Electrical Engineering", Tata McGraw Hill, 2009.
3. E. Hughes, "Electrical and Electronics Technology", 10th Edition, Pearson, 2010.

REFERENCES:

1. Vincent Deltoro, "Electrical Engineering Fundamentals", Second Edition, Prentice Hall India, 1989.
2. S.K.Bhattacharya , "Basic Electrical and Electronics Engineering", Pearson India, 2011.
3. William Hayt and Jack E. Kemmerly, "Engineering circuit analysis", Mc Graw Hill Company, 6th edition, 2016.
4. Newnes Electrical Power Engineers handbook, II edition, Elsevier publications, 2005.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Analyze DC and AC electrical circuits using Kirchoff's law.	4
CO2	Explain the working principle of electrical machines	4
CO3	Choose the appropriate electrical machines for various applications.	4
CO4	Understand the principles of electrical machines and power converters.	4
CO5	Explain the types and operating principle of measuring instruments.	4
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX:

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	-	-	-	-	-	-	-	3	3
2.	3	3	-	-	-	-	-	-	-	-	-	-	3	3
3.	3	3	-	-	-	-	-	-	-	-	-	-	3	3
4.	3	2	-	-	-	-	-	-	-	-	-	-	3	2
5.	3	2	-	-	2	-	-	-	-	-	-	-	3	2
1- Weak; 2 - Moderate; 3 - Strong.														

IT22101	PROGRAMMING FOR PROBLEM SOLVING (Common to IT, AD, CS, EE, EC)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Learn the organization of a digital computer.
- Learn to think logically and write algorithms or draw flow charts for problems.
- Be exposed to the syntax of C.
- Be familiar with programming in C.
- Learn to use arrays, strings, functions, pointers, structures and unions in C.

UNIT 1	**INTRODUCTION TO PROBLEM SOLVING**	**6**

Simple model of a Computer – Hardware – Software – Data Representation, Introduction to Computer Networks and Internet, Problem Solving Techniques – Bottom up design and top down design - applications, Introduction to Algorithms and Flow Chart

Suggested Activities:

Casestudy – Understanding the analysis and design of the Student Management System (SMS).

UNIT 2	**C PROGRAMMING BASICS**	**12**

Introduction to 'C' programming – structure of a 'C' program – Conversion of simple algorithm to program. Constants, Variables – Data Types – Expressions using operators in 'C' – Managing Input and Output operations – Decision Making and Branching – Looping statements – solving simple scientific and statistical problems.

Suggested Activities

Casestudy: Dataset creation and Grade calculation in SMS

UNIT 3	**ARRAYS AND STRINGS**	**9**

Array: declaration, initialization. Multi dimensional arrays. Strings: Strings vs Character arrays, string operations

Suggested Activities - Grade sheet generation in SMS

UNIT 4	**FUNCTIONS AND STRUCTURES**	**9**

Need for Modular programming, Functions: definition, call, arguments, call by value. Call by reference, Recursion. structures and unions: Need, declaration, Accessing Structure elements, Arrays of structures

Suggested Activities: Redesigning SMS in terms of modules

UNIT 5	**POINTERS AND FILE HANDLING IN C**	**9**

Pointers: Introduction, pointers to primitive datatypes, pointers to user defined datatypes: arrays and structures, array of pointers, Dynamic Memory Allocation. Files: Read/Write of binary and text files. Preprocessor directives

Suggested Activities: Mange I/O in SMS using Files

TOTAL (L:45): 45 PERIODS

TEXT BOOKS:

1. Pradip Dey, Manas Ghosh, " Programming in C ", First Edition, Oxford University Press, 2018.
2. R G Dromey, "How to Solve it using Computer", Pearson,2006

REFERENCES:

1. Kernighan,B.W and Ritchie,D.M, "The C Programming language", Second Edition, PearsonEducation, 2015.
2. Yashavant P. Kanetkar. "Let Us C", BPB Publications, 2011.
3. Byron S Gottfried, "Programming with C", Schaum's Outlines, Third Edition, Tata McGraw Hill, 2010
4. Reema Thareja, "Programming in C", 2nd ed., Oxford University Press, 2016

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Identify input and output from the real word problem scenarios.	3
CO2	Represent the design flow using Flow-charts and application logic using pseudo code.	3
CO3	Apply appropriate programming constructs to implement a given design using C.	3
CO4	Debug and customize an existing software developed in C.	5
CO5	Develop a modularised software application In C for the given user requirements	6
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX:

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	1	3	-	-	-	-	-	2	3	-	-	2	2	2
2.	1	3	-	-	-	-	-	2	3	-	-	2	2	2
3.	1	-	3	2	1	-	-	2	3	-	-	2	2	2
4.	1	-	3	2	1	-	-	2	3	-	-	2	2	2
5.	1	-	3	2	1	-	-	2	3	-	-	2	3	3
1- Weak; 2 - Moderate; 3 - Strong.														

PH22161	PHYSICS LABORATORY (Common to all Branches except BT)	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To introduce different experiments to test basic understanding of physics concepts applied in optics, thermal physics and properties of matter.

LIST OF EXPERIMENTS: (Any EIGHT Experiments)

1. a) Determination of Wavelength, and particle size using Laser.
   b) Determination of acceptance angle in an optical fiber.
2. Determination of velocity of sound and compressibility of liquid – Ultrasonic Interferometer.
3. Determination of wavelength of mercury spectrum – spectrometer grating.
4. Determination of thermal conductivity of a bad conductor – Lee's Disc method.
5. Determination of Young's modulus by Non uniform bending method.
6. Determination of specific resistance of a given coil of wire – Carey Foster's Bridge.
7. Determination of Rigidity modulus of a given wire -Torsional Pendulum
8. **Energy band gap of a Semiconductor**
9. Determine the Hysteresis loss of a given Specimen
10. **Calibration of Voltmeter & Ammeter using potentiometer.**

Total (P:30): 30 PERIODS

REFERENCE:

1. "Physics Laboratory practical manual", 1st Revised Edition by Faculty members, 2018.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO 1	Apply the physical principle involved in the various instruments; also relate the principle to new application.	3
CO 2	Utilized the principle of optics, mechanics and thermal physics to cater the need of various engineering field.	3
CO 3	Make use of the basic concept of physical science to think innovatively and develop engineering skills	3

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

*COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1.	3	3	2	3	-	-	-	2	3	2	-	3	-	-
2.	3	3	2	3	-	-	-	2	3	2	-	3	-	-
3.	3	3	2	3	-	-	-	2	3	2	-	3	-	-
4.	3	3	2	3	-	-	-	2	3	2	-	3	-	-
5.	3	3	2	3	-	-	-	2	3	2	-	3	-	-

*1- Weak; 2 - Moderate; 3 - Strong.

ME22161	BASIC CIVIL AND MECHANICAL ENGINEERING LABORATORY (Common to CE, EE, EC)	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To provide an exposure and hands on experience to the students on various civil and mechanical engineering processes.

LIST OF EXPERIMENTS

1- Carpentry – Preparation of Cross half lap joint and Tee joint using power tools.
2- Plumbing – Basic pipe line connection used in houses with PVC pipes, valves, taps, couplings, unions, reducers, elbows.
3- Welding - Butt joint and lap joint using Electric Arc welding.
4- Machining – Turning and facing using Centre Lathe.
5- Sheet metal work – Making of a cylinder using GI sheet and finishing using rivets.
6- Fitting – Preparation of metal pieces by grinding and filing to maintain flat sides at right angles
7- Drilling and Tapping – Drilling of holes precisely and making internal threads by Tapping for various sizes.
8- Casting – Mould preparation using simple solid pattern and casting.
9- Automation – Basic pneumatic circuit using single and double acting cylinder.
10- 3D printing –Demonstration of printing of simple solids using Additive Manufacturing/3D printing.

TOTAL: 30 PERIODS

TEXT BOOKS:

1. Jeyachandran K., Natarajan S. & Balasubramanian S., "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
2. Jeyapoovan T., Saravanapandian M. & Pranitha S., "Engineering Practices Lab Manual", Vikas Publishing House Pvt.Ltd, 2006.
3. Bawa H.S., "Workshop Practice", Tata McGraw Hill Publishing Company Limited, 2007.
4. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
5. Anthony Esposito, Fluid Power with Applications, Pearson Education, 7th edition, 2009.
6. Civil & Mechanical engineering practices lab manual, SVCE, 2022.

OUTCOMES:

CO	*CO statements*	RBT* level
CO1	Students will be able to ***Prepare*** various joints used for assembling wooden parts.	3
CO2	Students will be able to ***Make*** required pipeline connection by selecting the suitable components	3
CO3	Students will be able to ***Fabricate*** components by various manufacturing processes.	3
CO4	Students will be able to ***Understand*** the principles of low-cost automation using pneumatic circuits.	2
CO5	Students will be able to ***Understand*** the principle of additive manufacturing/3D printing	2

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

	POs												PSOs	
***COs**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	1	-	-	-	2	-	-	-	-	-	-	-	-	-
CO5	1	-	-	-	2	-	-	-	-	-	-	-	-	-

*1- Weak; 2 - Moderate; 3 - Strong.

IT22111	PROGRAMMING FOR PROBLEM SOLVING LABORATORY (Common to IT, AD, CS, EE, EC)	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- Be exposed to the syntax of C.
- Be familiar with programming in C.
- Learn to use arrays, strings, functions, pointers, structures and unions in C.

LIST OF EXERCISES

1. Usage of Basic Linux commands.
2. C Programming using Simple statements and expressions.
3. Scientific problem solving using decision making and looping.
4. Simple programming for one dimensional and two dimensional arrays.
5. Solving problems using Strings.
6. C Programming using Pointers.
7. C Programming using user defined functions (Pass by value and Pass by reference) .
8. C Programming using Recursion.
9. C Programming using structures and union.
10. C Programming using enumerated data types.
11. C Programming using macros and storage classes.
12. C Programming using Files.
13. Develop modularized application for any one of the following scenarios.

Scenarios:

- Student Management System
- Stock Management System
- Banking Application
- Ticket Reservation System

Total (P:45): 45 PERIODS

Hardware/Software Requirements (For a batch of 30 students)

Computer with Windows/Linux OS and C compiler -30 No.s

TEXT BOOKS:

1. Pradip Dey, Manas Ghosh, " Programming in C ", First Edition, Oxford University Press, 2018.
2. Byron S Gottfried, "Programming with C", Schaum's Outlines, Third Edition, Tata McGraw Hill, 2010.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* LEVEL**
CO1	Apply appropriate programming constructs to solve problems.	3
CO2	Design, implement, test and debug programs that use the basic features of C.	5
CO3	Design modularized applications in C to solve real world problems.	6
CO4	Use C pointers and dynamically allocated memory to solve complex problems	4
CO5	Apply file operations to develop solutions for real-world problems	3
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX:

***COs**	**POs**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1.	1	3	-	-	-	-	-	2	3	-	-	2	2	2	1
2.	1	3	-	-	-	-	-	2	3	-	-	2	2	2	1
3.	1	-	3	2	1	-	-	2	3	-	-	2	2	2	1
4.	1	-	3	2	1	-	-	2	3	-	-	2	2	2	1
5.	1	-	3	2	1	-	-	2	3	-	-	2	3	3	1
* 1- Weak; 2 - Moderate; 3 - Strong.															

SEMESTER II

HS22251	அறிவியல் மற்றும் தொழில்நுட்பத்தில் தமிழ் SCIENCE AND TECHNOLOGY IN ANCIENT TAMIL SOCIETY (Common to all branches)	L	T	P	C
		2	0	0	2

பாடத்தின்நோக்கங்கள் :

1. **அறிவியலில் தமிழின் பயன்பாடு பற்றி தெரிந்து கொள்வார்கள்.**
2. **தொழில்நுட்பத்தில் தமிழ் பாரம்பரியத்தின் தாக்கம் பற்றி அறிந்து கொள்வார்கள்.**

Course Objectives :

1. They will know about the use of Tamil in science.
2. Learn about the impact of Tamil heritage on technology.

அலகு 1	**அறிவியல் தமிழ்**	**6**

கருவி உருவாக்கம் – ஆராய்ச்சி மேம்பாடு – கல்வி வளர்ச்சி – அறிவியல் தமிழ் சொற்கள் உருவாக்கம்.

UNIT -1 SCIENTIFIC TAMIL

Tool Development - Research Development - Educational Development - Scientific Tamil words Creation.

அலகு 2	**தொழில்நுட்பத்தில் தமிழ்**	**24**

வடிவமைப்பு மற்றும் கட்டுமான தொழில்நுட்பம் : சங்க காலத்தில் கட்டுமானப் பொருட்கள் – சோழர்களின் பெரியகோவில்கள் மற்றும் பிற வழிபாட்டுதலங்கள் – பல்லவர்களின் சிற்பங்கள் மற்றும் கோவில்கள் (மாமல்லபுரம்) - நாயக்கன் கால கோவில்கள் (மதுரை மீனாட்சி அம்மன் கோவில்), திருமலை நாயக்கர் மஹால், செட்டிநாட்டு வீடுகள்.

உற்பத்தி தொழில் நுட்பம் : கப்பல் கட்டும் கலை, உலோகவியல் ஆய்வுகள், தங்கம், தாமிரம், இரும்பு பற்றிய அறிவு – தொல்பொருள் சான்றுகள் – சுட்டக் களிமண் மணிகள், சங்கு மணிகள், எலும்பு மணிகள்.

விவசாயம் மற்றும் நீர்ப்பாசன தொழில்நுட்பம் : அணைகள், ஏரிகள், குளங்கள், மதகுகள், சோழர் கால குமுழி தூம்பு ஆகியவற்றின் முக்கியத்துவம் – கால்நடை பராமரிப்பு, கால்நடைகளின் பயன்பாட்டிற்காக வடிவமைக்கப்பட்ட கிணறுகள். விவசாயம் மற்றும் வேளாண் செயலாக்கம் – கடல் பற்றிய அறிவு – மீன் பிடித்தல், முத்து குளித்தல், சங்கு சேகரித்தல்.

தமிழ் கணினி: அறிவியல் தமிழ் வளர்ச்சி – தமிழ் கணினி, தமிழ் புத்தகங்களின் டிஜிட்டல்மயமாக்கல், தமிழ் டிஜிட்டல் நூலகம், தமிழ் மென்பொருள் உருவாக்கம் – தமிழ் மெய் நிகர் அகாடமி – சொற்குவை திட்டம்.

தமிழின் எதிர்காலமும் தகவல் தொழில்நுட்பமும்- உலகமயமாக்கலும் தகவல் தொழில்நுட்பமும் – கணினிக்கு தமிழ் கற்று கொடுத்தல் – தமிழ்மொழித் தொழில்நுட்பத்தில் வளங்கள்.

UNIT -2 TAMIL IN TECHNOLOGY

Design and Construction Technology: Building materials in Sangam age – Great temples of Cholas and other workship places – Sculptures and Temples of Pallavas (Mamallapuram) – Temples of Nayakas period (Madurai Meenakshi amman temple), Thirumalai Nayakar Mahal, Chetti Nadu Houses.

Manufacturing Technology: Art of Ship building, Metallurgical studies, Knowledge about Gold, Copper,

Iron – Archeological evidences – Terracotta beads, Shell beads, Bone beads.

Agriculture and Irrigation Technology: Dams, Tank, ponds, sluice, Significance of Kumuzhi Thoompu of Cholas period- Animal Husbandry, Wells designed for cattle use. Agriculture and Agro processing, - Knowledge about Sea – Fisheries, Pearl, Conche diving.

Tamil Computing: Development of Scientific Tamil – Tamil Computing, Digitization of Tamil books, Tamil Digital Library, Development of Tamil Softwares – Tamil virtual Academy – Sorkuvai project. Future of Tamil and Information Technology- Globalization and Information Technology-Teaching Tamil for Computer-Resources in Tamil Language Technology.

பாடநூல்கள்:

1. டாக்டர், வா.செ .குழந்தைசாமி (1985), "அறிவியல் தமிழ்" , பாரதி பதிப்பகம், 126/108, உஸ்மான் சாலை, தியாகராய நகர் , சென்னை 600017
2. சுப. திண்ணப்பன், (1995), "கணினியும் தமிழ் கற்பித்தலும்", புலமை வெளியீடு, 38-B மண்ணத்நதோட்டத் தெரு, ஆழ்வார்பேட், சென்னை 600018
3. மு. பொன்னவைக்கோ, (2003), "வளர்தமிழில் அறிவியல் – இணையத் தமிழ்", அனைத்திந்திய அறிவியல் தமிழ்க் கழகம், தஞ்சாவூர் 615 005.
4. துரை. மணிகண்டன், (2008), "இணையமும் தமிழும்", நல்நிலம் பதிப்பகம், 7-3, சிமேட்லி சாலை, தியாகராய நகர், சென்னை 600 017.

பாடநெறி முடிவுகள் : படிப்பை வெற்றிகரமாக முடித்தவுடன், மாணவர்கள் பின்வருவனவற்றைச் செய்ய முடியும்.

COURSE OUTCOMES : On completion of the course, the student will be able to

பா .வெ . எண் **CO No**	பாடத்திட்டத்தின்வெளிப்பாடு **Course Outcomes**	**RBT* level**
1	அறிவியலில் தமிழ் மொழியின் பயன்பாடு பற்றி தெரிந்து கொள்வார்கள் They will know about the use of Tamil language in science	2
2	பல்வேறு தொழில்நுட்பத்தில் தமிழ்மொழியின் தாக்கம் பற்றி அறிந்து கொள்வார்கள் They will learn about the influence of Tamil language in various technologies	3
1- Weak; 2 - Moderate; 3 - Strong.		

HS22252	TECHNICAL ENGLISH (Common to all branches)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Enable learners to define and understand technical communication and scientific writing
- Expose learners to the technicalities of seminar presentation, group discussion, and public speaking
- Develop learners' writing skills for scientific and documenting purposes
- Improve learners' ability to draft correspondences for business purposes
- Cultivate learners' ability to holistically understand the nuances of job interviews and recruiting process.

UNIT I	**9**
Listening - AV files pertaining to manufacturing processes of products, scientific documentaries; Speaking - syllable division and word stress, intonation, sharing opinions; Reading - news articles related to science and technology; Writing - definitions, instruction, recommendation, data interpretation, resume; Grammar -tenses and their aspects, sentence connectors – discourse markers, sequential words, active and passive voice, subject-verb agreement.	
UNIT II	**9**
Listening - AV pertaining to marketing strategies, peer reading and pronunciation; Speaking- turn taking, sharing opinions; conducting and attending a meeting, understanding the nuances of spoken communication among internal audience and external audience; Reading - analytical documents, descriptive documents; Writing - fliers, brochures, resume - letter of application, checklists; Grammar - modal verbs, clauses - types and uses, conditional clauses, articles.	
UNIT III	**9**
Listening - AV related to how to use components, scientific description, Speaking - speaking for motivation and initiation, speaking at a seminar presentation; Reading - scientific journals, papers; Writing - Technical descriptions - process description, purpose and function, PowerPoint, Google forms, user manuals; Grammar - phrasal verbs, prepositions, technical and scientific affixes.	
UNIT IV	**10**
Listening - scientific debates, crisis management; Speaking - handling conflicts, speaking about the loss of benefits, progress or decline of business, identifying the connotative meanings, Reading- documented evidences of uses and functions of a product, review of a product, Writing - memos, follow-up letters, reports - proposal, project, progress reports, sales reports, reports on industrial visits, executive summary. Grammar - reported speech and tag questions, sentence structure - comparative, imperative, cause and effect, infinitive of result.	
UNIT V	**8**
Listening - AV of Group discussions, panel discussions, face to face interviews for recruitment purposes; Speaking- speaking at group discussions, interviewing a personality, answering at the interviews; Reading - WebPages of top notch engineering companies, Writing - blogging, e-mails, letter of complaint, minutes of the meeting; Grammar - one word substitution, collocations, better word/sentence substitution (rephrasing the content/improvising ideas).	
	TOTAL: 45 PERIODS

REFERENCES:

1. Department of English, Anna University. *Mindscapes: English for Technologists and Engineers.* Orient Blackswan, Chennai. 2012.
2. Downes, Colm, *Cambridge English for Job-hunting*, Cambridge University Press, New Delhi. 2008.
3. Murphy, Raymond, *Intermediate English Grammar with Answers*, Cambridge University Press 2000.
4. Thomson, A.J., *Practical English Grammar 1 & 2*, Oxford, 1986.
5. Herbert A J, *The Structure of Technical English*, Longman, 1965.

Websites

1. http://www.usingenglish.com
2. http://www.uefap.com3
3. https://owl.english.purdue.edu/owl/
4. www.learnenglishfeelgood.com/esl-printables-worksheets.html

Software

1. Face 2 Face Advance – Cambridge University Press, 2014.
2. English Advance Vocabulary- Cambridge University Press.
3. IELTS test preparation – Cambridge University Press 2017.
4. Official Guide to the TOEFL Test With CD-ROM, 4th Edition.
5. Cambridge Preparation for the TOEFL TEST- Cambridge University Press, 2017.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1.	Understand the nuances of technical communication and scientific writing	3
CO2.	Present papers and give seminars	6
CO3.	Discuss in groups and brainstorm	6
CO4.	Draft business correspondences and write for documenting purposes	6
CO5.	Face job interviews with confidence	6

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	-	-	-	-	-	-	-	-	-	3	-	-	-	-
2.	-	-	-	-	-	-	-	-	-	3	-	-	-	-
3.	-	-	-	-	-	-	-	-	-	3	-	-	-	-
4.	-	-	-	-	-	-	-	-	-	3	-	-	-	-
5.	-	-	-	-	-	-	-	-	-	3	-	-	-	-

*1- Weak; 2 - Moderate; 3 - Strong.

MA22251	APPLIED MATHEMATICS II (Common to all Branches except MR)	L 3	T 1	P 0	C 4

COURSE OBJECTIVES:

The Student should be made to:

- Acquire the concepts of vector calculus needed for problems in all engineering disciplines and compute different types of integrals using Green's, Stokes' and Divergence theorems.
- Skilled at the techniques of solving ordinary differential equations that model engineering problems.
- Extend their ability of using Laplace transforms to create a new domain in which it is easier to handle the problem that is being investigated.
- Explain geometry of a complex plane and state properties of analytic functions.
- Understand the standard techniques of complex variable theory so as to apply them with confidence in application areas such as heat conduction, elasticity, fluid dynamics and flow of electric current.

UNIT I	**VECTOR CALCULUS**	**(9+3)**

Gradient, divergence and curl - Directional derivative - Vector identities – Irrotational and solenoidal vector fields - Line integral over a plane curve – Surface integral - Area of a curved surface - Volume integral - Green's theorem in a plane, Gauss divergence theorem and Stokes'theorem (excluding proofs) – Verification and application in evaluating line, surface and volume integrals.

UNIT II	**ORDINARY DIFFERENTIAL EQUATIONS AND ITS APPLICATIONS**	**(9+3)**

Differential equations of first order – Equations of the first order and first degree – Linear equations – Higher order linear differential equations with constant coefficients - Method of variation of parameters - Cauchy's and Legendre's linear equations - Simultaneous first order linear equations with constant coefficients – Applications of Linear differential equations – Oscillatory electrical circuit – Deflection of beams.

UNIT III	**LAPLACE TRANSFORM**	**(9+3)**

Conditions for existence - Transform of elementary functions - Transforms of unit step function and impulse functions – Basic properties – Shifting theorems - Transforms of derivatives and integrals of functions - Derivatives and integrals of transforms - Initial and final value theorems - Transform of periodic functions. Inverse Laplace transforms - Convolution theorem – Application to solution of linear ODE of second order with constant coefficients using Laplace transformation techniques.

UNIT IV	**ANALYTIC FUNCTIONS**	**(9+3)**

Analytic functions - Necessary and sufficient conditions (Cauchy-Riemann equations) - Properties of analytic function - Harmonic conjugates - Construction of analytic functions - Conformal mapping – Mapping by functions $W = Z + C$, CZ, $1/Z$, Z^2 – Joukowski's transformation- Bilinear transformation.

UNIT V	**COMPLEX INTEGRATION**	**(9+3)**

Cauchy's integral theorem - Cauchy's integral formula - Taylor's and Laurent's series expansions - Singular points - Residues - Cauchy's Residue theorem – Application of residue theorem for evaluation of real integrals – Use of circular contour and semi-circular contour.

TOTAL (L:45+T:15): 60 PERIODS

TEXT BOOKS:

1. Erwin Kreyszing, Herbert Kreyszing, Edward Norminton, "Advanced Engineering Mathematics", 10th Edition, John Wiley, (2015).
2. Grewal .B.S, Grewal .J.S "Higher Engineering Mathematics",43rd Edition, Khanna Publications, Delhi, (2015).

REFERENCES:

1. Dass, H.K., and Rajnish Verma, "Higher Engineering Mathematics", S.Chand Private Ltd., 2011.
2. Ramana B.V, "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company, New Delhi, (2013).
3. Bali N. P and Manish Goyal, "A Text book of Engineering Mathematics", 9th edition, Laxmi Publications(p) Ltd., 2014.

WEB LINK:

1. https://nptel.ac.in/courses/111/105/111105134/
2. https://nptel.ac.in/courses/111/105/111105121/

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Interpret the fundamentals of vector calculus and execute evaluation of line, surface and volume integrals using Gauss, Stokes and Green's theorems.	3
CO2	Solve first order linear, homogeneous differential equations and use series solution method to solve second order differential equations.	3
CO3	Determine the methods to solve differential equations using Laplace transforms and Inverse Laplace transforms.	3
CO4	Explain Analytic functions and Categorize transformations.	3
CO5	Perform Complex integration to evaluate real definite integralsusing Cauchy integral theorem and Cauchy's residue theorem.	3

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	2	-	-	-	-	-	-	-	3	-	-
2.	3	3	3	3	-	-	-	-	-	-	-	3	-	-
3.	3	3	3	3	-	-	-	-	-	-	-	3	-	-
4.	3	3	-	-	-	-	-	-	-	-	-	3	-	-
5.	3	3	-	-	-	-	-	-	-	-	-	3	-	-

*1- Weak; 2 - Moderate; 3 - Strong.

PH22252	PHYSICS OF MATERIALS (Common to EE, EC)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the physical properties of materials like electrical and thermal conductivity.
- To understand various types of semiconducting materials, their applications in the field of Engineering and understand the concept of Fermi energy.
- To understand the different types of dielectric materials and their applications in Engineering fields.
- To understand the phenomena of superconductor, properties and their applications and the different types of magnetic materials.
- Ability to understand different types of Transistors and its characteristics and to construct Basic Logic Gates and simplification of circuits using K-map.

UNIT I	**CONDUCTING MATERIALS**	**9**

Introduction – Classification of materials based on the electrical resistivity - Classical Free electron theory – Electrical and thermal conductivity of metal (derivation) – Wiedemann – Franz law – Lorentz number – Drawbacks of Classical Free electron theory – Quantum Free electron theory – Fermi distribution function – Effect of temperature of Fermi function – Density of energy states (derivation) – Carrier concentration in metals – Emission of electrons from metals – Thermionic emission – Photoelectric emission – Field emission

UNIT II	**SEMICONDUCTING MATERIALS**	**9**

Introduction – Classification of materials based on band theory (metals, semiconductors and insulators) – Intrinsic and extrinsic semiconductors – Carrier concentration in intrinsic semiconductor (derivation) - Effect of temperature on Fermi level - Compound semiconductors – Variation of electrical conductivity in intrinsic semiconductors with temperature - Band gap determination of intrinsic semiconductor (derivation and Experiment to determine Band Gap) – Hall effect (derivation and experiment).Tunnel diode, Schottky diode.

UNIT III	**DIELECTRIC PROPERTIES OF MATERIALS**	**9**

Introduction to dielectric materials - Dielectric constant - Polarization of dielectric materials - Types of Polarization (Polarisability) - Equation of internal fields in solid (One- Dimensional) (Derivation) - Clausius – Mossotti Relation for elemental dielectric materials - Dielectric Breakdown - Frequency dependence of dielectric constant, Dielectric Losses - Important applications of dielectric material - Ferro and Piezo electricity (Qualitative).

UNIT IV	**MATERIALS AT LOW TEMPERATURE AND MAGNETIC PROPERTIES**	**10**

Temperature dependence of resistivity in superconducting materials - Meissner effect – Properties of superconductors - Type I and Type II superconductors - BCS theory (Qualitative) – Low Tc and High Tc (alloy) superconductors – Ceramic superconductors (oxide superconductors) - LaBaCuO, YBaCuO, BiSrCaCuO - Josephson's effect (AC and DC) – - Applications of Superconductors-SQUIDS – CRYOTRON – MAG LEV.

Dia, Para and Ferro magnetic material – Domain theory for Ferro magnetic materials - Phenomena of Hysteresis and its applications –Magnetic Semiconductor- Ferrites and its structures.

UNIT V	**FUNDAMENTALS OF ELECTRONIC SCIENCE**	**8**
JFET-Drain and Transfer Characteristics- Electronic Transistor (SET), Spintronics-Electronic devices vs Spintronic Devices-Design of Basic Logic gates using transistor, Karnaugh map SoP and PoS forms.		
		TOTAL: 45 PERIODS

TEXT BOOKS:

1. Arumugam M, "Materials Science", Anuradha Publications, 2015.
2. Rajendran V, "Engineering Physics", Tata McGraw Hill, 2015.
3. Suresh R, Jayakumar V, "Materials Science", Lakshmi Publications 2003.
4. Palanisamy P.K, "Materials Science", SciTech publications, 2015.
5. V.K. Mehta , Rohit Mehta, Principles of Electronics", 2020
6. M. Morris Mano, "Digital Design", 3rd edition, Pearson Education, 2014.

REFERENCES:

1. Gaur R.K, Gupta S.L, "Engineering Physics", Dhanpat Publications, 2015.
2. Avadhnaulu M.N, Kshirsagar P.G, "A Textbook of Engineering Physics", S. Chand, 2006.
3. Kittel C, "Introduction to Solid State Physics", 7th Edition, Wiley Eastern Ltd, 2004.
4. Azaroff L.V, Brophy J.J., "Electronic Processes In Materials", McGraw Hill.,1963.
5. A.B. Gupta, Nurul Islam, "Solid State Physics and Electronics", 2017.
6. John F. Wakerley, "Digital Design-Principle & practice", 3rd edition, Pearson, 2008.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO 1	Comprehend the behavior of electrons in solids.	2
CO 2	Demonstrate an understanding of various properties of Semiconducting materials and their internal structure	3
CO 3	Analyses the properties of dielectric materials and apply them in various fields.	3
CO 4	Summarize basics of magnetism and superconductivity. Explore a few of their technological applications.	2
CO 5	Develop an understanding the Fundamentals of Electronic Science and its applications.	3

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	-	-	-	-	-	-	-	2	-	2	-	-
2.	3	2	2	2	-	-	-	-	-	2	-	2	-	-
3.	3	2	2	2	-	3	-	-	-	2	-	2	-	-
4.	3	2	3	2	-	3	-	-	-	2	-	2	-	-
5.	3	2	2	2	-	-	-	-	-	2	-	2	-	-

*1- Weak; 2 - Moderate; 3 - Strong.

EC22201	ELECTRON DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide the necessary skill to understand the basics of semiconductor diode.
- To provide the basics of bipolar junction transistors.
- To provide the basics of field effect transistors.
- To provide comprehensive understanding of special semiconductor diodes.
- To provide comprehensive understanding of power and display devices.

UNIT I	**SEMICONDUCTOR DIODE**	**9**

PN junction diode, Current equations, Diffusion and drift current densities, forward and reverse bias characteristics, Switching Characteristics, Diode as a Rectifier

UNIT II	**BIPOLAR JUNCTION TRANSISTOR**	**9**

NPN - PNP – Junctions - Early effect - Current equations – Input and Output characteristics of CE, CB, CC – BJT as an amplifier, Hybrid - π model - h-parameter model, Ebers Moll Model- Gummel Poon-model, Multi Emitter transistor.

UNIT III	**FIELD EFFECT TRANSISTORS**	**9**

Review of JFETs – Drain and Transfer characteristics - Current equations - Pinch off voltage and its significance – MOSFET - Characteristics - Threshold voltage - Channel length modulation, D-MOSFET, E-MOSFET- Current equation - Equivalent circuit model and its parameters, FINFET, DUAL GATE MOSFET.

UNIT IV	**SPECIAL SEMICONDUCTOR DEVICES**	**9**

Metal-Semiconductor Junction- MESFET - Zener diode - Varactor diode - Gallium Arsenide device, LASER diode, LDR, PIN Diode, Point Contact Diode, IGBT.

UNIT V	**POWER DEVICES AND DISPLAY DEVICES**	**9**

UJT, SCR, Diac, Triac, Power BJT, LED, Photo diode, Photo transistor, Opto Coupler, Solar cell, LCD, CCD.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Donald A Neaman, “Semiconductor Physics and Devices”, Fourth Edition, Tata Mc Graw Hill Inc., 2012.
2. Adel S. Sedre and Kenneth C. Smith, “Microelectronic Circuits: Theory and Applications”, 6th Edition, Oxford University Press, 2013
3. Robert Boylestad and Louis Nashelsky, “Electron Devices and Circuit Theory”, Pearson Prentice Hall, 11th edition, 2013.
4. Dr. Sanjay Sharma, “Basic Electronics”, First Edition, S.K. Kataria & Sons, 2012.

REFERENCES:

1. Jacob Millman & Christos C. Halkias, "Electronic Devices & Circuits", Fourth Edition, McGraw Hill 2015.
2. Salivahanan. S, Suresh Kumar. N, Vallavaraj.A, "Electronic Devices and circuits", Third Edition, Tata McGraw Hill, 2012.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Gain knowledge of PN diodes.	2
CO2	Analyze the characteristics of BJT and use it in designing simple circuits.	4
CO3	Analyze the characteristics of FET and use it in designing simple circuits.	4
CO4	Analyze the working principle of Special diodes and use it in designing simple circuits.	4
CO5	Analyze the working principle of power and display devices and use it in designing simple circuits.	4

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	-	2	2	-	-	-	-	1	-	-	3	3
2.	3	3	-	3	2	-	-	-	-	1	-	-	3	3
3.	3	3	-	3	2	-	-	-	-	1	-	-	3	3
4.	3	2	-	1	2	-	-	-	-	1	-	-	3	3
5.	3	2	-	1	2	-	-	-	-	1	-	-	3	3

1- Weak; 2 - Moderate; 3 - Strong.

EC22202	CIRCUIT THEORY	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- To analyze electrical network with suitable network theorems.
- To classify and analyze series and parallel resonance and coupled circuit.
- To determine the transient response of RL, RC and RLC circuits for AC and DC inputs.
- To infer the concept two-port networks.
- To sketch the network topology.

UNIT I	**NETWORK THEOREMS FOR DC & AC CIRCUITS**	**12**

Thevenin Theorem, Norton's Theorem, Superposition Theorem, Reciprocity theorem, Maximum Power transfer Theorem - Analysis using Dependent Current sources and Voltage sources.

UNIT II	**RESONANCE AND COUPLED CIRCUITS**	**9**

Resonance: Series and parallel resonance – Frequency response – Quality factor and Bandwidth-Selectivity-Basic filter design.

Coupled Circuits: Self and Mutual inductance – Dot rule-Coefficient of coupling – Linear Transformer – Ideal Transformer - Tuned circuits – Single tuned circuits.

UNIT III	**TRANSIENT ANALYSIS**	**9**

Basic RL and RC Circuits, The Source- Free RL Circuit, The Source-Free RC Circuit, The Unit Step Function, Transient response of RL, RC and RLC Circuits using Laplace transform for DC and AC input.

UNIT IV	**TWO PORT NETWORKS**	**6**

Characterization of two port networks in terms of Z, Y, ABCD and h parameters. Interconnection of two port network, Symmetrical properties of T and π networks.

UNIT V	**NETWORK TOPOLOGY**	**9**

Network terminology - Graph of a network - Trees and Co-Tree - Twigs and Links - Incidence Matrix (A), Properties of Incidence Matrix (A) - Link Current and Tie-set Matrix (B) - Twig Voltages and Cut-set Matrix (C) - Mesh Analysis and Nodal Analysis.

L: 45 PERIODS

Practical Exercises:

1. Verifications of KVL & KCL.
2. Verifications of Thevenin & Norton's theorem.
3. Verification of Superposition Theorem.
4. Verification of maximum power transfer Theorem
5. Determination of Resonance Frequency of Series & Parallel RLC Circuits.
6. Transient analysis of RL and RC circuits.
7. Determination of Z and Y parameters for the two port network.

P: 30 PERIODS

TOTAL PERIODS: 75

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

	Quantity

Resistors, Capacitors, Inductors	Required
Bread Boards	15
CRO (30MHz)	5
Function Generators (3MHz)	5
Multimeter	5
Dual Regulated Power Supplies (0 – 30)V	10
Voltmeter and Ammeter	Required

TEXT BOOKS:

1. Hayt Jack Kemmerly, Steven Durbin, "Engineering Circuit Analysis", Mc Graw Hill education, 9th Edition, 2018.
2. Joseph Edminister and Mahmood Nahvi, ― Electric Circuits, Schaum's Outline Series, Tata McGraw Hill Publishing Company, New Delhi, Fifth Edition Reprint 2016.

REFERENCES:

1. David Bell, "Fundamentals of Electric Circuits", Oxford University press, 7th Edition, 2009.
2. John O Mallay, Schaum's Outlines "Basic Circuit Analysis", The Mc Graw Hill companies, 2nd Edition, 2011
3. Robert.L. Boylestead, "Introductory Circuit Analysis", Pearson Education India, 12th Edition, 2014.
4. Sudhakar, A., Shyammohan, S. P. "Circuits and Networks"; Tata McGraw-Hill New Delhi, 2015.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Apply suitable network theorems and analyze AC and DC circuits.	3
CO2	Infer the phenomenon of series and parallel resonance in electrical circuits and understand the effect of magnetic coupling between windings.	2
CO3	Analyze the transient response for any RC, RL and RLC circuits.	4
CO4	Evaluate the two port network parameters.	5
CO5	Sketch the various network topologies.	4

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	-	3	3	-	-	-	-	-	-	-	3	3
2.	3	3	-	3	3	-	-	-	-	-	-	-	3	3
3.	3	3	-	2	3	-	-	-	-	-	-	-	3	3
4.	3	3	-	2	2	-	-	-	-	-	-	-	3	3
5.	3	3	-	1	-	-	-	-	-	-	-	-	3	3

1- Weak; 2 - Moderate; 3 - Strong.

CY22161	CHEMISTRY LABORATORY (Common to all Branches except AD, CS & IT)	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES

- To acquaint the students with the basic phenomenon/concepts of chemistry, the student face during course of their study in the industry and engineering field.
- To appreciate the need and importance of water quality parameters for industrial and domestic use.
- To gain the knowledge on electrochemical instrumention techniques like potentialand current measuring used in electrochemistry applications
- To impart knowledge on separation of components using paper chromatography.
- To enhance the thinking capabilityabout polymer and properties like molecular weight.

LIST OF EXPERIMENTS (Minimum 8 Experiments)

1. Determination of DO content of water sample by Winkler's method.
2. Determination of strength of given hydrochloric acid using pH meter
3. Determination of strength of acids in a mixture using conductivity meter
4. Estimation of iron content of the water sample using spectrophotometer (phenanthroline / thiocyanate method)
5. Determination of total, temporary & permanent hardness of water by EDTA Method.
6. Estimation of iron content of the given solution using potentiometer.
7. Determination of alkalinity in water sample.
8. Determination of Single electrode potential.
9. Separation of components from a mixture of red and blue inks using Paper chromatography.
10. Determination of molecular weight of polymer by using Ostwald's/Ubbelohde viscometer.

TOTAL: 30 Periods

REFERENCES:

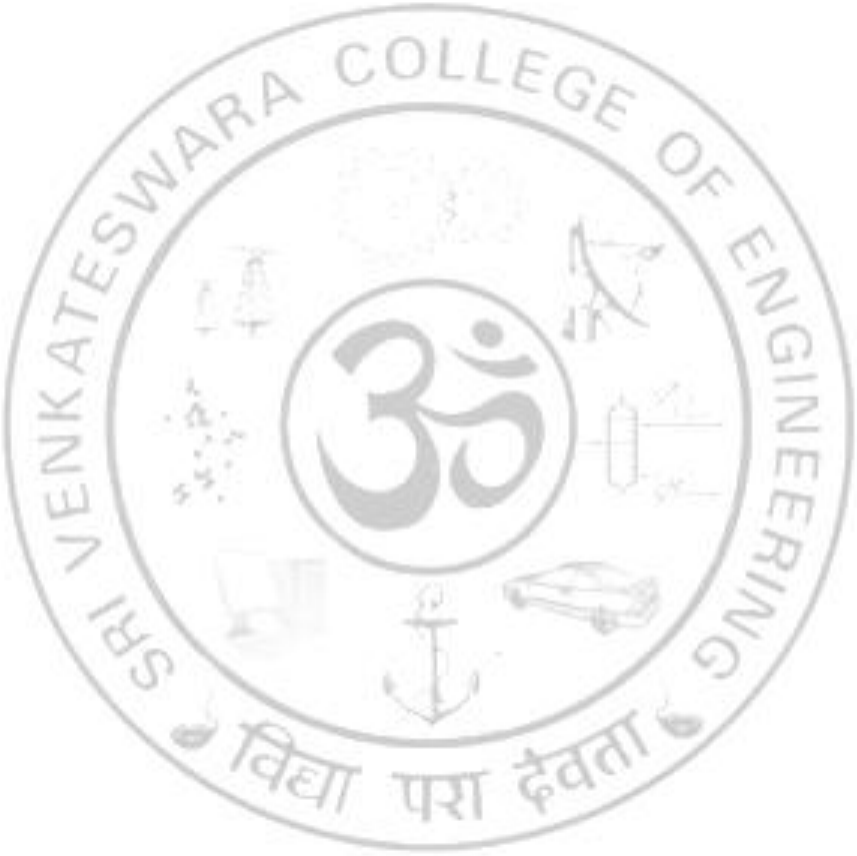
1. Daniel R. Palleros, "Experimental organic chemistry" John Wiley & Sons, Inc., New York 2001.
2. Furniss B.S. Hannaford A.J, Smith P.W.G and Tatchel A.R., "Vogel"s Textbook of practical organic chemistry", LBS Singapore 1994.
3. Jeffery G.H., Bassett J., Mendham J.and Denny vogel"s R.C, "Text book of quantitative analysis chemical analysis", ELBS 5th Edn. Longman, Singapore publishers, Singapore, 1996.
4. Kolthoff I.M., Sandell E.B. et al. "Quantitative chemical analysis", Mcmillan, Madras 1980

COURSE OUTCOMES: On the successful completion of the course, students will be able to		**RBT* Level**
CO1	Distinguish hard and soft water, solve the related numerical problems on water, purification and its significance in industry and daily life.	4
CO2	Interpret the knowledge of instruments to measure potential and current related parameters.	2
CO3	Demonstrate the basic principle for separation of components using paper chromatography.	4
CO4	Evaluate the molecular weight of polymer using Ostwald's/Ubbelohde viscometer.	4

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO-1	PSO-2
CO1	3	2	-	-	-	3	3	3	1	-	1	2	-	-
CO2	3	2	1	-	-	3	3	3	-	-	-	-	-	-
CO3	3	-	-	-	-	3	3	-	-	-	-	2	-	-
CO4	3	-	-	1	-	3	3	3	-	-	-	-	-	-
1- Weak; 2 - Moderate; 3 - Strong.														



EC22211	TECHNICAL DRAWING LABORATORY	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To draw free hand sketches of the schematic diagrams of electronic circuits using standard symbols.
- To prepare the drawing from the rough sketches and/or enlarge/reduce the given drawing to the desired scale.
- To draw the cables and connectors using CAD tools.
- To draw exploded views of components & assemblies in preparation of service drawing.
- To construct and verify the electric circuits using simulation tools.

LIST OF EXPERIMENTS

1. **Drawing Fundamentals on Electronics**
   (a) Hand drawing Symbols of all the electronic components.
   (b) Soldering of resistive components.
2. **Drawing of standard symbols of basic electronic components using AutoCAD Electrical**
   (a) Resistors, Capacitors, Inductors, Potentiometer, Crystal, Switches and Transformers
   (b) Active Devices – AC and DC sources, PN diode, Zener Diode, Varactor Diode, LED, BJT, JFET, MOSFET, UJT, SCR, DIAC, TRIAC
   (c) Telephone components – Transmitter, Receiver, Filter, Hybrid Transformer
   (d) Logic Gates – NOT, AND, OR, XOR, NAND, NOR
3. **Drawing cables and connectors using AutoCAD Electrical**
4. **Drawing Electric circuits:**
   (a) Circuit diagram of a Wein's bridge oscillator
   (b) Circuit diagram of a Battery eliminator
   (c) Circuit of Emergency light
   (d) Circuit diagram of Voltage stabilizers
   (e) Circuit diagram of Fan regulator
5. **Drawing of electronic components - 2D and 3D view**
6. **Construction and Verification of Electric circuits using simulation tools.**

TOTAL: 30 PERIODS

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

Description of Items	Quantity
PC Desktop	10
Soldering Iron with accessories	10
AutoCAD software	10

TEXT BOOKS:

1. Prof. Sham Tickoo, "AutoCAD Electrical 2020 for Electrical Control Designers", 11th Edition, Tickoo-CADCIM Series, ISBN: 978-1-64057-079-5.
2. Gaurav Verma, Matt Weber, "AutoCAD Electrical 2016 Black Book.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Perform free-hand sketching of electronic circuits.	3
CO2	Draw the complete circuit with the correct dimensions.	4
CO3	Demonstrate computer-aided drawing for fabricating electronic products.	4
CO4	Project the 2D and 3D views of electronic components.	3
CO5	Construct the electric circuit using SPICE simulator.	4
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	1	-	-	-	-	-	-	3	-	-	-	2	1
2.	3	1	-	-	3	-	-	-	3	-	-	-	2	3
3.	3	1	-	-	3	-	-	-	3	-	-	-	2	3
4.	3	1	-	-	3	-	-	-	3	-	-	-	2	3
5.	3	1	-	-	3	-	-	-	3	-	-	-	2	3
1- Weak; 2 - Moderate; 3 – Strong														

EC22212	ELECTRON DEVICES AND ELECTRICAL MACHINES LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES

- To be exposed to the characteristics of basic electronic devices.
- To be exposed to study the behavior of various passive and active electronic components
- To be familiar with the working of diodes, transistors and their applications.
- To impart hands on experience on rudimentary engineering practices in Electrical Engineering
- To understand the Concepts of Solar PV system
- To familiarize with the operation of DC machines, AC machines and Transformers equip with experimental skills.

LIST OF EXPERIMENTS:

ELECTRON DEVICES

1. VI Characteristics of PN Diode and PN Diode as a Rectifier
2. Reverse Characteristics of Zener Diode and Zener Diode as a Regulator
3. Input-Output Characteristics of BJT in CE configuration
4. Drain and Transfer Characteristics of JFET
5. VI Characteristics of LED and Photo Diode/Photo Transistor
6. VI Characteristics of UJT and SCR

ELECTRICAL MACHINES

1. Residential house wiring using switches, fuse, indicator, lamps and energy meter
2. Load test on single-phase transformer
3. Load test on DC shunt motor
4. Speed Control of DC shunt motor
5. Load test on three phase Induction motor
6. Load test on single phase Induction motor
7. Study of 1kWp Solar PV System with Net meter

TOTAL: 45 PERIODS

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS: (ELECTRON DEVICES)

	Quantity
BC107, BC148, 2N2646, BFW10	Required
1N4007, Zener diodes	Required
Bread Boards	15
CRO (30MHz)	5
Function Generators (3MHz)	5
Multimeter	5
Dual Regulated Power Supplies (0 – 30)V	10
Voltmeter and Ammeter	Required

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS: (ELECTRICAL MACHINES)

	Quantity
1. Assorted electrical components for house wiring	2 sets
2. 1Kw Solar PV system	1
3. DC Shunt Motor - 1.5kW, 220V, 9A, 1500RPM,	1
4. DC Shunt Motor with Loading Arrangement- 3.5kW, 220 Volts, 18.6 Amps, 1500 RPM	1
5. Single Phase Transformer- 1 KVA, 230/115V, 50Hz	2

6. Three Phase Induction Motor with Loading Arrangement- 3.7kW, 415V, 7.8A, 1430 RPM	1
7. Single Phase Induction Motor with Loading Arrangement-1.5kW, 230V,9.9A,1440rpm	1
8. Single Phase Auto Transformer- 4KVA, 0-270V, 50Hz	2
9. Three Phase Auto Transformer - 12KVA, 0-415V, 50Hz	2
10. MC Voltmeter- (0-300)V	3
11. MC Ammeter- (0-10/20)A	2
12. MC Ammeter - (0-1/2)A	2
13. MI Voltmeter - (0-300/600)V	5
14. MI Voltmeter - (0-75/150)V	2
15. MI Ammeter - (0-10)A	5
16. UPF Wattmeter (300/600V, 5/10A)	4
17. Single Phase Resistive Loading Bank- 5 KW)	2
18. Rheostats - 50Ω,5A, 700Ω,1.5A,1000Ω,1A)	Each 2
19. Single phase Energy meter	1
20. Net meter	1
21. Fuse various ranges as per the requirement	Required
22. Wires As per the requirement	Required

TEXT BOOKS: (Electronics Part)

1. Jacob Millman & Christos C. Halkias, “Electronic Devices & Circuits”, Fourth Edition, McGraw Hill, 2015.
2. Salivahanan. S, Suresh Kumar. N, Vallavaraj.A, “Electronic Devices and circuits”, Third Edition, Tata McGraw Hill, 2012.

TEXT BOOKS: (Electricals Part)

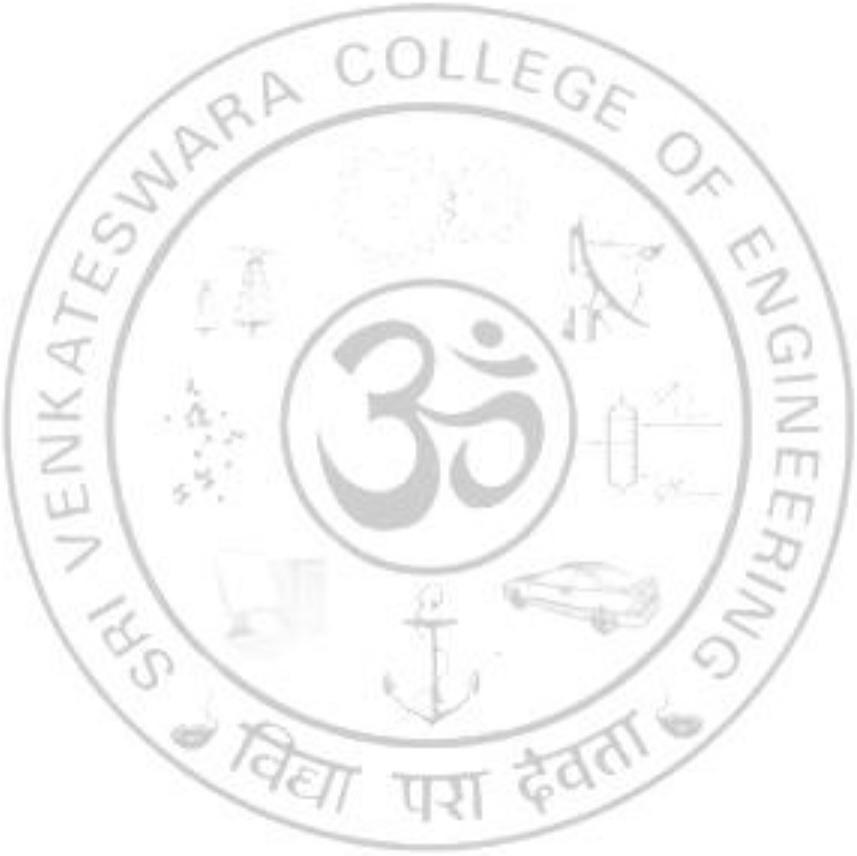
1. Arora, B.D, “HOUSE WIRING” R.B.Publishers (1999).
2. Uppal, S.L; Laroia, J.M “ELECTRICAL WIRING ESTIMATING AND COSTING “ Khanna Publishers (2003).
3. Theraja, B.L; Theraja A.K , “A TEXTBOOK OF ELECTRICAL TECHNOLOGY VOLUME II: AC AND DC MACHINES “ S.Chand publications,(2015).
4. Rai G.D, “Non-conventional Energy Sources”, Khanna Publishers (2014).

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Learn the characteristics of basic electronic devices.	2
CO2	Construct, analyze and troubleshoot the designed circuits.	4
CO3	Implement the various wiring methods.	4
CO4	Analyze the behavior of DC machines, AC machines and Transformers.	4
CO5	Evaluate the performance of Solar PV system.	4

***Bloom’s Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX:

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	-	-	3	-	-	-	3	-	-	-	2	3
2.	3	2	-	-	3	-	-	-	3	-	-	-	2	3
3.	3	3	-	-	3	-	-	-	3	-	-	-	2	3
4.	3	3	-	-	3	-	-	-	3	-	-	-	2	3
5.	3	3	-	-	3	-	-	-	3	-	-	-	2	3
1- Weak; 2 - Moderate; 3 – Strong														



SEMESTER III

MA22358	TRANSFORM AND RANDOM PROCESSES	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

- To introduce Fourier series analysis this is central to many applications in engineering.
- To understand the basic concepts of the Fourier transform and Z-transform techniques and its application in Engineering.
- To introduce the effective mathematical tools for the solutions of partial differential equations that model several physical processes.
- To provide the required Mathematical suppot in real life problems and develop probabilistic models. This can be used in several areas of science and engineering. To acquire skills in handling situations involving more than one random variable and functions of random variables.
- To Understand and characterize phenomena which evolve with respect to time in Probabilistic manner.

UNIT I	**FOURIER SERIES**	**9+3**
Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series –Parseval's identity – Harmonic Analysis		
UNIT II	**FOURIER AND Z -TRANSFORMS**	**9+3**
Fourier transform pair – Fourier sine and cosine transforms – Properties (without proof) – Convolution theorem – Parseval's identity. Z- Transforms – Elementary properties – Inverse Z - transform (using partial fraction) – Convolution theorem – Solution of difference equations using Z - transform.		
UNIT III	**PARTIAL DIFFERENTIAL EQUATION**	**9+3**
Formation of partial differential equations – Singular integrals - Solutions of standard types of first order partial differential equations - Lagrange's linear equation - Linear homogeneous partial differential equations of second and higher order with constant coefficients.		
UNIT IV	**RANDOM VARIABLE**	**9+3**
Discrete and continuous random variables – Moment generating functions. Joint distributions – Marginal and conditional distributions – Covariance – Correlation and Linear regression –Central limit theorem.		
UNIT V	**RANDOM PROCESS**	**9+3**
Classification – Stationary process – Poisson process – Gaussian process - Random telegraph process - Auto correlation functions.		
	TOTAL: (L:45 + T:15): 60 PERIODS	

TEXT BOOKS:

1. Grewal. B.S., "Higher Engineering Mathematics", 42nd Edition, Khanna Publishers, Delhi 2012.
2. Narayanan.S., Manicavachagom Pillay.T.K and Ramanaiah.G "Advanced Mathematics for Engineering Students" Vol. II & III, S.Viswanathan Publishers Pvt. Ltd. 1998.
3. Ibe. O.C., "Fundamentals of Applied Probability and Random Processes", Elsevier, 1st Indian Reprint, 2007.
4. Peebles Jr. P.Z., "Probability Random Variables and Random Signal Principles", Tata McGraw-Hill Publishers, Fourth Edition, New Delhi, 2002.

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", *10* th Edition, Wiley India, 2011.
2. Bali.N.P and Manish Goyal, "A Textbook of Engineering Mathematics", 7th Edition, Laxmi Publications Pvt Ltd , 2007
3. Veerarajan. T., "Transforms and Partial Differential Equations", Tata MGraw Hill Publishing Company Ltd., New Delhi, 2012
4. Hwei Hsu, "Schaum's Outline of Theory and Problems of Probability, Random Variables and Random Processes", Tata McGraw Hill Edition, New Delhi, 2004.

Links:

1. https://nptel.ac.in/courses/111103021
2. http://bme.elektro.dtu.dk/31610/notes/RandomProcess_California.pdf
3. http://www.ifp.illinois.edu/~hajek/Papers/randomprocJuly14.pdf

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Acquire the skill in examining a signal in another domain rather in the original domain by handling Full and Half Range Fourier Series.	3
CO2	Develops the skill of conversion between time domain to frequency domain using the concept of Fourier Transforms and Z-transform.	3
CO3	Express proficiency in handling higher order Partial differential equations	3
CO4	Reproduce and explain the basic concepts such as probability and random variable and identify the distribution. Acquire skills in handling situations involving more than one random variable	3
CO5	Apply the relationship within and between random processes	3
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***Cos**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	-	-	-	-	-	-	-	2	-	-
2.	3	3	3	3	-	-	-	-	-	-	-	-	2	2
3.	3	3	3	3	-	-	-	-	-	-	-	2	-	-
4.	3	3	-	-	-	-	-	-	-	-	-	2	2	2
5.	3	3	-	-	-	-	-	-	-	-	-	-	2	2
1- Weak; 2 - Moderate; 3 - Strong.														

EC22301	OBJECT ORIENTED PROGRAMMING AND DATA STRUCTURES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To acquire knowledge on core programming basics of C++ language.
- To possess a fundamental understanding of an Object-Oriented Programming concepts.
- To deepen the empirical knowledge on linear and non-linear data structures.
- To develop logical thinking abilities to relate real world problems with data structure concepts in an object-oriented style.
- To be familiar with different sorting and searching algorithms.

UNIT I	**DATA ABSTRACTION & OVERLOADING**	**9**

Overview of C++ – Structures – Class Scope and Accessing Class Members – Reference Variables – Initialization – Constructors – Destructors – Member Functions and Classes – Friend Function – Dynamic Memory Allocation – Static Class Members – Proxy Classes – Overloading: Function overloading and Operator Overloading.

UNIT II	**INHERITANCE & POLYMORPHISM**	**9**

Base Classes and Derived Classes – Protected Members – Casting Class pointers and Member Functions – Overriding – Public, Protected and Private - Inheritance – Types of Inheritance- Constructors and Destructors in derived Classes – Implicit Derived – Composition Vs. Inheritance – Virtual functions – This Pointer – Abstract Base Classes and Concrete Classes – Virtual Destructors – Dynamic Binding

UNIT III	**LINEAR DATA STRUCTURES**	**9**

Abstract Data Types (ADTs) – List ADT – Array based linked list implementation — Singly linked lists – Doubly linked list - Polynomial Manipulation - Stack ADT – Evaluating arithmetic expressions- Queue ADT – Circular Queue implementation.

UNIT IV	**NON-LINEAR DATA STRUCTURES**	**9**

Trees – Binary Trees – Binary tree representation and traversals - The Search Tree ADT - Binary Search Trees- – Application of trees – Graph and its representations – Graph Traversals – Representation of Graphs – Breadth-first search – Depth-first search- Dijkstra's shortest path algorithm.

UNIT V	**SORTING AND SEARCHING**	**9**

Insertion sort - Shell sort – Selection Sort - Bubble sort - Merge sort - Quick sort - Radix Sort - Searching: Linear search – Binary Search.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Deitel and Deitel, "C++, How To Program", Tenth Edition, Pearson Education, 2017.
2. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C++", 2nd Edition, Pearson Education, 2017.

REFERENCES:

1. Bjarne Stroustrup, "The C++ programming language", Fourth Edition, Addison Wesley, 2018.
2. Bhushan Trivedi, “Programming with ANSI C++, A Step-By-Step approach”, Oxford University Press, 2012.
3. Goodrich, Michael T., Roberto Tamassia, David Mount, “Data Structures and Algorithms in C++”, Second Edition, Wiley. 2011.
4. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to Algorithms", Third Edition, MIT Press, 2009.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Read, Write and Execute simple C++ programs.	2
CO2	Choose appropriate object-oriented programming principles and propose novel solution to solve computational problem.	3
CO3	Understand the core data structures like lists, stack and queue using C++.	2
CO4	Design and implement non-linear data structures using C++ programs.	3
CO5	Discuss different sorting and searching techniques to organizing the large amount of data.	3
***Bloom’s Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	-	-	-	-	-	-	2	3	-	3	-	3
2.	3	3	2	-	-	-	-	-	3	-	-	3	3	3
3.	3	2	2	-	-	-	-	-	2	3	-	3	3	-
4.	3	2	-	-	-	-	-	-	-	-	-	3	-	3
5.	3	3	-	-	-	-	-	-	-	3	-	3	2	3
1- Weak; 2 - Moderate; 3 - Strong.														

EC22302	DIGITAL SYSTEM DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand Boolean algebra and illustrate boolean expression simplification using Karnaugh ma
- Design combinational circuits using logic gates.
- Describe latches,flip flops,registers and counters.
- Investigate and design synchronous and asynchronous sequential circuits.
- Examine the applications of digital circuits.

UNIT I	**DIGITAL FUNDAMENTALS**	**7**

A review of Boolean algebra and minimization using Boolean postulates-minterms and maxterms, SOP, POS- Minimization of Boolean expression using Karnaugh's map: 3 variables, 4 variables and 5 variables-Don't care combinations-Implementation of Logic Functions using gates, NAND–NOR implementation

UNIT II	**COMBINATIONAL CIRCUIT DESIGN**	**9**

Arithmetic operations: Half adder, full adder, ripple carry adder, lookahead adder, BCD adder-subtractor-binary multiplier-Barrel shifter-Selection logic: multiplexer, demultiplexer, decoder, encoder, priority encoder.

UNIT III	**SEQUENTIAL CIRCUIT DESIGN**	**9**

Latches and Flip flops: SR, JK, T, D and Master slave flipflop, excitation tables and excitation equations,realization of one flip flop using other flip flops-Counters: Synchronous and asynchronous counters- Shift registers-Types, Universal shift registers.

UNIT IV	**FINITE STATE MACHINE: SYNCHRONOUS AND ASYNCHRONOUS**	**10**

FSM-Mealy machine, Moore machine-state machine analysis, state diagram, state assignment, state minimization-Asynchronous logic design- Hazards-types and design of hazard free circuit, cycles and race conditions- race free assignment.

UNIT V	**APPLICATIONS OF DIGITAL CIRCUITS**	**10**

Design of sequence detector, code converters and comparator-design of Serial adder-design of digital circuits using PLA,PAL, ROMs

Case study-ALU, MAC and pipelined adder.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Morris Mano M and Michael D. Ciletti, Digital Design, Pearson, Fifth Edition, 2015
2. S. Lee, "Digital Circuits and Logic Design," 1st Ed., Prentice Hall India, 2008.
3. D. P. Leach, A.P. Malvino and G. Saha, "Digital Principles and Applications," 8th Ed., McGraw Hill Education, 2014.

REFERENCES:

1. Charles H. Roth and Larry M. Hanny, Fundamentals of Logic Design, Cengage learning, Sixth Edition, 2013
2. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, Digital Integrated circuits: A design perspective, Pearson, Second Edition, 2016.
3. Kenneth L. Short, VHDL for Engineers, Prentice Hall, 2009.
4. Donald P.Leach and Albert Paul Malvino, "Digital Principles and Applications", 6th Edition, TMH, 2006
5. Thomas L. Floyd, "Digital Fundamentals", 10th Edition, Pearson Education Inc, 2011

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Examine different methods used for simplification of Boolean expressions.	2
CO2	Design combinational logic circuits using logic gates.	3
CO3	Design sequential logic circuits using flipflops.	3
CO4	Investigate and design synchronous and asynchronous sequential circuits.	4
CO5	Apply the digital circuits for solving real world problems and implement the logic function using different types of PLD.	4

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	-	-	-	-	-	-	-	-	-	2	2	-
2.	3	2	3	3	2	-	-	2	-	-	-	2	3	2
3.	3	2	3	3	2	-	-	2	-	-	-	2	3	2
4.	3	2	3	3	2	-	2	-	-	-	-	2	3	2
5.	3	3	3	3	2	1	2	2	-	-	-	3	3	2

1- Weak; 2 - Moderate; 3 - Strong.

EC22303	ELECTROMAGNETIC FIELDS AND WAVES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce students with different coordinate systems and to understand the Theorem, Laws, Principle and their related problems over Static Electric Fields.
- To learn the basic laws in Static Magnetic Field and able to find various parameters with the related problems.
- To know how the Electric Field is applied in Dielectrics with various equations and applications and to understand how the Magnetic Field works with Ferromagnetic Materials.
- To analyze how the Time is Varying in both Electric and Magnetic Fields with various derivation.
- To understand and analyze the Electromagnetic Field distribution which forms the basis for advanced subjects related to Electromagnetic Field.

UNIT I	**STATIC ELECTRIC FIELD**	**9**

Review of Co-ordinate System-Introduction to line, Surface and Volume Integrals-Meaning of Stokes theorem and Divergence theorem.

Coulomb's Law and Electric field Intensity-Principle of Superposition-Electric field due to discrete charges-Electric field due to continuous charge distribution-Electric field due to charges distributed uniformly on an infinite and finite line-Electric Field on the axis of a uniformly charged circular disc-Electric Field due to an infinite uniformly charged sheet. Electric Flux Density-Gauss Law and its applications.

UNIT II	**STATIC MAGNETIC FIELD**	**9**

The Biot-Savart Law-Magnetic Field intensity due to a finite and infinite wire carrying a current I-Magnetic field intensity on the axis of a circular and rectangular loop carrying a current I–Ampere's circuital law-Force on a wire carrying a current I placed in a magnetic field–Torque on a loop carrying a current I

UNIT III	**ELECTRIC AND MAGNETIC FIELDS IN MATERIALS**	**9**

Poisson's and Laplace's equation-Capacitance of various geometries using Laplace's equation-Boundary conditions for electric fields-Point form of ohm's law-Continuity equation for current.

Inductance of loops and solenoids-Energy density in magnetic fields-magnetization and permeability-Magnetic boundary conditions.

UNIT IV	**TIME VARYING ELECTRIC AND MAGNETIC FIELDS**	**9**

Maxwell's Equation from Ampere's Law, Faraday's Law and Gauss Law in both point form and Intergral form and Time Varying Potentials.

UNIT V	**ELECTROMAGNETIC WAVES**	**9**

Poynting Vector-Instantaneous Average and Complex Poynting Vector-Wave Equation-Uniform plane waves-Maxwell's equation in Phasor form-Plane waves in free space and in a homogeneous material-Skin effect.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. David K Cheng, "Field and Wave Electromagnetics", Pearson Education Inc, Delhi, 2004.
2. John D Kraus and Daniel A Fleisch, "Electromagnetics with Applications", McGraw Hill Book Co,2005.
3. W H.Hayt & J A Buck: "Engineering Electromagnetics" TATA McGraw-Hill, 7th Edition 2007.
4. M.N.O.Sadiku and S.V. Kulkarni, Principles of electromagnetics, 6th ed., Oxford(Asian Edition), 2015

REFERENCES:

1. E.C. Jordan & K.G.Balmain "Electromagnetic Waves and Radiating Systems." Prentice Hall of India 2nd edition 2003.
2. Narayana Rao. N: "Engineering Electromagnetics" 4th edition, Prentice Hall of India, New Delhi, 2006.
3. Electromagnetics Joseph Edminister - Schaum's Outline Series, TMH

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Apply the fundamentals of different coordinate systems to relate the electromagnetic concepts in Engineering.	3
CO2	Evaluate the physical quantities of electromagnetic fields in different media .	4
CO3	Analyze the boundary conditions for different media and to design the storage devices.	3
CO4	Justify concepts of electromagnetic waves means of transporting energy in dielectric medium.	4
CO5	Analyze the concept of Plane waves in homogeneous medium.	3

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	-	-	2	-	-	-	2	-	2	3	-
2.	3	3	3	-	-	2	-	-	-	2	-	2	3	-
3.	3	3	3	-	-	2	-	-	-	2	-	2	3	-
4.	3	3	3	-	-	2	-	-	-	2	-	2	3	-
5.	3	3	3	-	-	2	-	-	-	2	-	2	3	-

1- Weak; 2 - Moderate; 3 - Strong.

EC22304	ELECTRONIC CIRCUITS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn about biasing of BJT and FET circuits.
- To understand the design and working principle of BJT and FET.
- To understand the small signal analysis of BJT and FET.
- To study about feedback amplifiers.
- To understand the analysis and design of power amplifier and tuned amplifier.

UNIT I	**TRANSISTOR BIASING**	**9**

BJT Biasing Circuits – Types, Q Point, Bias Stability, Stability factors- Concept of DC and AC load lines, Fixing of operating point. Biasing methods for JFET and MOSFET.

UNIT II	**BJT AMPLIFIERS**	**7**

Transistor amplifying action – small signal analysis of CE amplifier – AC load line – Voltage swing limitations. Darlington amplifier, Cascaded stages – Cascode amplifier – Frequency response of CE amplifier. Bandwidth of Single Stage and Multistage Amplifiers.

UNIT III	**JFET and MOSFET Amplifiers**	**9**

Small signal analysis of MOSFET and JFET- Common Source amplifiers- Voltage swing limitations- Source follower and Common gate amplifiers and BIMOS amplifiers.

UNIT IV	**FEEDBACK AMPLIFIERS AND OSCILLATORS**	**10**

Advantages of negative feedback – Voltage / Current Series, Shunt feedback amplifiers- Positive feedback – Conditions for oscillations, Phase shift , Wien bridge, Hartley, Colpitt's and Crystal oscillators.

UNIT V	**POWER AMPLIFIERS AND TUNED AMPLIFIERS**	**10**

Power amplifiers- Types. Analysis and Types of Class A, Class B, Class AB. Small signal tuned amplifiers – Analysis of capacitor coupled single tuned amplifier – double tuned amplifier –Stagger tuned amplifiers Stability of tuned amplifiers – Neutralization – Hazeltine neutralization method.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. David A. Bell, Solid state Pulse Circuits, PHI, 4th Edition 2007.
2. Robert L Boylestead and Louis Nashelsky, "Electronic Devices and circuit theory", Pearson, Tenth edition 2009.
3. Sedra and Smith, "Micro Electronic Circuits"; Sixth Edition, Oxford University Press, 2011.

REFERENCES:

1. Millman and Halkias. C., Integrated Electronics, TMH, 2007.
2. S.Salivahanan, N. Suresh Kumar and A. Vallava Raj, "Electronic Devices and circuits", TMH, 2nd Edition 2008.
3. Spencer R. R. and M. S. Ghausi, Introduction to Electronic Circuit Design, Pearson, 2003,
4. Schilling and Belove, Electronic Circuits, 3rd Edition, TMH, 2002.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Choose appropriate biasing circuits for BJT and MOSFET discrete amplifiers.	4
CO2	Design and analyze BJT amplifier.	4
CO3	Analyze the modeling of MOSFET amplifiers.	4
CO4	Design feedback amplifiers and analyze stabilization techniques and Oscillators	4
CO5	Analyze Power amplifiers and tuned amplifiers	4
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	-	3	3	-	-	-	-	-	-	2	3	3
2.	3	3	3	3	3	-	-	-	-	-	-	2	3	3
3.	3	3	3	3	3	-	-	-	-	-	-	2	3	3
4.	3	2	-	3	3	-	-	-	-	-	-	2	3	3
5.	3	2	-	3	-	-	2	-	-	-	-	2	3	2
1- Weak; 2 - Moderate; 3 - Strong.														

EC22305	SIGNALS AND SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of signals & systems
- To analyze continuous time signals in Fourier and Laplace domain
- To analyze discrete time signals in Fourier and Z domain
- To study the characteristics of continuous time systems
- To study the characteristics of discrete time systems

UNIT I	**FUNDAMENTALS OF SIGNALS AND SYSTEMS**	**9**

Signals: Continuous time and Discrete time - Elementary signals - Basic operations on signals- Signal properties – Periodicity, Deterministic and Stochastic, Energy & Power
Systems: Continuous time and Discrete time - System properties – Linearity: additivity and homogeneity, Time-invariance, Causality, Stability, Invertibility.

UNIT II	**ANALYSIS OF CONTINUOUS TIME SIGNALS**	**9**

Continuous Time Fourier Transform (CTFT) - Periodic and Aperiodic signals - Convergence of CTFT - Properties: Linearity, Symmetry, Time shifting, Time scaling, Parseval's theorem, Convolution.
Laplace Transform - Unilateral and Bilateral Laplace Transform - Region of Convergence - Properties: Linearity, Symmetry, Time shifting, Time scaling, Initial and Final value theorem, Convolution, Inverse Laplace Transform.

UNIT III	**LINEAR TIME INVARIANT CONTINUOUS TIME SYSTEMS**	**9**

Differential Equation - Impulse response - Convolution integrals and its properties – Analysis of systems using Fourier and Laplace transforms: Stability and Causality - Frequency response, Impulse response and Transfer function of LTI systems.

UNIT IV	**ANALYSIS OF DISCRETE TIME SIGNALS**	**9**

Sampling and reconstruction of signals: Sampling Theorem, Effects of under sampling: aliasing - Discrete Time Fourier transform (DTFT) - Properties: Linearity, Periodicity, Symmetry, Time shifting, Frequency shifting, Time scaling, convolution,
Z -Transform – Region of Convergence - Properties: Linearity, Symmetry, Time reversal, Time scaling, Time shifting, Differentiation, Convolution – Inverse Z - transform – Relationship between DTFT and Z transform

UNIT V	**LINEAR SHIFT INVARIANT DISCRETE TIME SYSTEMS**	**9**

Difference equation – Convolution sum and its properties - Interconnection of LSI Systems – Analysis of LSI systems using DTFT and Z transform: Stability and Causality - Frequency response, Impulse response and Transfer function of LSI systems

	TOTAL: 45 PERIODS

TEXT BOOKS:

1. Alan V Oppenheim, Alan S Wilsky, and S Hamid Nawab, "Signals and Systems", Pearson, 2013.
2. P. Lathi, "Principles of Linear Systems and Signals", Second Edition, Oxford, 2009.

REFERENCES:

1. John Alan Stuller, "An Introduction to Signals and Systems", Thomson, 2008
2. M.J.Roberts, "Signals & Systems Analysis using Transform Methods & MATLAB", Tata McGraw Hill, 2012.
3. R.E.Zeimer, W.H.Tranter and R.D.Fannin, "Signals & Systems – Continuous and Discrete", Pearson, 2014.
4. Simon Haykin, Barry Van Veen, "Signals and Systems" , Wiley, 2003

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Categorize signals and systems based on their properties.	3
CO2	Analyze the characteristics of continuous time signals using Fourier and Laplace transform.	4
CO3	Characterize the Linear Time Invariant systems in time and frequency domain.	3
CO4	Analyze the characteristics of discrete time signals using Fourier transform and Z transform.	4
CO5	Characterize the Linear Shift Invariant systems in time and frequency domain.	3
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	3	3	1	1	-	2	-	-	1	3	3
2.	3	3	3	3	3	1	-	-	2	-	-	1	3	3
3.	3	3	3	3	3	1	-	-	2	-	-	1	3	3
4.	3	3	3	3	3	1	-	-	2	-	-	1	3	3
5.	3	3	3	3	3	1	-	-	2	-	-	1	3	3
1- Weak; 2 - Moderate; 3 - Strong.														

EC22311	ANALOG AND DIGITAL CIRCUITS LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

Analog:

- To study the frequency response characteristics of BJT and FET amplifiers
- To learn the characteristics of IGBT and its application
- To design low and high frequency oscillators
- To simulate various analog circuits using SPICE

Digital:

- To study the fundamentals of combinational and sequential circuits
- To design, implement and verify the functionality of various digital circuits

LIST OF EXPERIMENTS

ANALOG CIRCUITS

1. Frequency response of CE and CS amplifier
2. Frequency response of series/shunt feedback amplifier
3. Design of single tuned amplifier
4. Design of low and high frequency oscillator
5. Design an application using IGBT
6. Simulation of frequency response of CE and CS amplifier using SPICE

DIGITAL CIRCUITS

1. Implementation of binary adder and subtractor
2. Implementation of decimal adder
3. Implementation of logic design using multiplexer/decoder
4. Data transfer using shift register
5. Design of counters
6. Design of sequence detector

CHALLENGING EXPERIMENTS (Any one)

1. Blinking LED using active and passive components
2. Design of Buzzer using Counter
3. Automatic Night Light using LDR
4. Simple Water level indicator using active and passive components

TOTAL: 45 PERIODS

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

Description of Items	Quantity
CRO (Min 30MHz)	15
Signal Generator /Function Generators (2 MHz)	15
Dual Regulated Power Supply (0 – 30V)	15
Digital Multimeter	5
LCR Meter	5
Standalone desktops PC	10
SPICE Circuit Simulation Software	15

IC Trainer Kit	15
Bread Boards	25
ICs 7400/ 7402 / 7404 / 7486 / 7408 / 7432 / 7483 / 74150 /74151 / 74147 / 7445 / 7476/7491/ 555 / 7494 / 7447 / 74180 / 7485 / 7473 / 74138 / 7411 / 7474	25 Each

TEXT BOOKS:

1. Robert L Boylestad, Louis Nashelsky, Lab Manual to accompany "Electronic Devices and Circuit Theory", 11th Edition, Pearson Education, 2012
2. M. Morris Mano, Michael D. Ciletti, "Digital Design", Global Edition, Pearson Higher Education & Professional Group, 2018

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Design and analyze the frequency response characteristics and bandwidth of various amplifiers using BJT & FET and using simulation tool	4
CO2	Analyze the characteristics of tuned amplifiers and IGBT	4
CO3	Design low and high frequency oscillators	4
CO4	Design, implement and verify the functionality of combinational digital circuits	4
CO5	Design, implement and verify the functionality of sequential digital circuits	4
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	1	1	1	-	-	-	2	3	3
2.	3	3	3	3	3	1	1	1	-	-	-	2	3	3
3.	3	3	3	3	3	1	1	1	-	-	-	2	3	3
4.	3	3	3	3	3	-	-	1	-	-	-	2	3	3
5.	3	3	3	3	3	-	-	1	-	-	-	2	3	3
1- Weak; 2 - Moderate; 3 - Strong.														

EC22312	OBJECT ORIENTED PROGRAMMING AND DATA STRUCTURES	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

The students should be made:

- To be familiar with good programming design methods, particularly in Bottom- up design.
- To understand Object-oriented methodology.
- To develop C++ programs for data structures and its applications.
- To relate real world problems with data structures concepts in an object-oriented style.
- To understand different sorting and searching techniques.

LIST OF EXPERIMENTS

1. Write C++ Programs for
    i. Prime number generation
    ii. Factorial with and without recursion
    iii. Bank account using Constructor and destructor.
    iv. Static data member and member function.
    v. Friend Function.
    vi. Area and of a circle, square, rectangle and triangle using function overloading
    vii. Operator Overloading
    viii. Inheritance – Single, Multiple, Multilevel, Hybrid and Hierarchical
    ix. Virtual Function
2. Array implementation of List ADT.
3. Linked list implementation.
4. Doubly Linked list implementation.
5. Application of List - Polynomial Manipulation
6. Stack ADT - Array and linked list implementations.
7. Application of Stack:
    i. Evaluation of Arithmetic Expressions
    ii. Converting Decimal to Binary
8. Queue ADT – Array and linked list implementations.
9. Binary Search Tree with Tree traversal Techniques – Preorder, Post-order and In-order.
10. Graphs - Breadth-first search and Depth-first search.
11. Sorting – Insertion, Merge and Quick sort.
12. Searching – Linear and Binary Search.

TOTAL: 45 PERIODS

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

Description of Items	Quantity
Standalone desktops with C++ compiler	30

TEXT BOOKS:

1. Deitel and Deitel, “C++, How To Program”, Tenth Edition, Pearson Education, 2017.
2. Mark Allen Weiss, “Data Structures and Algorithm Analysis in C++”, 2nd Edition, Pearson Education, 2017.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Create C++ programs to implement Classes & Objects, friend function, constructors & destructors.	2
CO2	Design and implement various forms of inheritance and polymorphism	3
CO3	Deploy various data structure concepts like linked lists, stacks, queues, trees and graphs using C++ program.	3
CO4	Analyze real world problems and possess novel solutions to it in an object-oriented style	3
CO5	Use different sorting and searching algorithms.	2
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	-	-	-	-	-	2	3	-	3	-	3
2.	3	3	3	-	-	-	-	-	3	-	-	3	3	3
3.	3	3	3	-	-	-	-	-	2	3	-	3	3	-
4.	3	2	-	-	-	-	-	-	-	-	-	2	-	3
5.	2	2	-	-	-	-	-	-	-	3	-	-	2	3
1- Weak; 2 - Moderate; 3 - Strong.														

SEMESTER IV

EC22401	ANALOG INTEGRATED CIRCUITS AND ITS APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the basic building blocks of linear integrated circuits
- To construct the linear and non-linear applications of operational amplifiers
- To introduce the various data converters and its working principles.
- To introduce the theory and applications of analog multipliers and PLL.
- To study various special function ICs

UNIT I	**BASICS OF OPERATIONAL AMPLIFIERS**	**9**

General operational amplifier stages -BJT Differential amplifier analysis-Concept of CMRR – methods to improve CMRR- Wilson Current source-IC 741-Ideal Operational Amplifier - DC and AC performance characteristics, Open and Closed loop configurations of Op-amp-Inverting, Non-inverting and Differential amplifiers-Voltage Follower.

UNIT II	**APPLICATIONS OF OPERATIONAL AMPLIFIERS**	**9**

Linear Circuits: Adder and Subtractor, Differentiator, Integrator, Voltage to Current converter, Instrumentation amplifier, **Nonlinear Circuits:** Sine wave Oscillators, Active filters-LPF, HPF, BPF, Comparator, Multivibrators, Schmitt trigger, Precision rectifier, Log and Antilog amplifiers.

UNIT III	**ANALOG TO DIGITAL AND DIGITAL TO ANALOG CONVERTERS**	**9**

Sample and hold circuit, Types of D/A converter-Weighted Resistor,R-2R Current driven DAC, A/D converter - Flash, Single slope, Dual slope, Successive approximation.

UNIT IV	**ANALOG MULTIPLIER AND PLL**	**9**

Gilbert Multiplier cell - Variable transconductance technique, analog multiplier ICs and their applications, Voltage Controlled Oscillator, Operation of the basic PLL, Closed loop analysis of PLL, Monolithic PLL IC 565, Applications of PLL-Frequency synthesizing, AM detection, FM detection and FSK demodulation.

		9
UNIT V	**SPECIAL FUNCTION ICS**	

555 Timer, Voltage regulators - linear and switched mode types, Switched capacitor filter, SMPS, features of TPS40200, TPS40210 buck and boost converters, Frequency to Voltage converters, ICL 8038 function generator, Isolation Amplifiers, Audio Amplifier, Video amplifiers, Fiber optics ICs and Opto couplers.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. D.Roy Choudhry, Shail Jain, “Linear Integrated Circuits”, New Age International Pvt. Ltd., 2018, Fifth Edition.
2. Sergio Franco “Design with Operational Amplifiers and Analog Integrated Circuits”, 4th Edition, Tata McGraw-Hill, 2016.

REFERENCES:

1. B.S.Sonde, "System design using Integrated Circuits", 2nd Edition, New Age Pub, 2001.
2. Robert F.Coughlin, Frederick F.Driscoll, "Operational Amplifiers and Linear Integrated Circuits", Sixth Edition, PHI, 2001.
3. Gray and Meyer, "Analysis and Design of Analog Integrated Circuits", Wiley International, 5th Edition, 2009.
4. Michael Jacob, "Applications and Design with Analog Integrated Circuits", Prentice Hall of India, 1996.
5. .Ramakant A. Gayakwad, "OP-AMP and Linear ICs", 4th Edition, Prentice Hall / Pearson Education, 2015.
6. William D.Stanley, "Operational Amplifiers with Linear Integrated Circuits", Pearson Education, 4th Edition, 2001.
7. S. Salivahanan, V S Kanchana Baskaran, "Linear Integrated Circuits", second edition, McGraw-Hill education India pvt ltd., 2015.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Infer the DC and AC characteristics of operational amplifiers and its effect on output and their compensation techniques.	2
CO2	Elucidate and analyze the linear and non-linear applications of an opamp.	4
CO3	Classify and comprehend the working principle of data converters.	4
CO4	Illustrate the function of application specific ICs such as Analog multiplier, PLL and its application in communication.	2
CO5	Explain the working of multivibrators using IC 555, the special function ICs such as Voltage regulators, buck-boost converters, A/V amplifiers etc.	3
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	1	-	2	2	-	-	-	-	-	3	3	2
2.	3	2	1	-	2	3	-	-	-	-	-	3	3	2
3.	3	2	1	-	2	2	-	-	-	-	-	3	3	2
4.	3	2	1	-	2	2	-	-	-	-	-	3	3	2
5.	3	3	3	-	2	3	-	-	-	-	-	3	3	2
1- Weak; 2 - Moderate; 3 - Strong.														

EC22402	LINEAR CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the elements of control system and its representations
- To analyze the time response and stability of systems
- To learn various frequency response plots
- To study the state variable representation of systems
- To design various types of compensators

UNIT I	**SYSTEM COMPONENTS AND THEIR REPRESENTATION**	**9**

Control System: Terminology and Basic Structure -Feed forward and Feedback control theory - Modeling of Electrical and Mechanical Systems: Block diagram models-Signal flow graphs models- - Introduction to multivariable control system

UNIT II	**TIME RESPONSE AND STABILITY ANALYSIS**	**11**

Time response: Transient and Steady state response - Impulse and Step response analysis of first and second order systems - Steady state errors - Concepts of stability-Routh stability criterion- Relative Stability - Root Locus Technique- Guidelines for sketching root locus - P, PI, PD and PID Controllers: characteristics and applications

UNIT III	**FREQUENCY RESPONSE AND STABILITY ANALYSIS**	**9**

Frequency response: Closed loop – Frequency response of second order system - Frequency domain specifications - Bode plot- Polar plot - Stability analysis -Nyquist stability criterion

UNIT IV	**CONTROL SYSTEM ANALYSIS USING STATE VARIABLE METHODS**	**8**

State variable representation: state equations - Conversion of state variable models to transfer functions and vice versa - Solution of state equations - Concepts of Controllability and Observability

UNIT V	**COMPENSATORS**	**8**

Compensators - Effect of adding poles and zeros – Design of cascade lag, lead and lag-lead compensators using Bode plot

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Nagarath I.J. and Gopal M., "Control Systems Engineering", New Age International Publishers, 2017
2. Norman S Nise, "Control Systems Engineering", 7th Edition, Wiley, 2015
3. Benjamin C. Kuo, "Automatic Control systems", Wiley, 2014

REFERENCES:

1. M. Gopal, "Control Systems, Principles and Design", 4th Edition, Tata McGraw Hill, New Delhi, 2012.
2. S.K.Bhattacharya, "Control System Engineering", 3rd Edition, Pearson, 2013.
3. Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", Prentice Hall, 2012.
4. K. Ogata, "Modern Control Engineering", 5th edition, PHI, 2012.
5. NPTEL Online Courses on "Control Engineering" and "Digital Control Systems".

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Compute the transfer function of different physical systems	3
CO2	Compute the time response and analyze the stability using various techniques.	3
CO3	Illustrate the frequency response characteristics of open loop and closed loop systems.	4
CO4	Illustrate the state space model of a physical system	4
CO5	Design compensators to satisfy the desired specifications of control systems	3
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	2	2	-	-	-	-	-	-	-	3	3	3
2.	3	2	2	2	3	-	-	-	-	-	-	3	3	3
3.	3	2	2	2	3	-	-	-	-	-	-	3	3	3
4.	3	2	2	2	-	-	-	-	-	-	-	3	3	3
5.	3	2	2	2	3	-	-	-	-	-	-	3	3	3
1- Weak; 2 - Moderate; 3 - Strong.														

EC22408	MACHINE LEARNING: THEORY AND PRACTICES	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- To learn the basic concepts of machine learning.
- To learn and build supervised learning models.
- To learn and build unsupervised learning models.
- To evaluate the algorithms based on corresponding metrics identified
- To analyse the machine learning experiments

UNIT I	**INTRODUCTION TO MACHINE LEARNING**	**8**

Review of Linear Algebra for machine learning; Introduction and motivation for machine learning; Examples of machine learning applications, Vapnik-Chervonenkis (VC) dimension, Probably Approximately Correct (PAC) learning, Hypothesis spaces, Inductive bias, Generalization, Bias variance trade-off.

UNIT II	**SUPERVISED LEARNING**	**10**

Linear Regression Models: Least squares, single & multiple variables, Bayesian linear regression, gradient descent, Linear Classification Models: Discriminant function – Perceptron algorithm, Probabilistic discriminative model - Logistic regression, Probabilistic generative model – Naive Bayes, Maximum margin classifier – Support vector machine, Decision Tree, Random Forests

UNIT III	**ENSEMBLE TECHNIQUES AND UNSUPERVISED LEARNING**	**9**

Combining multiple learners: Model combination schemes, Voting, Ensemble Learning - bagging, boosting, stacking, Unsupervised learning: K-means, Instance Based Learning: KNN, Gaussian mixture models and Expectation maximization.

UNIT IV	**NEURAL NETWORKS**	**9**

Multilayer perceptron, activation functions, network training – gradient descent optimization – stochastic gradient descent, error backpropagation, from shallow networks to deep networks –Unit saturation (aka the vanishing gradient problem) – ReLU, hyperparameter tuning, batch normalization, regularization, dropout.

UNIT V	**DESIGN AND ANALYSIS OF MACHINE LEARNING EXPERIMENTS**	**9**

Guidelines for machine learning experiments, Cross Validation (CV) and resampling – K-fold CV, bootstrapping, measuring classifier performance, assessing a single classification algorithm and comparing two classification algorithms – t test, McNemar's test, K-fold CV paired t test

	L: 45 PERIODS

Practical Exercises:

1. Write a python program to import and export data using Pandas library functions and data Visualization Techniques. (3 hours)
2. Demonstrate various data pre-processing techniques for a given dataset. (2 hours)
3. Implement Simple and Multiple Linear Regression Models(2 hours)
4. Develop Decision Tree Classification model for a given dataset and use it to classify a new sample. (2 hours)
5. Implement Naïve Bayes Classification in Python. (2 hours)
6. Implement Random forest ensemble method on a given dataset. (2 hours)
7. Build KNN Classification model for a given dataset. (2 hours)
8. Implement classification using SVM. (2 hours)
9. Implement classification using Multilayer perceptron(2 hours)
10. Implement of ADAM optimiser from scratch (2 hours)
11. Evaluating ML algorithm with balanced and unbalanced datasets Comparison of Machine Learning algorithms. (3 hours)
12. Performance analysis of specific datasets (mini project) (6 hours)

	P: 30 PERIODS
	TOTAL PERIODS: 75

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

	Quantity
1. Processors: Intel Atom® processor or Intel® Core™ i3 processor. Disk space: 1 GB. Operating systems: Windows 7/10	15 Nos.
2. Python versions: 3.6.X. with Anaconda 2020.07	15 Nos.

TEXT BOOKS:

1. Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press, Fourth Edition, 2020.
2. Stephen Marsland, “Machine Learning: An Algorithmic Perspective, “Second Edition”, CRC Press, 2014

REFERENCES:

1. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006
2. Tom Mitchell, “Machine Learning”, McGraw Hill, 3rd Edition, 1997.
3. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, “Foundations of Machine Learning”, Second Edition, MIT Press, 2012, 2018.
4. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press, 2016
5. Sebastain Raschka, Vahid Mirjalili, “Python Machine Learning”, Packt publishing, 3rd Edition, 2019.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Explain the basic concepts of machine learning.	2
CO2	Construct supervised learning models.	3
CO3	Construct unsupervised learning algorithms.	3
CO4	Evaluate and compare different models	4
CO5	Evaluate the machine learning experiments	4
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
2.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
3.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
4.	3	3	2	2	2	2	-	-	-	-	1	1	3	1
5.	3	2	2	2	3	2	-	-	-	-	1	1	3	3
1- Weak; 2 - Moderate; 3 - Strong.														

EC22409	MICROCONTROLLER SYSTEMS: THEORY AND PRACTICES	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- To understand the fundamentals of PIC 16f84A and Atmega microcontrollers.
- To develop Programme using Embedded 'C' and introduced to the 'C' Data types.
- To introduce the concepts of timer/counters, Serial ports and interrupts using PIC and SPI, I^2C, LCD and Keyboard using Atmega.
- To develop Programme codes for interfacing keyboard/display,motor and sensor using PIC and Atmega.
- To Interface sensors, motors, relays, and various input/output devices and programming with PIC16f84A and Atmega microcontrollers.

UNIT I	**INTRODUCTION TO PIC MICROCONTROLLER**	**9**

Architecture-16F84/16F877, Register File Structure, Addressing Modes, Assembly Language Programming-Arithmetic and Logical Instructions, Branch, Call and Time Delay Loop, PIC I/O Port Programming.

		9
UNIT II	**PIC PROGRAMMING IN C**	

Data types and time delays in C-I/O Programming-Logical Operations-Data Serialization-Program ROM allocation -Data RAM allocation.

UNIT III	**PIC PERIPHERALS AND INTERFACING**	**9**

Timer Programming, Serial Port Programming, Interrupt Programming, LCD and Keyboard Interfacing, ADC, DAC and Sensor Interfacing, Motor Control.

UNIT IV	**INTRODUCTION TO ATMEL AVR MICROCONTROLLER**	**9**

AVR Architecture, Registers and Data Memory, Instruction Set-Branch, Call and Time Delay Loop, Datatypes and directives, Parallel I/O Port, Programming in 'C'

UNIT V	**AVR PERIPHERAL INTERFACING**	**9**

Timer/counters, Analog Interface, SPI, I^2C, LCD and Keyboard, PWM Programming and DC Motor control.

L: 45 PERIODS

Practical Exercises:

1. Verification of Logic Gates (OR, AND & NOT), LED interfacing using PIC16f84A.
2. Interfacing PWM to control the brightness of LED using PIC16f84A.
3. LCD Interfacing using PIC16f84A.
4. Stepper Motor Interfacing using PIC16f84A.
5. Temperature sensor Interfacing using PIC16f84A.
6. Verification of Logic Gates (XOR, NAND & NOR), LED interfacing using ATMEGA.
7. Interfacing DC motor to control the RPM of Motor using ATMEGA.
8. LCD and Keyboard Interfacing using ATMEGA.
9. Servo Motor Interfacing using ATMEGA.
10. Ultrasonic sensor Interfacing using ATMEGA.
11. Application Development using PIC/ATMEGA.

P: 30 PERIODS

	TOTAL PERIODS: 75

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:	
	Quantity
PIC Universal Programmer and IC	15 nos
ATMEGA Programmer and IC	15 nos
LCD	10 nos
Ultrasonic Sensor	10 nos
DC motors and DC motor Drivers	10 nos
Stepper motors and drivers	10 nos
Temperature sensor and Interface	10 nos
LED	30 nos
1KΩ and 10 KΩ	40 nos
Crystal Oscillator16 MHz	40 nos
Capacitor 22pf	40 nos
Matrix Keypad	10 nos

TEXT BOOKS:

1. Muhammad Ali Mazidi, Rolin D.Mckinlay, Danny Causey, "PIC Microcontroller and Embedded Systems Using ASM & C for PIC18", Pearson Education International, Edition 2008.
2. Muhammad Ali Mazidi,Sepehr Naimi, Sarmad Naimi, "The AVR Microcontroller and Embedded systems Using Assembly and C", Pearson Education International, Edition 2017
3. Richard H.Barnett,Sarah Cox,Larry O'Cull, "Embedded C programming and the Atmel AVR", Cengage Learning India Private Limited, January 2007.

REFERENCES:

1. Peatman,J.B., "Design with PIC Micro Controllers "Pearson Education, 3rd Edition, 2004.
2. Tim Wilmshurst, "Designing Embedded Systems with PIC Microcontrollers – Principles and Applications", Newnes Publication, 2007
3. John Iovine, 'PIC Microcontroller Project Book ', McGraw Hill 2000
4. Julio Sanchez Maria P. Canton, "Microcontroller Programming: The microchip PIC", CRC Press, Taylor & Francis Group, 2007

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Identify and understand function of different blocks of PIC and Atmega microcontroller.	3
CO2	Develop programs for data transfer, arithmetic, logical and I/O port operations for PIC16 using "C"	4
CO3	Develop programs for Serial port, Timers, Interrupts and various Interfacing devices with PIC16f84A and Atmega Microcontrollers.	4
CO4	Develop program codes with PIC16f84A and Atmega for specific application.	4
CO5	Measure the performance of A/D and D/A.	3

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

*COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	3	3	3	-	-	-	1	-	-	-	3	3
2.	3	3	3	3	3	-	-	-	3	-	-	-	3	3
3.	3	3	3	3	3	-	-	-	3	-	-	-	3	3
4.	3	3	3	3	3	-	-	-	3	-	-	-	3	3
5.	3	2	3	3	3	-	-	-	1	-	-	-	3	3
1- Weak; 2 - Moderate; 3 - Strong.														

EC22403	DISCRETE TIME SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn Discrete Fourier Transform, properties of DFT and FFT.
- To know the characteristics and design of FIR filter.
- To design a IIR filters to filter undesired signals.
- To understand Finite word length effects.
- To study the concept of Digital Signal Processors and various applications of Digital Signal Processing.

UNIT I	**DISCRETE FOURIER TRANSFORM**	**9**

DSP advantages – Introduction to DFT – Properties of DFT – Circular Convolution - Filtering methods based on DFT – FFT Algorithms – Decimation-in-Time (DIT), Decimation-in-Frequency (DIF).

UNIT II	**DESIGN OF FIR FILTER**	**9**

Linear phase FIR filter - Symmetric, Antisymmetric filters - Filter design (Low Pass, High Pass filters) using windowing techniques (Rectangular Window, Hamming Window, Hanning Window), Need for choice of window- Realization structures of FIR Filter - Transversal, Poly-phase and Linear phase structures.

UNIT III	**DESIGN OF IIR FILTER**	**9**

Characteristics of Analog filters – Butterworth filters, Chebyshev Type I filters. Transformation of analog filters into equivalent digital filters using Impulse invariant method and Bilinear transformation method - Realization structures for IIR filters – direct, cascade, parallel forms.

UNIT IV	**FINITE WORD LENGTH EFFECTS**	**9**

Fixed point and floating point number representations – ADC – Quantization- Truncation and Rounding errors - Quantization noise – coefficient quantization error – Product quantization error – Round-off noise power - limit cycle oscillations due to product round off and overflow errors – Principle of scaling.

UNIT V	**APPLICATIONS OF DIGITAL SIGNAL PROCESSING**	**9**

Digital Signal Processors-Fixed and floating point; Basic Architectural features, Introduction to Multirate Signal Processing- Decimation, Interpolation, Sampling rate conversion by a rational factor, Applications of DSP to Image and Speech signal processing.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. John G. Proakis & Dimitris G.Manolakis, "Digital Signal Processing – Principles, Algorithms & Applications", Fourth Edition, Pearson Education / Prentice Hall, 2007.
2. B. Venkataramani and M. Bhaskar, ―Digital Signal Processors – Architecture, Programming and Applications‖ – Tata McGraw – Hill Publishing Company Limited. New Delhi, 2003.
3. Rafael C.Gonzalez & Richard E.Woods – Digital Image Processing – Pearson Education- 4/e – Reprint 2018
4. Lawrence Rabiner and Biing-Hwang Juang, "Fundamentals of Speech Recognition", Pearson Education India, 2008.

REFERENCES:

1. Alan V. Oppenheim and Ronald W. Schafer, "Discrete-Time Signal Processing" 3rd edition, 2010, Prentice Hall, Upper Saddle River, NJ.
2. Sanjit Mitra, "Digital Signal Processing", 4th edition, 2011, McGraw-Hill, New York, NY.
3. DSP Processor and Fundamentals: Architecture and Features. Phil Lapsley, JBier, Amit Sohan, Edward A Lee; Wiley IEEE Press;2009
4. Weltch , T.B., Wright, C.H.G. and Morrow, G.M., "Real-Time Digital Signal Processing from MATLAB to C with the TMS320C6x DSPs.", 2nd Ed., CRC Press,2011.
5. Rabiner, L.R. and Schafer, R.W., "Digital Processing of Speech Signals", Pearson Education, 2003.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Analyze the frequency spectrum of Discrete time signal using Discrete Fourier Transform and Fast Fourier Transform.	4
CO2	Interpret the characteristics of FIR filters and articulate the design of Finite Impulse Response filters for filtering undesired signals.	3
CO3	Observe the IIR filter characteristics and design IIR filters according to the user specifications.	3
CO4	Assess the word length effects in signal processing systems.	4
CO5	Explore the architecture of Digital Signal Processor and inspect the various applications of Digital Signal Processing.	3

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
2.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
3.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
4.	3	3	2	2	2	2	-	-	-	-	1	1	3	1
5.	3	2	2	2	3	2	-	-	-	-	1	1	3	3

1- Weak; 2 - Moderate; 3 - Strong.

GE22451	ENVIRONMENTAL SCIENCES AND SUSTAINABILITY (Common to all Branches)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the basic concepts of environment, ecosystems and biodiversity and emphasize the biodiversity of India and its conservation.
- To impart knowledge on the causes, effects and control or prevention measures of environmental pollution.
- To study and understand the various types of renewable sources of energy and their applications.
- To familiarize the concept of sustainable development goals, economic and social aspects of sustainability, recognize and analyze climate changes, and environmental management challenges.
- To inculcate and embrace sustainability practices, develop a broader understanding of green materials and energy cycles, and analyze the role of sustainable urbanization.

UNIT I	ENVIRONMENT AND BIODIVERSITY	9

Definition, scope and importance of environment – need for public awareness. Eco-system and Energy flow– food chains, food webs and ecological pyramids, ecological succession. Biodiversity-types- genetic, species and ecosystem diversity– values of biodiversity, India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: fragmentation and habitat loss, poaching of wildlife, human-wildlife conflicts – endangered and endemic species of India –conservation of biodiversity: In-situ and ex-situ.

UNIT II	ENVIRONMENTAL POLLUTION	9

Definition, causes, effects and preventive measures of air, water and soil pollution. Marine and thermal pollution - causes, effects and control measures. Light and noise pollution - effect on flora and fauna. Nuclear pollution- Sources, effects and control measures. Disposal of radioactive wastes (Nuclear hazards). Pollution case studies. Role of an individual in the prevention of pollution. Solid, hazardous and E-waste management. Occupational health and safety management system (OHASMS). Environmental protection, Environmental protection acts, categorization of spices according to IUCN.

UNIT III	RENEWABLE SOURCES OF ENERGY	9

Energy resources: Growing energy needs, Nonrenewable resources – types, uses. Energy management and conservation - New energy sources, Need of new sources - geo suitability of establishing renewable energy sources, different types new energy sources. Applications of hydrogen energy, ocean energy resources, Tidal energy conversion. Concept, origin and power plants of geothermal energy. Role of an individual in conservation of energy.

UNIT IV	SUSTAINABILITY AND MANAGEMENT	9

Development, GDP, Sustainability- concept, needs and challenges-economic, social and aspects of sustainability-from unsustainability to sustainability-millennium development goals, and protocols, Sustainable Development Goals-targets, indicators and intervention areas - Principles of green chemistry, Climate change- Global, Regional and local environmental issues and possible solutions-case studies - Role of non-governmental organization, Concept of carbon credit, carbon footprint - Environmental management in industry - A case study,

UNIT V	SUSTAINABILITY PRACTICES	9
Zero waste and R concept, circular economy, ISO 18000 series, material life cycle assessment, environmental impact assessment. Wasteland reclamation, Sustainable habitat: green buildings, green materials, energy efficiency and energy audit, sustainable transports. Energy cycles, carbon cycle, emission and sequestration, Green engineering: sustainable urbanization- socio-economical and technological change. Rainwater harvesting, watershed management, environmental ethics: Issues and possible solutions.		
	TOTAL: 45 PERIODS	

TEXT BOOKS:

1. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 7th Edition, New Age International Publishers, 2022.
2. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016.
3. Gilbert M. Masters, 'Introduction to Environmental Engineering and Science', 2nd edition, Pearson Education, 2004.
4. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Pearson. 2011.
5. Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design and development, CL Engineering, 2015.
6. Environment Impact Assessment Guidelines, Notification of Government of India, 2006.
7. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998.

REFERENCES:

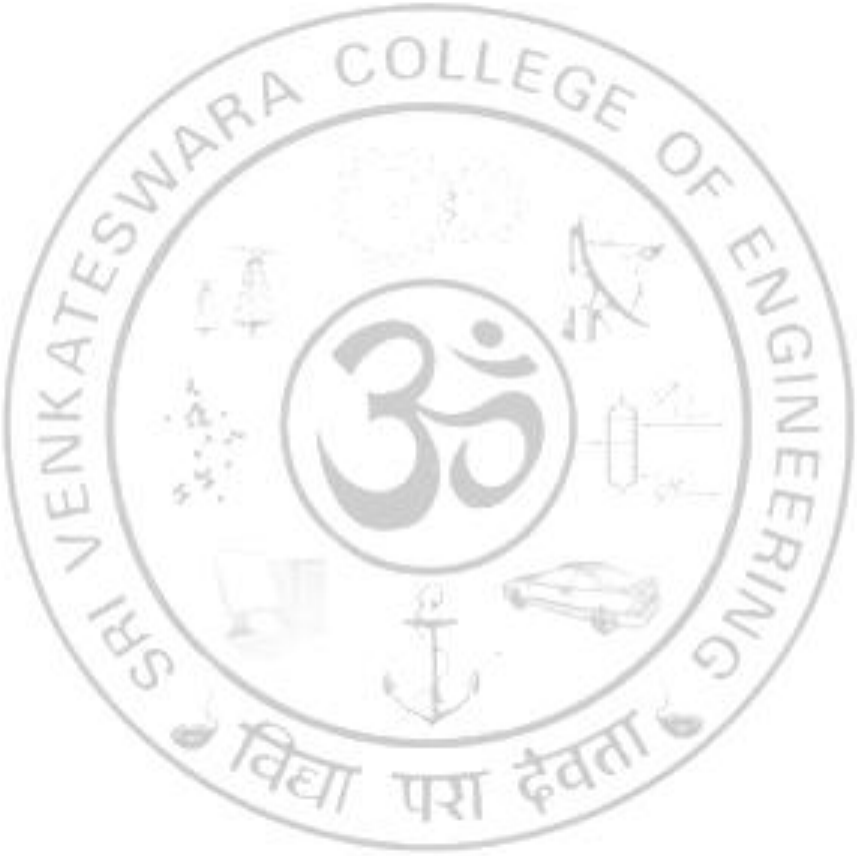
1. R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38
2. Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3. Dharmendra S. Sengar, 'Environmental law', Prentice hall of India PVT. LTD, New Delhi, 2007.
4. Rajagopalan, R, 'Environmental Studies-From Crisis to Cure', Oxford University Press, 3rd edition, 2015.
5. Erach Bharucha "Textbook of Environmental Studies for Undergraduate Courses" Orient Blackswan Pvt. Ltd. 3rd edition, 2021.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Explain the fundamental role of ecosystems and biodiversity and discuss the importance of their conservation.	2
CO2	Describe the different types of pollution, their effects and strategies to minimize or eliminate pollution.	2
CO3	Identify the need of renewable and non-renewable resources and describe energy management measures to preserve them for future generations.	2
CO4	Explain the various goals of sustainable development applicable for suitable technological advancement and societal development.	2
CO5	Demonstrate the knowledge of sustainability practices and identify green materials, energy cycles and the role of sustainable urbanization.	2

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

*COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1.	3	-	-	-	-	3	3	2	-	2	-	1	-	-
2.	3	-	-	-	-	3	3	2	-	2	-	2	-	-
3.	3	-	1	-	-	3	3	1	-	2	-	1	-	-
4.	3	-	-	-	-	3	3	3	-	2	-	2	-	-
5.	3	-	-	-	-	3	3	3	-	2	-	2	-	-
1- Weak; 2 - Moderate; 3 - Strong.														



EC22411	ANALOG INTEGRATED CIRCUITS AND SIMULATION LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

1. To expose the students to linear and integrated circuits
2. To understand the basics of linear integrated circuits and available ICs
3. To understand characteristics of operational amplifier.
4. To apply operational amplifiers in linear and nonlinear applications.
5. To acquire the basic knowledge of special function IC.
6. To use any simulation software for circuit design

LIST OF EXPERIMENTS

1. Design of inverting and non-inverting amplifier using Op-amp.
2. Design of integrator and differentiator using Op-amp.
3. Design of instrumentation amplifier using Op-amp.
4. Design of active low-pass, high-pass and Narrow band-pass filters using Op-amp.
5. Design of Astable and Monostable multivibrators using Op-amp.
6. Design of Schmitt Trigger using Op-amp.
7. Design of Wein Bridge and Colpitt's Oscillator Using Op-amp.
8. Applications of NE555 Timer.
9. PLL characteristics and its use as Frequency Multiplier.
10. DC power supply design using LM317 and LM723.
11. Simulation of experiments 3,4,5,6 using any simulation software.

TOTAL: PERIODS

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

Description of Items	Quantity
CRO (Min 30MHz)	15 Nos.
Signal Generator /Function Generators (2 MHz)	15 Nos.
Dual Regulated Power Supplies (0 — 30V)	15 Nos.
Digital Multimeter	15 Nos.
IC tester	5 Nos.
Standalone desktops PC	15 Nos.
Circuit Simulation Software: (any public domain or commercial software)	15 Nos.
Components and Accessories: Op-Amps, Resistors, Capacitors, diodes, Zener diodes, Bread Boards, Transformers, wires, Power transistors, Potentiometer, LEDs.	
Op-Amps uA741, LM 301, LM311, LM 324, LM317, LM723, 7805, 7812, 2N3524, 2N3525, 2N3391, AD 633, LM 555, LM 565	

TEXT BOOKS:

1. D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New Age International Pvt. Ltd., 2018, Fifth Edition.
2. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 4th Edition, Tata McGraw-Hill, 2016.
3. Ramakant A. Gayakwad, "OP-AMP and Linear ICs", 4th Edition, Prentice Hall / Pearson Education, 2015.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Develop a various linear and nonlinear applications using Operational Amplifier.	4
CO2	Construct Astable and Monostable Multivibrator using NE555 Timer.	4
CO3	Examine the Characteristics and applications of PLL.	3
CO4	Design DC Power supply using LM317 and LM723.	4
CO5	Simulate and validate the results of various operational amplifier applications using any simulation software.	3
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	2	-	-	-	-	-	-	-	3	3	2
2.	3	3	3	2	-	-	-	-	-	-	-	3	3	2
3.	3	3	3	3	-	-	-	-	-	-	-	3	3	2
4.	3	3	3	2	-	2	2	-	-	-	-	3	3	2
5.	3	3	3	2	3	-	-	-	-	-	-	3	3	3
1- Weak; 2 - Moderate; 3 - Strong.														

EC22412	DISCRETE TIME SIGNAL PROCESSING LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To implement DFT and FFT.
- To implement Linear and Circular Convolution.
- To design a FIR filter using windowing method.
- To design a IIR filter.
- To study the architecture of DSP processor.

LIST OF EXPERIMENTS

Experiments using MATLAB

1. Generation of elementary Discrete-Time sequences
2. Study of properties of LTI systems using Simulink
3. Linear and Circular convolution, Cross correlation of two sequences
4. Discrete Fourier Transform (DFT) and Inverse Discrete Fourier Transform (IDFT)
5. Radix-2 FFT algorithms - Decimation in Time / Decimation in Frequency
6. Spectral estimation through DTFT and DFT
7. Design of digital Butterworth and Chebyshev IIR filter
8. Design of FIR filter (LPF/HPF/BPF/BSF) and demonstrates the filtering operation
9. Processing of an image : Representation, Histogram plot, Image filtering

Experiments using DSP processor

1. Study of architecture of Digital Signal Processor
2. MAC application in LTI systems.
3. Generation of various signals
4. Design of FIR filter
5. Implementation of Up-sampling and Down-sampling

Mini Project (Any one)

1. Noise cancellation of audio signal
2. Disease detection based on EEG/ECG
3. Simple Image processing Technique

TOTAL: 45 PERIODS

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

Description of Items	Quantity
PCs with Fixed / Floating point DSP Processors (Kit / Add-on Cards)	15
MATLAB with Simulink and Signal Processing Tool Box or Equivalent Software in desktop systems	15 Licenses

TEXT BOOKS:

1. John G. Proakis& Dimitris G.Manolakis, "Digital Signal Processing – Principles, Algorithms & Applications", Fourth Edition, Pearson Education / Prentice Hall, 2007.
2. B. Venkataramani and M. Bhaskar, ―Digital Signal Processors – Architecture, Programming and Applications‖ – Tata McGraw – Hill Publishing Company Limited. New Delhi, 2003.
3. Rafael C.Gonzalez & Richard E.Woods – Digital Image Processing – Pearson Education- 4/e – Reprint 2018
4. Lawrence Rabiner and Biing-Hwang Juang, "Fundamentals of Speech Recognition", Pearson Education India, 2008.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Simulate standard signals.	3
CO2	Demonstrate the applications of FFT in signal processing	3
CO3	Design digital filters.	3
CO4	Demonstrate their abilities towards DSP processor based implementation of DSP systems	3
CO5	Implement signal processing applications in image and speech signal.	3
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	1	3	2	2	3	-	-	-	-	-	-	-	1	1
2.	3	3	1	2	3	2	-	-	2	-	-	-	3	3
3.	3	3	1	2	3	2	2	-	2	-	-	-	3	3
4.	3	3	1	2	3	2	-	-	-	-	-	-	2	2
5.	2	3	2	2	3	3	2	-	2	-	-	-	3	3
1- Weak; 2 - Moderate; 3 - Strong.														

SEMESTER V

EC22501	COMMUNICATION SYSTEMS	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

- To introduce the concepts of various continuous wave modulations
- To understand some of the essential pulse modulation techniques
- To understand the various Band pass signaling schemes
- To know the fundamentals of channel coding
- To understand the concepts of information theory

UNIT I	**CONTINUOUS WAVE MODULATION**	**9+3**

Amplitude Modulation – DSBFC, DSBSC, SSBSC, VSB- Demodulation – Envelope Detector; Superheterodyne receivers

Angle modulation – PM and FM – Narrow band, Wideband FM- FM Modulators and Demodulators- Foster Seeley Discriminator; Applications. (Qualitative Analysis)

UNIT II	**PULSE MODULATION**	**9+3**

Low Pass Sampling - Aliasing - Signal Reconstruction - Quantization - Types of Quantization (Uniform & Non-uniform) - Line Coding - PCM - TDM - Delta Modulation - Adaptive Delta Modulation - Differential PCM - Adaptive DPCM.

UNIT III	**PASSBAND DIGITAL TRANSMISSION**	**9+3**

Generation, detection, PSD & BER of Coherent BPSK, BFSK, QPSK, DPSK - Principle of M-ary Modulation – Direct Sequence and Frequency Hop Spread Spectrum Techniques

UNIT IV	**CHANNEL CAPACITY**	**9+3**

Information & Entropy - Source Coding Theorem - Huffman & Shannon-Fano Coding - Discrete Memoryless Channel - Mutual Information & its properties - Channel Capacity (Hartley-Shannon Law) - Channel Coding theorem

UNIT V	**ERROR CONTROL CODING**	**9+3**

Channel coding theorem - Linear Block codes - Hamming codes - Cyclic codes - Convolutional codes - Viterbi Decoder

TOTAL: (L: 45 + T: 15): 60 PERIODS

TEXT BOOKS:

1. Simon Haykin, “Communication Systems”, 4th edition, Wiley Publications, 2013.
2. Amitabha Bhattacharya, “Digital Communication”, TMH, Ninth Reprint 2017.

REFERENCES:

1. B. Sklar, “Digital Communication Fundamentals and Applications”, 2nd Edition, Pearson Education, 2009
2. B.P.Lathi, “Modern Digital and Analog Communication Systems”, 3rd Edition, Oxford University Press 2007.
3. H P Hsu, “Schaum Outline Series - Analog and Digital Communications”, TMH 2006.
4. J.G Proakis, “Digital Communication”, 4th Edition, Tata Mc Graw Hill Company, 2001

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Acquire the knowledge on different continuous wave modulation techniques.	2
CO2	Explore and appreciate the significance of the different pulse modulation techniques in communication system	3
CO3	Determine and manipulate the spectral characteristics of band pass signaling schemes and their noise performance of a communication system	3
CO4	Develop error control coding schemes for real time applications.	4
CO5	Develop source coding schemes for real time applications	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	3	2	-	2	-	-	-	-	-	3	3	2
2.	3	3	3	3	-	2	-	-	-	-	-	3	3	2
3.	3	3	3	3	-	2	-	-	-	-	-	3	3	2
4.	3	3	3	3	-	2	-	-	-	-	-	3	3	2
5.	3	3	3	3	-	2	-	-	-	-	-	3	3	2
*1 – Weak, 2 – Moderate, 3 - Strong														

EC22502	COMPUTER ORGANIZATION AND DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic structure and operation of computers.
- To acquire knowledge about the various arithmetic operations that performed by ALU.
- To expose the students to the concept of Pipelining.
- To introduce the students to the major ideas and concepts in parallel processing.
- To describe hierarchical memory systems including cache memories and virtual memory.

UNIT I	**OVERVIEW AND INSTRUCTIONS**	**9**

Historical evolution of computers and their impact on society-Eight ideas in Computer Architecture – Components –Technology – Performance –Power wall – Uniprocessors to multiprocessors; Instructions – operations and Operands – Representing instructions – Logical operations – Control operations – Addressing and addressing modes.

UNIT II	**ARITHMETIC OPERATIONS**	**9**

ALU - Addition and subtraction – Multiplication – Division –IEEE 754 Single and Double Precision formats- Floating Point operations-Subword parallelism.

UNIT III	**PROCESSOR AND CONTROL UNIT**	**9**

Basic MIPS Implementation -Building datapath – Control Implementation scheme – Instruction Cycle-single and Multicycle -Pipelining – Pipelined datapath and control – Handling Data hazards & Control hazards – Exceptions.

UNIT IV	**PARALLEL PROCESSORS**	**9**

Instruction-level-parallelism – Parallel processing challenges –Flynn's classification-Parallel computing principles- Parallelism –Task, Data – Hardware Multithreading – Multicore processors-Shared Vs Distributed Memory systems.

UNIT V	**MEMORY SYSTEMS**	**9**

Memory hierarchy - Memory technologies – Cache basics – Measuring and improving cache performance - Virtual memory, Translation Lookaside buffers(TLB's).

TOTAL:45 PERIODS

TEXT BOOKS:

1. David A. Patterson and John L. Hennessey, "Computer organization and design", MIPS Edition Morgan kauffman, Fifth Edition, 2014.
2. William Stallings, "Computer Organization and Architecture" Eleventh edition,2019,Pearson Education.

REFERENCES:

1. Govindarajalu, "Computer Architecture and Organization, Design Principles and Applications", Tata McGraw Hill, Second Edition,2017.
2. Shuangbao Paul Wang,"Computer Architecture and Organization: Fundamentals and Architecture Security by, Springer Verlag, Singapore; 1st ed. 2021 edition (1 December

2021).
3. Mano M Morris, "Computer System Architecture, Revised Third Edition 30 June 2017, Pearson Education.
4. John P. Hayes, "Computer Architecture and Organization", Third Edition, Tata McGraw Hill, 2012.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Compute the performance of various computer architecture and to interpret the instruction set of MIPS processor	4
CO2	Design and construct various arithmetic circuits for an Arithmetic and Logic units of computing systems	3
CO3	Assessing various pipelining techniques to implement it for better data path construction for Control units of computing systems	3
CO4	Categorize various paralleling process techniques and its challenges and also to distinguish various multithreading techniques	3
CO5	Organize the different Memory technologies and I/O systems to be preferred for computer architectural design	3

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	2	-	-	-	-	-	-	-	3	2	2
2.	3	3	3	2	-	-	-	-	-	-	-	3	2	2
3.	3	3	3	2	-	-	-	-	-	-	-	3	2	2
4.	3	3	3	2	-	-	-	-	-	-	-	3	2	2
5.	3	3	3	2	-	-	-	-	-	-	-	3	2	2
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22503	COMMUNICATION NETWORKS AND SECURITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the network models and functionalities of Data Link layer.
- To understand the routing protocols and various addressing schemes.
- To learn congestion control algorithm and techniques to improve QoS.
- To be familiar with real time applications of networks.
- To describe the principles of symmetric and asymmetric key cryptosystems.

UNIT I	**NETWORK MODELS AND DATA LINK LAYER**	**12**

Overview of Networks and its Attributes – Network Topology – OSI, TCP/IP, Addressing – Introduction to Data link Layer – Error Detection and Correction – Ethernet (802.3) - Wireless LAN – IEEE 802.11– Flow and Error Control Protocols.

UNIT II	**NETWORK LAYER**	**9**

Logical addressing - IPv4 and IPv6 Addresses: Datagram Format - Transition from IPv4 to IPv6– Address Mapping - Network Layer Protocols (IP and ICMP) - Unicast and Multicast Routing protocol.

UNIT III	**TRANSPORT LAYER**	**9**

Client/Server Paradigm - Transport Layer Protocols – UDP and TCP - TCP Connection and State Transition Diagram - Congestion Control and Avoidance - QoS

UNIT IV	**APPLICATION LAYER**	**6**

Application Layer Paradigms – Client – Server Programming – Domain Name System – World Wide Web, HTTP, Electronic Mail.

UNIT V	**SYMMETRIC AND ASYMMETRIC KEY CRYPTOSYSTEMS**	**9**

OSI Security Architecture – Attacks – Security Services and Mechanisms - Classical Encryption techniques – Symmetric Key Cryptography: Advanced Encryption Standard (AES) – Asymmetric Key Cryptography: Rabin Cryptosystem.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Behrouz.A.Forouzan, Data Communication and Networking, Fifth Edition, TMH, 2017.
2. William Stallings, Cryptography and Network Security, Seventh Edition, Pearson Education, 2017.
3. Behrouz A. Forouzan, "Cryptography and Network Security", 2nd edition Tata McGraw Hill, 2010.

REFERENCES:

1. James.F.Kurose and Keith.W.Ross, Computer Networking – A Top – Down Approach, Sixth Edition, Pearson, 2017.
2. Doughlas .E.Comer, Computer Networks and Internets with Internet Applications, Fourth Edition, Pearson Education, 2008.
3. Bruce Schneier and Neils Ferguson, "Practical Cryptography", First Edition, Wiley Dreamtech India Pvt Ltd, 2003.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Distinguish the functionalities of OSI and TCP/IP reference models and apply the error control and flow control protocols for reliable data transmission.	3
CO2	Apply the knowledge of addressing scheme and various routing protocols in data.	3
CO3	Categorize the various policies for handling congestion in TCP and define the characteristics of QoS.	4
CO4	Develop different application layer level protocols based on user's request	4
CO5	Implement the symmetric and asymmetric cryptosystems in real time applications.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX:

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	1	-	3	3	1	-	-	3	3
2.	3	3	3	3	3	-	-	3	3	1	-	-	3	3
3.	3	3	3	3	3	-	-	3	3	1	-	-	3	3
4.	1	1	3	3	3	1	-	3	3	1	-	-	3	3
5.	3	3	3	3	3	1	-	3	3	1	-	-	3	3
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22504	PHYSICAL VLSI DESIGN (Common to EC and EE)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fabrication processes of MOS circuits, design rules for layouts and the limitations in scaling.
- To learn about realization of MOS circuits for various combinational logic blocks and analyze the performance trade-offs with respect to the area, power and delay.
- To study the various arithmetic building blocks and their timing constraints.
- To learn about the various synchronous and asynchronous sequential designs and analyze the timing constraints.
- To learn about the various architectural choices available for FPGA.

UNIT I	**MOS TRANSISTOR PRINCIPLE**	**9**

NMOS, PMOS -Enhancement and depletion MOSFET; MOS transistor-Ideal I-V characteristics; Fabrication Process - MOSFET, CMOS- n-well, p-well, Twin tub, SOI; Scaling principles and fundamental limits; CMOS inverter characteristics; Stick diagram; Layout diagrams; Design rules; Layer Representation.

UNIT II	**COMBINATIONAL LOGIC CIRCUITS**	**9**

Static CMOS Design: Examples of Combinational Logic Design; Complementary CMOS concept and properties; Ratioed Logic -DCVSL logic gate; Pass Transistor Logic - Concept, Complementary PTL and Differential PTL; CMOS transmission gate; Elmore's constant; Dynamic CMOS design: Dynamic Logic - Basic Principles; Issues in Dynamic Design; Cascading Dynamic Gates.

UNIT III	**SEQUENTIAL LOGIC CIRCUITS**	**9**

Timing Metrics for Sequential Circuits; Static Latches and Registers; Bi-stability Principle; Multiplexer Based Latches; Master-Slave based Edge Triggered Register; Non-ideal clock signals; Dynamic Latches and Registers; Transmission-Gate Edge-triggered Registers; C^2MOS Register; Dual-Edge Registers; Timing issues; Pipelines; Clock Strategies; Synchronous and Asynchronous design. Introduction to Memory.

UNIT IV	**DESIGNING ARITHMETIC BUILDING BLOCKS**	**9**

Data path circuits: Architectures for Ripple Carry Adders; Carry Look Ahead Adders; Carry Select Adder; Carry Bypass Adder; High speed adders - Brent Kung adder, Kogge Stone; Multipliers - Wallace Tree multiplier, Booth Multiplier; Barrel shifters; Speed and Area Trade-off for all above Arithmetic Building Blocks.

UNIT V	**IMPLEMENTATION STRATEGIES**	**9**

Full custom and Semi-custom design; Standard cell design and cell libraries; FPGA building block architecture - FPGA interconnect routing procedures; Design for Testability: Ad Hoc Testing, Scan Design, BIST. Low power design principles.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. N.H.E. Weste, D. Harris and A. Banerjee, “CMOS VLSI Design: A Circuits and Systems Perspective”, Fourth Edition, Pearson, 2023.
2. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, “Digital Integrated Circuits-A Design Perspective”, Pearson, Second Edition, 2023.
3. M.J.Smith, “Application Specific Integrated Circuits, Pearson Education, 2013.

REFERENCES:

1. Jacob Baker “CMOS: Circuit Design, Layout, and Simulation”, Third Edition, Prentice Hall of India, Fourth Edition, 2019.
2. A.Pucknell,Kamran Eshraghian, “BASIC VLSI Design”, Third Edition, Prentice Hall of India, 2021.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Represent the CMOS logic circuit design using Stick Diagrams and Layout Diagrams.	3
CO2	Realize the MOS circuits for various combinational logic blocks.	4
CO3	Choose a suitable MOS logic style for designing Sequential logic blocks.	4
CO4	Select suitable MOS logic style for designing arithmetic logic blocks.	4
CO5	Choose a suitable FPGA implementation strategy.	3
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	-	2	3	-	-	-	-	-	-	2	3	3
2.	3	2	1	3	3	-	2	-	-	-	-	2	3	3
3.	3	2	1	3	3	-	2	-	-	-	-	2	3	3
4.	3	2	1	3	3	-	-	-	-	-	-	2	3	3
5.	3	2	-	2	3	-	-	-	-	-	-	2	3	1

* 1 – Weak, 2 – Moderate, 3 - Strong

EC22505	TRANSMISSION LINES AND RF SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To inculcate the various types of transmission lines.
- To give thorough understanding about high frequency line, power and impedance measurements.
- To impart technical knowledge in impedance matching using smith chart.
- To introduce waveguides and high frequency parameters for circuit representation of RF network.
- To deal with the issues in the design of RF amplifiers and filters.

UNIT I	**TRANSMISSION LINE THEORY**	**9**

Symmetrical networks- Characteristic impedance and Propagation constant, General theory of Transmission lines-Types, General solution, The infinite line, Wavelength, Velocity of propagation, Waveform distortion, the distortion-less line, Line not terminated in Z_0, Reflection coefficient, Reflection factor, Reflection Loss, Input and transfer impedance, Open and short circuited lines.

UNIT II	**HIGH FREQUENCY TRANSMISSION LINES**	**9**

Transmission line equations at radio frequencies, Line constants of Zero dissipation, Voltage and current on the dissipation less line, Standing Waves, Standing Wave Ratio, Input impedance of the dissipation-less line - Open and short-circuited lines, Power and Impedance measurement

UNIT III	**IMPEDANCE MATCHING IN HIGH FREQUENCY LINES**	**9**

Impedance matching: $\lambda/8$, $\lambda/2$ lines, Quarter wave transformer- Impedance matching by stubs - Single stub and double stub matching - Smith chart-Solutions of problems using Smith chart -Single stub matching using Smith chart.

UNIT IV	**TWO PORT NETWORK THEORY AND WAVEGUIDES**	**9**

High Frequency parameters, Formulation of S parameters, Properties of S parameters, Reciprocal and lossless Network, Transmission matrix, Waveguides- Rectangular and Circular, TE and TM modes in rectangular waveguides. Introduction to resonators.

UNIT V	**RF AMPLIFIERS AND FILTERS**	**9**

RF amplifiers- design of amplifiers, Filter fundamentals, Design of filters of Constant K - Low Pass, High Pass, Band Pass, Band Elimination, m- derived sections - low pass, high pass.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. John D.Ryder, "Networks, Lines and Fields", Prentice Hall of India, 2nd Edition, 2006.
2. Reinhold Ludwig and Gene Bogdanov, "RF Circuit Design: Theory and Applications", Pearson Education Inc., 2011.
3. Samuel Y Liao, "Microwave Devices and Circuits" Prentice Hall of India 2012.

REFERENCES:

1. Umesh Sinha, "Transmission Lines and Networks: Networks, Filters and Transmission lines" Satya Prakashan, Publication, 2010.
2. E.C.Jordan and K.G. Balmain, ―Electromagnetic Waves and Radiating System, Prentice Hall of India, 2006.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Explain line theory and classify transmission lines. Assess distortion less transmissions on lines.	2
CO2	Express transmission lines at high frequency and assess the performance.	2
CO3	Assess performance of lines implementing impedance matching techniques using Smith chart.	3
CO4	Explain the high frequency parameters and waveguides.	2
CO5	Analyze amplifiers at RF amplifier and design filters.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	1	1	2	-	-	3	1	1	-	2	-	1	2	-
2.	1	1	2	-	-	3	1	1	-	2	-	1	2	-
3.	1	1	2	-	-	3	1	1	-	2	-	1	2	-
4.	1	1	2	-	-	3	1	1	-	2	-	1	2	-
5.	1	1	2	-	-	3	1	1	-	2	-	1	2	-
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22511	COMMUNICATION SYSTEMS LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To visualize the effects of sampling, multiplexing and digital pulse modulation techniques.
- To implement AM & FM modulation and demodulation.
- To implement FSK, PSK and M-ary schemes.
- To implement Equalization algorithms and Error control coding schemes.
- To simulate communication link and CDMA link

LIST OF EXPERIMENTS

1. Signal Sampling and reconstruction
2. Time Division Multiplexing
3. AM Modulator and Demodulator
4. FM Modulator and Demodulator
5. Pulse Code Modulation and Demodulation
6. Delta Modulation and Demodulation
7. Observation (simulation) of signal constellations of BPSK, QPSK
8. Line coding schemes
9. ASK, FSK, PSK, DPSK, BPSK, QPSK and M-ary schemes (Simulation)
10. Error control coding schemes - Linear Block Codes (Simulation)
11. Communication link simulation
12. CDMA- DSSS and FHSS (simulation)

Note: Observed outputs of experiments and Simulated outputs must be plotted and attached to the records written by the students.

TOTAL: 45 PERIODS

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

Description of Items	Quantity
Kits for Signal Sampling, TDM, AM, FM, PCM, DM and Line Coding Schemes	2 Nos. each
MATLAB / SCILAB or equivalent software package for simulation experiments	10 Licenses
CRO's	10 Nos
PCs	10 No
Signal Generator /Function Generators (2 MHz)	10 Nos
Components and Accessories: Transistor-BC 107, XR 2206, Resistors, Capacitors, diodes,Bread Boards,wires,IC 565	-

TEXT BOOKS:

1. Simon Haykin, "Communication Systems", 4th edition, Wiley Publications, 2013.
2. Amitabha Bhattacharya, "Digital Communication", TMH, Ninth Reprint 2017.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Construct and validate the results of AM, FM modulator and Demodulator, Time Division Multiplexing (TDM), Signal Sampling and Reconstruction, Pulse Code Modulation (PCM), Delta Modulation and Demodulation	3
CO2	Construct and observe the results of Base Band Signaling techniques	3
CO3	Simulation and forecasting of Signal Constellations, Digital Modulation Schemes in MATLAB	4
CO4	Simulate and verify the results of error detection and correction coding techniques in MATLAB.	4
CO5	Simulate and validate the results of AM Communication link(system) using MATLAB.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	2	-	-	-	-	-	-	3	3	3
2.	3	3	3	3	2	-	-	-	-	-	-	3	3	3
3.	3	3	3	3	2	-	-	-	-	-	-	3	3	3
4.	3	3	3	3	-	-	-	-	-	-	-	3	3	3
5.	3	3	3	3	-	-	-	-	-	-	-	3	3	3
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22512	COMMUNICATION NETWORKS LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To understand the working of various network protocols through implementation.
- To have hands-on experience in configuring and simulating computer networks using network simulation tools.
- To examine the functionality of networking devices like hub, switch, router, repeater, etc. through practical implementation.
- To implement and analyze various network topologies through practical setup.
- To understand routing algorithms through practical implementation.

LIST OF EXPERIMENTS

1. Implementation of Ethernet/Fast Ethernet and TCP protocol
2. Implementation of Stop and Wait, Goback-N and Selective Repeat Protocol
3. Simulation of a Client-Server Model including the configuration of Telnet
4. Simulation of Echo/Ping/Talk commands
5. Implementation of CSMA / CA protocol and compare with CSMA/CD protocols.
6. Implementing Standard Network Topologies: Star, Bus and Ring using LAN Trainer Kit
7. Implementation of Distance Vector and Link State Routing algorithm
8. Implementation of Encryption and Decryption Using LAN Trainer Kit
9. Configuration of VLAN
10. Simulation of HTTP and DNS Server
11. Configuration of Wireless LAN
12. Configuration of Address Resolution protocol
13. Simulation of DHCP protocol

TOTAL: 45 PERIODS

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

Description of Items	Quantity
Desktop Computers-8GB RAM/512GB HDD, Processor i3/i5	30
Cisco Packet Tracer Software	30
N-Sim	15
LAN Trainer Kit	3

TEXT BOOKS:

1. William Stallings, Cryptography and Network Security, Seventh Edition, Pearson Education, 2017.
2. Behrouz A. Forouzan, "Cryptography and Network Security", 2nd edition Tata McGraw Hill, 2010.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		RBT Level
CO1	Design & simulate computer networks using network simulation tools and analyze performance.	6
CO2	Examine functionality of networking devices through practical setup.	4
CO3	Design and implement different network topologies.	6
CO4	Implement and analyze various network protocols.	4
CO5	Obtain the comprehensive hands-on experience in configuring, managing and troubleshooting computer networks.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	2	3	1	-	-	-	3	1	1	3	2
2.	3	2	2	3	3	2	-	-	-	2	-	1	2	1
3.	3	3	3	2	3	1	-	-	-	3	1	1	3	2
4.	3	2	2	3	3	1	-	-	-	2	-	1	2	1
5.	3	3	2	3	3	2	-	-	-	2	-	1	2	1
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22513	VLSI DESIGN LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To learn Hardware Descriptive Language
- To learn the fundamental principles of VLSI circuit design in digital and analog domain.
- To familiarize fusing of logical modules on FPGAs
- To provide hands on design experience with professional design (EDA) platforms
- To provide an idea of making an effective report based on experiments.

LIST OF EXPERIMENTS

1. HDL based design and simulation of Combinational circuits
   (a) 4-bit Ripple Carry Adder
   (b) Carry Look ahead adder
   (c) Multiplexer and Demultiplexer
   (d) Decoder and Priority Encoder
   (e) Code Converters
2. HDL based design and simulation of Sequential circuits
   (a) Shift register (SISO, SIPO, PIPO)
   (b) Synchronous and asynchronous Counter design
   (c) Mealy and Moore model
3. HDL based design, simulation and synthesis of Multiplier and ALU - Perform Synthesis, Place & Route, post Place & Route simulation and static timing analysis. Identification of critical path
4. Simulation of Static and Dynamic logic using EDA tool.
5. Design and schematic simulation of a simple analog circuit and analyze the same
6. Layout generation, parasitic extraction and post-simulation of Inverter & Universal Gates
7. Analyze the Area, Power and Delay for sequential circuits using the EDA tool.

TOTAL: 45 PERIODS

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

Description of Items	Quantity
1. Xilinx software, Xilinx or Altera FPGA	15 Nos.
2. Cadence/Tanner or equivalent software package	15 Licenses
3. PCs	15 Nos.

TEXT BOOKS:

1. R. Jacob Baker, "CMOS: Circuit Design, Layout, and Simulation", IEEE Press, Wiley, 2010
2. Sung-Mo Kang & Yusuf Leblebici, CMOS Digital Integrated Circuits - Analysis & Design, MGH, Second Ed., 1999.
3. Kang, Leblibici, CMOS Digital Integrated Circuits, 3rd Ed., Tata Mc-Graw Hill, 2001.
4. Jan M. Rabaey, Digital Integrated Circuits, 2nd Ed., Pearson Education, 2002.
5. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", Pearson Education, 2nd Edition, 2010.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Prepare HDL code for basic as well as advanced digital integrated circuits.	3
CO2	Use and import the logic modules into FPGA Boards.	4
CO3	Design, Synthesize, Place and Route the digital ICs.	4
CO4	Design, Simulate and Extract the layouts of IC Blocks using EDA tools.	4
CO5	Compute Area, Delay and Power report of digital circuits using EDA tools.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	-	-	-	-	-	-	-	-	-	-	-	3
2.	2	2	2	-	-	-	-	-	-	-	-	2	-	3
3.	2	3	3	-	-	-	-	-	-	-	-	-	-	3
4.	1	2	-	-	-	-	-	-	-	-	-	-	-	3
5.	2	2	1	-	-	-	-	-	-	-	-	-	-	3
* 1 – Weak, 2 – Moderate, 3 - Strong														

SEMESTER VI

EC22601	ANTENNAS AND MICROWAVE ENGINEERING	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

- To provide an understanding of radiation principles and antenna parameters.
- To familiarize in understanding radiation mechanism of various antenna designs.
- To analyze antenna arrays and explore smart antenna concepts.
- To design various microwave devices and understand their operational concepts.
- To give insight to design and analyze RF microwave circuits.

UNIT I	**INTRODUCTION TO ANTENNAS AND ITS PARAMETERS**	**9+3**

Microwave frequency bands-Review of low frequency parameters, S-Parameters-Properties of S-Parameters, Physical concept of radiation-Near and far field regions, Fields and Power Radiated by an antenna, Antenna Parameters, Antenna Noise Temperature, Friis transmission equation.

UNIT II	**RADIATION MECHANISM OF VARIOUS ANTENNA DESIGNS**	**9+3**

Radiation Mechanisms of Linear wire antenna, Aperture antennas, Reflector antennas, Microstrip antennas, Frequency Independent antennas, Design considerations and applications.

UNIT III	**ANTENNA ARRAYS AND SMART ANTENNAS**	**9+3**

Two-element array, Array factor, Pattern multiplication, Uniformly spaced arrays with uniform excitation amplitudes, Non-uniform excitation amplitudes, Binomial Array, Smart antennas-Antenna for 5G applications.

UNIT IV	**PASSIVE AND ACTIVE MICROWAVE DEVICES**	**9+3**

Microwave Passive Devices: Directional Coupler, Isolator, Magic Tee, Attenuator, Microwave Active Devices: Gunn Diode Microwave tubes: Klystron and Travelling Wave Tube (TWT).

UNIT V	**MICROWAVE CIRCUIT DESIGN**	**9+3**

Amplifier power relation, Stability considerations, Microwave Filter design, Radio Frequency (RF) Microwave amplifier design and Low Noise amplifier design.

TOTAL (L:45+T:15): 60 PERIODS

TEXT BOOKS:

1. John D Krauss, Ronald J Marhefka and Ahmad S. Khan, "Antennas and Wave Propagation: Fifth Edition, Tata McGraw-Hill, 2017.
1. David M. Pozar, "Microwave Engineering", Fourth Edition, Wiley India, 2013.

REFERENCES:

1. Constantine A.Balanis, “Antenna Theory Analysis and Design”, Fourth Edition, John Wiley India Pvt Ltd., 2016.
2. R.E.Collin, "Foundations for Microwave Engineering", Second edition, IEEE Press, 2014.
3. A.R. Harish, M. Sachidananda, “Antenna and Wave Propagation”, Standard Edition, Oxford University Press,2007.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Apply the radiation principles and evaluate antenna parameters.	3
CO2	Design and analyze the performance of various antenna designs.	4
CO3	Design and evaluate the performance of antenna array and smart antennas.	4
CO4	Apply the fundamental concepts to active and passive microwave devices.	3
CO5	Design a microwave circuit and examine its performance metrics.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	1	-	-	-	-	-	-	-	3	-	-	3	-
2.	3	2	-	-	-	-	-	1	2	2	-	-	3	3
3.	3	2	-	-	-	-	-	1	2	2	-	-	3	3
4.	3	2	-	-	-	-	-	-	2	-	-	-	3	-
5.	3	2	3	-	3	-	-	2	2	3	-	1	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22602	EMBEDDED SYSTEMS AND IOT DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study the architecture and programming of ARM processors
- To learn Arduino programming
- To understand different IoT Communication Models and open platforms
- To explore various IoT implementation tools
- To apply the concept of Internet of Things in real world scenario

UNIT I	**INTRODUCTION TO EMBEDDED COMPUTING AND ARM PROCESSORS**	**9**

Concept of RISC, RISC vs CISC, RISC-V Architecture – Pipeline – RISC-V Ecosystem – Applications of RISC-V in Embedded Systems, ARM Processor Fundamentals, Instruction Set and Programming using ARM Processor, Embedded system design process – Design example

UNIT II	**ARDUINO PROGRAMMING**	**9**

Introduction to Arduino – Types of Arduino – Arduino Toolchain – Arduino Programming Structure – Sketches – Pins – Input/Output from Pins Using Sketches – Introduction to Arduino Shields – Integration of Sensors and Actuators with Arduino

UNIT III	**IOT COMMUNICATION AND OPEN PLATFORMS**	**9**

Concept of IoT Devices – IoT Configurations – Basic Components–IoT Communication Models and APIs – IoT Communication Protocols – Bluetooth – WiFi – ZigBee – GPS – GSM modules – Open Platform (like Raspberry Pi) – Architecture – Programming – Interfacing – Accessing GPIO Pins – Sending and Receiving Signals Using GPIO Pins – Connecting to the Cloud

UNIT IV	**IOT IMPLEMENTATION RESOURCES**	**9**

Introduction to Python, Introduction to different IoT tools, developing applications through IoT tools, developing sensor-based application through embedded system platform, Implementing IoT concepts with python, Implementation of IoT with Raspberry Pi

UNIT V	**APPLICATIONS AND CASE STUDIES**	**9**

Design and Development of IoT Applications – Home Automation – Smart Agriculture – Smart Cities – Healthcare– Logistics

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Cem Unsalan, Huseyin Deniz Gurhan, Mehmet Erkin Yucel, "Embedded System Design with ARM Cortex-M Microcontrollers: Applications with C, C++ and MicroPython", Springer, 2022.
2. Wayne Wolf, “Computers as Components: Principles of Embedded Computer System Design”, Elsevier, 2006.
3. Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, 2015.
4. Ryan Turner, Arduino Programming: 3 Books in 1 - The Ultimate Beginners,

Intermediate and Expert Guide to Master Arduino Programming, Nelly B.L. International Consulting Limited, 2020.

REFERENCES:

1. Michael J. Pont, "Embedded C", Pearson Education, 2007.
2. Andrew N. Sloss, D. Symes, C. Wright, "Arm System Developer's Guide", Morgan Kauffman/ Elsevier, 2006.
3. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things: David Hanes, Gonzalo Salgueiro, Patrick Grossetete ,Robert Barton, Jerome Henry, Cisco Press,2017
4. Constandinos X. Mavromoustakis, George Mastorakis, Jordi Mongay Batalla, "Internet of Things (IoT) in 5G Mobile Technologies" Springer International Publishing Switzerland 2016.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Design and develop ARM processor based embedded systems	3
CO2	Integrate Sensors and Actuators with Arduino.	3
CO3	Compare the communication models in IOT and build a small low-cost embedded and IoT system using open platform.	4
CO4	Analyze different tools for IoT implementation.	4
CO5	Build Domain specific applications of IoT	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	2	1	1	2	-	-	-	-	-	2	3	2
2.	3	1	3	3	2	-	-	-	2	2	2	3	3	2
3.	3	2	3	2	1	-	-	-	2	2	3	3	3	2
4.	3	3	2	2	2	1	1	1	2	2	2	3	3	2
5.	2	3	3	2	2	1	1	1	2	2	2	3	3	2
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22603	WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To know the characteristics of the wireless channel
- To learn the various cellular architectures
- To understand the concepts behind various digital signaling schemes for fading channels
- To be familiar with various multipath mitigation techniques
- To acquire knowledge of a few cellular standards

UNIT I	**WIRELESS CHANNELS**	**9**

Spectrum - Large scale path loss – Path loss models: Free Space and Two-Ray models - Link Budget design – Small scale fading - Parameters of mobile multipath channels – Time dispersion parameters - Coherence bandwidth – Doppler spread & Coherence time, Fading due to Multipath time delay spread – flat fading – frequency selective fading – Fading due to Doppler spread – fast fading – slow fading.

UNIT II	**CELLULAR ARCHITECTURE**	**9**

Multiple Access techniques - FDMA, TDMA, CDMA – Capacity calculations – Cellular concept Frequency reuse - channel assignment - hand-off - interference & system capacity - trunking & grade of service – Coverage and capacity improvement.

UNIT III	**MODULATION TECHNIQUES FOR MOBILE RADIO**	**9**

Structure of a wireless communication link, Principles of Offset-QPSK, p/4-DQPSK, QAM, Minimum Shift Keying, Gaussian Minimum Shift Keying, OFDM principle – Cyclic prefix, Windowing, PAPR

UNIT IV	**MULTIPATH MITIGATION TECHNIQUES**	**9**

Fundamentals of Equalization – Adaptive equalization, Linear and Non-Linear equalization, Algorithms for Adaptive Equalization - Zero Forcing and LMS - Principle of Diversity - Micro Diversity and Macro Diversity – Space Diversity - Polarization Diversity - Frequency Diversity - Time Diversity - Diversity combining techniques - Selection Diversity - Switched Diversity - Maximal Ratio Combining - Equal Gain Combining - Rake receiver

UNIT V	**WIRELESS COMMUNICATION STANDARDS**	**9**

GSM - Services and Features - System Architecture - Radio Subsystem - Channel Types - evolution of 2.5 G mobile radio networks - IS-95 - Frequency and Channel Specification - CDMA Channel Modulation Process - key features of IS-95 - 3G WCDMA - UMTS, LTE physical layer - UMTS network architecture - CDMA 2000 physical layer – Introduction to 5G Wireless Technology

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Rappaport. T.S., “Wireless communications”, Pearson Education, Second edition updated, 3rd impression, 2024.
2. Haykin & Moher, "Modern Wireless Communications" Pearson 2011 (Indian Edition).

3. Vijay K Garg, ―Wireless Communications and networking, First Edition, Elsevier 2007.

REFERENCES:

1. Andreas.F. Molisch, “Wireless Communications”, John Wiley – India, 2006.
2. Andreas Goldsmith, “Wireless Communication Cambridge University Press, Aug-2005.
3. D. Tse and P. Viswanath, "Fundamentals of Wireless Communications," Cambridge University Press, 2005.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	To characterize wireless channels and evaluate the various wave propagation models	5
CO2	To analyze various multiple-access techniques adopted in wireless applications and methodologies applied to increase the capacity of cellular system	4
CO3	To examine various digital signalling under fading conditions and calculate its error performance	4
CO4	To investigate various multipath mitigation techniques to retrieve signals under various channel conditions and evaluate their error probability	4
CO5	To be familiar with wireless standards, and generations and analyze their evolutions	4
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	2	3	1	2	2	2	1	2	3	2	2	2
2.	3	2	2	3	2	3	3	3	-	2	3	3	2	2
3.	2	3	3	2	1	1	1	1	-	-	1	1	2	2
4.	3	3	3	3	3	1	2	2	1	1	1	1	2	1
5.	2	2	2	2	1	3	2	3	2	3	3	3	1	1

* 1 – Weak, 2 – Moderate, 3 - Strong

EC22611	ANTENNA AND MICROWAVE ENGINEERING LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To provide students with a fundamental understanding of microwave theory and principles.
- To equip students with the ability to design and analyze various microwave components and antennas.
- To familiarize students with the practical aspects of microwave measurements and characterization techniques.
- To develop students' skills in using computational tools and software for microwave circuit and antenna design.
- To prepare students for advanced topics and research in the field of microwave engineering.

LIST OF EXPERIMENTS

1. Design and analysis of Rectangular Waveguide
2. Design and analysis of a microstrip transmission line with characteristic impedance (Z0) 50 ohm
3. Design of a rectangular microstrip patch antenna and analyze its radiation characteristics.
4. Design and analysis of 3 element Yagi-Uda antenna and calculate beam-width, front/back ratio, and gain of the antenna.
5. Construction of E-plane, H-plane and Magic Tee junctions and compare its field distributions.
6. Design of an array antenna
7. Design and analysis of microstrip LPF
8. Verification of mode characteristics of reflex klystron
9. Study of V-I characteristics of the Gunn diode
10. Study of characteristics of three port circulator and two port isolator
11. Study and measurement of indirect frequency and guide wavelength of rectangular waveguide
12. S Matrix formulation of a Directional coupler
13. Measurement of VSWR and reflection co-efficient for the given unknown load using slotted line technique.

TOTAL: 60 PERIODS

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

Description of Items	Quantity
Microwave Test benches using Klystron tube	7
Microwave Test benches using Gunn diode	4
Slotted Line Section	3
Isolator	4
Matched Termination	10
E-Plane Tee, H-Plane Tee, Magic Tee	2
Microwave Power Meter	2
Direct Frequency Meter X Band	4
Directional Coupler X Band	3
Spectrum Analyzer -Hameg	1

IE3D-SSD-N2-IE3D Software	1
Agilent _ADS SOFT-EM Simulation Software	1
CST Studio Suite Software-EM Simulation Software (Research Pack-Single User and Lab Version-15 User License)	1

TEXT BOOKS:

1. David M Pozar, "Microwave Engineering-Theory and Techniques", An Indian Adaptation, John Wiley India Pvt Ltd., 1st Edition, 2020.
2. John D. Kraus, Ronald J Marhefka, Ahmad S Khan, "Antennas and Wave Propagation", McGraw Hill Education, 5th Edition, 2017
3. Annapurna Das, Sisir K Das, "Microwave Engineering", McGraw-Hill Publication, 4th edition, 2020.
4. Sushrut Das, "Microwave Engineering", Oxford Higher Education, 2nd Edition, 2015
5. A.R.Harish, M.Sachidananda, "Antennas and Wave Propagation", Oxford University Press, 1st Edition, 2016

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Design and analyze microstrip transmission lines, antennas, and filters using appropriate techniques and tools. (RBT Level 4: Analyzing)	4
CO2	Characterize the performance of microwave components and systems, such as waveguides, junctions, circulators, and isolators.	4
CO3	Apply theoretical concepts to practical microwave engineering problems and measurements.	3
CO4	Acquire proficiency in using computational tools and software for microwave circuit and antenna design and analysis.	4
CO5	Equip with the knowledge and skills necessary for further studies or careers in the field of microwave engineering.	4

COURSE ARTICULATION MATRIX

COs	**POs**												**PSO**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	2	1	2	-	-	-	-	1	3	2
2.	3	3	3	3	2	1	2	-	-	-	-	1	3	2
3.	3	3	3	2	3	1	1	-	-	-	-	1	2	2
4.	3	2	2	2	3	1	1	-	-	-	-	2	2	3
5.	3	2	2	2	3	2	1	-	-	-	-	2	2	3
	* 1 – Weak, 2 – Moderate, 3 – Strong													

EC22612	EMBEDDED SYSTEMS AND IOT LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To learn the working of ARM processor
- To write programs to interface the I/Os , and various peripherals with the processor
- To learn the Raspberry Pi initial setup and web interface
- To write programs for IoT-based applications on Raspberry Pi
- To write programs to interface the I/Os , and various peripherals with the NodeMCU

LIST OF EXERCISES USING uKeil / IAR WORK BENCH /ARM C COMPILER

1. Study of ARM evaluation system.
2. Interfacing ADC and DAC.
3. Interfacing LED and PWM.
4. Interfacing keyboard and LCD.
5. Interfacing of stepper motor and servo motor.
6. Implementing ZigBee protocol with ARM.

LIST OF EXERCISES USING RASPBERRY PI 3

7. Study of Raspberry Pi and OS installation
8. Simple web interface for Raspberry Pi to control the connected LEDs remotely through the interface.
9. Implementation of client and server applications on Raspberry Pi.
10. Interface a temperature sensor to build a weather reporting system.

LIST OF EXERCISES USING NODEMCU

11. Study of NodeMCU features.
12. Interfacing NodeMCU board to a computer via USB for serial communication.

TOTAL: 45 PERIODS

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS:

Description of Items	Quantity
HARDWARE: Embedded Trainer kits with ARM Boards	10 Nos.
SOFTWARE: uKeil / IAR WORK BENCH, Raspbian OS, Python 3 compiler	10 Nos.
Embedded Trainer kits suitable for wireless communication	10 Nos.
Raspberry pi 3 board with essential components	10 Nos.
NodeMCU board with essential components	10 Nos.
Stepper motor, Servo motor and DC motor	Each 5 Nos.
Sensors: Temperature, Ultrasonic and soil moisture	3 Nos.

TEXT BOOKS:

1. Wayne Wolf, “Computers as Components: Principles of Embedded Computer System Design”, Elsevier, 2006.
2. Robert Barton, Patrick Grossetete, David Hanes, Jerome Henry, Gonzalo Salgueiro, “IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things”, CISCO Press, 2017.
3. Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, 2015

COURSE OUTCOMES: **Upon successful completion of the course, students should be able to:**		**RBT Level**
CO1	Write programs in ARM for a specific Application.	3
CO2	Interface A/D and D/A convertors, keyboard, display, motor and sensor with ARM system.	4
CO3	Complete the initial setup of Raspberry Pi and web interface	4
CO4	Interface sensors with Raspberry Pi board.	5
CO5	Interface sensors with NodeMCU board.	5
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSO**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	3	3	-	3	3	-	3	3	3
2.	3	3	3	3	3	3	3	-	3	3	-	3	3	3
3.	3	3	3	3	3	3	3	-	3	3	-	3	3	3
4.	3	3	3	3	3	3	3	-	3	3	-	3	3	3
5.	3	3	3	3	3	3	3	-	3	3	-	3	3	3
	* 1 – Weak, 2 – Moderate, 3 – Strong													

HS22511	INTERVIEW AND CAREER SKILLS LABORATORY	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES:

- Build confidence and develop learners' language proficiency.
- Better learners' performance in competitive examinations.
- Improve learners' employability skills.
- Develop entrepreneurship skills.
- Expose learners to the use of professional English.

UNIT I	**LISTENING AND SPEAKING SKILLS**	**12**

Conversation Skills – types small talk, face to face and telephonic, formal and informal conversations – skills in presenting ideas and collating information during conference calls (one –to one and technical group / team) – academic and workplace situations – conversing with faculty/visiting faculty/guests/officials/employers and employees – group discussion – etiquette and dos and don'ts, turn taking –presentation skills – seminars and projects using digital tools; mock interview – etiquette and dos and don'ts – audio-visual interface for enhancement of listening and speaking skills. IELTS and TOEFL (Listening related exercises)

UNIT II	**READING / SPEED READING, CRITICAL THINKING AND WRITING SKILLS**	**12**

Reading Comprehension – general and scientific texts/articles/case studies from different or relevant fields of study for analysis and critical thinking; employability skills – writing job applications – cover letter accompanying résumé – types of business letters and email writing and etiquette; writing reports – statement of purpose – writing articles for publication style and format – creating blogs or company profiles – speed reading of voluminous reports / documents and exacting necessary information and abstract preparation including dissemination. IELTS and TOEFL(Reading related exercises)

UNIT III	**ENGLISH FOR PROFESSIONAL EXAMINATIONS**	**12**

Sentences, paragraphs and reading comprehension – vocabulary building – general and technical terms – contextual meaning – spelling – subject specific words – usage and user specific terminology. IELTS and TOEFL(Grammar and verbal exercises)

UNIT IV	**ENTREPRENEURSHIP SKILLS**	**9**

Introduction to entrepreneurship - fundamentals of entrepreneurial skills - developing leadership qualities and team work;– marketing strategies microcosmic and macrocosmic levels of product sales and survey – sector / industry appraisal and appreciation (review and understanding state of the nation / economy / environment / sector reports published) interaction and understanding the role of multilateral financial / institutional / industrial agencies such as World Bank, ADB, UNDP, CII - Influencing in Business Meetings - Active Listening and responding - Role-play - Strengthening – Negotiating/ Argumentative and Persuasive Skills - Defend a character/idea or attack it. - Networking Skills - engaging strangers in a conversation - introducing themselves, making small talk.

TOTAL: 45 PERIODS

REFERENCES:

1. Business English Certificate Materials, Cambridge University Press.
2. Graded Examinations in Spoken English and Spoken English for Work downloadable materials from Trinity College, London
3. International English Language Testing System Practice Tests, Cambridge University Press.
4. Interactive Multimedia Programs on Managing Time and Stress.
5. Personality Development (CD ROM), Times Multimedia, Mumbai.

WEB SOURCES:

http://www.slideshare.net/rohitjsh/presentationon group discussion
http://www.washington.edu/doit/TeamN/present_tips.html
http://www.oxforddictionaries.com/words/writingjobapplications
http://www.kent.ac.uk/careers/cv/coveringletters.html
http://www.mindtools.com/pages/article/newCDV_34.html

COURSE OUTCOMES: **Upon successful completion of the course, students should be able to:**		**RBT Level**
CO1	Develop approaches for mastering international English language tests such as IETLS and TOEFL, as well as national-level competitive exams	6
CO2	Make presentations and participate in Group Discussions.	6
CO3	Face interviews with confidence and develop strategies for negotiating job offers.	6
CO4	Build effective resumes, cover letters and professional emails to enhance job application success.	6
CO5	Explore strategies for scaling and growing entrepreneurial ventures.	6
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

COs	**POs**											**PSO**	
	1	2	3	4	5	6	7	8	9	10	11	1	2
1.	-	-	-	-	-	-	-	-	-	3	-	-	-
2.	-	-	-	-	-	-	-	-	-	3	-	-	-
3.	-	-	-	-	-	-	-	-	-	3	-	-	-
4.	-	-	-	-	-	-	-	-	-	3	-	-	-
5.	-	-	-	-	-	-	-	-	-	3	-	-	-
* 1 – Weak, 2 – Moderate, 3 – Strong													

SEMESTER VII

EC22701	OPTICAL COMMUNICATION AND NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To review various optical fiber modes, configuration and transmission characteristics of optical fibers.
- To relate the knowledge about various types signal degradation that occurs in optical fibers.
- To learn about the various optical sources, detectors and transmission techniques with coupling schemes.
- To explore various idea about optical fiber measurements and receiver performance with error calculation.
- To Enrich the idea of optical fiber networks algorithm such as SONET/SDH and optical CDMA.

UNIT I	**INTRODUCTION TO OPTICAL FIBERS**	**9**

Evolution of fiber optic system- Element of an Optical Fiber Transmission link -Nature of Light - Ray Optics: Meridional rays , Axial rays, Skew Ray-Wave Optics: Mode theory for Circular Wave guides -Optical Fiber Modes and LP mode Configurations –Fiber types: Single Mode and Multimode fibers-Step and Graded Index fiber Structure, Single index power control.

UNIT II	**SIGNAL DEGRADATION IN OPTICAL FIBERS**	**9**

Attenuation – Attenuation units - Absorption losses, Scattering losses, Bending Losses, Core and Cladding losses, Signal Distortion in Optical Wave guides-Information Capacity determination - Group Delay, Material Dispersion, Wave guide Dispersion, Signal distortion in SM fibers-Intermodal dispersion, Pulse Broadening in GI fibers.

UNIT III	**FIBER OPTICAL SOURCES,DETECTORS AND COUPLING**	**9**

Direct and indirect Band gaps - LED structures - Quantum efficiency and LED power, Modulation of a LED, Lasers Diodes - Modes and Threshold condition - Rate equations-External Quantum efficiency - Temperature effects,Fiber amplifiers, Power Launching and coupling, Lensing schemes, Fiber -to- Fiber joints, Fiber splicing –Photo Detectors, Signal to Noise ratio, Detector response time.

UNIT IV	**FIBER OPTIC RECEIVER AND MEASUREMENTS**	**9**

Fundamental receiver operation, Pre amplifiers, Error sources – Receiver Configuration– Probability of Error – Quantum limit. Fiber Attenuation measurements- Dispersion measurements – Fiber Refractive index profile measurements – Fiber cut- off Wave length Measurements – Fiber Numerical Aperture Measurements – Fiber diameter measurements.

UNIT V	**OPTICAL NETWORKS AND SYSTEM TRANSMISSION**	**9**

Basic Networks – SONET / SDH – Broadcast and select WDM Networks –Wavelength Routed Networks – Non-linear effects on Network performance –-Budget Analysis: Link Power budget - Rise time budget, Non-Linear Optics-Schrodinger equation application-Soliton, Noise Effects on System Performance- EDFA system –.Optical CDMA – Ultra High Capacity Networks.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. P Chakrabarti, "Optical Fiber Communication‖, McGraw Hill Education (India) Private Limited, 2015
2. Gred Keiser,"Optical Fiber Communication‖, McGraw Hill Education (India) Private Limited. Fifth Edition, 2015.
3. John M. Senior, "Optical Fiber Communications: Principles and Practice", Third Edition, Pearson Education, 2014.

REFERENCES:

1. Ramaswami, Sivarajan and Sasaki "Optical Networks", Morgan Kaufmann, 3rd edition 2009.
2. Govind P. Agrawal, "Fiber optic communication systems", 5th edition, John Wiley & sons, 2021.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Recognize and classify the structures of Optical fiber and its types.	2
CO2	Investigate the various signal degradation factors associated with optical fiber.	4
CO3	Evaluate the various optical sources and optical detectors and their use in the optical communication systems.	4
CO4	Examine the digital transmission and its associated parameters on system performance with the optical fiber measurements	4
CO5	Enrich one's own knowledge on design of optical fiber networks such as SONET/SDH and optical CDMA system.	4

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
2.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
3.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
4.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
5.	3	3	3	1	-	-	-	-	1	1	-	3	3	2

* 1 – Weak, 2 – Moderate, 3 - Strong

EC22702	MANAGEMENT PRINCIPLES AND ETHICAL CONDUCT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To facilitate student understanding of the fundamentals of management concepts and the history behind the evolution of management thought, as well as knowledge about culture and current issues in management.
- To enable students to study the nature of planning, including its tools, techniques, and the decision-making process.
- To emphasize the importance of controlling as a management function and various control techniques and procedures adopted to handle productivity problems.
- To analyze key ethical theories including utilitarianism, rights ethics, duty ethics, virtue ethics, and ethical egoism, and apply them to ethical issues in engineering.
- To examine ethical issues related to teamwork, confidentiality, conflicts of interest, professional rights of engineers, employee rights, and whistleblowing.

UNIT I	**INTRODUCTION TO MANAGEMENT AND ORGANIZATIONS**	**9**

Definition of Management –Why are managers important? Nature of Management-Management as Science or Art-Management and Administration-Evolution of Management-Contribution of Taylor and Fayol – Manager Vs Entrepreneur - Types of Managers - Managerial Roles and Skills-Organization Culture and Environment.

UNIT II	**PLANNING**	**9**

Nature and Purpose of Planning – Steps Involved in Planning Process – Types of Planning – Objectives – Setting Objectives – Policies – Planning Premises – Strategic Management – Planning Tools and Techniques-Forecasting – Decision Making Steps and Process.

UNIT III	**CONTROLLING**	**9**

System and Process of Controlling – Requirements for Effective Control - Budgetary and Non - Budgetary Control Techniques – Use of Computers and IT in Handling the Information – Productivity Problems and Management – Control of Overall Performance – Direct and Preventive Control – Reporting.

UNIT IV	**ENGINEERING ETHICS**	**9**

Scope of Engineering Ethics-Overview of Themes, What Is Engineering Ethics? Why Study Engineering Ethics? Utilitarianism-Utilitarianism versus Cost-Benefit Analysis, Act-Utilitarianism versus Rule-Utilitarianism, Theories of Good, Rights Ethics and Duty Ethics-Human Rights, Varieties of Rights Ethics, Duty Ethics, Prima Facie Duties, Ethical Egoism-Motives of Engineers, Self-Realization, Personal Commitments, and Communities, Religious Commitments

UNIT V	**WORKPLACE CULTURES, RESPONSIBILITIES AND RIGHTS:**	**9**

Teamwork-An Ethical Corporate Climate, Loyalty and Collegiality, Managers and Engineers, Managing Conflict, Confidentiality and Conflicts of Interest-Confidentiality: Definition, Confidentiality and Changing Jobs, Confidentiality and Management Policies,

Confidentiality:Justification, Conflicts of Interest: Definition and Examples, Moral Status of Conflicts of Interest, Rights of Engineers-Professional Rights, Employee Rights, Whistleblowing-Definition, Two Cases, Moral Guidelines, Protecting Whistleblowers, Commonsense Procedures, Beyond Whistleblowing

	TOTAL: 45 PERIODS	

TEXT BOOKS:

1. Stephen P. Robbins & Mary Coulter, "Management", Prentice Hall (India) Pvt. Ltd., 11th Edition,2012.
2. Heinz Weihrich, Mark V Cannice, and Harold Koontz "Management: A Global, Innovative and Entrepreneurial Perspective", 15th Edition, McGrawHill, 2019.
3. Qin Zhu, Mike W. Martin and Roland Schinzinger, "Ethics in Engineering", Fifth Edition, Tata McGraw Hill, New Delhi, 2022

REFERENCES:

1. Harold Kootnz, Heinz Weihrich & Mark V. Cannice, "Essentials of Management", Mc Graw Hill, 11th Edition, 2020.
2. Charles B. Fleddermann, "Engineering Ethics", fourth edition, Pearson Prentice Hall, New Jersey, 2012
3. Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", 12th Edition, Prentice Hall of India, New Delhi, 2011.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Apply managerial approaches and practice managerial roles as demanded by the current environment of the organization	3
CO2	Develop planning process and apply strategies, planning tools and techniques to attain organizational objectives	4
CO3	Apply control techniques to monitor the progress of activities and to take corrective measures accordingly	3
CO4	Evaluate ethical dilemmas in engineering using major ethical frameworks and to recommend solutions that uphold professional and ethical standards.	4
CO5	Recommend ethical courses of action in situations involving teamwork, confidentiality, conflicts of interest, rights of engineers, and whistleblowing.	4

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	1	1	2	1	-	1	1	1	2	2	-	2	-	1
2.	1	2	2	2	2	2	1	1	3	2	-	3	-	2
3.	1	2	2	3	2	2	1	1	3	2	1	3	-	1
4.	-	2	2	1	-	1	2	3	1	1	-	1	-	2
5.	-	-	1	1	-	1	2	3	1	1	1	1	-	2

* 1 – Weak, 2 – Moderate, 3 - Strong

EC22711	PROJECT WORK - PHASE I	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To define, formulate and analyze a real-world problem in the field of ECE.
- To solve complex engineering problems
- To acquire knowledge in terms of the innovation & product design development process of the project work.
- To work independently as well as in teams.
- To manage the project from start to finish.

PROJECT WORK MODALITIES

Students can take up small real world problems in the field of electronics and communication engineering as project. Each student or as a team should conceive, design develop and realize an electronic product. The basic elements of product design - the function ergonomics and aesthetics - should be considered while conceiving and designing the product. It can be related to solution to an engineering problem, verification and analysis of experimental data available, by conducting suitable experiments on various engineering subjects, characterization, studying a software tool for the solution of an engineering problem etc.

The realization of the product should include design and fabrication of PCB. The student should submit a soft bound report at the end of the semester. The product should be demonstrated at the time of examination.

TOTAL: 60 PERIODS

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Identify problems and perform survey on the existing methods	3
CO2	Develop a novel idea and analyze the various implementation issues	3
CO3	Implement the design and develop a prototype	4
CO4	Demonstrate the working module.	4
CO5	Prepare a presentation and a report and explain the project work	5

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	3	3	-	3	3	-	3	3	3
2.	3	3	3	3	3	-	-	-	3	3	3	3	3	3
3.	3	3	3	3	3	3	-	3	3	-	3	3	3	3
4.	3	3	3	3	3	3	3	3	3	-	3	3	3	3
5.	3	3	3	3	3	3	3	3	3	3	3	3	3	3

* 1 – Weak, 2 – Moderate, 3 - Strong

SEMESTER VIII

EC22811	PROJECT WORK - PHASE II	L	T	P	C
		0	0	16	8

COURSE OBJECTIVES:

- To solve complex engineering problems relevant to the society
- To offer students an opportunity to integrate the knowledge gained in various subjects of the degree course.
- To demonstrate their competence in practical courses
- To apply communication skills, both oral and written, to communicate results, concepts and ideas.

PROJECT WORK MODALITIES

The objective of Project Work is to enable the student to take up investigative study in the broad field of Electronics and Communication Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on an individual basis or two/three students in a group, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good initiation and training for the student(s) in R&D work and technical leadership. The assignment to normally include:

1. In depth survey and study of published literature on the assigned topic;
2. Review and finalization of the Approach to the Problem relating to the assigned topic
3. Preparing an Action Plan for conducting the investigation, including team work
4. Working out a preliminary Approach to the Problem relating to the assigned topic and Conducting preliminary Analysis/Modelling/Simulation/Experiment/Design/Feasibility
5. Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed;
6. Final development of product/process, testing, results, conclusions and future directions;
7. Preparing a paper for Conference presentation/Publication in Journals, if possible;
8. Preparing a Dissertation in the standard format for being evaluated by the Department
9. Final Seminar Presentation before a Departmental Committee.

TOTAL: 240 PERIODS

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Identify challenging practical problems and solutions to cope up with present scenario in the field of Electronics and Communication Engineering.	4
CO2	Analyze various methodologies and technologies and discuss with team for solving the problem.	4
CO3	Apply technical knowledge and project management skills for solving the problem.	3
CO4	Design and develop specific hardware and/or software for the project	4
CO5	Conclude concepts, results and analysis in written and oral form.	5

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

*COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	3	3	-	3	3	-	3	3	3
2.	3	3	3	3	3	-	-	-	3	3	3	3	3	3
3.	3	3	3	3	3	3	-	3	3	-	3	3	3	3
4.	3	3	3	3	3	3	3	3	3	-	3	3	3	3
5.	3	3	3	3	3	3	3	3	3	3	3	3	3	3
* 1 – Weak, 2 – Moderate, 3 - Strong														

PROFESSIONAL ELECTIVE COURSES: VERTICALS

VERTICAL 2
WIRELESS SYSTEMS ENGINEERING

EC22021	COGNITIVE RADIO	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the evolution and applications of Cognitive Radio (CR) technologies.
- To gain knowledge on the various methods of Spectrum Sensing, Identification and the associated Trade–offs.
- To learn about Cooperative Communication techniques.
- To provide insights of optimization problem in multihop cognitive radio networks.
- To identify the feasibility of cognitive radio technology for public safety applications.

UNIT I	COGNITIVE RADIO TECHNOLOGY	9

Introduction-Software Defined Radio, Cognitive Radio – Evolution of Cognitive Radio, Spectrum Measurements and Usage- Applications for Spectrum Occupancy Data.

UNIT II	SPECTRUM SENSING AND IDENTIFICATION	9

Primary Signal Detection: Energy Detector, Cyclostationary Feature Detector, Matched Filter, Cooperative Sensing, Definition and Implications of Spectrum Opportunity, Spectrum Opportunity Detection, Fundamental Trade-offs: Performance versus Constraint, MAC Layer Performance - Measures, Global Interference Model, Local Interference Model, Fundamental Trade-offs: Sensing Accuracy versus Sensing Overhead.

UNIT III	USER COOPERATIVE COMMUNICATION	9

User Cooperation and Cognitive Systems, Relay Channels: General Three-Node Relay Channel, Wireless Relay Channel, User Cooperation in Wireless Networks: Two-User Cooperative Network, Cooperative Wireless Network, Multihop Relay Channel.

UNIT IV	CROSS-LAYER OPTIMIZATION FOR MULTIHOP COGNITIVE RADIO NETWORKS	9

Introduction – Mathematical Models at Multiple Layers: Scheduling and Power Control, Routing – Case Study: Throughput Maximization Problem, problem Formulation, Solution Overview, Linear relaxation, Local search Algorithm, Selection of Partition Variables – Numerical results for the Throughput Maximization problem: Simulation Setting, Results and Observation.

UNIT V	PUBLIC SAFETY MEASURES IN COGNITIVE RADIO	9

Introduction- Requirements, Commercial Wireless Communication Networks, Economic Value of the Spectrum, Benefits of Cognitive Radio; Standards for Public Safety Communication- TETRA, C2000; Applications of Cognitive Radio- The Firework Disaster in The Netherlands – A Case Study, Bandwidth Requirements, Spectrum Organization, Propagation Conditions, White Space Assessment, System Spectral Efficiency, Anti Jamming.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Alexander M. Wyglinski, Maziarnekovee, Y. Thomas Hu, “Cognitive Radio Communication and Networks”, Elsevier, 2010.
2. Joseph Mitola III, “Software Radio Architecture: Object-Oriented Approaches to Wireless System Engineering”, John Wiley & Sons Ltd. 2000.

REFERENCES:

1. Thomas W.Rondeau, Charles W. Bostain, "Artificial Intelligence in Wireless communication", ARTECH HOUSE, 2009.
2. Bruce A. Fette, "Cognitive Radio Technology", Elsevier, 2009.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Analyze the application of cognitive radio technology to the different wireless communication standards.	3
CO2	Identify a suitable spectrum sensing and identification scheme and carryout a proper trade–off for a given wireless communication scenario to improve the performance.	3
CO3	Apply user cooperative communication techniques, interference avoiding and controlling techniques to improve the performance of cognitive radio networks.	3
CO4	Analyze the challenges in optimization problem in multihop cognitive networks.	3
CO5	Identify the requirements of public safety applications and apply cognitive radio technology to meet out the same.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	2	3	2	2	-	-	-	-	-	2	-	-	2	3
2.	2	3	3	2	-	-	-	-	-	3	-	-	2	3
3.	3	3	3	3	-	-	-	-	-	3	-	-	2	3
4.	3	3	3	3	2	-	-	-	-	2	-	-	3	3
5.	3	3	3	3	2	-	-	-	-	3	-	-	3	3
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22022	EMERGING WIRELESS TECHNOLOGIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To review challenges in cooperative networks.
- To understand the concept of broadband applications.
- To develop the Internet of Things for 5G applications.
- To understand the specifications of the transceiver.
- To develop applications towards e-Health Care systems.

UNIT I	**TRENDS AND CHALLENGES IN COOPERATIVE NETWORKS**	**9**

Introduction-Cooperative Mesh Networks: Wireless Mesh Networks-Realizing Virtual MIMO-Cooperative in Delay Tolerant Networks: Routing Protocols-Approaches-Incentive Schemes-Game Theory-Other Cooperation Schemes-Wireless Multimedia (4G and Beyond)

UNIT II	**WIRELESS COMMUNICATION AND APPLICATIONS**	**9**

Vehicular Ad-hoc Networks: Communication Modes-Routing Protocols-Security Challenges-Broadband Wireless Technologies: Overview of WiMAX and LTE-Qos Support-Security Challenges-Mobility in LTE Networks-Energy Efficient Routing in Wireless Sensor Networks: Energy Consumption-Classification-Delay Sensitive Applications-Delay Tolerant Applications.

UNIT III	**FUTURE INTERNET SYSTEMS**	**9**

Internet of Things: Enabling Technologies-Connected Object's Communication-SoA Architecture-Communication Issues: Standardization Efforts of the IoT Protocol Stack-Proposed IoT Communication Protocol Stack-Communication within the IoT Ecosystem-Machine to Machine Communication-Architectures-Security in emerging Networks: Basic Concepts-Emerging network Security.

UNIT IV	**ULTRA WIDEBAND TECHNOLOGY**	**9**

Transceiver Specifications: Receiver Sensitivity, Noise Figure, Signal to Noise Ratio-Receiver Linearity and Filter requirements-Transmitter requirements-Synthesizer requirements-RF Receiver Building Blocks: Low Noise Amplifier-Down Converter Mixers-IF/Baseband Filter-RF Transmitter Building Blocks-Fast Hopping Synthesizer-RF Transceivers for MB-OFDM UWB.

UNIT V	**HUMANBODY AREA NETWORKS**	**9**

Growing economic burden of Health care systems-e Health towards proactive and connected health-Body Area Networks: An Enabling e-Health Technology-Ambulatory Multiparameter Monitoring as Test Case-Wireless Communication: UWB Pulse Generator-UWB Analog Receiver-Micropower Generation and Storage-Sensors and Actuators-Integration Technology.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Naveen Chilamkurti, Sherali Zeadally, Hakima Chaouchi, "Next-Generation Wireless Technologies: 4G and Beyond", Springer, 2013.

2. Krzysztof Iniewski, “Wireless Technologies: Circuits, Systems and Devices”, CRC Press, Taylor and Francis Group, 2008.

REFERENCES:

1. Steve Rackley, “Wireless Networking Technology: From Principles to Successful Implementation”, Elsevier, 2007.
2. Upena Dalal, Manoj K Shukla, “Wireless and Mobile Communication”, Oxford University Press, 2016.
3. Arsheep Bahga, Vijay Madisetti, “Internet of Things - A Hands-on Approach”, Orient Blackswan Private Limited, 2015.
4. Sunil Jogi, Manoj Choudhary, “Ultra Wideband Demystified Technologies, Applications, and System Design Considerations”, River Publishers, 2022.
5. R. Maheswar, G. R. Kanagachidambaresan, R. Jayaparvathy, Sabu M. Thampi, “Body Area Network Challenges and Solutions”, Springer, 2018.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Implement routing protocol techniques required for wireless applications.	4
CO2	Perform energy efficient routing algorithms for wireless sensor networks.	3
CO3	Understand the Internet systems for IoT Communication Protocols.	2
CO4	Implement transceiver techniques involved in OFDM applications.	4
CO5	Develop applications towards Body area networks.	3
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	2	2	3	3	-	-	-	1	2	2	3	3
2.	3	2	2	2	3	2	-	-	-	1	2	2	3	3
3.	3	2	1	2	3	2	-	-	-	1	1	2	3	2
4.	3	2	3	2	3	2	-	-	-	1	2	2	3	3
5.	3	2	1	2	2	3	2	-	-	-	2	2	3	2

*1 – Weak, 2 – Moderate, 3 – Strong

EC22023	FREE SPACE OPTICAL COMMUNICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn about the various losses and mitigation in channel concepts.
- To apply the concepts of optical transmitter and receiver configuration in free space communication.
- To study the effects of coherent and non-coherent systems with BER in free space optical communication.
- To analyze the different diversity schemes in link budget analysis performance techniques.
- To apply different channel coding techniques in free space transmission.

UNIT I	**FREE-SPACE OPTICAL CHANNEL MODELS**	**9**

Atmospheric Channel: Atmospheric, Absorption and Scattering Losses, Free-Space Loss, Beam Divergence Loss - Loss due to Weather Conditions, Pointing Loss -Effect of Atmospheric Turbulence on Gaussian Beam -Techniques for Turbulence Mitigation-Aperture Averaging - Hybrid RF/FSO.

UNIT II	**FSO SYSTEM MODULES AND DESIGN ISSUES**	**9**

Optical Transmitter: Modulation Schemes - Optical Receiver: Receiver Configuration, Coherent PSK Homodyne Receiver, Coherent FSK Heterodyne Receiver, Direct Detection (PIN + OA) Receiver for OOK, Direct Detection (APD) Receiver for OOK, Direct Detection (APD) for M-PPM.

UNIT III	**BER PERFORMANCE OF FSO SYSTEM**	**9**

System Model-, BER Evaluation: Coherent Subcarrier Modulation Schemes, Noncoherent Modulation Schemes, On Off Keying, M-ary Pulse-Position Modulation, Differential Amplitude Pulse Position Modulation, Dual header- pulse interval modulation

UNIT IV	**DIVERSITY**	**9**

Diversity - Types of Diversity Techniques: Diversity Combining Techniques, Alamouti's Transmit Diversity Scheme, Two Transmitter and One Receiver Scheme, BER Performance with Spatial Diversity, BER Performance Without Spatial Diversity-Link budget.

UNIT V	**CODING**	**9**

Need of Coding, Channel Capacity, Channel Coding in FSO System, Convolutional, Low Density Parity Check Codes, Adaptive Optics, Relay-Assisted FSO Transmission,

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Hemani Kaushal, V.K. Jain, Subrat Kar, Free Space Optical Communication, , Springer, 2018
2. Olivier Bouchet, Hervé Sizun, Christian Boisrobert, Frédérique de Fornel, Pierre-Noël Favennec, Free-Space Optics: Propagation and Communication, WILEY, 2010,

REFERENCES:

1. Principles and Applications of Free Space Optical Communications (Telecommunications) IET – 18 July 2019
2. A. Arockia Bazil Raj, De Gruyter Oldenbourg, Free Space Optical Communication: System Design, Modeling, Characterization and Dealing with Turbulence, 2015
3. Saleh Faruque, Free Space Laser Communication With Ambient Light Compensation, Springer, 2021

COURSE ARTICULATION MATRIX

*COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
2.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
3.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
4.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
5.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22024	INTELLIGENT COMMUNICATION NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the key insights of carrier networks, challenges of cellular network operations, and the requirements for future network moving into cloud.
- To provide exposure to various wired network virtualization technologies and Wireless Virtualization.
- To provide extensive survey over existing NFV technologies.
- To review various SDN technology and business drivers, high-level SDN architecture and principles.
  To implement case studies of NFV in the next generation 5G networks.

UNIT I	**INTRODUCTION TO INTELLIGENT COMMUNICATION NETWORKS**	**9**

Cloud-enabled 5G: Software Defined Network (SDN) and Network Function Virtualization (NFV) – Benefits and Challenges, Supporting technologies – Cloud computing, Network virtualization, Network functions Virtualization and Software-Defined networking.

UNIT II	**VIRTUALIZATION AND CLOUD COMPUTING**	**9**

Cloud computing – Architecture types of clouds & Challenges; Host virtualization – Overview, virtualization techniques & containers; Network virtualization – Overlay networks, Virtual private networks, Virtual sharing networks, Switch-based SDN Virtualization, Host-based network Virtualization and Wireless virtualization.

UNIT III	**NETWORK FUNCTION VIRTUALIZATION**	**9**

NFV – Architecture, Use Cases, Challenges, Orchestration; NF Modelling – Source code based modelling, Black box modeling & Modeling applications and VNF placement.

UNIT IV	**SOFTWARE-DEFINED NETWORKS PRINCIPLES AND APPLICATIONS**	**9**

SDN Overview – Motivations, Architecture & Use cases; SDN controller – Controller deployment choices & Apps on SDN controller; SDN data plane; SDN management; SDN security attack prevention and SDN traffic engineering.

UNIT V	**SDN AND NFV IN 5G NETWORK**	**9**

5G Overview; Service function chaining – Openflow based SFC solution, SFC monitoring, Optical SFC & Verification of service function chaining; Core network functions and virtualizations: vEPC and Virtualized Customer Premises Equipment.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ying Zhang, Network Function Virtualization – Concepts and Applicability in 5G Networks, Wiley Publications, 2018.

REFERENCES:

1. Rajkumar Buyya, James Broberg and Andrzej M.Goscinski, "Cloud Computing: Principles and Paradigms", Wiley Publications, 2011.
2. Rajendra Chayapathi, Syed Hassan and Paresh Shah, "Network Functions Virtualization (NFV) with a touch of SDN", Prentice Hall, 2016.
3. Mathew Portnoy, "Virtualization Essentials", 3rd edition, Wiley Publications, 2023.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Learn the various challenges in the cellular network operations and future networking model.	3
CO2	Acquire knowledge in wired and wireless virtualization technologies	3
CO3	Analysis over the existing NFV technologies	3
CO4	Understand about high level SDN architecture and technology	2
CO5	Acquire knowledge on various case studies of NFV in the next generation 5G Networks	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	-	-	-	-	-	-	-	-	-	2	3
2.	3	3	2	-	-	-	-	-	-	-	-	-	2	3
3.	3	3	2	-	-	-	-	-	-	-	-	-	2	3
4.	3	3	2	-	-	-	-	-	-	-	-	-	2	3
5.	3	3	2	-	-	-	-	-	-	-	-	-	2	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

\\

EC22025	MOBILE TECHNOLOGIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic concepts of a cellular network.
- To learn the different types of radio propagation models.
- To illustrate the architecture of 3G mobile technologies.
- To characterize and analyze the concepts of emerging technologies for 4G standards.
- To gain knowledge about the 5G technology.

UNIT I	**FUNDAMENTALS OF MOBILE TECHNOLOGIES**	**9**

Introduction to Wireless Communication: Mobile Radio Telephony, Examples of Wireless Communication Systems, The Cellular Concept System Design Fundamentals: Frequency reuse, Channel assignment strategies, Interference and system capacity, Trunking and Grade of service, Improving Coverage and Capacity in Cellular Systems and related problems.

UNIT II	**MOBILE RADIO PROPAGATION**	**9**

Small scale fading: Small-scale multipath propagation, parameters of mobile multipath channels, types of small-scale fading, Rayleigh and Ricean distributions.

Features of all conventional multiple access techniques: Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Space Spectrum Multiple Access (SSMA), Space Division Multiple Access (SDMA), Orthogonal Frequency Division Multiple Access (OFDMA), OFDM-PAPR.

UNIT III	**3G TECHNOLOGIES**	**9**

UMTS: Objectives, standardization and releases, network architecture, air interface specifications, channels, security procedure, W-CDMA air interface, attributes of WCDMA system, W-CDMA channels.

Cdma 2000 cellular technologies: Forward and Reverse Channels, Handoff and Power Control.

UNIT IV	**ADVANCED TECHNIQUES FOR 4G DEPLOYMENT**	**9**

Multi-antenna Techniques: Smart antennas, Multiple input Multiple output systems. Cognitive radio: Architecture, spectrum sensing. Software Defined Radio (SDR): Components and Applications. Introduction to 5G network and technologies used in 5G such as small cell concept, (Massive MIMO, Beamforming, NOMA, and mm wave).

UNIT V	**5G AND BEYOND**	**9**

Wireless energy harvesting: Energy-rate trade-off Simultaneous wireless information and power transfer (SWIPT), time-switching, power splitting Wireless powered communication networks Outage probability and throughput.

Machine learning applications: Channel modeling and estimation Spectrum sensing and sharing Resource allocation (NOMA, mmWave massive MIMO).

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Theodore S. Rappaport “wireless communications - principles and practice”, PEARSON, Second edition updated, 2024.
2. Andreas F. Molisch “wireless communications” WILEY INDIA PVT LTD, Second edition, 2021.
3. R. Vannithamby and S. Talwar, Towards 5G: Applications, Requirements and Candidate Technologies., John Willey & Sons, West Sussex, 2017.

REFERENCES:

1. Vijay K.Garg “Wireless Communications and Networking” ,Morgan–Kaufmann series in Networking-Elsevier, 2007
2. Travis F. Collins Robin Getz, Di Pu, Alexander M. Wyglinski “Software-Defined Radio for Engineers”, Engineering, Computer science, 2018.
3. Andrea Goldsmith “Wireless Communications” Stanford University, 2020.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Distinguish and understand the cellular fundamentals and estimate the coverage and capacity of cellular systems.	4
CO2	Classify different types of propagation models and analyze the link budget	3
CO3	Apply the concepts of 3G technologies for UMTS and CDMA 2000.	3
CO4	Discuss the emerging 4G technologies for upcoming mobile communication systems.	4
CO5	Apply energy harvesting schemes and machine learning applications in 5G and beyond wireless technologies.	3
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	2	3	1	2	2	2	1	-	3	2	2	2
2.	3	2	2	3	2	3	3	3	-	-	3	3	2	2
3.	2	3	3	2	1	1	1	1	-	-	1	1	2	2
4.	3	3	3	3	3	1	2	2	1	-	1	1	2	1
5.	2	2	2	2	1	3	2	3	2	-	3	3	1	1

* 1 – Weak, 2 – Moderate, 3 – Strong

EC22026	MULTIMEDIA COMMUNICATION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To examine the essential principles of multimedia communication techniques and their diverse applications.
- To explore various text and image compression techniques.
- To investigate various audio compression techniques.
- To analyze the video compression standards and its applications.
- To apply the different networking aspects with reference to multimedia transmission.

UNIT I	**MULTIMEDIA COMMUNICATIONS**	**9**

Introduction, multimedia information representation, multimedia networks, multimedia applications, Application and networking terminology, QoS, Digitization principles,. Text, images, audio and video.

UNIT II	**TEXT AND IMAGE COMPRESSION**	**9**

Text and image compression, compression principles, text compression- Run Length, Huffman, LZW, Document Image compression using T2 and T3 coding, image compression Standards.

UNIT III	**AUDIO COMPRESSION**	**9**

Audio and video compression, audio compression – DPCM-Adaptive PCM –adaptive predictive coding-Linear predictive coding, Code-Excited LPC, Perceptual coding, MPEG and Dolby coders

UNIT IV	**VIDEO COMPRESSION**	**9**

Video compression principles. Video compression standards: H.261, H.263, MPEG, MPEG 1, MPEG 2, MPEG-4

UNIT V	**MULTIMEDIA COMMUNICATION ACROSS NETWORKS**	**9**

Multimedia networking, applications-streamed stored audio and audio-making the best effort service, scheduling and policing Mechanisms-integrated services-differentiated Services-RSVP

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Fred Halsall, “Multimedia Communications”, Pearson education,2007.
2. Raif Steinmetz, Klara Nahrstedt, “Multimedia: Computing, Communications and Applications”, Pearson education, Second edition ,2004.
3. Kalid Sayood, “Introduction to Data Compression”, Margan Kaufmann, 2005

REFERENCES:

1. K. R. Rao, Zoran S. Bojkovic, Dragorad A. Milovanovic, “Multimedia Communication Systems”, Pearson education, 2004.
2. John Billamil, Louis Molina, “Multimedia : An Introduction”, PHI, 2002.
3. Ranjan Parekh ―Principles of Multimedia, Tata Mc Graw Hill, 2006.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT* Level**
CO1	Comprehend the Principles of Multimedia Communication.	3
CO2	Apply image and text compression techniques to real world applications.	3
CO3	Apply audio compression techniques to real world applications.	3
CO4	Analyze different Video compression tools and evaluate its performance.	4
CO5	Develop the real-time multimedia network applications.	4
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	1	-	2		2	-	-	-	-	-	-	2	-
2.	3	1	2	-	-	-	-	-	-	-	-	-	2	-
3.	3	1	2	-	-	-	-	-	-	-	-	-	2	-
4.	3	1	2	3	-	-	-	-	-	-	-	-	2	1
5.	3	1	2	3	-	2	-	-	-	-	-	-	2	1
1- Weak; 2 - Moderate; 3 - Strong.														

EC22027	RADIO OVER FIBER SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basics of Radio over Fiber.
- To learn about RoF architecture for Broadband systems.
- To enrich knowledge about the lasers and amplifiers required for RoF links.
- To analyze different candidate architectures for future broadband networks.
- To develop various deployment scenarios for access networks.

UNIT I	**INTRODUCTION TO RADIO OVER FIBER**	**9**

Introduction-The Concept of a Radio over Fiber System-Categories of Radio over Fiber Systems: Types of Transport, Modulation, Subcarrier Multiplexing, mmWave over Fiber systems-Performance of Radio over Fiber Systems-Applications of Radio over Fiber Technology.

UNIT II	**ROF SYSTEM DESIGN FOR DBWS**	**9**

Distributed Broadband Wireless Systems (DBWS) Architecture Elements-Physical Elements of the DBWS Radio over Fiber Link Design Issues-Link Architecture-Optical Source and Receiver Types-Link Budget Calculations-EVM Measurements-Wireless Range Calculations.

UNIT III	**LASERS FOR ROF APPLICATIONS**	**9**

Basics of Semiconductor Lasers and Reflective SOAs-Distributed Feedback Laser-Specifications of Semiconductor Lasers: Laser Static Characteristics, RIN Measurements, Modulation Bandwidth, Linearity-Applications of DFB Lasers in RoF Systems-RSOA Characteristics for a RoF Link.

UNIT IV	**ARCHITECTURES FOR FUTURE WIRELESS NETWORKS**	**9**

Wavelength Allocation Plans - Multiplexing Schemes-Candidate Architectures: Separate Up and Downlink Wavelengths, Shared Downlink Wavelengths, Single CWDM Channel, Broadcast and Select, Reflective RAUs, Comparison of candidate architectures-Power-Loss budget analysis.

UNIT V	**ENABLING TECHNOLOGIES**	**9**

RoF vs. R&F technologies-Evolution of Services in Advanced Access Technologies-RoF testbed - Deployment Models-Greenfield Deployment-Evolution from Existing Legacy Wireless Systems-Challenges and open issues.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Martin Maier, Navid Ghazisaidi, "Hybrid Communication Systems for future 6G and Beyond: Visible Light Communication and Radio Over Fiber Technology," Wiley, IEEE Press, 2024.
2. Nikola Zlatanov, "Semiconductor Processing, Power Distribution, Equipment Safety and Laser Applications," Kindle Edition, 2017.
3. Shivika Rajpal, Monika Rani Rakesh Goyal, "Radio-Over-Fiber Technology Based Integrated Optical Wireless Networks," LAMBERT Academic Publishing, 2017.

REFERENCES:

1. Hans-Joerg Thiele, Marcus Nebeling, "Coarse Wavelength Division Multiplexing Technologies and Applications," CRC Press, 2020
2. A.Miller, D.M.Finlayson, "Laser Sources and Applications", CRC Press, 2020.
3. Vincent J.Urick Jr, Jason D.McKinney, Keith J.Williams, "Fundamentals of Microwave Photonics," Wiley Series in Microwave and Optical Engineering, 2015.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Explain the basic concepts and categories of Radio over Fiber networks.	3
CO2	Analyze the physical design and architecture for DBWS.	3
CO3	Investigate the various types and characteristics of lasers for RoF applications.	3
CO4	Compare the performance of different deployment categories for future wireless networks.	4
CO5	Evaluate the challenges involved for evolving from existing wireless systems.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	3	2	2	-	-	-	-	2	-	3	3	3
2.	3	2	3	2	2	-	-	-	-	2	-	3	3	3
3.	3	2	3	2	2	-	-	-	-	2	-	3	3	3
4.	3	2	3	2	2	-	-	-	2	2	-	3	3	3
5.	3	2	3	2	2	-	-	-	2	2	-	3	3	3
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22028	SATELLITE COMMUNICATION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide an insight of communication using satellites and its launching procedures.
- To give thorough understanding and evaluation of the space and ground segment that makes the satellite system.
- To analyse the uplink and downlink behavior and work out link budget.
- To analyse the access techniques of satellites through FDMA, TDMA and CDMA and develop satellite based system design.
- To identify the different areas in which satellite systems are applied and enhance the applications.

UNIT I	**SATELLITE ORBITS**	**9**

Kepler's Laws, Newton's law, orbital parameters, orbital perturbations, geo stationary vs Geo-synchronous orbits – Look Angle Determination- Limits of visibility –Eclipse-Sub satellite point – Sun transit outage-Launching Procedures, Launching system & launching pad.

UNIT II	**SPACE SEGMENT AND EARTH SEGMENT**	**9**

Spacecraft subsystems- Primary power, Attitude and Orbit control, communication subsystem, Telemetry, Tracking and command, Antenna subsystem, System reliability and design lifetime. **Earth segment -** Receive – Only home TV systems – Outdoor unit – Indoor unit for analog (FM) TV – Master antenna TV system – Community antenna TV system – Transmit – Receive earth stations – Problems

UNIT III	**SATELLITE LINK DESIGN**	**9**

Free-space transmission –Transmission losses–Noise– Carrier to- Noise ratio – Satellite uplink and downlink Analysis and Design, Link power budget equation, E/N calculation, Effects of rain – Fade margin – Combined uplink and downlink C/N ratio – Performance impairments.

UNIT IV	**SATELLITE ACCESS AND SYSTEMS**	**9**

Modulation and Multiplexing: Voice, Data, Video, Analog – digital transmission system, multiple access: FDMA, TDMA, CDMA, ATM over Satellite, Satellite Links and TCP, Split TCP Connections.

UNIT V	**SATELLITE APPLICATIONS**	**9**

INTELSAT Series, INSAT, VSAT, Mobile satellite services: GSM, GPS, INMARSAT, LEO, MEO, Satellite Navigational System. Direct Broadcast satellites (DBS)- Direct to home Broadcast (DTH), Digital video Broadcast(DVB), Digital audio broadcast (DAB)- Worldspace services, Business TV(BTV), GRAMSAT, Specialized services – E –mail, Video conferencing, Internet.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Dennis Roddy, "Satellite Communication", 4th Edition, Mc Graw Hill International, 2017.
2. Timothy Pratt, Charles Bostian and Jeremy Allnutt, "Satellite Communications", Wiley India, 3rd Edition, 2021.

3. Tri.T.Ha, “Digital Satellite Communication”, McGraw Hill, 2nd Edition, 2017.

REFERENCES:

1. Wilbur L.Pritchard, Hendri G. Suyderhoud, Robert A. Nelson, “Satellite Communication Systems Engineering”, Prentice Hall/Pearson, 2013.
2. Bruce R. Elbert, “The Satellite Communication Applications”, Hand Book, Artech House Bostan London, 2003.
3. M.Richharia, “Satellite Communication Systems-Design Principles”, Macmillan 2003

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Explain the various terms and parameters of satellites and develop equations of orbit to locate satellite in space.	2
CO2	Categorise and recognise the significance of various satellite subsystems and ground segment.	2
CO3	Identify the various aspects involved in satellite communication link and measure link budget.	3
CO4	Classify and grade the varied multiple access techniques and develop enhanced satellite based systems.	3
CO5	Develop various satellite based applications.	3
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	2	2	3	-	-	-	-	-	-	2	-	1	3	-
2.	2	2	3	-	-	-	-	-	-	2	-	1	3	-
3.	2	2	3	-	-	-	-	-	-	2	-	1	3	-
4.	2	2	3	-	-	-	-	-	-	2	-	1	3	-
5.	2	2	3	-	-	-	-	-	-	2	-	1	3	-

* 1 – Weak, 2 – Moderate, 3 - Strong

EC22029	NEXT GENERATION MOBILE NETWORKS – 5G	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the next generation mobile networks and their need
- To provide overview of Internet on 5G networks
- To introduce mobile cloud for next generation mobile networks
- To provide insights on wireless spectrum crunch
- To know the security issues related to 5G networks

UNIT I	**DRIVERS FOR 5G**	**9**

Introduction- Evolution of LTE Technology to Beyond 4G, 5G Roadmap, 10 Pillars of 5G, 5G in Europe, 5G in North America, 5G in Asia, 5G Architecture, Small cells -WiFi and Femto Cells for 5G

UNIT II	**THE 5G INTERNET**	**9**

Introduction, Internet of Things and Context‐Awareness; Networking Reconfiguration and Virtualisation Support; Mobility; Quality of Service Control, Emerging Approach for Resource Over‐Provisioning, Green Inter-Networking experience and a vision for 5G mobile

UNIT III	**MOBILE CLOUD AND COGNITIVE RADIO FOR NEXT GENERATION MOBILE NETWORKS**	**9**

Mobile Cloud, Mobile Cloud Enablers, Spectrum Optimization using Cognitive radio, Spectrum Optimization in 5G, Cognitive Radio and Carrier Aggregation, Energy Efficient Cognitive Radio Technology, Key requirements and Challenges for 5G Cognitive Terminals

UNIT IV	**WIRELESS SPECTRUM CRUNCH**	**9**

Introduction, Background, TV White Space Technology, White Space Spectrum Opportunities and Challenges, TV White Space Applications, Internationals Efforts, Roles of WS in 5G

UNIT V	**EVOLUTION OF SON AND SECURITY FOR 5G NETWORKS**	**9**

Introduction; SON in UMTS and LTE; The Need for SON in 5G, New SON Architecture for 5G; Security Issues and Challenges in 5G Communications Systems- User Equipment, Access Networks, Mobile Operator's Core Network, External IP Networks

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Jonathan Rodriguez, "Fundamentals of 5G Mobile Networks", Wiley 2015
2. Jyh-Cheng Chen and Tao Zhang, "IP-Based Next-GenerationWireless Networks Systems, Architectures, and Protocols," John Wiley & Sons, Publication, 2006

REFERENCES:

1. Zhang, Yin, Chen, Min, "Cloud Based 5G Wireless Networks", Springer, 2016
2. http://ieeexplore.ieee.org/document/7414384/
3. http://ieeexplore.ieee.org/document/7794586/

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Identify the driving force for 5G networks	4
CO2	Differentiate the internet used in 5G and the previous generations	4
CO3	Investigate the effects of wireless spectrum crunch	4
CO4	Examine the services of mobile cloud and cognitive radio for future mobile networks.	4
CO5	Analyse the self organisation networks and security issues related to 5G networks	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
2.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
3.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
4.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
5.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22020	MINI PROJECT	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To describe, structure, and examine a complex engineering problem solving in the field of wireless communications domain.
- To solve the problems independently or as part of a team.
- To acquire knowledge in terms of the innovation & product design development process of the project work.
- To work independently as well as in teams.
- To manage the project from start to finish.

PROJECT WORK MODALITIES

Students can take up small real world problems in the field of wireless communication as mini project. Each student or as a team should conceive, design develop and realize an electronic product. The basic elements of product design - the function ergonomics and aesthetics - should be considered while conceiving and designing the product. It can be related to solution to an engineering problem, verification and analysis of experimental data available, by conducting suitable experiments on various engineering subjects, characterization, studying a software tool for the solution of an engineering problem etc. The realization of the product should include design and fabrication/simulation. The student should submit a soft bound report at the end of the semester. The product should be demonstrated at the time of examination.

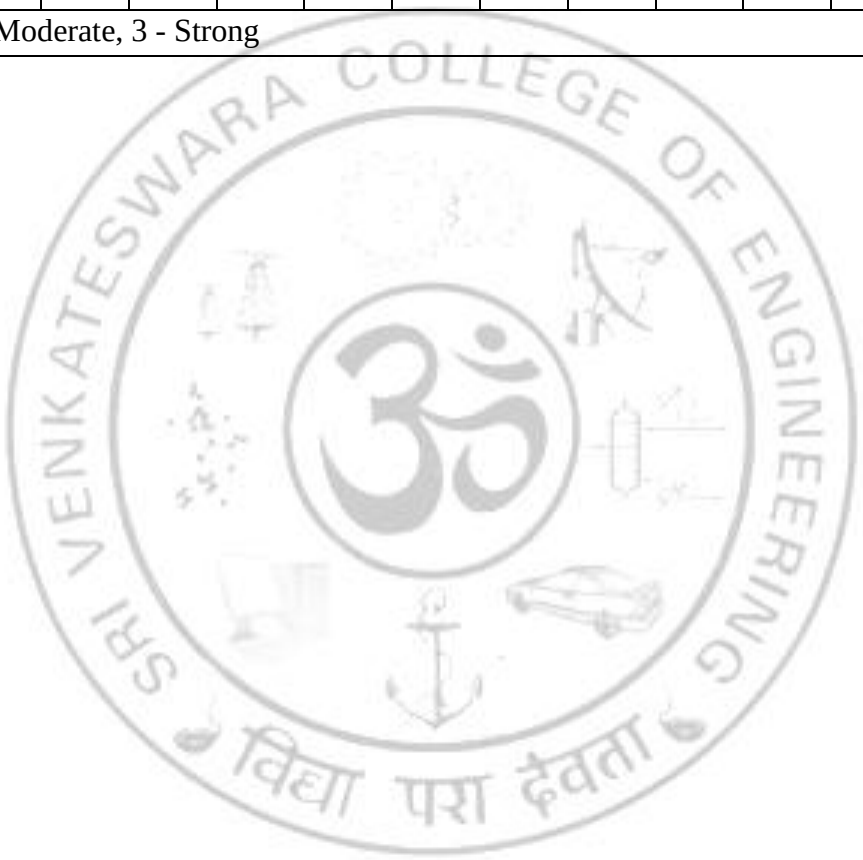
TOTAL: 60 PERIODS

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Identify problems and perform survey on the existing methods	4
CO2	Develop a novel idea and analyze the various implementation issues	5
CO3	Implement the design and develop a prototype/simulation module	3
CO4	Demonstrate the working module.	3
CO5	Prepare a presentation and a report to explain the project work	3

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

*COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2.	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3.	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4.	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5.	3	3	3	3	3	3	3	3	3	3	3	3	3	3
* 1 – Weak, 2 – Moderate, 3 - Strong														



VERTICAL 3
ANTENNA AND MICROWAVE TECHNOLOGY

EC22031	ANTENNA THEORY AND DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the basic concepts of antenna.
- To discuss the analytical models of microstrip patch antenna.
- To introduce the concepts of smart antennas.
- To understand and analyse the recent special antennas.
- To discuss the different types of propagation mechanisms and measurement techniques.

UNIT I	**ANTENNA FUNDAMENTALS**	**9**

Radiation Mechanism of Antenna, Types of Antenna, Antenna terms and parameters, Radiation from Half wave dipole. Monopole antenna and loop antenna.

UNIT II	**ANALYTICAL MODELS OF MICROSTRIP ANTENNAS**	**9**

Transmission Model- Simple Transmission Line Model, Transmission Line Model with Mutual Coupling, Cavity Model - Generalized Cavity Model, Multiport Network Model, Radiation Fields, Aperture Admittance, Aperture Conductance, Edge Susceptance, Mutual Admittance, Mutual Conductance, Mutual Susceptance, Comparison of Analytical Models.

UNIT III	**SMART ANTENNAS**	**9**

Introduction, Need for Smart Antenna, Smart Antenna Configuration- Switched- Beam Antennas, Adaptive Antenna Approach, Space Division Multiple Access (SDMA), Architecture of a Smart Antenna System- Receiver and Transmitter, Benefits and Drawbacks, N-element Smart Antenna- Mutual Coupling Effects.

UNIT IV	**SPECIAL ANTENNAS**	**9**

Spiral antenna, Helical antenna, Log periodic, Yagi antenna-Design, Modern antennas- Reconfigurable antenna, Reflect array antenna, Electronic band gap (EBG) antennas, MIMO Antenna

UNIT V	**ANTENNA MEASUREMENTS AND PROPAGATION**	**9**

Antenna Measurements- Measurement of Gain and Radiation pattern. Modes of propagation, Ground wave propagation, Tropospheric propagation, Duct propagation, Sky wave propagation – Virtual height, Critical frequency, Maximum usable frequency, Skip distance, Fading, Multi hop propagation.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. John D Kraus,"Antennas for all Applications", 3rd Edition, Mc Graw Hill, 2016.
2. Constantine.A.Balanis, "Antenna Theory Analysis and Design", Wiley Student Edition, 2016.
3. Constantine.A.Balanis, Panayiotis I.Ioannides, "Introduction to Smart Antennas-Synthesis Lecture on Antennas", 2007.

REFERENCES:

1. W.L.Stutzman and G.A.Thiele, ―Antenna Theory and Design, John Wiley & Sons, 22 May 2012 - Technology & Engineering.
2. S. Drabowitch, "Modern Antennas" Second Edition, Springer Publications, 2007.
3. Robert S.Elliott "Antenna Theory and Design" Wiley Student Edition, 2006.
4. R.E.Collin,"Antennas and Radio-wave Propagation", McGraw Hill, December 2013.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Describe the basics of antenna and its parameters.	2
CO2	Assess the various analytical models of microstrip patch antennas.	3
CO3	Understand the need and applications of Smart antennas.	2
CO4	Show the recent special antennas and its analysis.	3
CO5	Analyze the different types of propagation mechanisms at different frequencies.	3

Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	1	1	3	1	-	2	1	1	-	2	-	1	2	-
2.	1	1	3	1	-	2	1	1	-	2	-	1	2	-
3.	1	1	3	1	-	2	1	1	-	2	-	1	2	-
4.	1	1	3	1	-	2	1	1	-	2	-	1	2	-
5.	1	1	3	1	-	2	1	1	-	2	-	1	2	-

* 1 – Weak, 2 – Moderate, 3 - Strong

EC22032	ANTENNAS FOR WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To recommend reconfigurable techniques for system design based on requirements and constraints.
- To demonstrate in-depth learning on various techniques to realize polarization reconfigurable printed antennas
- To investigate the polarization/pattern reconfigurable compact MIMO antennas for next-generation wireless devices
- To acquire competence in analyzing phase shifting techniques for beam control in oscillators
- To examine challenges and applications of adaptive antennas through system-level analysis

UNIT I	PRINCIPLES AND TYPES OF RECONFIGURABILITY	9

Principle of Reconfigurability, Electronic Reconfiguration, Mechanical Reconfiguration, Optical Reconfiguration, Material Reconfiguration, Advantages and Disadvantages of Different Reconfiguration Techniques-Frequency Reconfigurable Antennas, Polarization Reconfigurable Antennas, Radiation Pattern Reconfigurable Antennas, Compound Reconfigurable Antennas.

UNIT II	POLARIZATION RECONFIGURABLE PASSIVE AND ACTIVE PLANAR ANTENNAS	9

Basis of Polarization, Reconfigurable Microstrip Patch Antenna with Switchable Polarization-Stub Loaded Microstrip Patch Planar Antenna and Corner Truncated Microstrip Patch Planar Antenna, Polarization Reconfigurable Slot Antennas, Polarization Reconfigurable Active Planar Antennas - Active Antenna with a Symmetrically Coupled Passive Radiator and an Asymmetrically Coupled Passive Radiator.

UNIT III	RECONFIGURABLE MIMO ANTENNAS	9

Reconfigurable Antennas for MIMO Applications, Isolation Techniques in MIMO Antennas-Decoupling Network, Neutralization Lines, Using Artificial Material, Defected Ground Plane, Pattern Diversity Scheme, Reconfigurable Polarization MIMO Antenna, MIMO Antenna Performance Parameters-Envelope Correlation Coefficient (ECC), Total Active Reflection Coefficient (TARC), Mean Effective Gain (MEG)

UNIT IV	5G SILICON RFICs-BASED PHASED ARRAY ANTENNAS	9

Silicon Beamformer Technology, LO-Based Phase Shifting, IF- Based Phase Shifting, RF-Based Phase Shifting, Ku-Band Phased Arrays Utilizing Silicon Beamforming Chipsets, Ku-Band Phased Arrays on ROHACELL Utilizing Silicon Beamforming Chipsets, Ku-Band Phased Arrays with Wide Axial Ratios Utilizing Silicon Beamforming Chipsets.

UNIT V	ADAPTIVE ANTENNAS	9

Basic Architecture of an Adaptive Array Antenna, Adaptive Beamforming, Adaptive Antenna Applications-Spatial Filtering for Interference Reduction, Space Division Multiple Access, Multiple Input Multiple Output (MIMO) Systems, Optimum Combining - Formulation, Steering Vector for Uniform Linear Array, Steering Vector for Arbitrary Element Positions, Adaptive Antenna Channel Parameters.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Shiban Kishen Kou1, Rajesh K. Singh, “Reconfigurable Active and Passive Planar Antennas for Wireless Communication”, Signals and Communication Technology, Springer, 1st Edition, 2022.
2. Satish K. Sharma and Jia-Chi S. Chieh, “Multifunctional Antennas and Arrays for Wireless Communication Systems”, John Wiley & Sons, Inc. IEEE Press, 1st Edition, 2021.
3. Simon R. Saunders, & Alejandro Arago N-Zavala, “Antennas And Propagation For Wireless Communication Systems”, John Wiley & Sons Ltd, 2nd Edition, 2007.
4. Dr.FrankGustrau, Dr.Dirk Manteuffel, “EM Modeling of Antennas and RF Components for Wireless Communication Systems”, Springer, 1st Edition, 2006.

REFERENCES:

1. Constantine A. Balanis, "Modern Antenna Handbook", A John Wiley & Sons Inc., Publication, 1st Edition, 2008
2. Thomas A. Milligan, "Modern Antenna Design", IEEE Press, Wiley-lnterscience, 2nd Edition, 2005.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Compare reconfigurability techniques in various communication modules in line with the design requirements	5
CO2	Evaluate polarization reconfigurable antennas using different techniques	5
CO3	Analyze isolation enhancement techniques and performance of reconfigurable MIMO antennas.	4
CO4	Assess beamforming technologies and formulate techniques for phased and reflect arrays.	5
CO5	Analyze architectural designs, adaptive signal processing algorithms, and key channel/system parameters for smart antenna arrays.	4

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	1	1	3	1	2	-	-	-	-	-	-	-	2	2
2.	3	2	2	2	2	-	-	-	-	-	1	-	3	3
3.	3	2	3	2	2	-	-	-	-	-	1	-	3	2
4.	3	2	2	3	2	-	-	-	-	-	1	1	3	3
5.	3	2	1	3	2	-	-	-	-	-	1	1	2	2

* 1 – Weak, 2 – Moderate, 3 - Strong

EC22033	COMPUTATIONAL ELECTROMAGNETICS WITH EM SIMULATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To apply the mathematical methods for lines and waveguide problems.
- To analyze the variational concepts to solve the electromagnetic problems.
- To analyze the usage of the method of moments in computational electromagnetics.
- To analyze the applicability of Finite Element Method for EM problems.
- Analysis of electromagnetic problems for practical applications using finite volume method.

UNIT I	**FINITE DIFFERENCE METHOD (FDM)**	**9**

Finite Differencing of Parabolic PDEs, Finite Differencing of Hyperbolic PDEs, Finite Differencing of Elliptic PDEs, Band Matrix Method, Accuracy and Stability of FD Solutions, Wave Scattering analysis using FDTD, Yees Finite Difference Algorithm, Practical Applications: Guided Structures - Transmission Lines, Waveguides,

UNIT II	**VARIATIONAL METHODS**	**9**

Background, Calculus of Variations, Rayleigh-Ritz Method, Method of Weighted Residuals Galerkin Method, Functional from PDE, Practical Applications.

UNIT III	**METHOD OF MOMENTS (MOM)**	**9**

Integral Equations, Connection Between Differential and Integral Equations, Galerkin Method Integral Equation, Integral Equation to Matrix Form, Transformation to Matrix Equation Discretization, Evaluation of Matrix Elements, Solution of the Matrix Equation, Pocklington Integral Hallen Integral Convergence Comparison, Antenna Example.

UNIT IV	**FINITE ELEMENT METHOD (FEM)**	**9**

Typical finite elements, Solution of Laplaces Equation, FEM from Weighted Residuals Formulation (Basis Function, Mapping), Poisson Equation, Time Domain FEM (FETD), Three Dimensional Elements, Finite Element Methods for Exterior Problems, Boundary Element Method.

UNIT V	**FINITE VOLUME METHOD (FVM)**	**9**

Motivation and Background, Background Derivation of Eigenvalue Equation, Discretization Maxwell Equation, Flux Calculation: Gudnov, MUSCL, Central Flux,Truly Upwind Scheme, Geometrical Reconstruction, Practical Applications.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Matthew N.O.Sadiku, “Numerical Techniques in Electromagnetics with MATLAB,” CRC Press, Third Edition, 2018.
2. BharathiBhat,Shiban K.Koul, “Stripline-Like Transmission Lines for Microwave Integrated Circuits”, New Age International, 2007.
3. Dragan Poljak, “Advanced Modeling in Computational Electromagnetic Compatibility”, Wiley, 2007
4. David B. Davidson, “Computational Electromagnetics for RF and Microwave Engineering”, Cambridge, Second Edition, 2010.

REFERENCES:

1. Bondeson,A., Rylander, T., Ingelstrm,P. Computational Electromagnetics, Springer, 2013.
2. Jian-Ming Jin, "Theory and Computation of Electromagnetic Fields", Wiley IEEE Press, Second Edition, 2015.
3. Silvester and Ferrari, "Finite Elements for Electrical Engineers", Cambridge, Third Edition, 1996.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Analyze various EM problems using Finite Difference Methods.	4
CO2	Understand and apply different variational methods.	3
CO3	Construct various Moment methods for the analysis of EM equations.	3
CO4	Apply different Finite Element Method for EM problems.	3
CO5	Illustrate different Finite Volume Methods for various EM problems.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	1	3	-	-	-	-	-	-	2	2	1
2.	3	3	2	2	3	-	-	-	-	-	-	2	2	1
3.	3	2	2	2	3	-	-	-	-	-	-	2	2	1
4.	3	2	2	1	3	-	-	-	-	-	-	2	2	1
5.	3	2	2	1	3	-	-	-	-	-	-	2	2	1
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22034	EMI/EMC PRE COMPLIANCE TESTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the principles of Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC).
- To explore the various coupling mechanisms related to EMI.
- To explain various techniques and components used for mitigating EMI in electronic systems.
- To study the various emission immunity levels for different electronic circuits and optimize its performance.
- To impart knowledge on methods and standards used for testing.

UNIT I	EMI/EMC CONCEPTS	9

Electromagnetic Interference (EMI), Electromagnetic Compatibility (EMC)-Definitions, Sources and victims of EMI, Conducted and radiated EMI emission and Susceptibility, Case Studies: Radiation hazards to humans.

UNIT II	EMI COUPLING PRINCIPLES	9

Conducted, radiated and transient coupling, Common ground impedance coupling, Common mode and ground loop coupling, Differential mode coupling, Near field cable to cable coupling, Field to cable coupling, Power mains and Power supply coupling, Transient EMI, Electrostatic Discharge (ESD).

UNIT III	EMI MITIGATION TECHNIQUES	9

Shielding, EMI Filters, Grounding, Bonding, Isolation transformer, Transient suppressors, EMI suppression in cables.

UNIT IV	EMC DESIGN FOR CIRCUITS AND PCBS	9

Noise from Relays and Switches, Nonlinearities in Circuits, Crosstalk in transmission line and cross talk control, Component selection and mounting, PCB trace impedance, Routing, Power distribution decoupling, Zoning, Grounding and Terminations.

UNIT V	EMI MEASUREMENTS AND STANDARDS	9

Open area test site, Transverse Electromagnetic (TEM) cell, EMI test shielded chamber and shielded ferrite lined anechoic chamber, Line impedance, stabilization networks, EMI receiver and spectrum analyzer, Civilian standards - CISPR, FCC, IEC, EN and Military standards-MIL461E/462.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Tim Williams, "EMC for Product Designers", 5th Edition, Newnes Elsevier, 2017.
2. V.P.Kodali, "Engineering Electromagnetic Compatibility Principles, Measurements and Technologies and Computer Models", 2nd Edition, Wiley-IEEE Press, 2010.
3. Henry W.Ott., "Noise Reduction Techniques in Electronic Systems", 2nd Edition, A Wiley Inter Science Publications, John Wiley and Sons, 1988.

REFERENCES:

1. C.R.Paul, "Introduction to Electromagnetic Compatibility", 2nd Edition, John Wiley and Sons, Inc, 2010.
2. Bemhard Keiser, "Principles of Electromagnetic Compatibility", 3rd Edition, Artech house,

Norwood, 1987.
3. Don R. J.White Consultant Incorporate, "Handbook of EMI/EMC", Vol I-V, 1988.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Describe the fundamental principles of EMI and EMC.	2
CO2	Observe the coupling mechanisms and their impacts.	2
CO3	Develop the various solutions to reduce EMI.	3
CO4	Explore the solutions to challenges in the designing the EMC circuits.	3
CO5	Identify the knowledge and skills required to test devices for EMC compliance.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	2	1	1	-	-	-	-	-	-	-	-	-	-	2
2.	2	2	1	-	-	-	-	-	-	-	-	-	-	2
3.	2	2	2	-	-	-	-	-	-	-	-	-	-	2
4.	3	3	3	-	-	-	-	-	-	-	-	-	-	2
5.	3	3	3	-	-	-	-	-	-	-	-	-	-	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22035	RADAR AND MICROWAVE ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic concepts of radar principles and signal detection.
- To provide understanding of continuous wave, frequency-modulated radar, Doppler and MTI radar techniques,
- To acquire knowledge about tracking with radar.
- To examine the various passive microwave devices and active devices used for microwave generation.
- To provide comprehensive understanding of the principles, operation, and applications of RF measurement instruments,

UNIT I	**INTRODUCTION TO RADAR**	**9**

The Origins of Radar, Radar principles, Basic Block Diagram, Radar classifications based on Frequencies, Waveform and application, Radar Fundamentals- Detection, Range, Velocity, Radar Equation and Pulsed Radar equation, Detection of Signals in Noise- Receiver Noise, Signal-to-Noise Ratio, Probabilities of Detection and False Alarm, Integration of Radar Pulses, Radar Cross Section of Targets, Transmitter Power, Pulse Repetition Frequency.

UNIT II	**CW, MTI AND PULSE DOPPLER RADAR**	**9**

CW and Frequency Modulated Radar, Doppler and MTI Radar- Delay Line Cancellers, Staggered Pulse Repetition Frequencies, Doppler Filter Banks, Moving Target Indication- Pulse Cancellers, Limitations to MTI Performance, MTI from a Moving Platform, Pulse Doppler Radar.

UNIT III	**TRACKING RADAR**	**9**

Introduction, Range Tracking, Angle Tracking -Sequential Lobing, Conical-Scan Tracking and Monopulse Tracking Radar, Track While Scan (TWS) Radar- Target Prediction and Smoothing, Measurement models, alpha-beta tracker, Kalman Filtering, Extended Kalman filtering.

UNIT IV	**MICROWAVE DEVICES AND GENERATION**	**9**

Review of S parameters, Terminations, Isolator, E and H plane Tee, Read Diodes, TRAPATT diode, BARITT Diode, Reflex Klystron, Forward-Wave Crossed-Field Amplifier.

UNIT V	**MICROWAVE MEASUREMENTS**	**9**

Principle of operation and application of VSWR meter and Power meter, Spectrum analyzer, Network analyzer, Measurements- Impedance, Frequency, Power, VSWR, Q-factor, Dielectric constant and Scattering coefficients.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Habibur Rahman, "Fundamental Principles of Radar", CRC press, Taylor and Francis, 2019.
2. M. R. Richards, J. A. Scheer, W. A. Holm, (Editors) "Principles of Modern Radar, Basic Principles", SciTech Publishing, 2010.
3. David M. Pozar, "Microwave Engineering", Fourth Edition, Wiley India, 2012

REFERENCES:

1. E.Collin, "Foundations for Microwave Engineering", Wiley India, Second Edition, 2009.
2. Fred E. Nathanson, "Radar Design Principles-Signal Processing and Environment", PHI, Second Edition,2003.
3. M.I.Skolnik, "Introduction to Radar Systems", McGraw Hill, Third Edition, 2017.
4. Mark A. Richards, "Fundamentals of Radar Signal Processing", McGraw-Hill, Third Edition, 2022.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Identify and understand the radar parameters	3
CO2	Differentiate various radar types	4
CO3	Evaluate different tracking and filtering schemes	4
CO4	Understand the operation of active and passive microwave devices	2
CO5	Measure and analyze the microwave signal parameters	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	1	-	-	-	-	-	-	-	3	-	-	3	-
2	3	2	-	-	-	-	-	1	2	2	-	-	3	3
3	3	2	-	-	-	-	-	1	2	2	-	-	3	3
4	3	2	-	-	-	-	-	-	2	-	-	-	3	-
5	3	2	3	-	3	-	-	2	2	3	-	1	3	3
*1-Weak, 2 – Moderate, 3 - Strong														

EC22036	MIC AND RF SYSTEM DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basics of Microwave Integrated Circuits.
- To design and analyze matching networks and passive devices.
- To design and analyze the characteristics of active RF components and applications.
- To design the various components that constitute an RF radio system for wireless Communication.
- To design integrated antennas and analyze its performance using measurement techniques.

UNIT I	**INTRODUCTION TO MICROWAVE INTEGRATED CIRCUITS**	**9**

Overview of Planar transmission lines (Stripline, Microstripline, Slotline, CPW, Finline)-Design Parameters for Strip Line And Micro stripline-Active Device Technologies-Design Approaches, Multichip Module Technology-Substrates.

UNIT II	**IMPEDANCE MATCHING NETWORKS & PASSIVE DEVICES**	**9**

Matching with lumped Elements, Design of L matching network, Matching by micro strip line, S-parameters with Smith chart-Passive IC components, Basic properties of dividers and couplers-T Junction Power divider, Wilkinson Power divider, coupled line directional coupler.

UNIT III	**ACTIVE RF COMPONENTS AND APPLICATIONS**	**9**

Active RF components: Semiconductor basics in RF, bipolar junction transistors, RF field effect transistors, High electron mobility transistors, matching and biasing networks-impedance matching using discrete components, microstrip line matching networks, amplifier classes of operation and biasing networks.

UNIT IV	**RF FILTER DESIGN AND POWER AMPLIFIERS**	**9**

Basic concepts of RF Filter design, Mixers, Low noise amplifiers, voltage control oscillators, Power amplifiers, transducer power gain and stability considerations.

UNIT V	**INTEGRATED ANTENNA DESIGN AND MEASUREMENTS**	**9**

Integrated Antenna Design-Photonic Band Gap Antennas-Micromachined Antenna-Micro Electro Mechanical System (MEMS) Antennas, Test Fixture Measurements, Probe Station Measurements, Thermal and Cryogenic Measurements, Experimental Field Probing Techniques.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Mathew M. Radmanesh, “Radio Frequency & Microwave Electronics”, Pearson Education Asia, Second Edition, 2015.
2. Reinhold Ludwig and Powel Bretchko, RF Circuit Design – Theory and Applications, Pearson Education Asia, Second Edition, 2009.
3. Bharathi Bhat, Shiban K. Koul, “Stripline-like Transmission Lines for Microwave Integrated Circuits”, New Age International Pvt Ltd Publishers, First Edition, 2007.

REFERENCES:

1. Gupta KC and Amarjit Singh, “Microwave Integrated circuits”, Wiley Eastern, First Edition, 1974.
2. D. K. Misra, “Radio Frequency and Microwave Communication Circuits- Analysis and Design”, John Wiley & Sons, First Edition, 2004.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the various aspects and significance of Microwave Integrated circuits.	2
CO2	Design and Analyze impedance matching networks and passive devices.	4
CO3	Analyze and identify appropriate RF active components and design circuits for obtaining the required performance.	4
CO4	Design a complete RF transceiver system for wireless communication.	3
CO5	Design microwave integrated circuit based antennas and analyze the performance using measurement techniques**.**	4

Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	3	-	-	-	1	1	-	-	-	-	2	-
2.	3	2	3	-	-	-	1	1	-	-	-	-	2	-
3.	3	2	3	-	-	-	1	1	-	-	-	-	2	-
4.	3	2	3	-	-	-	1	1	-	-	-	-	2	-
5.	3	2	3	-	-	-	1	1	-	-	-	-	2	-

* 1 – Weak, 2 – Moderate, 3 - Strong

EC22037	MILLIMETER WAVE ANTENNA TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals and analyze various channel models of millimeter wave communication.
- To study and analyze antenna arrays for various applications of mm waves in wireless communications.
- To analyze millimeter wave MIMO systems for wireless communications.
- To study and implement the millimeter wave technology for 5G applications.
- To design the millimeter wave technology in wireless access systems.

UNIT I	**INTRODUCTION TO MILLIMETER WAVE TECHNOLOGY**	**9**

Millimeter wave characteristics and implementation challenges, Radio wave propagation for millimeter (mm) wave: Large scale propagation channel effects, small scale channel effects, Outdoor and Indoor channel models, Emerging applications of millimeter wave communications and its Standardization.

UNIT II	**MILLIMETER WAVE ANTENNA ARRAYS**	**9**

Antenna arrays for mm-wave applications: Fundamentals of On-Chip and In-Package mm-wave antennas, Antenna topologies for mm-wave communications, Techniques to improve gain of On-Chip antennas, Adaptive antenna arrays - Implementation for mm-wave communications and Characterization of On-Chip antenna performance.

UNIT III	**MILLIMETER WAVE ANTENNAS FOR MIMO SYSTEMS**	**9**

Massive MIMO communications, Potential benefits for mm-wave systems, Diversity-Spatial, Temporal and Frequency, Dynamic spatial, frequency and modulation allocation, Spatial diversity of antenna arrays, Multiple antennas, Multiple transceivers, Noise coupling in MIMO systems.

UNIT IV	**MILLIMETER WAVE ANTENNAS FOR 5G**	**9**

Spatial characterization of multipath and beam combining, Angle spread and multipath angle of arrival, Antenna polarization, Antenna beamwidth, Advanced beam steering, Beamforming, mm-wave design consideration, Device to device communications over 5G systems and Design techniques of 5G mobile.

UNIT V	**APPLICATION OF MILLIMETER WAVE SYSTEMS**	**9**

Channel station at 50 GHz-Wireless LAN Systems-Wireless access systems through mm-wave band, Wireless train communication system-Intelligent Transport Systems (ITS) through mm-wave technology,Satellite broadcasting systems through mm-wave band and Broadband wireless communication using High Altitude Platform (HAP).

TOTAL: 45 PERIODS

TEXT BOOK:

1. K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, First Edition,March 2011.
2. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, First Edition , 2014.
3. Xiang, W; Zheng, K; Shen, X.S. "5G Mobile Communications": First Edition, Springer, 2016.
4. S-Q. Xiao, M-T. Zhou ,Yang Zhang ."Millimeter Wave Technology in Wireless PAN, LAN, and MAN" CRC Press, 2008.

REFERENCES:

1. Prakash Bhartia, and Inder Bahl, MmWave Engineering and Applications, Wiley Interscience.
2. . Teshirogi, T. YoneyAma , "Modern Millimeter Wave Technologies", IOS Press, 2001.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the fundamental concepts and channel effects of millimeter wave communications.	2
CO2	Study and Analyze antenna arrays for various applications of mm waves in wireless communications.	4
CO3	Develop and analyze MIMO antenna systems for mm waves communications.	4
CO4	Implementation of millimeter wave technology for 5G applications.	3
CO5	Design and analyze Millimeter Wave antenna for different applications.	4

Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	3	-	-	-	1	1	-	-	-	-	2	-
2.	3	2	3	-	-	-	1	1	-	-	-	-	2	-
3.	3	2	3	-	-	-	1	1	-	-	-	-	2	-
4.	3	2	3	-	-	-	1	1	-	-	-	-	2	-
5.	3	2	3	-	-	-	1	1	-	-	-	-	2	-

* 1 – Weak, 2 – Moderate, 3 - Strong

EC22038	SMART ANTENNA SYSTEMS AND TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To evaluate adaptive antenna and spatial processing techniques to design and optimize antenna systems and beamforming networks.
- To analyze different multi-user spatial processing techniques and channel models to optimize system capacity and coverage.
- To analyze various Direction of arrival and localization estimation algorithms to select optimal techniques and make design tradeoff decisions.
- To apply the smart antenna systems in 4G and 5G applications.
- Apply simulation techniques to design smart antennas for Long Range (LoRa) and GPS communication systems.

UNIT I	**INTRODUCTION TO ANTENNAS**	**9**

Spatial processing-Adaptive antennas-Beamforming networks, Switched Beam systems, Spatial Processing Receivers, Adaptive Antenna Systems, Transmission beamforming, Digital radio receiver techniques and software radios.

UNIT II	**MULTI-USER SPATIAL PROCESSING TECHNIQUES**	**9**

Multi-user spatial Processing, Dynamic re-sectoring-Range and Capacity analysis using smart antennas. Wireless Multipath Channel Models, Environment and Signal Parameters, Spatial Temporal Channel Models for Smart Antenna design, Spatial Channel Measurements, Application of Spatial Channel Models-Geometrically based single bounce elliptical model.

UNIT III	**DOA ESTIMATION**	**9**

Adaptive Beam Steering DOA estimation, Techniques of Maximum Likelihood estimation, Eigen decomposition, Coherent signal conditions, Integrated approach to DOA estimation, True range and direction finding, Elliptic and hyperbolic PL systems, Time Approach to DOA estimation, AOA estimation.

UNIT IV	**APPLICATION ON OF SMART ANTENNAS**	**9**

Smart antennas in Cellular Communication, IoT, Satellite Communication, Vehicular Networks, Wireless LAN Networks, Broadcasting systems, Cognitive radio networks, Wearable devices, Case studies of smart antennas in commercial 4G and 5G networks.

UNIT V	**SIMULATION OF SMART ANTENNAS**	**9**

Smart antenna design of LoRa nodes using GPS Data, Target node, Modeling of smart antenna using antenna array, Direction of optimal beam using GPS Coordinates, Integration of LoRa Communication using Matlab, Smart Antenna design using Simulink, Smart Antenna design using CST Microwave Studio, Network Level Simulation and Custom Simulation.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. S.Kannadhasan, R.Nagarajan, Alagar Karthick, Aritra Ghosh, "Smart Antennas, Electromagnetic Interference and Microwave Antennas for Wireless Communication", River Publishers, First Edition, 2023.
2. David A.Sanchez-Hernandez, Steven R.Best, Manos M.Tentzeris, Sungtek Kahang, Gert

F.Pedersen, “Smart Antennas for 5G+”, Wiley, IEEE Press, First Edition, 2024.
3. Frank Gross, “Smart Antennas for Wireless Communication With MATLAB”, McGraw-Hill Education, First Edition, 2005.

REFERENCES:

1. Gross, “Smart Antennas”, McGraw-Hill Education, Second Edition, 2015.
2. Praveen Kumar Malik, Pradeep Kumar, Sachin Kumar, Dushyant Kumar Singh, “Smart Antennas: Recent Trends in Design and Applications”, Bentham Books, First Edition, 2021.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Evaluate different beamforming algorithms for spatial processing in adaptive antenna systems in terms of computational complexity, antenna pattern control, and bit error rate performance and choose the ideal configuration.	5
CO2	Analyze and compare different dynamic re-sectoring and spatial multiplexing methods to improve multi-user capacity in a given propagation environment.	4
CO3	Compare and contrast conventional, subspace and Maximum likelihood estimation methods for DOA under both coherent and non-coherent signal conditions.	4
CO4	Analyze the role of smart antennas in modern wireless communication systems such as Wi-Fi and IoT applications.	4
CO5	Analyze the smart antenna optimization using various simulation tools.	4
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	1	1	-	1	-	-	1	-	3	-
2.	3	3	1	2	1	-	-	-	-	-	-	-	3	3
3.	3	3	2	3	1	1	-	1	-	-	1	-	3	3
4.	3	3	1	2	1	-	-	-	-	-	-	-	3	-
5.	3	2	3	3	3	1	-	1	-	-	1	-	3	3
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22030	MINI PROJECT	L	T	P	C
		0	0	4	2

OBJECTIVES:

- Understand to apply RF engineering principles to address complex engineering problems
- Apply antenna design principles to enhance understanding and practical application.
- Demonstrate clear and concise communication of engineering concepts through effective presentations and technical reports.
- Cultivate the ability to work independently or as a team to address and solve societal challenges.
- Identify engineering challenges and apply standards to devise innovative solutions

PROJECT WORK MODALITIES

RF and Microwave Engineering real-world challenges can be solved by students as a mini-project. The literature review pertaining to their particular problem statement must be conducted by each student individually or as a team. After learning about the principles of Electromagnetic Fields, Transmission Lines, RF Systems, Antennas and Microwave Engineering, the students can use the knowledge to speculate a solution relevant to the goal of their project. Using a variety of numerical simulation tools such as Computer Simulation Technology (CST) and Advanced Design System (ADS), students can design and simulate antennas and RF components. The validity of simulated results is determined using a Vector Network Analyzer (VNA). At the conclusion of the semester, the student is required to turn the project in a softbound report.

TOTAL: 60 PERIODS

COURSE ARTICULATION MATRIX

*COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1.	3	3	3	3	3	1	2	2	3	3	3	3	3	3
2.	3	3	3	3	3	1	2	2	3	3	3	3	3	3
3.	3	3	3	3	3	1	2	2	3	3	3	3	3	3
4.	3	3	3	3	3	1	-	2	3	3	3	3	3	3
5.	3	3	3	3	3	1	-	2	3	3	3	3	3	3

* 1 – Weak, 2 – Moderate, 3 – Strong

VERTICAL 4
VLSI

EC22041	ANALOG IC DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To acquire the basic knowledge on operation and the tradeoffs involved in the MOS amplifier
- To determine the frequency and noise performance of amplifiers
- To analyze the feedback amplifiers and noise-reduction network
- To investigate and design of two stage operational amplifier
- To analyze of reference generators in CMOS technology

UNIT I	**SINGLE STAGE AMPLIFIERS**	**9**

Basic MOS physics and equivalent circuits-MOS Device models- Common Source- Common Gate -Source Follower-Cascode and folded cascode configurations, Differential amplifiers configurations and analysis, Analog to Digital converter, Comparator.

UNIT II	**HIGH FREQUENCY AND NOISE CHARACTERISTICS OF AMPLIFIERS**	**9**

Current mirrors- cascode current mirrors-current mirror loads for differential pairs-Miller effect-association of poles with nodes- frequency response of CS, CG -Cascode and differential pair stages-Noise Spectrum- SNR- noise in single stage amplifiers-noise in differential amplifiers.

UNIT III	**FEEDBACK AND OPERATIONAL AMPLIFIERS**	**9**

Properties of feedback circuits and types of amplifier - feedback typologies - effect of loading in feedback networks - One-stage Op Amps- Phase-Locked Loops - Low-dropout (LDO) regulator - Switched Mode Power Supplies-Power supply rejection.

UNIT IV	**STABILITY AND FREQUENCY COMPENSATION**	**9**

General considerations-Multipole systems-Phase Margin-Frequency Compensation-Compensation of two stage Op Amps- Slewing in two stage Op Amps- Other compensation techniques.

UNIT V	**BANDGAP REFERENCES**	**9**

Supply independent biasing-Temperature independent references-Negative TC voltage-Bandgap reference- PTAT current generation, Constant-Gm biasing-Speed and noise issues.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Behzad Razavi, “Design of Analog Cmos Integrated Circuits”, Tata Mcgraw Hill, 2nd Edition 2017.
2. Wiley M.C. Sansen, “Analog Design Essentials", Springer, 2006.

REFERENCES:

1. Grebene, “Bipolar and MOS Analog Integrated Circuit Design”, John Wiley & Sons, Inc., 2003.
2. Phillip E.Allen, Douglas R .Holberg, “CMOS Analog Circuit Design”, Oxford University Press, 2nd Edition, 2002.
3. Gabriel Alfonso Rincón-Mora, Analog IC Design with Low-Dropout Regulators, McGraw-

Hil, 2nd Edition, 2014.
4. Jacob Baker "CMOS: Circuit Design, Layout, And Simulation, Wiley IEEE Press, 3rd Edition, 2010.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Describe the basic operation of amplifiers and configurations	2
CO2	Compute the frequency and noise performance of amplifiers	3
CO3	Examine the performance of feedback amplifiers and operational amplifiers	4
CO4	Analyze stability and frequency compensation of stage op amps	4
CO5	Analyze reference generators in CMOS technology	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	1	-	-	-	-	-	-	-	-	2	2
2.	3	2	2	1	-	-	-	-	-	-	-	-	2	2
3.	3	2	2	1	2	-	-	-	-	-	-	-	2	2
4.	3	2	2	1	2	-	-	-	-	-	-	-	2	2
5.	2	2	1	1	2	-	-	-	-	-	-	-	2	1
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22042	ASIC AND FPGA DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the different types of programmable logic devices.
- To understand partitioning, floor planning, placement, routing and circuit extraction
- To understand synthesis, simulation and testing of systems
- To understand the various architectures of FPGAs
- To understand the design issues of System on Chip (SOC)

UNIT I	**OVERVIEW OF ASIC AND PLD**	**9**

Types of ASICs - Design flow – CAD tools used in ASIC Design – Programming Technologies: Antifuse – static RAM – EPROM and EEPROM technology, Programmable Logic Devices: ROMs and EPROMs – PLA –PAL. Gate Arrays – CPLDs and FPGAs

UNIT II	**ASIC PHYSICAL DESIGN**	**9**

System partition -partitioning - partitioning methods – interconnect delay models and measurement of delay - floor planning - placement – Routing global routing - detailed routing - special routing – circuit extraction - DRC

UNIT III	**LOGIC SYNTHESIS, SIMULATION AND TESTING**	**9**

Design systems - Logic Synthesis - Half gate ASIC -Schematic entry - Low level design language - PLA tools -EDIF- CFI design representation. Verilog and logic synthesis -VHDL and logic synthesis - types of simulation -boundary scan test - fault simulation - automatic test pattern generation

UNIT IV	**FPGA Fabrics**	**9**

Introduction, FPGA Architectures; SRAM-Based FPGAs; Permanently Programmed FPGAs; Chip I/O; Circuit Design of FPGA Fabrics; Architecture of FPGA Fabrics

UNIT V	**SOC DESIGN**	**9**

Design Methodologies – Processes and Flows - RTL to GDS - Embedded software development for SOC - Techniques for SOC Testing – Configurable SOC – Hardware / Software co-design Case studies: Digital camera, Bluetooth radio / modem, SDRAM and USB

TOTAL: 45 PERIODS

TEXT BOOKS:

1. M.J.S.Smith, "Application Specific Integrated Circuits, Pearson India; 1st edition (1 January 2002)
2. Wayne Wolf, FPGA-Based System Design, Prentice Hall PTR, 2004.
3. P.K.Chan & S. Mourad, Digital Design Using Field Programmable Gate Array, Prentice Hall, (1 January 2009)
4. Modern VLSI Design: System-on-Chip Design (3rd Edition) Subsequent Edition, by Wayne Wolf (Author), Prentice Hall, January 14, 2002

REFERENCES:

1. S.Trimberger, Field Programmable Gate Array Technology, Springer-Verlag New York Inc.; Softcover reprint of the original 1st ed. 1994 edition (22 December 2012)
2. John V.Oldfield, Richard C Dore, Field Programmable Gate Arrays, Wiley Publications 1995.
3. Lala Parag K., Digital System Design using PLD's, BS Publications, Rpt. 2015.

4. S. Brown, R. Francis, J. Rose, Z. Vransic, Field Programmable Gate Array, Kluwer Publications, 1992.
5. J. Old Field, R.Dorf, Field Programmable Gate Arrays, John Wiley & Sons, New York, 1995.
6. Farzad Nekoogar and Faranak Nekoogar, From ASICs to SOCs: A Practical Approach, Prentice Hall PTR, 2003.
7. R. Rajsuman, System-on-a-Chip Design and Test. Santa Clara, CA: Artech House Publishers, 2000.
8. F. Nekoogar. Timing Verification of Application-Specific Integrated Circuits (ASICs). Prentice Hall PTR, 1999.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Choose appropriate types of programming technologies and logic devices	2
CO2	Apply partitioning, floor planning, placement, routing and circuit extraction in ASIC Designs	3
CO3	Synthesize, simulate and test the designed systems	4
CO4	Choose appropriate architecture of FPGA for an application	2
CO5	Apply design methodologies, processes and flows in an SOC design	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	2	1	2	3	2	1	-	-	-	-	-	-	2	2
2.	2	1	2	3	2	1	-	-	-	-	-	-	2	2
3.	2	1	2	3	2	1	-	-	-	-	-	-	2	2
4.	2	1	2	3	2	1	-	-	-	-	-	-	2	2
5.	2	1	2	3	1	1	-	-	-	-	-	-	2	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22043	CAD FOR VLSI DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To be exposed to the VLSI design methodologies and design methods.
- To familiarize data structures and algorithms required for VLSI design.
- To be exposed to algorithms for partitioning and placement.
- To study algorithms for floor planning and routing.
- To study algorithms for modelling, simulation and synthesis.

UNIT I	**INTRODUCTION TO VLSI DESIGN FLOW**	**9**

Introduction to VLSI Design methodologies, Review of MOS and CMOS Fabrication process, Basics of VLSI design automation tools, Algorithmic Graph Theory and Computational Complexity, Tractable and Intractable problems.

UNIT II	**LAYOUT, PLACEMENT AND PARTITIONING**	**9**

Layout Compaction, Design rules, Problem formulation, Algorithms for constraint graph compaction, Placement and partitioning, Circuit representation, Placement algorithms, Partitioning, Implementation of KL,FM and Genetic algorithm for VLSI CAD design.

UNIT III	**FLOOR PLANNING AND ROUTING**	**9**

Floor planning concepts, Shape functions and floorplan sizing, Types of local routing problems, Area routing, Channel routing, Introduction to system C for VLSI design.

UNIT IV	**SIMULATION AND LOGIC SYNTHESIS**	**9**

Simulation, Gate-level modeling and simulation, Switch-level modeling and simulation, Combinational Logic Synthesis, Two Level Logic Synthesis, Synthesis of reversible logic circuits-reversible gates

UNIT V	**HIGH LEVEL SYNTHESIS**	**9**

Hardware models for high level synthesis, internal representation, allocation, assignment and scheduling, High level transformations.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Sabih H. Gerez, “Algorithms for VLSI Design Automation”, Second Edition, Wiley-India, 2017.
2. Naveed a. Sherwani, “Algorithms for VLSI Physical Design Automation”, 3rd Edition, Springer, 2017.

REFERENCES:

1. Charles J. Alpert, Dinesh P. Mehta and Sachin S Sapatnekar, “Handbook of Algorithms for Physical Design Automation, CRC Press, 1st Edition, 2.
2. N.a. Sherwani, "Algorithms for VLSI Physical Design Automation", Kluwer Academic Publishers, 2002

3. Pinaki Mazumder, Elizabeth M.Rudnick, "Genetic Algorithms for VLSI Design, Layout & Automation",Prentice Hall,1999.
4. https://archive.nptel.ac.in/content/syllabus_pdf/106103229.pdf -C for VLSI Design

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Determine the VLSI design methodologies for tractable and Intractable problems	2
CO2	Design compact layouts and develop algorithms for circuit placement and partitioning	3
CO3	Identify routing problems and develop floor planning and routing	3
CO4	Simulate and synthesize logical functions using simulation tools.	3
CO5	Synthesize with proper alignment and scheduling develop hardware models for high level synthesis.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	2	2	-	-	-	-	-	2	3	3
2.	3	3	2	2	1	2	-	-	-	-	-	2	3	3
3.	3	3	2	2	2	2	-	-	-	-	-	2	3	3
4.	3	3	3	2	2	1	-	-	-	-	-	2	1	2
5.	3	3	3	2	2	2	-	-	-	-	-	3	2	2
* 1 – Weak, 2 – Moderate, 3 - Strongs														

EC22044	LOW POWER IC DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the fundamentals of low power low voltage VLSI design.
- To understand the impact of power on system performances.
- To understand the design of different adders.
- To understand the design of different multipliers.
- To develop the low power low voltage memories

UNIT I	**FUNDAMENTALS OF LOW POWER CIRCUITS**	**9**

Need for Low Power Circuit Design, Sources of Power Dissipation – Switching Power Dissipation, Short Circuit Power Dissipation, Leakage Power Dissipation, Glitching Power Dissipation, Short Channel Effects -Drain Induced Barrier Lowering and Punch Through, Surface Scattering, Velocity Saturation, Impact Ionization, Hot Electron Effect.

UNIT II	**LOW-POWER DESIGN APPROACHES**	**9**

Low-Power Design through Voltage Scaling: VTCMOS circuits, MTCMOS circuits, Architectural Level Approach –Pipelining and Parallel Processing Approaches. Switched Capacitance Minimization Approaches: System Level Measures, Circuit Level Measures, Mask level Measures, RTL power estimation and Gate-level power estimation

UNIT III	**LOW-VOLTAGE LOW-POWER ADDERS**	**9**

Introduction, Standard Adder Cells, CMOS Adders Architectures – Ripple Carry Adders, Carry Look-Ahead Adders, Carry Select Adders, Carry Save Adders, Low Voltage Low Power Design Techniques -Trends of Technology and Power Supply Voltage, Low Voltage Low-Power Logic Styles.

UNIT IV	**LOW-VOLTAGE LOW-POWER MULTIPLIERS**	**9**

Introduction, Overview of Multiplication, Types of Multiplier Architectures, serial and parallel multipliers, Array Multiplier, Column Bypass multiplier,Braun Multiplier, Baugh Wooley Multiplier, Booth Multiplier, Introduction to Wallace Tree Multiplier

UNIT V	**LOW-VOLTAGE LOW-POWER MEMORIES**	**9**

Basics of ROM, Low-Power ROM Technology, Future Trend and Development of ROMs, Basics of SRAM, Memory Cell, Precharge and Equalization Circuit, Low Power SRAM Technologies, Basics of DRAM, Self-Refres Circuit, Future Trend and Development of DRAM.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Sung-Mo Kang, Yusuf Leblebici, CMOS Digital Integrated Circuits – Analysis and Design, TMH, 2018.

2. Kiat-Seng Yeo, Kaushik Roy, Low-Voltage, Low-Power VLSI Subsystems, TMH Professional Engineering, 2017.

REFERENCES:

1. Ming-BO Lin, "Introduction to VLSI Systems: A Logic, Circuit and System Perspective", CRC Press, 2012.
2. Anantha Chandrakasan, "Low Power CMOS Design", IEEE Press, /Wiley International, 2012
3. Kaushik Roy, Sharat C. Prasad, "Low Power CMOS VLSI Circuit Design", John Wiley, & Sons, 2005.
4. Gary K. Yeap, "Practical Low Power Digital VLSI Design", Kluwer Academic Press, 2008
5. Bellamour, M. I. Elamasri, "Low Power CMOS VLSI Circuit Design", A Kluwer Academic Press, 1995.
6. Siva G. Narendran, Anatha Chandrakasan, "Leakage in Nanometer CMOS Technologies", Springer, 2006

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the fundamentals of Low power circuit design.	2
CO2	Attain the knowledge of architectural approaches.	3
CO3	Analyze and design Low-Voltage Low-Power Combinational Circuits.	4
CO4	Learn the design of Low-Voltage, Low-Power Memories	2
CO5	Design and develop Low Power, Low Voltage Circuits	5
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	3	2	-	-	-	-	-	-	2	2	2
2.	3	2	1	2	3	-	-	-	-	-	-	1	2	1
3.	3	3	3	2	2	-	-	-	-	-	-	1	2	2
4.	2	3	3	3	3	-	-	-	-	-	-	1	3	3
5.	3	3	3	2	2	-	-	-	-	-	-	2	2	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22045	MIXED SIGNAL IC DESIGN AND TESTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To know about mixed-signal devices and the need for testing these devices.
- To study the various techniques for testing.
- To learn about ADC and DAC based testing.
- To understand the Clock and Serial Data Communications Channels
- To study the general-purpose measuring devices.

UNIT I	**MIXED – SIGNAL TESTING**	**9**

Common Types of Analog and Mixed- Signal Circuits – Applications of Mixed-Signal Circuits - PostSilicon Production Flow - Test and Packing – Characterization versus Production Testing - Test and Diagnostic Equipment - Automated Test Equipment – Wafer Probers – Handlers – E-Beam Probers – Focused Ion Beam Equipment – Forced –Temperature

UNIT II	**YIELD, MEASUREMENT ACCURACY, AND TEST TIME**	**9**

Yield - Measurement Terminology - Repeatability, Bias, and Accuracy - Calibrations and Checkers - Tester Specifications - Reducing Measurement Error with Greater Measurement Time – Guard bands - Effects of Measurement Variability on Test Yield - Effects of Reproducibility and Process Variation on Yield - Statistical Process Control

UNIT III	**DAC TESTING**	**9**

Basics of Data Converters -Principles of DAC and ADC Conversion, Data Formats, Comparison of DACs and ADCs, DAC Failure Mechanisms - Basic DC Tests - Transfer Curve Tests - Dynamic DAC Tests - Tests for Common DAC Applications

UNIT IV	**ADC TESTING**	**9**

ADC Testing Versus DAC Testing - ADC Code Edge Measurements - Edge Code Testing Versus Center Code Testing, Step Search and Binary Search Methods, Servo Method, Linear Ramp Histogram Method, Histograms to Code Edge Transfer Curves, Rising Ramps Versus Falling Ramps, Sinusoidal Histogram Method - DC Tests and Transfer Curve Tests - Dynamic ADC Tests - Tests for Common ADC Applications

UNIT V	**CLOCK, SERIAL DATA COMMUNICATIONS AND CHANNEL MEASUREMENT**	**9**

Synchronous and Asynchronous Communications - Time-Domain Attributes of a Clock Signal - Frequency-Domain Attributes of a Clock Signal - Communicating Serially Over a Channel - Bit Error Rate Measurement - Methods to Speed Up BER Tests in Production - Deterministic Jitter Decomposition - Jitter Transmission Tests.

TOTAL:45 PERIODS

TEXT BOOKS:
1. Gordon W.Roberts, Friedrich Taenzler, Mark Burns, "An Introduction to Mixed-signal IC Test and Measurement" Oxford University Press, Inc.2012 2. M.L.Bushnell and V.D.Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers, 2002.
REFERENCES:
1. BapirajuVinnakota, "Analog and mixed-signal test", Prentice Hall, 1998.(Unit - II) 2. Digital and Analogue Instrumentation: Testing and Measurement by NihalKularatna

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Learn the fundamentals of mixed signal circuits.	2
CO2	Define the various measurement terminologies.	3
CO3	Acquire knowledge of Analog to Digital Converters.	3
CO4	Learn testing of Analog to Digital Converters.	2
CO5	Comprehend the attributes of a clock signal.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	2	2	-	-	-	-	-	2	3	3
2.	3	3	2	2	1	2	-	-	-	-	-	2	3	3
3.	3	3	2	2	2	2	-	-	-	-	-	2	3	3
4.	3	3	3	2	2	1	-	-	-	-	-	2	1	2
5.	3	3	3	2	2	2	-	-	-	-	-	3	2	2
* 1 – Weak, 2 – Moderate, 3 - Strong														

EC22046	SOC DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the overall structure and interconnection of its components.
- To familiarize the design concepts of various processors for SOC design.
- To learn the concepts of On-die and Off-Die memory systems.
- To impart knowledge on basic interconnect architectures and effectiveness of customization.
- To understand the concept of reconfigurable technologies and case studies of SOC design.

UNIT I	**INTRODUCTION TO THE SYSTEMS APPROACH**	**9**

System Architecture, Components of the system, Hardware & Software, Processor Architectures, Memory and Addressing. System level interconnection, An approach for SOC Design, System Architecture and Complexity.

UNIT II	**PROCESSORS**	**9**

Introduction, Processor Selection for SOC, Basic concepts in Processor Architecture, Basic concepts in Processor Microarchitecture, Basic elements in Instruction handling. Buffers: minimizing Pipeline Delays, Branches, More Robust Processors, Vector Processors and Vector Instructions extensions, VLIW Processors, Superscalar Processors.

UNIT III	**MEMORY DESIGN FOR SOC**	**9**

Overview of SOC external memory, Internal Memory, Size, Scratchpads and Cache memory, Basic Notions, Cache Organization, Cache data, Write Policies, Strategies for line replacement at miss time, Types of Cache, Split – I, and D – Caches, Multilevel Caches, Virtual to real translation, SOC Memory System, – board based memory systems – Models of Simple Processor – memory interaction.

UNIT IV	**INTERCONNECT AND SOC CUSTOMIZATION**	**9**

Bus: Basic Architectures, SOC Standard Buses, Analytic Bus Models, Using the Bus model, Effects of Bus transactions and contention time. SOC Customization: An overview, Customizing Instruction Processor.

UNIT V	**CONFIGURABILITY AND APPLICATION STUDIES**	**9**

Reconfiguration Technologies, Mapping design onto Reconfigurable devices, Instance- Specific design, Reconfiguration - overhead analysis and trade-off analysis on reconfigurable Parallelism, RISC V and accelerator architecture. Application Studies: AES, Image Compression.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Michael J. Flynn and Wayne Luk, "Computer System Design System-on-Chip", John Wiley & Sons, 2011.
2. Joseph Yiu, "System-on-Chip Design with Arm(R) Cortex(R)-M Processors", ARM Education Media, 2019.
3. John L. Hennessy, David A. Patterson, "Computer Architecture: A Quantitative Approach", 6th edition, Morgan Kaufmann, 2017.

REFERENCES:

1. Ricardo Reis, "Design of System on a Chip: Devices and Components", 1st Edition, 2004, Springer
2. Prakash Rashinkar, Peter Paterson and Leena Singh L, "System on Chip Verification – Methodologies and Techniques", Springer Science & Business Media, 2007.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Identify and comprehend the various elements that constitute a system, including both hardware and software components.	2
CO2	Interpret the fundamental elements and processes involved in handling instructions of various processors.	3
CO3	Analyze the memory required for SOC and board-based memory systems.	4
CO4	Identify the effects of contention time on the efficiency of data transfer and recognize the challenges associated with SOC customization.	2
CO5	Analyze the reconfigurable technologies and use cases of SOC design.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	2	-	-	-	-	-	-	3	3
2.	3	3	2	3	3	2	-	-	-	-	-	-	3	3
3.	3	3	2	2	3	2	-	-	-	-	-	-	3	3
4.	3	3	3	2	2	1	-	-	-	-	-	-	3	3
5.	3	3	3	1	-	2	-	-	-	-	-	-	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22047	TESTING OF VLSI CIRCUITS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the VLSI testing and fault modeling.
- To study the test generation for combinational and sequential circuits
- To understand the design for testability.
- To learn the logic and fault simulation and testability measures
- To study the fault diagnosis of logic circuits

UNIT I	**BASICS OF TESTING AND FAULT MODELING**	**9**

Introduction - Faults in digital circuits -Challenges in VLSI Testing - Modeling of faults - Logical Fault Models - Fault detection - Fault location - Fault dominance - Logic Simulation - Types of simulation - Delay models - Gate level Event-driven simulation.

UNIT II	**TEST GENERATION FOR COMBINATIONAL AND SEQUENTIAL CIRCUITS**	**9**

Test generation for combinational logic circuits - Fault Table, Boolean difference, Path sensitization, D - algorithm, PODEM - Combinational ATPG Algorithms - Test generation for sequential circuits - design of testable sequential circuits.

UNIT III	**DESIGN FOR TESTABILITY**	**9**

Design for Testability Basics – Testability Analysis - Ad Hoc design for Testability – scan based design – Scan Architecture – Random Logic BIST – DFT for Other Test Objectives

UNIT IV	**SELF-TEST AND TEST ALGORITHMS**	**9**

Built in Self-Test (BIST) -Test pattern generation for BIST - BIST Architectures-LFSR for pattern generation - Type of memory faults-Testable Memory Design -Test algorithms - Test generation for embedded RAM.

UNIT V	**FAULT DIAGNOSIS**	**9**

Introduction and Basic Definitions-Logic level diagnosis - Generation of vectors for diagnosis-Combinational Logic Diagnosis - Logic BIST diagnosis- system level diagnosis, TetraMAX Overview, Benefits and Features.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. M. Abramovici, M.A. Breuer and A.D. Friedman, "Digital Systems and Testable Design", Jaico Publishing House, 2002.
2. P.K. Lala, "Digital Circuit Testing and Testability", Academic Press, 2002.

REFERENCES:

1. Michael L. Bushnell and Vishwani D. Agrawal, "Essentials of Electronic Testing for Digital, Memory & Mixed-Signal VLSI Circuits", Kluwer Academic Publishers, 2017.
2. M.L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits", Kluwer Academic Publishers, 2002.
3. Zainalabedin Navabi, Digital System Test and Testable Design Using HDL Models and Architectures, springer, 2011
4. Laung-Terng Wang, and Xiaoqing Wen, "VLSI Test Principles and Architectures", Elsevier, 2017

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Model faults and delay in digital circuits.	2
CO2	Generate tests for combinational and sequential circuits.	2
CO3	Develop design for testability (DFT) approaches	3
CO4	Develop self-test methods and test algorithms for memories	4
CO5	Develop fault diagnosis for combinational circuits and system level circuits	4

Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	2	1	2	3	3	1	-	-	-	-	-	-	2	2
2.	2	1	2	2	3	1	-	-	-	-	-	-	2	2
3.	2	1	2	2	3	1	-	-	-	-	-	-	2	2
4.	2	1	2	3	2	1	-	-	-	-	-	-	2	2
5.	2	1	2	2	1	1	-	-	-	-	-	-	2	2

* 1 – Weak, 2 – Moderate, 3 – Strong

EC22048	VLSI FOR WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the concepts of basic wireless communication concepts.
- To study the parameters in receiver and low noise amplifier design.
- To study the various types of mixers designed for wireless communication.
- To study and design PLL and VCO.
- To understand the concepts of transmitters and power amplifiers in wireless communication.

UNIT I	**COMMUNICATION CONCEPTS**	**9**

Introduction – Overview of Wireless systems – Standards – Access Methods – Modulation schemes – Classical channel – Wireless channel description – Path loss – Multipath fading – Standard Translation.

UNIT II	**RECEIVER ARCHITECTURE & LOW NOISE AMPLIFIERS**	**9**

Receiver front end – Filter design – Non-idealities – Design parameters – Noise figure & Input intercept point. LNA Introduction – Wideband LNA design – Narrow band LNA design: Impedance matching & Core amplifier.

UNIT III	**MIXERS**	**9**

Balancing Mixer - Qualitative Description of the Gilbert Mixer - Conversion Gain – Distortion – Noise - A Complete Active Mixer. Switching Mixer – Distortion, Conversion Gain & Noise in Unbalanced Switching Mixer - A Practical Unbalanced Switching Mixer. Sampling Mixer - Conversion Gain, Distortion, Intrinsic & Extrinsic Noise in Single Ended Sampling Mixer.

UNIT IV	**FREQUENCY SYNTHESIZERS**	**9**

PLL – Phase detector – Dividers – Voltage Controlled Oscillators – LC oscillators – Ring Oscillators – Phase noise – Loop filters & design approaches – A complete synthesizer design example (DECT) – Frequency synthesizer with fractional divider.

UNIT V	**TRANSMITTER ARCHITECTURES & POWER AMPLIFIERS**	**9**

Transmitter back end design – Quadrature LO generator – Power amplifier design.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Bosco H Leung “VLSI for Wireless Communication”, Pearson Education, 2002.
2. B.Razavi ,”RF Microelectronics” , Prentice-Hall ,1998.

REFERENCES:

1. Behzad Razavi, “Design of Analog CMOS Integrated Circuits” McGraw-Hill, 1999.

2. Emad N Farag and Mohamed I Elmasry, "Mixed Signal VLSI wireless design – Circuits & Systems", Kluwer Academic Publishers, 2000.
3. J. Crols and M. Steyaert, "CMOS Wireless Transceiver Design," Boston, Kluwer Academic Pub., 1997.
4. Thomas H.Lee, "The Design of CMOS Radio – Frequency Integrated Circuits", Cambridge University Press ,2003.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Recollect basic wireless communication concepts.	2
CO2	Apply design parameters and design low noise amplifiers for receivers	3
CO3	Design various types of mixers needed for wireless communication.	4
CO4	Design PLL, VCO and Frequency synthesizer.	4
CO5	Design transmitters and power amplifiers needed for wireless communication.	4

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	1	-	-	3	-	-	-	-	-	-	2	3	3
2.	3	3	3	2	3	-	2	-	-	-	-	2	3	3
3.	3	3	3	2	3	-	2	-	-	-	-	2	3	3
4.	3	3	3	2	3	-	2	-	-	-	-	2	3	3
5.	3	3	3	2	3	-	2	-	-	-	-	2	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22040	MINI PROJECT	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To Define, formulate and analyze a real-world problem in the field of VLSI technology.
- To solve complex engineering problems independently or as part of a team.
- To Acquire knowledge in terms of the innovation & product design development process of the project work.
- To Work independently as well as in teams.
- To Manage the project from start to finish.

PROJECT WORK MODALITIES

Students can take up small real-world problems in the field of Very Large-Scale Integrated circuits (VLSI) as a mini project. Each student or as a team should conceive, design, develop and realize a prototype of an electronic product. The basic elements of product design - the function ergonomics and aesthetics - should be considered while conceiving and designing the product. It can be related to solutions to an engineering problem/ verification and analysis of experimental data available/ conducting suitable experiments on various engineering subjects/ characterization/ studying a software tool for the solution of an engineering problem etc. The realization of the prototype / product should include design and fabrication of PCB. The student should submit a soft bound project report at the end of the semester. The product should be demonstrated at the time of examination. Few thrust areas to be concentrated for doing VLSI mini projects are:

1. Design and implementation of cutting-edge 8-bit arithmetic architectures (Adder/Multiplier) and compare the synthesized results with conventional architectures.
2. Design a Digital/ Analog circuit and compare the results in terms of Area, Delay and Power estimation.
3. Design of analog integrated circuits and generation of layout with parasitic extraction and post-simulation.
4. Design and analysis of VLSI architecture for real time application and hardware implementation using FPGA
5. Design of efficient test pattern for testing of integrated circuits

TOTAL: 60 PERIODS

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Define, formulate and analyze a real-world problem in the field of VLSI technology	4
CO2	Design, analyze and optimize, analog and digital subsystems	4
CO3	Design, analyze and optimize, analog and digital complex systems	4
CO4	Learn to write technical reports and work as a team.	3
CO5	Develop skills to present and defend their work in front of a technically qualified audience.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	1	2	2	3	3	3	3	3	3
2.	3	3	3	3	3	1	2	2	3	3	3	3	3	3
3.	3	3	3	3	3	1	2	2	3	3	3	3	3	3
4.	3	3	3	3	3	1	0	2	3	3	3	3	3	3
5.	3	3	3	3	3	1	0	2	3	3	3	3	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

VERTICAL 5
SIGNAL PROCESSING AND DATA SCIENCE

EC22051	AUDIO SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Introduce fundamentals of audio signal digitization and representation.
- Understand digital audio fundamentals, compression, and codecs in communication.
- Introduce time-domain audio processing and digital filtering techniques.
- Introduce Fourier analysis and frequency-domain filtering techniques for audio signals.
- Explore advanced algorithms and real-time techniques for audio processing.

UNIT I	**FOUNDATIONS OF AUDIO SIGNALS**	**9**

Overview of audio signals: Analog vs. digital, continuous vs. Discrete, Characteristics of audio signals: Amplitude, frequency, and phase - Sampling and quantization: Basics of digitizing analog signals, Digital representation of audio signals: Pulse Code Modulation (PCM), Nyquist theorem and its implications.

UNIT II	**DIGITAL AUDIO FUNDAMENTALS**	**9**

Sampling theorem and its application in communication systems, Quantization techniques and their impact on signal quality, Introduction to digital audio compression: Lossless vs. lossy compression, Common digital audio file formats: WAV, MP3, AAC, MPEG standard, Basics of audio codecs and their role in communication systems.

UNIT III	**TIME DOMAIN PROCESSING**	**9**

Time-domain representation of signals, Convolution and its application to audio processing, Windowing techniques for signal analysis, Application of time-domain effects: Echo, reverberation, and filtering, Introduction to digital filters and their applications in communication systems.

UNIT IV	**FREQUENCY DOMAIN PROCESSING**	**9**

Fourier Transform and its application to audio signals, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT) in communication systems, Frequency domain effects: Filtering, equalization, and modulation, Filter design techniques: FIR and IIR filters.

UNIT V	**ADVANCED AUDIO PROCESSING**	**9**

Pitch shifting and time-stretching algorithms in communication applications, MELP (Mixed Excitation Linear Prediction) signal processing, Stochastic processes and their application in audio signal processing, Spatial audio processing: Stereo imaging, surround sound principles in communication systems, architectures and algorithms for real-time audio processing.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ken C. Pohlmann, “Principles of Digital Audio," 6th Edition, McGraw-Hill Education, 2017.
2. Tanja Obretenova, Alexander Lerch, "An Introduction to Audio Content Analysis: Applications in Signal Processing and Music Informatics," Wiley, 2017
3. Tae Hong Park, “Introduction to Digital Audio Signal Processing,” World Scientific Publishing, 2016.
4. Udo Zolzer, “DAFX: Digital Audio Effects," 2nd Edition, Wiley, 2016.

REFERENCES:

1. Udo Zolzer, “Digital Audio Signal Processing”, 3rd Edition, Wiley, 2021.
2. Thomas Holton, “Digital Audio Processing: Fundamentals and Techniques,” Oxford University Press, 2021.
3. Stefania Cecchi, Luca Romoli, Francesco Piazza, “Audio Signal Processing for Next-Generation Multimedia Communication Systems,” Springer, 2021.
4. Alexander Lerch, “An Introduction to Audio Content Analysis: Applications in Signal Processing and Music Informatics,” Wiley, 2017.
5. Steven W. Smith, “The Scientist and Engineer's Guide to Digital Signal Processing,” California Technical Publishing, 2015.
6. Richard G. Lyons, “Understanding Digital Signal Processing,” 3rd Edition, Pearson Education, 2015.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Interpret the fundamentals of digital communications and demonstrate generation and reconstruction of PCM.	2
CO2	Differentiate compression techniques and explain digital audio formats	3
CO3	Apply convolution, windowing, and filtering for audio signal processing	4
CO4	Apply Fourier transforms and design FIR/IIR filters for audio processing.	4
CO5	Implement pitch shifting, MELP, and spatial audio processing techniques.	3
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	3	3	-	-	-	-	-	-	-	3	2
2.	3	3	2	3	3	-	-	-	-	-	-	-	3	2
3.	3	3	2	3	3	-	-	-	-	-	-	-	3	2
4.	3	3	2	3	3	-	-	-	-	-	-	-	3	2
5.	3	3	2	3	3	-	-	-	-	-	-	-	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22052	ARTIFICIAL INTELLIGENCE FOR SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To characterize different types of AI environments and learn basic Search Strategies
- To apply different searching algorithms in AI
- To learn knowledge representation and associated logic in solving AI problems
- To introduce probabilistic reasoning, knowledge representation in uncertain domain
- To explore the various applications of AI.

UNIT I	**SOLVING PROBLEMS BY SEARCHING**	**9**

Introduction-Foundation-Agents and Environment-Structure of Agents-Problem Solving Agents-Examples-Searching for Solutions-Uninformed Search Strategies-Informed (Heuristic) Search Strategies-Heuristic Functions.

UNIT II	**SEARCH TECHNIQUES**	**9**

Local Search Algorithms and Optimization Problems-Local Search in Continuous Spaces-Searching with Non deterministic Actions-Searching with Partial Observations-Online Search Agents and Unknown Environments-Defining Constraint Satisfaction Problems.

UNIT III	**LOGICAL REPRESENTATION AND KNOWLEDGE REASONING**	**9**

Knowledge Based Agents-The Wumpus World-Logic-Propositional Logic: A Very Simple Logic-Certainly Factors and Rule based Systems-Representation Revisited-Syntax and Semantics of First Order Logic-Knowledge Engineering in First Order Logic-Propositional Vs First Order Inference-Fuzzy logic

UNIT IV	**PROBABILISTIC REASONING**	**9**

Acting under Uncertainty-Basic Probability Notation-Inference using Full Joint Distributions-Independence-Bayes Rule-Representing Knowledge in an Uncertain Domain-The Semantics of Bayesian Networks-Clustering algorithms-Speech recognition.

UNIT V	**PERCEPTION**	**9**

Image Formation-Early Image Processing Operations-Object Recognition by Appearance-Reconstructing the 3D World-Object Recognition from Structural Information-Using Vision.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Stuart J.Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", Pearson Education Asia, 2022.
2. Elaine Rich, Kevin Knight, Shivashankar B Nair, "Artificial Intelligence", Tata McGraw-Hill Education Private Limited, 2016.

REFERENCES:

1. Deepak Khemani, "Artificial Intelligence", Tata McGraw Hill Education, 2017.
2. Dan W. Patterson, "Introduction to AI and ES", Pearson Education, 2017.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Classify problem solving agents and searching strategies	2
CO2	Apply appropriate searching techniques to solve a real world problem	3
CO3	Analyze the problem and infer new knowledge using suitable knowledge/logic representation schemes	4
CO4	Apply the basic probability uncertainty techniques needed for AI Applications	3
CO5	Implement AI techniques in signal processing	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	2	1	-	-	-	-	-	-	-	2	1	-
2	3	3	2	1	-	-	-	-	-	-	-	2	2	-
3	3	3	2	2	-	-	-	-	-	-	-	2	2	-
4	3	3	3	3	1	1	-	-	-	-	-	2	3	-
5	3	3	3	3	1	1	-	-	1	1	-	2	3	1
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22053	BIOMEDICAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To acquire a comprehensive understanding of Biomedical Signals and its analysis.
- To comprehend the various types and characteristics of noises and artifacts present in biomedical signals.
- To acquire knowledge of the nonstationary and multicomponent biomedical signals.
- To study the various biomedical signals and their significance.
- To analyze the case studies related to ECG, EMG, and PCG signals.

UNIT I	**INTRODUCTION TO BIOMEDICAL SIGNALS**	**9**

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

UNIT II	**REMOVAL OF NOISE AND ARTIFACTS FROM BIOMEDICAL SIGNAL**	**9**

Random and Structured Noise, Physiological Interference, Stationary and Nonstationary Processes, Noises, and Artifacts Present in ECG, Time and Frequency Domain Filtering.

UNIT III	**STUDY OF NONSTATIONARY SIGNALS**	**9**

Heart Sounds and Murmurs, Characterization of Nonstationary Signals and Dynamic Systems, Short-Time Fourier Transform, Considerations in Short-Time Analysis, and Adaptive Segmentation.

UNIT IV	**ANALYSIS OF BIOSIGNALS**	**9**

P-wave detection, QRS complex detection-derivative based method, Pan Tompkins algorithm, Template matching method, Signal averaged ECG, Analysis of heart rate variability-time domain method and frequency domain method, Synchronized averaging of PCG envelopes, envelogram, analysis of PCG signal, EMG signal analysis.

UNIT V	**CASE STUDIES**	**9**

ECG rhythm analysis, normal and ectopic ECG beats, analysis of exercise ECG, analysis of respiration, spectral analysis of EEG signals, case studies in ECG and PCG, PCG and carotid pulse, ECG and atrial electrogram, cardiorespiratory interaction, and EMG and Vibromyogram (VMG).

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Rangaraj. M. Rangayyan, “Biomedical signal processing," Wiley-IEEE Press, 2nd edition, 2015.
2. Reddy D.C., “Biomedical signal processing: Principles and techniques," Tata McGraw-Hill, New Delhi, 2nd edition, 2005.

REFERENCES:

1. S. Salivahanan, “Digital Signal Processing,” Tata McGraw, New Delhi, 4th edition, 2019.
2. Dr. Bhumika Gupta, Dr. Devendra Singh, Dr. Rohit, and Ms. Pragya Baluni, Advancement in Healthcare Applications Using Biomedical Signal Processing, Book Rivers, 2024.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the characteristics of various biomedical signals.	2
CO2	Attain in-depth knowledge about the techniques used for removing noise in biomedical signals.	3
CO3	Analyze the concept of nonstationary and multicomponent biomedical signals.	3
CO4	Apply different methods of signal processing techniques in analyzing the various bio-signals, such as Electrocardiogram (ECG), Electromyogram (EMG) and Phonocardiogram (PCG).	4
CO5	Analyze the various case studies approach in processing the bio-signals.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	3	3	-	-	-	-	-	2	1	3	2
2.	3	3	2	3	3	-	-	-	-	-	2	1	3	2
3.	3	3	2	3	3	-	-	-	-	-	2	2	3	2
4.	3	3	3	3	3	-	-	-	-	-	1	1	3	2
5.	3	3	3	3	3	-	-	-	-	-	1	1	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22054	BIOMETRIC SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the basics of biometrics and its functionalities.
- To understand the technologies of fingerprint recognition.
- To identify the issues in realistic evaluation of Face and hand recognition biometrics systems.
- To acquire knowledge in building a multimodal biometric system and its performance evaluation.
- To express knowledge in various computation of authentication methods

UNIT I	**INTRODUCTION TO BIOMETRICS**	**9**

Introduction and background – biometric technologies – passive biometrics – active biometrics - Biometric systems – Enrollment – templates – algorithm – verification – Biometric applications – biometric characteristics- Authentication technologies –Need for strong authentication - Protecting privacy and biometrics and policy – Biometric applications – biometric characteristics.

UNIT II	**FINGERPRINT RECOGNITION**	**9**

History of fingerprint pattern recognition - General description of fingerprints - Fingerprint feature processing techniques - fingerprint sensors using RF imaging techniques – fingerprint quality assessment – computer enhancement and modeling of fingerprint images – fingerprint enhancement – Feature extraction – fingerprint classification – fingerprint matching

UNIT III	**FACE RECOGNITION AND HAND GEOMETRY**	**9**

Introduction to face recognition, Neural networks for face recognition – face recognition from correspondence maps – Hand geometry – scanning – Feature Extraction – Adaptive Classifiers - Visual-Based Feature Extraction and Pattern Classification - feature extraction – types of algorithm – Biometric fusion.

UNIT IV	**MULTIMODAL BIOMETRICS AND PERFORMANCE EVALUATION**	**9**

Voice Scan – physiological biometrics –Behavioral Biometrics - Introduction to multimodal biometric system – Integration strategies – Architecture – level of fusion – combination strategy – training and adaptability – examples of multimodal biometric systems – Performance evaluation- Performance metrics.

UNIT V	**BIOMETRIC AUTHENTICATION**	**9**

Introduction - Biometric Authentication Methods - Biometric Authentication Systems – Biometric authentication by fingerprint -Biometric Authentication by Face Recognition. Expectation-Maximization theory - Support Vector Machines. – biometric authentication by hand geometry- Multibiometric authentication.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Anil K Jain, Patrick Flynn and Arun A Ross, “Handbook of Biometrics”, Springer, 2018. ISBN: 978-0-387-71040-2.

2. Anil K. Jain, Arun Ross, and Karthik Nandakumar, “Introduction to Biometrics”, Springer, 2014.

REFERENCES:

1. Khalid Saeed, “New Directions in Behavioral Biometrics', CRC Press 2020
2. Massimo Tistarelli and Christophe Champod, “Handbook of Biometrics for Forensic Science” Springer 2018.
3. Nikolaos V Boulgouris, Konstatinos N Plataniotis and Evangelia Micheli Tzanakov,“Biometrics Theory, Methods and Applications”, IEEE & Wiley, 2009, ISBN: 978-0470-24782-2
4. John D Woodward, Nicholas M Orlans and Peter T Higgin, “Biometrics: The Ultimate Reference”, Dream Tech, 2009.
5. https://archive.nptel.ac.in/content/syllabus_pdf/106104119.pdf

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Demonstrate the knowledge of engineering principles underlying biometric systems.	2
CO2	Apply the feature extraction, segmentation and synthesis of fingerprint recognition systems.	3
CO3	Apply the feature extraction, segmentation and synthesis of face and hand recognition systems.	3
CO4	Apply data analytics and evaluate the performance metrics of Multimodal biometric systems.	4
CO5	Explain various computation of authentication methods	2
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	2	2	-	-	1	1	1	2	3	3
2.	3	3	3	3	2	2	-	-	1	1	1	2	3	3
3.	3	3	3	3	2	2	-	-	1	1	1	2	3	3
4.	3	3	3	3	2	2	-	-	1	1	1	2	3	3
5.	3	3	3	3	2	2	-	-	1	1	1	2	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22055	DATA SCIENCE AND ITS APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basics of data science.
- To explain the techniques and processes of data science.
- To describe various processes involved in data visualization.
- To develop machine learning algorithms.
- To apply data science concepts and methods to solve problems in real-world contexts.

UNIT I	**INTRODUCTION TO DATA SCIENCE**	**9**
Introduction to Data Science – Benefits and uses – Facets of data – Data science process – Big data ecosystem and data science		
UNIT II	**DATA SCIENCE PROCESS**	**9**
The Data science process – Overview – research goals - retrieving data - transformation – Exploratory Data Analysis – Model building		
UNIT III	**DATA VISUALIZATION**	**9**
Designing Data Visualizations - The Purpose of Visualization - Selecting Visual Layouts - Choosing Effective Graphical Encodings - Expressive Data Displays.		
UNIT IV	**MACHINE LEARNING ALGORITHMS**	**9**
Algorithms - Machine learning algorithms – Modeling process – Types – Supervised – Unsupervised -Semi-supervised		
UNIT V	**APPLICATIONS OF DATA SCIENCE**	**9**
Healthcare Analytics Applications, Predictive Analytics Applications-Regression, Classification, Clustering. Dimensionality Reduction Application-PCA. Prescriptive Analytics Application.		
	TOTAL: 45 PERIODS	

TEXT BOOKS:

1. Davy Cielen, Arno D. B. Meysman, Mohamed Ali, “Introducing Data Science”, manning publications 2016.
2. Cathy O’Neil and Rachel Schutt. Doing Data Science, Straight Talk From The Frontline. O’Reilly. 2014.

REFERENCES:

1. Murtaza Haider, “Getting Started with Data Science – Making Sense of Data with Analytics”, IBM press, first edition, 2015.
2. Davy Cielen, Arno D.B. Meysman, Mohamed Ali,“Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools”, Dreamtech Press 2016.
3. Annalyn Ng, Kenneth Soo, “Numsense! Data Science for the Layman: No Math Added”, 2017,1st Edition.
4. Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press. 2014. (free online)
5. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective. ISBN 0262018020. 2013.
6. Mohammed J. Zaki and Wagner Miera Jr. Data Mining and Analysis: Fundamental Concepts and Algorithms. Cambridge University Press. 2014.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Describe the overview of data science.	3
CO2	Illustrate the concepts of the Data Science process.	3
CO3	Apply the various processes used for data visualization.	3
CO4	Interpret the machine learning algorithms	3
CO5	Identify the real world applications of data science.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	-	-	-	-	-	-	-	-	1	3	1
2.	3	3	2	1	2	2	2	-	2	1	-	2	3	2
3.	3	3	2	1	2	2	2	-	2	1	-	2	3	2
4.	3	3	2	1	2	2	2	-	2	1	-	2	3	2
5.	3	3	2	1	2	2	2	2	2	1	-	2	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22056	DEEP LEARNING FOR COMPUTER VISION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the theoretical foundations of machine learning models.
- To illustrate the different working principles of deep learning architectures.
- To analyze how to reduce the dimensions of high resolution data.
- To evaluate the generalizability of the optimized deep networks.
- To apply optimized deep networks for appropriate real-time applications.

UNIT I	**FUNDAMENTALS OF MACHINE LEARNING**	**9**

Linear models (SVMs and Perceptron, logistic regression)- Intro to Neural Nets: What a shallow network computes- Training a network: loss functions, back propagation and stochastic gradient descent- Neural networks as universal function approximates

UNIT II	**DEEP LEARNING ARCHITECTURE**	**9**

History of Deep Learning- A Probabilistic Theory of Deep Learning Backpropagation and regularization, batch normalization- VC Dimension and Neural Nets-Deep Vs Shallow Networks Convolutional Networks- Generative Adversarial Networks (GAN), Semi Supervised Learning, NVDLA.

UNIT III	**DIMENSIONALITY REDUCTION**	**9**

Linear (PCA, LDA) and manifolds, metric learning - Autoencoders and dimensionality reduction in networks - Introduction to Convnet - Architectures – AlexNet, VGG, Inception, ResNet - Training a Convnet: weights initialization, batch normalization, hyperparameter optimization

UNIT IV	**OPTIMIZATION AND GENERALIZATION**	**9**

Optimization in deep learning– Non-convex optimization for deep networks- Stochastic Optimization Generalization in neural networks Spatial Transformer Networks- Recurrent networks, LSTM - Recurrent Neural Network Language Models- Word-Level RNNs & Deep Reinforcement Learning - Computational & Artificial Neuroscience

UNIT V	**APPLICATIONS AND CASE STUDY**	**9**

Imagenet- Detection-Audio Wave Net-Natural Language Processing Word2Vec - Joint Detection BioInformatics- Face Recognition- Scene Understanding Gathering Image Captions

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Aggarwal, Charu C, Neural networks and deep learning, Springer, 2018
2. Bengio, Yoshua, Ian J. Goodfellow, and Aaron Courville. "Deep learning", MIT 2017
3. Cosma Rohilla Shalizi, Advanced Data Analysis from an Elementary Point of View, 2015.

REFERENCES:

1. Mohamad H. Hassoun, Fundamentals of Artificial Neural Networks, The MIT Press 2013.
2. Michael Nielsen, Neural Networks and Deep Learning, Determination Press,2015.
3. Deng & Yu, Deep Learning: Methods and Applications, Now Publishers, 2013
4. Adrian Rosebrock, Deep Learning for Computer Vision with Python, Pyimagesearch, 2017

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Demonstrate the basics of machine learning for a given context.	2
CO2	Implement various deep learning models to solve the given problem.	3
CO3	Implement realignment high dimensional data using reduction techniques for the given problem.	3
CO4	Analyze the optimization and generalization techniques of deep learning for the given problem.	4
CO5	Evaluate the given deep learning application and enhance by applying latest techniques	5
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
2.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
3.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
4.	3	3	2	2	2	2	-	-	-	-	1	1	3	1
5.	3	2	2	2	3	2	-	-	-	-	1	1	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22057	IMAGE ANALYSIS AND MACHINE VISION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To describe the essentials of image processing and filtering concepts through mathematical interpretation.
- To acquire knowledge of various image enhancement and image restoration techniques involved.
- To acquire the basics of computer vision and different geometric transformations.
- To evaluate various motion analysis and tracking techniques for various aspects of image processing.
- To analyze and implement computer vision and image processing algorithms for various real-time applications.

UNIT I	**INTRODUCTION TO IMAGE PROCESSING AND IMAGE FILTERING**	**9**

Overview of image representation - Digital images, pixels, Image enhancement techniques - contrast adjustment, histogram equalization, Image Filtering and Restoration-Spatial domain filtering -convolution, mean filtering, median filtering, Frequency domain filtering -Fourier transform, high-pass and low-pass filters.

UNIT II	**IMAGE SEGMENTATION AND FEATURE EXTRACTION**	**9**

Thresholding techniques -global, local, adaptive, Edge detection -Sobel, Canny, Prewitt operators, Region-based segmentation, Point-based features -Harris corner detection, SIFT,Region-based features-Histogram of Oriented Gradients – HOG

UNIT III	**INTRODUCTION TO COMPUTER VISION**	**9**

Basics of computer vision and its applications, Camera models and calibration, Geometric transformations -homography, affine transformation.

UNIT IV	**OBJECT DETECTION AND RECOGNITION**	**9**

Object detection techniques - Haar cascades, HOG, SVM, Deep learning for object detection - Object recognition and classification - Basic CNN architectures (Algorithmic approach only)

UNIT V	**APPLICATIONS OF COMPUTER VISION AND IMAGE PROCESSING**	**9**

Motion analysis and tracking, Machine Learning applications in Medical Image Segmentation, Applications in healthcare, autonomous vehicles, Face and Facial Expression Recognition, Gesture recognition.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", Pearson Education, Fourth Edition, 2018.
2. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, Second edition, ISBN-10: 1848829345, ISBN-13: 978-1848829343, 2022, http://szeliski.org/Book/
3. Manas Kamal BhuyanComputer Vision and Image Processing Fundamentals and Applications, CRC Press,2020
4. S. Sridhar, "Digital Image Processing", Second Edition, Oxford University, 2016.

REFERENCES:

1. Anil K. Jain "Fundamentals of Digital Image Processing", PHI, Learning Private Ltd, 2011.
2. https://onlinecourses.nptel.ac.in/noc21_ee23/
3. David Marr," Vision: A Computational Investigation into the Human Representation and Processing of Visual Information", The MIT Press, 2010

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Demonstrate a comprehensive understanding of digital image fundamentals, including pixel representation, color models, and image formats.	3
CO2	Employ segmentation algorithms to partition images and identify distinct objects or areas.Utilize feature extraction methods to identify and describe image features effectively.	3
CO3	Understand camera models, geometric transformations, 3D vision principles, and their application in computer vision systems.	3
CO4	Implement object detection and recognition algorithms, ranging from traditional methods like Haar cascades to modern deep learning approaches such as CNN.	4
CO5	Apply learned techniques to analyze and solve real-world problems in diverse domains.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	2	2	1	-	-	-	-	-	-	1	3	-
2.	3	2	2	2	1	-	-	-	-	-	-	1	3	-
3.	3	2	2	2	1	-	-	-	-	-	-	1	3	-
4.	3	2	2	2	1	-	-	-	-	-	-	1	3	2
5.	3	2	2	2	1	-	-	-	-	-	-	1	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22058	SOFT COMPUTING TECHNIQUES AND ITS APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the basic concept of soft computing
- To know the basics of artificial neural networks.
- To apply the concept of fuzzy logic in various systems.
- To explain the idea about genetic algorithm
- To provide adequate knowledge about the applications of Soft Computing.

UNIT I	**INTRODUCTION TO SOFT COMPUTING**	**9**

Introduction-Artificial Intelligence-Artificial Neural Networks-Fuzzy Systems-Genetic Algorithm and Evolutionary Programming-Swarm Intelligent Systems-Classification of ANNs-McCulloch and Pitts Neuron Model-Learning Rules: Hebbian and Delta- Perceptron Network-Adaline Network-Madaline Network.

UNIT II	**ARTIFICIAL NEURAL NETWORKS**	**9**

Back propagation Neural Networks - Kohonen Neural Network -Learning Vector Quantization - Hamming Neural Network - Hopfield Neural Network- Bi-directional Associative Memory - Adaptive Resonance Theory Neural Networks- Support Vector Machines - Spike Neuron Models.

UNIT III	**FUZZY SYSTEMS**	**9**

Introduction to Fuzzy Logic, Classical Sets and Fuzzy Sets - Classical Relations and Fuzzy Relations -Membership Functions -Defuzzification - Fuzzy Arithmetic and Fuzzy Measures -Fuzzy Rule Base and Approximate Reasoning - Mamdani Fuzzy Models – Sugeno Fuzzy Models – Tsukamoto Fuzzy Models

UNIT IV	**GENETIC ALGORITHMS**	**9**

Basic Concepts- Working Principles -Encoding- Fitness Function - Reproduction -Inheritance Operators - CrossOver - Inversion and Deletion -Mutation Operator - Bitwise Operators - Convergence of Genetic Algorithm. Applications – Match Word Finding, Travelling Sales Man Problem, Indiscernibility Relations, Reducts, Rough Approximation applications.

UNIT V	**APPLICATIONS OF SOFT COMPUTING**	**9**

Genetic Algorithm Application- Bagley and Adaptive Game-Playing Program- Greg Viols Fuzzy Cruise Controller-Air Conditioner Controller-Application of Back Propagation Neural Network.

TOTAL PERIODS : 45 PERIODS

TEXT BOOKS:

1. N.P.Padhy, S.P.Simon, "Soft Computing with MATLAB Programming", Oxford University Press, 2015.
2. S.N.Sivanandam , S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt. Ltd., 2nd Edition, 2011.
3. S.Rajasekaran, G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm, Synthesis and Applications ", PHI Learning Pvt. Ltd., 2017.

REFERENCES:

1. Jyh-Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, "Neuro-Fuzzy and Soft Computing‖, Prentice-Hall of India, 2002.
2. Kwang H.Lee, ―First course on Fuzzy Theory and Applications‖, Springer, 2005.
3. George J. Klir and Bo Yuan, ―Fuzzy Sets and Fuzzy Logic-Theory and Applications‖, Prentice Hall, 1996.
4. James A. Freeman and David M. Skapura, ―Neural Networks Algorithms, Applications, and Programming Techniques‖, Addison Wesley, 2003.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the key aspects of Soft computing and Neural networks.	2
CO2	Attain in-depth knowledge about the basic concepts of Artificial Neural Networks.	3
CO3	Apply knowledge in developing a Fuzzy expert system	3
CO4	Discover knowledge to develop Genetic Algorithm based Machine learning systems.	4
CO5	Integrate various soft computing techniques for complex problems.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	3	3	-	-	-	-	-	-	-	3	2
2.	3	3	2	3	3	-	-	-	-	-	-	-	3	2
3.	3	3	2	3	3	-	-	-	-	-	-	-	3	2
4.	3	3	3	3	3	-	-	-	-	-	-	-	3	2
5.	3	3	3	3	3	-	-	-	-	-	-	-	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22050	MINI PROJECT	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To understand the fundamentals of signal processing.
- To acquire practical experience in applying signal processing techniques to analyze and manipulate signals.
- To develop skills in implementing signal processing algorithms using programming languages such as Python or MATLAB.
- To apply signal processing techniques to solve real-world complex engineering problems in areas such as audio processing, image processing, and biomedical signal analysis.

PROJECT WORK MODALITIES

This mini project provides students with an opportunity to apply signal processing techniques to real-world problems. Through hands-on projects and practical exercises, students will explore various aspects of signal processing, including filtering, spectral analysis, feature extraction, and signal classification. Applications can be laid to:

- Introduction to Signal Processing-Overview of signals and systems, Basics of digital signal processing, Introduction to Fourier analysis
- Signal Representation and Sampling- Signal representation in time and frequency domains
- Filtering Techniques- FIR and IIR filter design
- Frequency Domain Analysis- Power spectral density estimation, Spectrogram analysis
- Feature Extraction- Time-domain features (mean, variance, etc.), Frequency-domain features (spectral centroid, bandwidth, etc.)
- Signal Classification
- Introduction to machine learning for signal classification
- Signal Processing Applications

Students will work on a mini project applying signal processing techniques to a real-world problem. Projects may include audio processing, image processing, biomedical signal analysis, etc. Project development, implementation, and presentation and Evaluation of

Students will present their mini projects to the class, demonstrating their understanding of signal processing concepts and techniques. Evaluation is based on project presentation, code quality, and project documentation.

Prerequisites:

Basic understanding of signals and systems

Familiarity with programming (MATLAB or Python preferred)

TOTAL: 60 PERIODS

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Identify challenges and carry out surveys on existing approaches.	2
CO2	Develop an innovative idea and consider all the possible implementation problems.	3
CO3	Create a prototype and implement the design into action work.	5
CO4	Demonstrate and display the functional module.	4
CO5	Prepare a report and a presentation outlining the project's	5
***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	3	2	2	2	1	1	-	1	2	2	2
2.	3	3	3	2	3	2	2	1	2	1	2	2	2	3
3.	3	3	3	2	3	2	2	1	2	1	3	1	3	3
4.	3	2	3	3	3	1	1	1	2	2	1	1	3	3
5.	3	2	3	3	3	2	1	2	3	3	3	1	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

VERTICAL 6
EMBEDDED SYSTEM DESIGN AND IOT

EC22061	INDUSTRY 4.0 AND IIOT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To impart basic ideas in Industry 4.0 and IIoT.
- To discover smart business perspectives and impacts of Industry 4.0.
- To grasp the core principles of IIoT.
- To understand and evaluate the primary drivers of IIoT.
- To become well-versed in the many IIoT applications.

UNIT I	OVERVIEW OF INDUSTRY 4.0 and IIoT	9

Introduction, Industry 4.0- Industrial revolution, Evolution of Industry 4.0, Environmental impacts, Industrial Internet, Applications. IIoT- Prerequisites, Basics of CPS, CPS and IIoT, Applications

UNIT II	FUNDAMENTALS OF INDUSTRY 4.0	9

Introduction, Design Requirements, Drivers of Industry 4.0, Four main characteristics of industry 4.0, Sustainability assessment of industries, Smart Business Perspective, Cybersecurity, Impacts of Industry 4.0, Smart Factories, Benefits of Industry 4.0, Digital Twin Technology.

UNIT III	INTRODUCTION TO IIOT	9

Basics of Industrial IoT, Industrial Internet Systems- Design, Impact and Benefits, Industrial Sensing- Traditional and contemporary, Industrial Processes - Features of IIoT for industrial processes, Business models of IIoT, Reference architecture of IioT

UNIT IV	ON AND OFF- SITE KEY TECHNOLOGIES	9

Cloud Computing, Fog Computing, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis, Smart Factories, Lean manufacturing system, Edge Computing

UNIT V	INDUSTRIAL MANAGEMENT AND CASE STUDIES	9

Inventory Management and Quality Control, Plant Safety and Security, Case Study-Automotive, Manufacturing and Mining Industries, Healthcare

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Jean-Claude Andre, ―Industry 4.0, Wiley- ISTE, July 2019, ISBN: 781786304827, 2019.
2. Sudip Misra, Chandana Roy, Anandarup Mukherjee, Introduction to Industrial Internet of Things and Industry 4.0, 2021
3. Alasdair Gilchrist, Industry 4.0, The Industrial Internet of Things, Apress, 2017.

REFERENCES:

1. NPTEL :: Computer Science and Engineering - NOC: Introduction to Industry 4.0 and Industrial Internet of Things.
2. Giacomo Veneri, Antonio Capasso, Hands-On Industrial Internet of Things: Create a powerful Industrial IoT.
3. Ismail Butun, Industrial IoT: Challenges, Design Principles, Applications, and Security, July 2020.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the basic concepts of Industry 4.0.	2
CO2	Comprehend on various aspects of Industry 4.0.	2
CO3	Interpret the basics of industrial IoT and its architecture.	3
CO4	Examine the key enablers of IIoT.	4
CO5	Implement the IIoT to industrial sectors and analyze the case studies.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	1	2	3	-	2	-	-	1	2	-	-	1	1	-
2.	1	2	3	-	2	-	-	1	2	-	-	1	1	-
3.	1	2	3	-	2	-	-	1	2	-	-	1	1	-
4.	1	2	3	-	2	-	-	1	2	-	-	1	1	-
5.	1	2	3	-	2	-	-	1	2	-	-	1	1	-
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22062	IOT BASED SYSTEM DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of IoT
- To acquire knowledge about IoT Access technologies
- To understand the design methodology and different IoT hardware platforms.
- To study the basics of IoT Data Analytics and supporting services.
- To study various IoT case studies and industrial applications.

UNIT I	**FUNDAMENTALS OF IoT**	**9**

Evolution of Internet of Things, Enabling Technologies, M2M Communication, IoT World Forum (IoTWF) standardized architecture, Simplified IoT Architecture, Core IoT Functional Stack, Fog, Edge and Cloud in IoT, Functional blocks of an IoT ecosystem, Sensors, Actuators, Smart Objects and Connecting Smart Objects.

UNIT II	**IoT PROTOCOLS**	**9**

IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.11ah and Lora WAN, Network Layer: IP versions, Constrained Nodes and Constrained Networks, 6LoWPAN, Application Transport Methods: SCADA, Application Layer Protocols: CoAP and MQTT.

UNIT III	**DESIGN AND DEVELOPMENT**	**9**

Design Methodology, Embedded computing logic, Microcontroller, System on Chips, IoT system building blocks

IoT Platform overview: Overview of IoT supported Hardware platforms such as: Raspberry pi, Arduino Board details

UNIT IV	**DATA ANALYTICS AND SUPPORTING SERVICES**	**9**

Data Analytics: Introduction, Structured Versus Unstructured Data, Data in Motion versus Data at Rest, IoT Data Analytics Challenges, Data Acquiring, Organizing in IoT/M2M,

Supporting Services: Computing Using a Cloud Platform for IoT/M2M Applications/Services, Everything as a service and Cloud Service Models.

UNIT V	**CASE STUDIES/REAL TIME APPLICATIONS**	**9**

Smart homes, Smart vehicles, Weather monitoring & forecasting, Indoor location-based services, Health monitoring of machines & structures, Augmented/Virtual reality.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry “IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things”, Cisco Press, 2017.
2. Arshdeep Bahga, Vijay Madisetti “Internet of Things – A hands-on approach”, Universities Press, 2014.
3. Vibha Soni, “IoT for Beginners: Explore IoT Architecture, Working Principles, IoT Devices, and Various Real IoT Projects”, BPB Publications, 2021.

REFERENCES:

1. Simone Cirani, Gianluigi Ferrari, Marco Picone, Luca Veltri, “Internet of Things – Architectures, Protocols and Standards” Wiley, 2019.
2. Rajkamal “Internet of Things: Architecture and Design Principles”, McGraw Hill Higher Education, 2017.
3. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand, David Boyle “From Machine-to-Machine to the Internet of Things – Introduction to a New Age of Intelligence", Elsevier Ltd., 2014.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Infer the state of architecture of IoT	2
CO2	Summarize the various protocols used in IoT	3
CO3	Interpret the design methodology and hardware platforms involved in IoT	3
CO4	Analyze the data and supporting services required for IoT	4
CO5	Examine the various real time applications of IoT	4
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	1	1	1	1	-	1	-	-	3	3	3
2.	3	3	2	3	3	2	2	1	2	2	3	3	3	3
3.	3	3	3	3	3	2	2	2	2	1	3	3	3	3
4.	3	3	3	3	3	3	3	3	2	-	2	3	3	3
5.	3	3	3	3	3	3	3	3	2	2	2	3	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22063	IOT FOR REAL TIME APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To comprehend various applications of IoT in the field of healthcare
- To understand the applications of IoT in agriculture
- To get familiarized on IoT based industrial automation
- To get conversant on Intelligent transportation system
- To understand the impact of IoT on society

UNIT I	**IOT IN HEALTHCARE**	**9**

IoT in Healthcare – Challenges in current healthcare systems – IoT healthcare services-Architecture of IoT for Healthcare, IoT based health monitoring system using Arduino, Smart continuous glucose monitoring (CGM) system and insulin pens, remote patient monitoring - IoT heart rate monitoring, remote monitoring of physiological parameters - ECG, EEG, Diabetics and BP

UNIT II	**IOT FOR SMART AGRICULTURE**	**9**

Animal Intrusion detection in farms, soil moisture detection and irrigation system, water quality monitoring, pest monitoring and control, Livestock monitoring system, IoT based Greenhouse environment monitoring and controlling

UNIT III	**IOT BASED INDUSTRIAL AUTOMATION**	**9**

IoT based gas leakage monitoring system, Temperature and liquid level monitoring in boilers, Fire detection system, wireless video surveillance robot, Automatic solar tracker

UNIT IV	**INTELLIGENT TRANSPORTATION SYSTEM**	**9**

Basics of ITS - Challenges and opportunities in ITS - Systems engineering in ITS and ITS architecture - ITS applications in transportation system management - Connected and autonomous vehicles (C&AV) - Indian Smart Cities Mission

UNIT V	**IOT FOR DISASTER MANAGEMENT**	**9**

Medical waste management, weather update system with IoT, women security system, GPS Smart sole, wearable glove to enable sign to speech conversation, IoT based air pollution meter

TOTAL: 45 PERIODS

TEXT BOOKS:

1. S Awasthi, MS Naruka, SP Yadav, "AI and IoT-based Intelligent Health Care & Sanitation", VHC De Albuquerque, 2023.
2. AK Kaviti, "Internet of Things for Agriculture 4.0: Impact and Challenges", 2022.
3. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things", 2017.

REFERENCES:

1. Olivier Hersent, David Boswarthick, Omar Elloumi and Wiley, "The Internet of Things – Key applications and Protocols", 2012.
2. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand. David Boyle and Elsevier,"From Machine-to-Machine to the Internet of Things – Introduction

to a New Age of Intelligence", 2014.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Interpret the applications of IoT in healthcare	3
CO2	Identify the various applications of IoT in agriculture	2
CO3	Discuss the different IoT based industrial automation systems	2
CO4	Describe the role of ITS, its benefits and challenges	3
CO5	Analyze the impact of IoT on disaster management	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	3	3	3	2	1	3	2	3	3
2.	3	3	3	3	3	3	3	3	2	1	3	2	3	3
3.	3	3	3	3	3	3	3	3	2	1	3	2	3	3
4.	3	3	3	3	3	3	3	3	2	1	3	2	3	3
5.	3	3	3	3	3	3	3	3	2	2	3	2	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22064	IOT SOLUTIONS FOR SMART CITIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the characteristics and basic architecture of smart cities
- To explore the resources required for smart cities to sustain themselves.
- To understand the IOT communication technologies and protocols for smart cities
- To learn about the transportation challenges and solutions for smart cities
- To understand the Security and Privacy Threats in IoT-Enabled Smart Cities

UNIT I	**INTRODUCTION TO IOT FOR SMART CITIES**	**9**

Introduction-Characteristics of Smart Cities, IoT-Based Solutions for Smart Cities, Smart Home, Transport and Traffic Management, Challenges, Smart City Planning and Management, The Fundamentals of Smart Infrastructure, Smart and Sustainable City, Smart City Areas (Sub-Areas), Examples of Smart Cities, Smart City Benefits.

UNIT II	**SMART AND CONNECTED CITIES**	**9**

An IoT Strategy for Smarter Cities -Vertical IoT Needs for Smarter Cities - Global vs. Siloed Strategies, Smart City IoT Architecture -Street Layer- City Layer -Data Center Layer- Services Layer - On-Premises vs. Cloud, Smart City Security Architecture, Smart City Use-Case Examples- Connected Street Lighting Solution - Smart Parking Use Cases.

UNIT III	**COMMUNICATION TECHNOLOGIES AND PROTOCOLS FOR INTERNET OF THINGS**	**9**

Communication Technologies for IoT Networks, Recent Protocols for IoT, Overview of Secure IoT Architectures, IoT-Based Services for Smart Cities, Cellular Mobile Networks, Cloud Internet of Things, Study of Communication Technologies: Intelligent Traffic System, Disaster Management, Implementation and Comparison of MQTT, WebSocket, and HTTP Protocols for Smart Room IoT Application in Node-RED.

UNIT IV	**TRANSPORTATION SYSTEM IN IOT**	**9**

Transportation Challenges, Roadways, Mass Transit, Rail, Challenges for Transportation Operators and Users, An IoT Architecture for Transportation, Traffic Management for Smart Cities, and Usage of various sensors in transportation systems.

UNIT V	**SECURITY AND PRIVACY IN IOT**	**9**

Privacy and Social Values in Smart Cities, Information Security in the Smart City, IoT Security Challenges, Blockchain Technology for IoT, Case Studies: Smart Homes, Food Supply Chain Traceability System, Smart building, smart irrigation, Security and Privacy Threats in IoT-Enabled Smart Cities.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Waleed Ejaz, Alagan Anpalagan, Internet of Things for Smart Cities: Technologies, Big Data and Security, 1st ed. Springer International Publishing, 2019.
2. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, Cisco Press, June 2017, ISBN-13: 978-1-58714-456-1.
3. Stimmel, Carol L, Building smart cities: analytics, ICT, and design thinking, Taylor & Francis, 2016.
4. Joel J. P. C. Rodrigues, Parul Agarwal, Kavita Khann, IoT for Sustainable Smart Cities and Society, 2022.

REFERENCES:

1. Vincenzo Piuri, Rabindra Nath Shaw, Ankush Ghosh, Rabiul Islam, AI and IoT for Smart City Applications, Springer, 2022.
2. Vincenzo Piuri, Rabindra Nath Shaw, Ankush Ghosh, Rabiul Islam, AI and IoT for Smart City Applications, Springer International Publishing , 2022.
3. Al-Turjman, Fadi, Intelligence in IoT-enabled smart cities, CRC Press, 2019.
4. Artificial Intelligence, Machine Learning, and Deep Learning, Oswald Campesato, Mercury Learning and Information, 2020.
5. Arpan Kumar Kar, M P Gupta, P. Vigneswara Ilavarasan, Yogesh K. Dwivedi, Advances in smart cities: smarter people, governance and solutions CRC Press, 2017.
6. Understanding IoT Security: https://iot-analytics.com/understanding-iot-security-part-1-iot-security-architecture/
7. Hammi, B., Khatoun, R., Zeadally, S., Fayad, A., & Khoukhi, L. IoT technologies for smart cities, 2018.

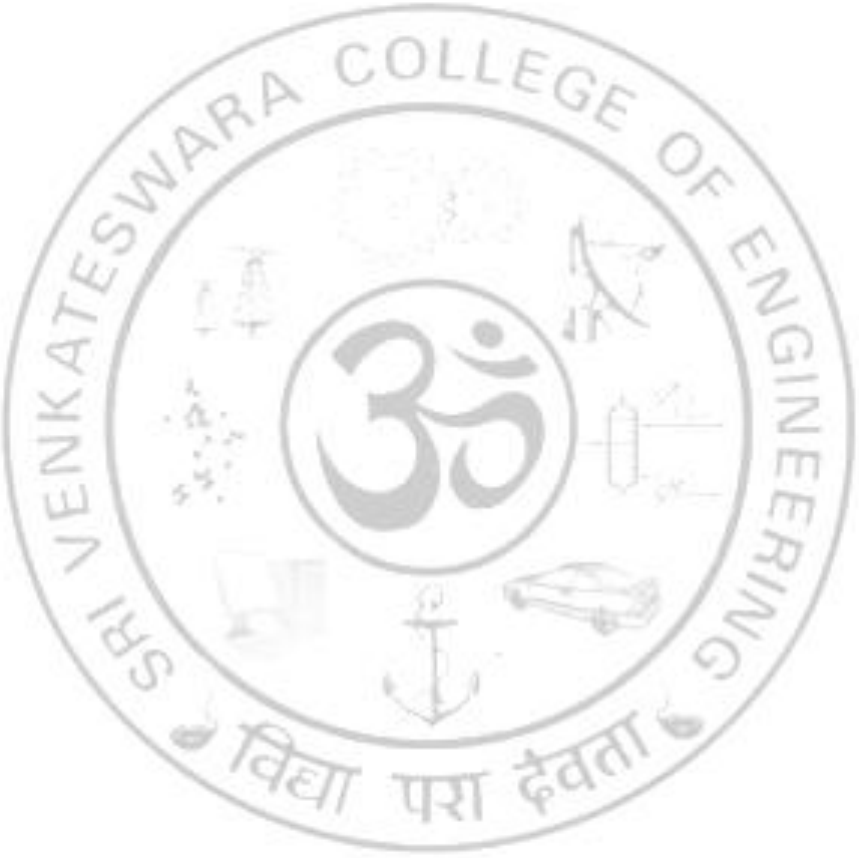
List of Open Source Software/ Learning Websites

1. https://www.coursera.org/lecture/network-transformation-101/iot-verticals-smart-cities-and-utilities-wN2aQ
2. https://www.udemy.com/course/introduction-to-smart-cities-technologies-bim-gis-iot-ai/
3. https://www.snap4city.org/drupal/node/577
4. https://academy.itu.int/training-courses/full-catalogue/acquiring-5g-iot-services-smart-cities-smart-villages
5. https://www.futurelearn.com/info/courses/gettingstartedwiththeiot/0/steps/149743
6. https://telecomstechacademy.com/course/smart-cities-101-online-academy/
7. Open source software: Node-RED, PubNub, IoT-AWS, PlatformIO, OpenIoT, CityOS etc.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the basic characteristics and architecture of smart cities	2
CO2	Interpret the resources required for smart cities to sustain themselves	3
CO3	Apply the IOT communication technologies and protocols for smart cities	3
CO4	Identify the transportation challenges and solutions for smart cities	3
CO5	Analyze the Security and Privacy Threats in IoT-Enabled Smart Cities and various case studies	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

*COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	2	2	2	1	-	2	-	-	-	2	2	3	3	3
2.	3	3	2	2	-	2	3	-	-	2	2	3	3	3
3.	2	2	3	2	3	3	2	-	-	2	3	3	3	3
4.	3	3	3	2	3	2	3	-	-	2	2	3	3	3
5.	2	3	2	2	2	2	2	-	-	2	2	3	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														



EC22065	REAL TIME OPERATING SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To expose the fundamentals of interaction of OS with a computer and User computation.
- To explain the fundamental concepts of process creation and control with OS.
- To explore the programming logic behind modeling processes with a variety of OS features.
- To analyze and contrast types and functionalities across commercial operating systems,
- To examine fundamentals of embedded OS and user interfaces.

UNIT I	**REVIEW OF OPERATING SYSTEMS**	**9**

Basic Principles - Operating System structures – System Calls – Files – Processes – Design and Implementation of processes – Communication between processes – Introduction to Distributed operating system – issues in distributed system: states, events, clocks - Distributed scheduling - Fault & recovery.

UNIT II	**OVERVIEW OF RTOS**	**9**

RTOS Task and Task state – Multithreaded Preemptive scheduler- Process Synchronization - Message queues– Mailboxes - pipes – Critical section – Semaphores – Classical synchronization problem – Deadlocks.

UNIT III	**REAL TIME MODELS AND LANGUAGES**	**9**

Event Based – Process Based and Graph-based Models – Real Time Languages – RTOS Tasks – RT scheduling - Interrupt processing – Synchronization – Control Blocks – Memory Requirements.

UNIT IV	**REAL TIME KERNEL**	**9**

Principles – Design issues – RTOS Porting to a Target – Comparison and Basic study of various RTOS like – VX works – Linux supportive RTOS – C Executive.

UNIT V	**INTRODUCTION TO EMBEDDED OS**	**9**

Discussions on Basics of Linux supportive RTOS – uCOS-C Executive for development of RTOS Application –introduction to Android Environment -The Stack – Android User Interface – Preferences, the File System, the Options Menu and Intents, with one Case study.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Introduction to Embedded System- Shibu KV, Mc-Graw Hill Higher Edition, 2nd Edition, 2017.
2. Raj Kamal, "Embedded Systems- Architecture, Programming and Design" Tata McGraw Hill, 2006.
3. C.M. Krishna, Kang, G.Shin, "Real Time Systems", McGraw Hill, 1997.
4. Herma K., "Real Time Systems – Design for Distributed Embedded Applications", Kluwer Academic, 1997.

REFERENCES:

1. K. C. Wang, Embedded and Real-Time Operating Systems, Second Edition, Springer Nature, 2023.
2. Silberschatz,Galvin, Gagne "Operating System Concepts", 6th ed, John Wiley,2003.
3. Charles Crowley, "Operating Systems-A Design Oriented approach" McGraw Hill,1997.

4. Karim Yaghmour, “Building Embedded Linux System”,O’reilly Pub,2003
5. Marko Gargenta, “Learning Android”, O’reilly 2011.
6. Corbet Rubini, Kroah-Hartman, “Linux Device Drivers”, O’reilly, 2016.
7. Mukesh Sighal and N G Shi, “Advanced Concepts in Operating System”, McGraw Hill, 2000.

COURSE OUTCOMES: **Upon successful completion of the course, students should be able to:**		**RBT Level**
CO1	Understand Real-time scheduling and schedulability analysis, including clock-driven and priority-driven scheduling	2
CO2	Apply Theoretical background (specification/verification) and practical knowledge of real-time operating systems.	3
CO3	Grasp the utilization of multitasking techniques in real-time systems.	3
CO4	Understand the fundamental concepts of real-time operating system	3
CO5	Analyze improved Employability and entrepreneurship capacity due to knowledge upgradation on recent trends in embedded systems design.	4

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	2	2	1	1	-	-	-	-	2	-	2	1
2.	3	2	2	2	1	-	-	-	-	-	2	-	2	2
3.	3	3	3	2	2	1	-	-	-	-	2	-	2	2
4.	3	3	3	3	2	-	-	-	-	-	2	-	2	2
5.	3	2	3	2	2	-	-	-	-	-	2	-	2	1
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22066	ROBOTICS AND AUTOMATION (Common to EC, EE)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To acquire basic knowledge on robotics and associated automation principles along with the existing industrial applications.
- To explore various types of sensors, robot actuators, end effectors concerned with manipulators.
- To study robot kinematics and end effectors.
- To acquire knowledge on vision systems and types of robot programming.
- To explore robotics automation and applications in industry.

UNIT I	FUNDAMENTALS OF ROBOTICS AND AUTOMATION	9

Robotics: Definition, Origin, Different types, Various generations –Degrees of freedom; Anatomy of a robot – Classification of robots – Cartesian, Cylindrical, Spherical, Articulated, SCARA; Precision of robot movements – Accuracy, Resolution, Repeatability– specifications – Pitch, yaw, Roll, Joint Notations, Speed of Motion, Payload.

Automation: Basic elements of an automated system – Level of automation; Computer process control – Control requirements, Forms of computer process control. Overview on controller and its types – PI, PD, PID

UNIT II	SENSORS AND ACTUATORS	9

Sensors: Sensor characteristics, Types of sensors – Tactile sensors, Touch sensors; Position sensors – Potentiometer, Encoder, LVDT, Resolvers; Proximity sensors – Magnetic, Optical, Ultrasonic, Inductive, Capacitive, Eddy current; Speed sensors – Velocity/motion sensors; Force/Pressure and torque sensors.

Actuators: Mechanical Actuation System – Cams, Gear trains, Ratchet and Pawl, Belt and chain drives, Bearings; Electrical Actuation System – Stepper motors, Servo motors , Brushless DC motor; Hydraulic and Pneumatic Actuation Systems - Principle of operation.

UNIT III	ROBOT MOTION ANALYSIS AND END EFFECTORS	9

Manipulator kinematics – Position representation and orientation – Forward, Reverse and Homogeneous transformation – Kinematic equations – Solving Inverse kinematic equations; End Effectors – Gripper mechanism –Types – Gripper selection and design –Tools.

UNIT IV	ROBOTIC VISION AND ROBOT PROGRAMMING	9

Architecture and components of robotic vision systems – Image acquisition and representation, Stereo vision – Image histograms – Spatial operations – Smoothing – Segmentation – Object descriptors – Object Recognition.

Robot programming – Methods –Lead through programming, Textual programming languages – Structure – Motion Commands –Sensors commands – End effector Commands

UNIT V	AUTOMATION IN INDUSTRIAL APPLICATIONS	9

Flexible Manufacturing Systems – Components, Planning and implementation issues, Benefits and applications; Automated Storage Retrieval Systems (ASRS) – types, components and operating features; Automated processing/machining – Transfer lines; Automatic assembly – System configuration, parts delivery, applications; Automatic inspection – types, procedure, accuracy; Internet of Robotic Things - Overview.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Nicholas Odrey, Mitchell Weiss, Mikell Groover, Roger Nagel, Ashish Dutta, "Industrial Robotics -Technology ,Programming and Applications", 2nd Edition, McGraw Hill Education, 2017.
2. Mikell P. Groover, "Automation, Production systems and Computer Integrated Manufacturing", 4th edition, Pearson, 2015.
3. Saeed B. Niku, "Introduction to Robotics: Analysis, control and applications", 3rd Edition, John Wiley & Sons Ltd, 2020.
4. Peter Corke, "Robotics, Vision and control-Fundamental algorithms in MATLAB", Springer International publishing AG, 2017.

REFERENCES:

1. Mittal R K, Nagrath I J, "Robotics and control", McGraw Hill Education, 2017.
2. Mark R. Miller, Rex Miller, Robots and Robotics - "Principles, Systems and Industrial Applications", McGraw-Hill Education, 2017.
3. Stamatios Manesis, George Nikolakopoulos, "Introduction to Industrial Automation", CRC press (Taylor and Francis), 2020.
4. Kevin M. Lynch and Frank C. Park, "Modern Robotics: Mechanics, Planning, and Control", Cambridge University Press, 2017.
5. Ganesh S Hegde, "A textbook on Industrial Robotics", University science press, 3rd edition, 2017.

e-RESOURCES:

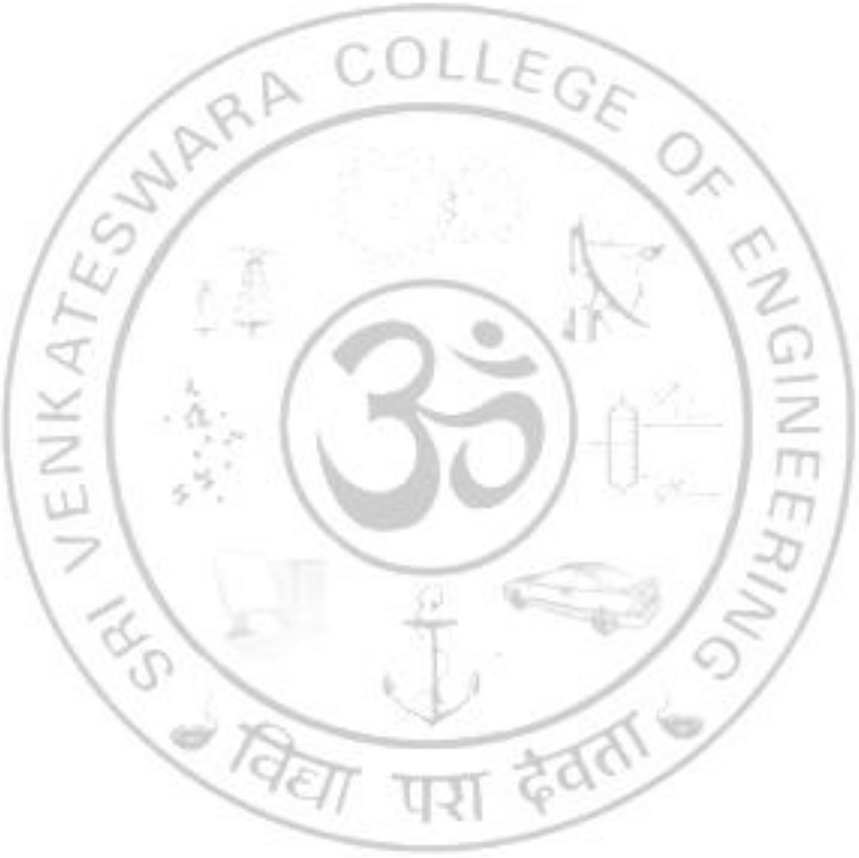
6. https://www.ieee-ras.org/educational-resources-outreach/educational-material-in-robotics-and-automation
7. https://www.academia.edu/20361073/Web_Based_Control_and_Robotics_Education_pdf
8. https://www.isa.org/
9. https://ieeexplore.ieee.org/document/7805273

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Classify robots and automation based on various aspects.	2
CO2	Identify appropriate sensors, actuators for certain robotic applications.	3
CO3	Solve the forward, inverse kinematics, basic homogeneous transformations and identify suitable end effectors for doing specific operations.	3
CO4	Select appropriate vision system components, methodologies and develop robot programming for certain robotic applications.	3
CO5	Acquire knowledge on robotics for certain automation in industry.	3

Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

*COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	-	-	-	-	-	-	-	-	2	3	-
2.	3	3	3	-	-	2	2	1	-	-	-	2	3	-
3.	3	3	3	-	-	2	2	1	-	-	-	2	3	-
4.	3	3	3	-	-	2	2	1	-	-	-	2	3	-
5.	3	3	3	-	-	2	2	1	-	-	-	2	3	-
* 1 – Weak, 2 – Moderate, 3 – Strong														



EC22067	VEHICLE INFOTAINMENT AND CONNECTED VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the electrical and electronic systems in vehicles.
- To learn the concept of remote sensing and the types of sensor technology implemented.
- To analyze the requirements and types of bus networking systems
- To comprehend the lighting systems and auxiliaries in connected vehicles
- To study autonomous automobiles and the overall impact of automating various driving functions.

UNIT I	FUNDAMENTALS OF ROBOTICS AND AUTOMATION	9

Concept of Automotive Electronics, Electronics Overview, History & Evolution, Infotainment, Body, and Powertrain Electronics, Introduction to Automated, Connected, and Intelligent Vehicles.

UNIT II	SENSOR NETWORKING TECHNOLOGY	9

Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Network topology, Network organization, OSI reference model, Control mechanisms.

UNIT III	NETWORKING PROTOCOL FOR CONNECTED VEHICLES	9

CAN bus: Topology, Data transmission system, CAN protocol, data transfer sequence, standardization, characteristics. LIN bus: Data transfer, LIN protocol, network management. MOST bus: Data transfer, Administrative functions, application layer, Bluetooth versions, transmission technology, topology, physical data channel, Architecture.

UNIT IV	LIGHTING AND AUXILIARIES IN VEHICLES	9

Lighting fundamentals, Lighting circuits, Gas discharge lamp and LED lighting, Windscreen washers and wipers, Signaling circuits, Diagnosing auxiliary system faults, Adaptive cruise control, Infotainment System.

UNIT V	CONNECTED VEHICLES TECHNOLOGY	9

Connectivity Fundamentals, Navigation and Other Applications, Vehicle-to-Vehicle Technology and Applications, Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications, Autonomous Vehicles - Driverless Car Technology, Moral, Legal, Roadblock Issues, Technical Issues, Security Issues

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Radovan Miucic, “Connected Vehicles: Intelligent Transportation Systems”, 2019, Springer.
2. The Rise of the Connected Car: A Technology and Business Model Overview, by Martin S. Koplin 2019.
3. Intelligent Transportation Systems and Connected and Automated Vehicles”, 2016, Transportation Research Board.

REFERENCES:

1. R. Krishnan, "Electric Motor Drives - Modeling, Analysis & Control", PHI Learning Private Ltd., 2009.
2. William B. Ribbens, "Understanding Automotive Electronics", 6th Edition, Elsevier, 2003.
3. Gary J. Mullett, "Wireless Telecommunications Systems and Networks", 1st Edition, 2013.
4. Arthur R Bergen and Vijay Vittal, "Power System Analysis", 2nd Edition, Pearson, 2009.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Identify various electrical & electronic systems in vehicles and understand their working.	3
CO2	Acquire knowledge of sensor technology and networking requirements in connected vehicles	3
CO3	Apply the concepts of networking bus protocol in automotive.	4
CO4	Comprehend the lighting systems and auxiliaries in vehicles	4
CO5	Analyse the concept of the connected vehicle and its role in automated vehicles	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	2	1	1	-	-	-	-	1	2	2	1
2.	3	3	2	2	1	1	-	-	-	-	1	2	2	1
3.	3	3	3	2	1	1	-	-	-	-	1	2	2	1
4.	3	3	3	2	1	1	-	-	-	-	1	2	2	1
5.	3	3	3	2	1	1	-	-	-	-	1	2	2	1
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22068	WEARABLE DEVICES FOR HEALTHCARE APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the importance of developing wearable devices and their impact on healthcare.
- To explore methods for capturing bio-signals and processing them for integration into human systems.
- To evaluate wearable device designs incorporating energy-efficient approaches.
- To create and implement wearable systems tailored for specific physiological functions.
- To understand the importance of smart sensor technologies and adherence to sensor interface standards in healthcare contexts.

UNIT I	**OVERVIEW OF SENSORS**	**9**

Fundamentals wearable systems - Sensors for wearable systems-Inertia movement sensors, Respiration activity sensor, Inductive plethysmography, Impedance plethysmography, pneumography, Wearable ground reaction force sensor, GSR, Radiant thermal sensor, Wearable motion sensors, CMOS –Based Biosensors, Bio compatibility

UNIT II	**SIGNAL PROCESSING**	**9**

Challenges in Wearability -physical shape and placement of sensor, Technical problems – sensor design, signal acquisition, Constraint on sampling frequency for reduced energy consumption, light weight signal processing, Rejection of irrelevant information, Data-mining.

UNIT III	**ENERGY HARVESTING FOR WEARABLE TECHNOLOGIES**	**9**

Energy harvesting from human body: Temperature gradient, Foot motion - Wireless energy transmission - Energy harvesting from light and RF energy - Energy and power consumption issues, Future considerations.

UNIT IV	**MONITORING PHYSICAL AND PHYSIOLOGICAL PARAMETERS**	**9**

Wearable sensors for physiological signal measurement - Wearable and non-invasive assistive technologies: Assistive devices for individuals with severe paralysis, Wearable tongue drive system, Sensor signal-processing algorithm, Dual-mode tongue drive system - Remote health monitoring using wearable sensors.

UNIT V	**APPLICATIONS OF WEARABLE IN HEALTHCARE**	**9**

Medical Diagnostics, Medical Monitoring, Multi parameter monitoring, Neural recording, Gait analysis, Sports Medicine, Smart Fabrics, E-textiles

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Wearable Computing: From Modeling to Implementation of Wearable Systems Based on Body Sensor Networks, Giancarlo Fortino, Raffaele Gravina, Stefano Galzarano, Wiley, IEEE Press, 2018.
2. Wearable Sensors -Fundamentals, Implementation and Applications, by Edward Sazonov and Michael R. Neuman, Elsevier Inc., volume1- 2017.

REFERENCES:

1. Seamless Healthcare Monitoring Toshiyo Tamura and Wenxi Chen, Springer 2018.
2. Wearable Technologies for Healthier Pregnancies", Nilanjan Dey, Amira S. Ashour, and Chintan Bhatt 2020.
3. Wearable Technologies: Concepts, Methodologies, Tools, and Applications", Victor C.M. Leung, Faisal Karim Shaikh, and Haider Abbas 2019.
4. "Wearable Electronics Sensors - For Safe and Healthy Living", Subhas Chandra Mukhopadhyay, Springer 2015.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Describe the concepts of wearable systems.	2
CO2	Recognize and apply signal processing techniques alongside methods for acquiring bio-signals.	3
CO3	Assess the implementation of energy-efficient strategies in wearable device technology.	4
CO4	Critically evaluate the design and creation of wearable physiological activity monitors.	4
CO5	Elucidate the applications of wearable technology in health care.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	3	2	1	-	-	1	2	3	2
2.	3	3	3	3	3	3	2	1	-	-	1	2	3	2
3.	3	3	3	3	3	3	2	1	-	-	1	2	3	2
4.	3	3	3	3	3	3	2	1	-	-	1	2	3	2
5.	3	3	3	3	3	3	2	1	-	-	1	2	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22060	MINI PROJECT	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To define, formulate, and analyze a real-world problem in the domain of IoT.
- To solve complex engineering problems independently or as part of a team.
- To learn the architecture and design flow of IoT & and build an IoT-based system.
- To work independently as well as in teams.
- To manage the project from start to finish.

PROJECT WORK MODALITIES

Students can take up small real-world problems in the domain of the Internet of Things as mini-projects. Each student or as a team should conceive, design, develop, and realize an IoT-based system for any application. The basic elements of system design should be considered while designing the system. It can be related to a solution to an engineering problem, verification, and analysis of experimental data available, by conducting suitable experiments on various courses on IoT implementation, characterization, studying a software tool for the solution of an engineering problem, etc. The realization of the product should include the design and fabrication of the PCB. The student should submit a soft-bound report at the end of the semester. The IoT-based system should be demonstrated at the time of examination.

TOTAL: 60 PERIODS

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Identify problems and perform a survey on the existing methods.	2
CO2	Develop a novel idea and analyze the various implementation issues.	3
CO3	Implement the design and develop a prototype model.	4
CO4	Demonstrate the working module.	5
CO5	Prepare a presentation and a report and explain the project work.	6

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	2	2	3	3	3	3	3	3	3
2.	3	3	3	3	3	2	2	3	3	3	3	3	3	3
3.	3	3	3	3	3	2	2	3	3	3	3	3	3	3
4.	3	3	3	3	3	2	2	3	3	3	3	3	3	3
5.	3	3	3	3	3	2	2	3	3	3	3	3	3	3

* 1 – Weak, 2 – Moderate, 3 – Strong

VERTICAL 7
NETWORKING AND SECURITY

EC22071	BLOCKCHAIN AND SMART CONTRACT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of Blockchain.
- To recall the concept of Bitcoin and Cryptocurrency.
- To assess knowledge on Bitcoin Consensus.
- To discover hyperledger Fabric and Ethereum platform.
- To devise various smart contracts mechanisms.

UNIT I	**INTRODUCTION TO BLOCKCHAIN**	**9**

Blockchain- Public Ledgers, Blockchain as Public Ledgers - Block in a Blockchain, Transactions- The Chain and the Longest Chain - Permissioned Model of Blockchain, Cryptographic -Hash Function, Properties of a hash function-Hash pointer and Merkle tree.

UNIT II	**BITCOIN AND CRYPTOCURRENCY**	**9**

A basic crypto currency, Creation of coins, Payments and double spending, FORTH – the precursor for Bitcoin scripting, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay.

UNIT III	**BITCOIN CONSENSUS**	**9**

Bitcoin Consensus, Proof of Work (PoW)- Hashcash PoW , Bitcoin PoW, Attacks on PoW ,monopoly problem- Proof of Stake- Proof of Burn - Proof of Elapsed Time - Bitcoin Miner, Mining Difficulty, Mining Pool-Permissioned model and use cases.

UNIT IV	**HYPERLEDGER FABRIC & ETHEREUM**	**9**

Architecture of Hyperledger fabric - chain code- Ethereum: Ethereum network, EVM, Transaction fee, Mist Browser, Ether, Gas, Solidity.

UNIT V	**SMART CONTRACTS**	**9**

Introduction, Smart Contract, Characteristics of a Smart Contract, Types of Smart Contracts, Types of Oracles, Smart Contracts in Ethereum, Smart Contracts in Industry Blockchain Applications in Supply Chain Management, Logistics, Smart Cities, Finance and Banking, Insurance,etc- Case Study.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Bashir and Imran, Mastering Blockchain: Deeper insights into decentralization, cryptography, Bitcoin, and popular Blockchain frameworks, Packt Publishing,2017.
2. Andreas Antonopoulos, “Mastering Bitcoin: Unlocking Digital Cryptocurrencies”, O’Reilly, 2014.
3. Chandramouli Subramanian, Asha George, Abhilash K A and Meena Karthikeyan , “Blockchain Technology “Universities Press Publication,2020

REFERENCES:

1. Daniel Drescher, “Blockchain Basics”, First Edition, Apress, 2017.
2. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. “Bitcoin and cryptocurrency technologies: a comprehensive introduction”. Princeton University Press, 2016.
3. Melanie Swan, “Blockchain: Blueprint for a New Economy”, O’Reilly, 2015
4. Ritesh Modi, “Solidity Programming Essentials: A Beginner’s Guide to Build Smart Contracts for Ethereum and Blockchain”, Packt Publishing,2018
5. Saravannan Krishnan ,Emila balas,Julie,”Handbook of Research on Blockchain Technology, published by Elsevier Inc”. ISBN: 9780128198162, 2020.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand emerging abstract models for Blockchain Technology	2
CO2	Interpret the practice in the Crypto currency domain.	2
CO3	Analyze the concept of Consensus in BitCoin with different mechanisms.	4
CO4	Apply hyperledger Fabric and Ethereum platform to implement the Block chain Application.	3
CO5	Apply the Smart contract technology in real-world scenarios.	3
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	1	1	-	-	-	-	-	3	3	2
2.	3	3	3	3	1	1	-	-	-	-	-	3	3	2
3.	3	3	3	3	1	1	-	-	-	-	-	3	3	2
4.	3	3	3	3	1	1	-	-	-	-	-	3	3	2
5.	3	3	3	3	1	1	-	-	-	-	-	3	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22072	CRYPTOGRAPHY AND NETWORK SECURITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand various symmetric and asymmetric key cryptographic algorithms.
- To acquire fundamental knowledge on the concept of authentication and hash functions.
- To describe the principles of Electronic Mail Security and authentication services.
- To give an insight on various system level security concepts.
- To expose the concepts of Lightweight and quantum cryptography.

UNIT I	**SYMMETRIC AND ASYMMETRIC KEY CRYPTOGRAPHY**	**9**

Mathematics of Symmetric and Asymmetric key Cryptography: Overview - Symmetric Key Ciphers: Block Cipher Operation, RC4 - Asymmetric key Ciphers: Diffie-Hellman key exchange, SIDH, ElGamal cryptosystem, Elliptic curve cryptography.

UNIT II	**AUTHENTICATION AND HASH FUNCTION**	**9**

Authentication requirements - Authentication functions - Message Authentication Codes - Hash Functions - Security of Hash Functions and MACs - Secure Hash Algorithm – HMAC - Digital Signatures - Authentication Protocols - Digital Signature Standard.

UNIT III	**NETWORK SECURITY**	**9**

Authentication Applications: Kerberos - X.509 Authentication Service - Electronic Mail Security - PGP-S/MIME - IP Security: Architecture, Authentication Header - Web Security: Threats, Secure Electronic Transaction (SET).

UNIT IV	**SYSTEM SECURITY**	**9**

Intrusion detection - Password Management - Viruses and related Threats - Virus Counter measures - Firewall Design Principles – Trusted Systems.

UNIT V	**LIGHTWEIGHT AND POST-QUANTUM CRYPTOGRAPHY**	**9**

Lightweight Cryptography: Concepts, Algorithm – Post-Quantum Cryptography: Quantum Computing, Concepts, Algorithms.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Behrouz A. Forouzan "Cryptography and Network security", McGraw- Hill, 2015.
2. William Stallings, "Cryptography and Network security: principles and practice", 2nd Edition, Prentice Hall of India, New Delhi, 2020.
3. Parag K Lala, "Quantum Computing A Beginner's Introduction", McGraw- Hill, 2019.

REFERENCES:

1. Charlie Kaufman and Radia Perlman, Mike Speciner, "Network Security, Second Edition, Private Communication in Public World", PHI 2002.
2. Bruce Schneier and Neils Ferguson, "Practical Cryptography", First Edition, Wiley Dreamtech India Pvt Ltd, 2003.
3. Man Young Rhee, "Internet Security: Cryptographic Principles", "Algorithms and Protocols", Wiley Publications, 2003.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Compare and implement symmetric and asymmetric key algorithms for real time applications.	3
CO2	Realize the authentication and hash function concepts.	3
CO3	Analyze network security issues and propose suitable solution	4
CO4	Categorize various system level security issues and identify suitable solution	4
CO5	Apply Lightweight Cryptographic algorithm over smart environment.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	1	-	-	3	-	-	-	-	-	-	2	3	3
2.	3	3	3	2	3	-	2	-	-	-	-	2	3	3
3.	3	3	3	2	3	-	2	-	-	-	-	2	3	3
4.	3	3	3	2	3	-	2	-	-	-	-	2	3	3
5.	3	3	3	2	3	-	2	-	-	-	-	2	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22073	IOT SECURITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of IoT security.
- To assess the concept of cryptography and access management.
- To acquire knowledge on IoT security architecture.
- To classify the process of network layer security.
- To explore various cloud security mechanisms.

UNIT I	**IOT ATTACKS**	**9**

Fundamentals of IoT - Security and Privacy Issues in IoT - IoT Security Requirements - IoT Privacy Preservation Issues - Vulnerabilities - IoT Attacks: Types, Cyber-physical attacks, Security protocol attacks, Application protocol attacks

UNIT II	**CRYPTOGRAPHY AND ACCESS MANAGEMENT**	**9**

Role of Cryptography in IoT - Cryptographic module principles - Cryptographic Key management - Cryptographic control for IoT protocols - Access management for IoT - IAM infrastructure - Authorization and Access control

UNIT III	**IOT SECURITY ARCHITECTURE**	**9**

Layered IoT Security Architecture - IoT Perception layer: Security mechanism, Security requirement, Security Threats, Methods of Protection for IoT devices - Security Protection for Up-stream data and Down-stream data

UNIT IV	**IOT NETWORK LAYER SECURITY**	**9**

Security threats in IoT network layer - Network security protocols - Network architecture model - IPSec - SSL - Security techniques in mobile communication networks: LTE, LPWAN, 5G

UNIT V	**CLOUD SECURITY FOR IOT**	**9**

Cloud services providers for IoT: AWS IoT, Microsoft Azure IoT suite, IBM Watson - IoT threats from cloud perspective - Cloud IoT security control - Security mechanism in cloud computing - New distributed trust models for cloud

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Chuan-Kun Wu, “Internet of Things Security: Architectures and Security Measures”, Springer Nature Singapore - 2021
2. Brian Russell, Drew Van Duren, “Practical Internet of Things Security”, Packt Publishing, 2022

REFERENCES:

1. Ali Ismail Awad, Jemal Abawajy, “Security and Privacy in the Internet of Things: Architectures, Techniques, and Applications”, Wiley, 2021.
2. Alasdair Gilchrist, “IoT Security Issues”, De Gruyter, 2017.
3. Ali Ismail Awad, Atif Ahmad, Kim-Kwang Raymond Choo, “Internet of Things Security and Privacy: Practical and Management Perspectives”, CRC Press, 2023.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Express the security and privacy issues of the IoT.	2
CO2	Recognize the cryptographic techniques for IoT	2
CO3	Discover the knowledge on security architecture and threats.	3
CO4	Analyze the security techniques of the IoT network layer.	4
CO5	Apply the security models in the cloud environment.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	1	1	-	-	-	-	-	3	3	2
2.	3	3	3	3	1	1	-	-	-	-	-	3	3	2
3.	3	3	3	3	1	1	-	-	-	-	-	3	3	2
4.	3	3	3	3	1	1	-	-	-	-	-	3	3	2
5.	3	3	3	3	1	1	-	-	-	-	-	3	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22074	SOFTWARE DEFINED NETWORKING IN IOT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To apply SDN techniques for converging cloud services.
- To categorize the IoT components in architecture framework.
- To explore quality of service (QoS) and quality of experience (QoE) in use case.
- To analyze the security issues of threats and attacks emerged with the evolution of SDN and NFV.
- To differentiate security issues and data protection merging from Cloud and IoT services.

UNIT I	**MODERN NETWORK ARCHITECTURES**	**9**

Cloud Services: Software as a Service, Platform as a Service, Infrastructure as a Service, Other Cloud Services, XaaS - Cloud Deployment Models: Public Cloud, Private Cloud, Community Cloud, Hybrid Cloud - Cloud Architecture: NIST Cloud Computing Reference Architecture, ITU-T Cloud Computing Reference Architecture

UNIT II	**IOT ARCHITECTURE**	**9**

Scope of the Internet of Things - Components of IoT-Enabled Things: Sensors, Actuators, Microcontrollers, Transceivers, RFID - IoT Architecture: ITU-T IoT Reference Model, IoT World Forum Reference Model - IoT Implementation: IoTivity

UNIT III	**QOE : USE CASES**	**9**

Need for QoE: Online Video Content - Service Failures Due to Inadequate QoE Considerations - Experience - Quality Formation Process - Definition of Quality of Experience - QoE Strategies in Practice: The QoE/QoS Layered Model.

UNIT IV	**SDN AND NFV SECURITY**	**9**

Security Requirements - Threats to SDN - Software-Defined Security - NFV Security - Attack Surfaces - ETSI Security Perspective

UNIT V	**CLOUD AND IOT SECURITY**	**9**

Cloud Security - Security Issues and Concerns .- Cloud Security Risks and Countermeasures - Data Protection in the Cloud - Cloud Security as a Service - IoT Security and Privacy Requirements Defined by ITU-T - An IoT Security Framework

TOTAL: 45 PERIODS

TEXT BOOKS:

1. William Stallings, "Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud," Addison-Wesley Professional, First Edition, 2015.
2. Jim Doherty, "SDN and NFV Simplified: A Visual Guide to Understanding Software Defined Networks and Network Function Virtualization," Pearson Education,2020.

REFERENCES:

1. Paresh Shah, Syed Farrukh Hassan, Rajendra Chayapath, "Network Function virtualization with a touch of sdn," Addison-Wesley Professional, First edition, 2016.
2. Thomas D. Nadeau & Ken Gray, "SDN - Software Defined Networks," O'Reilly, 2013.

3. Guy Pujolle, “Software Networks: Virtualization, SDN, 5G, Security,” Wiley-ISTE, second addition, 2020.
4. Paul Goransson Chuck Black, “Software Defined Networks: A Comprehensive Approach,” Morgan Kaufmann, Second edition, 2016.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand techniques to migrate legacy networks towards Cloud services.	2
CO2	Interpret the basic architecture framework of IoT.	3
CO3	Evaluate quality of service (QoS) and quality of experience (QoE) applied in use case.	4
CO4	Analyze the security issues emerged with the evolution of SDN and NFV.	4
CO5	Correlate the security issues and data protection revolves with Cloud and IoT.	4
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
2.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
3.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
4.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
5.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22075	SDN AND NFV ARCHITECTURES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn and differentiate between traditional networks and software defined networks
- To understand characteristics and functions of SDN architecture.
- To analyze virtual machines and approach for orchestration.
- To understand and differentiate about VLAN standard and VPN.
- To expand the knowledge learned with uses cases in SDN

UNIT I	**NETWORKING BASICS**	**9**

Types of Network and Internet Traffic- Demand: Big Data, Cloud Computing- Routing: :Characteristics, Packet Forwarding, Routing Protocols, Elements of a Router - Congestion Control:Effects of Congestion, Congestion Control Techniques - Software-Defined Networking (SDN)

UNIT II	**SDN ARCHITECTURE**	**9**

Requirements for SDN approach - SDN Architecture - Characteristics of Software-Defined Networking – SDN Data Plane: Functions and Protocols - OpenFlow Logical Network Device - OpenFlow Protocol - SDN Control Plane: Functions, Southbound and Northbound interfaces - OpenDaylight – SDN Application Plane: Network Services and applications, user interface.

UNIT III	**NETWORK FUNCTIONS VIRTUALIZATION**	**9**

Virtual Machines: Architectural Approaches, Container Virtualization - NFV Concepts - NFV Principles - High-Level NFV Framework - NFV Benefits - NFV Requirements - NFV Reference Architecture: NFV Management and Orchestration..

UNIT IV	**VIRTUAL LANS**	**9**

Virtual LANs - The Use of Virtual LANs - Defining VLANs Communicating VLAN Membership - IEEE 802.1Q VLAN Standard - Nested VLANs OpenFlow VLAN Support - Virtual Private Networks - IPsec VPNs - MPLS VPNs - Network Virtualization - Network Virtualization Architecture - Benefits of Network Virtualization

		9
UNIT V	**SDN AND NFV USE CASES**	

SDN and NFV - NFV Use Cases - Architectural Use Cases - Service-Oriented Use Cases - OpenDaylight's Virtual Tenant Network - Software-Defined Infrastructure - Software-Defined Storage - SDI Architecture - QoS Architectural Framework: Data, Control and Management Plane.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. William Stallings, "Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud," Addison-Wesley Professional, First Edition, 2019.
2. Jim Doherty, "SDN and NFV Simplified: A Visual Guide to Understanding Software Defined Networks and Network Function Virtualization," Addison-Wesley Professional, First Edition, 2016.

REFERENCES:

1. Paresh Shah, Syed Farrukh Hassan, Rajendra Chayapath, “Network Function virtualization with a touch of sdn,” Addison-Wesley Professional, First edition, 2019.
2. Paul Goransson Chuck Black, “Software Defined Networks: A Comprehensive Approach,” Morgan Kaufmann, Illustrated edition, 2016.
3. Thomas D. Nadeau & Ken Gray, “SDN - Software Defined Networks,” O'Reilly, 2016.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Recognize the challenges and opportunities associated with adopting SDN compared to traditional approaches to networking	2
CO2	Examine conceptual characteristics, components and functions of SDN architecture.	4
CO3	Categorize Network Functions Virtualization components and approach for orchestration.	4
CO4	Illustrate concepts of VLAN, VPN in SDN and NFV.	3
CO5	Analyze the knowledge deployment in SDN use cases.	4
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
2.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
3.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
4.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
5.	3	3	3	1	-	-	-	-	1	1	-	3	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22076	WIRELESS BROADBAND NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To get insights about network layer in LTE cellular network.
- To understand the basic concepts of network functions in 5G network.
- To acquire knowledge on the various next generation optical networks.
- To assess about the protocols functionalities in next generation optical networks.
- To introduce the emerging technologies in broadband networks.

UNIT I	**MOBILE NETWORK LAYER IN LTE**	**9**

LIPA, selected IP traffic offload, and IP flow mobility, Mobile IP-Client-based IP mobility, Network-based IP mobility, Network architecture evolution and small cells.

UNIT II	**NETWORK FUNCTIONS IN 5G**	**9**

Access and Mobility Management Function , Session Management Function ,Network Slice Selection Function ,Network Exposure Function , Network Function Repository Function ,Network Slicing, EDGE computing.

UNIT III	**NEXT GENERATION OPTICAL NETWORKS**	**9**

Next Generation-SONET/SDH, Next Generation Ring Network, Next Generation Mesh Network-Protection, Traffic, Wavelength, Network Management, Restoration.

UNIT IV	**NEXT GENERATION SDH/SONET PROTOCOLS**	**9**

Comparison between the legacy and the next generation SONET / SDH, Virtual Concentation, GMPLS, GFP, LACS , LAPS and Use cases

UNIT V	**EMERGING TECHNOLOGIES**	**9**

Fixed Wireless, Direct Broadcast Satellite (DBS), Multi-channel, multi point distribution services (MMDS), Local multi point distribution services (LMDS), and Wideband integrated Digital Interactive Services (WIDIS), Challenges, risks, and advances in wireless security.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Chris Johnson, "5G New Radio in Bullets" ,First edition, 2019.
2. William Webb, "Introduction to Wireless Local Loop Broadband and Narrow Band System", Mobile Communication Series, Artech House Publishers, Second Edition 2000.
3. Stamatios V. Kartalopoulos "Free Space Optical Networks For Ultra-Broad Band Services"Wiley,2011.

REFERENCES:

1. Vijay K.Garg, "Wireless Network Evolution - 2G & 3G". Prentice Hall, 2008.
2. Sassan Ahmadi, "LTE-Advanced – A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies", Elsevier, 2014.
3. Kaveh Pahlavan, "Principles of wireless networks", Prentice-Hall of India, 2008.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the network concepts LTE.	2
CO2	Examine the current generation (5G) network layer.	4
CO3	Analyze methodology of next generation optical networks	4
CO4	Apply the various protocols in next generation optical networks.	2
CO5	Explore various emerging technologies and the challenges associated with its implementation.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	3	-	-	-	-	-	-	-	3	3	2
2.	3	3	2	3	-	-	-	-	-	-	-	3	3	2
3.	3	3	2	3	-	-	-	-	-	-	-	3	3	2
4.	3	3	2	3	-	-	-	-	-	-	-	3	3	2
5.	3	3	2	3	-	-	-	-	-	-	-	3	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22077	WIRELESS NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To apply technical intricacies of IEEE 802.11 standards for WiFi and emerging high speed variants.
- To expertise in design, operation and performance of wireless personal area networks like Bluetooth and ZigBee.
- To assess and address security and privacy vulnerabilities in wireless networks.
- To explore technologies that enhance dependable long-haul communication systems, including satellite networks.
- To analyze recent developments in push to talk and emerging trends in wireless network innovations

UNIT I	**WIRELESS LANs**	**9**

Historical Overview of the LAN Industry-New Interest from Military and Service Providers-Wireless Home Networking: Need, HAN Technologies, Home Access Networks-IEEE 802.11: Overview, Architecture and Services, PHY Layer, MAC Sub Layer, MAC Management Sub Layer, Security, Gigabit Wi-Fi, Other IEEE 802.11 Standards

UNIT II	**WIRELESS PERSONAL AREA NETWORKS**	**9**

Introduction to IEEE 802.15- Home RF-Bluetooth: Architecture, Protocol Stack, Physical Connection, MAC Mechanism, Frame Formats, Connection Management, Security, Specification, Bluetooth High Speed and Bluetooth Smart-Ricochet-ZigBee–Interference between Bluetooth and IEEE 802.11: Interference Range, Probability of Interference, Empirical Results

UNIT III	**SECURITY AND PRIVACY IN WIRELESS NETWORKS**	**9**

Authentication in WiFi based AP Networks-Diffie Hellman Protocol-Firewalls and System Security-Security Issues in Mobile Ad Hoc Networks (MANETs): Intrusion Detection, Requirements for an IDS for MANETs, Mobile Agents for Intrusion Detection and Response in a MANET, Intrusion Detection Architecture (IDA) Based on a Static Stationary Database (SSD), Cluster-Based Intrusion Detection System in MANETs, Logging Module, Selfishness in a MANET

UNIT IV	**LONG RANGE COMMUNICATIONS**	**9**

Satellite Parameters and Configurations: Satellite Orbits, Frequency Bands, Transmission Impairments, Satellite Network Configurations- Satellite Capacity Allocation: Frequency Division Multiplexing, Frequency Division Multiple Access, Time Division Multiple Access-Satellite Applications: Global Positioning System, Direct Broadcast Systems-Fixed Broadband Wireless Access-Smart Grid

UNIT V	**RECENT ADVANCES IN WIRELESS NETWORK TECHNOLOGIES**	**9**

Push-To-Talk (PTT) Technology:PTT Network Technology, PTT in iDEN Cellular Networks, PTT in Non-iDEN Cellular Networks: PoC, Limitations of Current Services, Multimedia Services Requirements: Media Codecs, File Formats, Hypertext Transfer Protocol (HTTP), Media Control Protocols, Session Initiation Protocol (SIP), Multimedia Messaging Service (MMS), Mobility and Resource Management for Integrated Systems.

TOTAL: 45 PERIODS

TEXT BOOKS:		
1. Kaveh Pahlavan, Prashant Krishnamurthy, "Principles of Wireless Networks", Prentice Hall Communications,Second Edition, 2013 2. Dharma P. Agrawal, Qing-An Zeng, "Introduction to Wireless and Mobile Systems", Fourth Edition, Cengage Learning 2016 3. Cory Beard, William Stallings "Wireless Communication Networks and Systems", Pearson Publishers 2016		
REFERENCES:		
1. William Stallings, "Wireless Communications & Networks", Second Edition, Pearson Education Limited ,Third Edition, 2020 2. Vijay K.Garg, "Wireless Communication and Networking", The Morgan Kaufmann Publishers, Second Edition, 2010		

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Demonstrate comprehensive expertise in IEEE 802.11 WiFi architecture, services, layers, management, security, and emerging standards.	3
CO2	Apply WPAN technologies including Bluetooth, ZigBee, evaluating architectures, protocols, strengths and limitations.	3
CO3	Analyze the security solutions for wireless networks including cellular, WiFi, MANETs, and mobile devices.	4
CO4	Analyze long-range wireless communication solutions, differentiating their applicability for satellite networks, rural broadband, and smart grids.	4
CO5	Assess push to talk system performance by examining the integration of multimedia services and resource management.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	2	2	2	-	-	-	-	1	-	1	2	2
2	3	3	2	2	2	-	1	-	-	-	-	1	3	2
3	3	3	2	3	2	-	-	-	-	1	-	2	3	2
4	3	3	2	3	2	-	1	-	-	1	-	2	3	2
5	3	3	3	2	3	1	1	-	-	1	-	1	2	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22078	WIRELESS SENSOR NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn about sensor network fundamentals.
- To understand the different routing protocols.
- To assess knowledge on sensor network architecture and design.
- To summarize security issues in wireless sensor networks.
- To have an exposure to mote programming platforms and tools.

UNIT I	**INTRODUCTION TO WSN AND ITS ARCHITECTURES**	**9**

Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, WSN application examples, Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Network Architecture - Sensor Network Scenarios, Transceiver Design Considerations, Optimization Goals and Figures of Merit.

UNIT II	**WSN NETWORKING CONCEPTS AND PROTOCOLS**	**9**

MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wake Up Concepts - S-MAC, The Mediation Device Protocol, Contention based protocols - PAMAS, Schedule based protocols – LEACH, IEEE 802.15.4 MAC protocol.

UNIT III	**WSN NETWORK LAYER**	**9**

Need for Routing Protocols-Energy Efficient Routing, Gossiping and agent-based unicast forwarding, Broadcast and multicast, Geographic routing, Mobile nodes, Gateway concepts, Challenges and Issues in Transport layer protocol.

UNIT IV	**SENSOR NETWORK SECURITY**	**9**

Network Security Requirements, Issues and Challenges in Security Provisioning, Network Security Attacks, Layer wise attacks in wireless sensor networks, possible solutions for jamming, tampering, black hole attack, flooding attack, Key Distribution and Management, Secure Routing – SPINS, reliability requirements in sensor networks

UNIT V	**SENSOR NETWORK PLATFORMS AND TOOLS**	**9**

Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms – TinyOS, nesC, CONTIKIOS, Node-level Simulators – NS2 and its extension to sensor networks, COOJA.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Holger Karl, Andreas willig, “Protocol and Architecture for Wireless Sensor Networks,” John wiley publication, First Edition,2007.
2. Anna Forster, “Introduction to Wireless Sensor Networks,” Wiley, 2017.

REFERENCES:

1. Feng Zhao, Leonidas Guibas, “Wireless Sensor Networks: an information processing approach,” Elsevier publication, 2004.
2. Charles E. Perkins, “Ad Hoc Networking,” Addison Wesley, 2001.
3. I.F. Akyildiz, W. Su, Sankarasubramaniam, E. Cayirci, “Wireless sensor networks: a survey”, computer networks, Elsevier, 2002, 394 - 422.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the basics of Wireless Sensor Networks	2
CO2	Relate the suitable routing algorithm based on the network and user requirement.	3
CO3	Interpret the knowledge to identify appropriate network layer protocols	3
CO4	Devise security issues and routing in sensor networks.	4
CO5	Apply various OS and simulators used in Wireless Sensor Networks.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	2	-	-	-	-	-	-	-	2	3	2
2.	3	3	2	2	-	-	-	-	-	-	-	3	3	3
3.	3	3	2	2	-	-	-	-	-	-	-	3	3	3
4.	3	3	2	2	-	-	-	-	-	-	-	3	3	3
5.	3	3	3	2	3	-	-	-	-	-	-	3	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

EC22070	MINI PROJECT	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To investigate, formulate and analyze a real-world problem in the field of Networking and Security.
- To solve the complex engineering problems independently or as part of a team.
- To acquire knowledge in terms of the innovation & real time cases with implementation process of the project work.
- To work independently as well as in teams.
- To manage the project from start to finish.

PROJECT WORK MODALITIES

Students can take up small real world problems in the field of Networking and Security as a mini project. Each student or as a team should conceive, design, develop and realize simulation of networks with validation on real time systems. It can be related to solutions to a complex engineering problem/ verification and analysis of experimental data available/ conducting suitable experiments on various engineering subjects/ characterization/ studying a software tool for the solution of an engineering problem etc. The student should investigate a network related to real time system with applied knowledge on WSN, WBN areas. Also he can implement SDN with NFV concepts in Cloud/Big data analytics. The student should submit a soft bound project report at the end of the semester. The validation of results should be demonstrated at the time of examination. Few thrust area to be concentrated in new areas of interest in Networking and Security.

TOTAL: 60 PERIODS

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Investigate, formulate and analyze a real-world problem in the field of Networking and Security	4
CO2	Design, analyze and optimize a wireless network with standardization of security concepts applied in WSN, WBN areas.	4
CO3	Design, analyze and optimize, networks with SDN, NFV concepts.	4
CO4	Learn to write technical reports and work as a team.	3
CO5	Develop skills to present and defend their work in front of a technically qualified audience.	3

***Bloom's Taxonomy (RBT) Level:** Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

*COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1.	3	3	3	3	3	1	2	2	3	3	3	3	3	3
2.	3	3	3	3	3	1	2	2	3	3	3	3	3	3
3.	3	3	3	3	3	1	2	2	3	3	3	3	3	3
4.	3	3	3	3	3	1	-	2	3	3	3	3	3	3
5.	3	3	3	3	3	1	-	2	3	3	3	3	3	3

* 1 – Weak, 2 – Moderate, 3 – Strong

OPEN ELECTIVE COURSES

OE22701	AUTOTRONICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of automotive electronics
- To study about sensors and actuators used in automobiles
- To understand the working principles of fuel ignition and injection systems
- To acquire knowledge on engine control system
- To identify the various electronic devices used in vehicle intelligence system

UNIT I	**INTRODUCTION TO AUTOMOTIVE ELECTRONICS**	**9**

Evolution of Electronics in automobiles – Emission laws - Electronic Engine Management System – Components – Drivetrain - Working principles: Starting & Charging systems- Ignition system - Suspension systems - Brakes - ABS - Steering system

UNIT II	**SENSORS AND ACTUATORS**	**9**

Basic Sensor Arrangement – Types Of Sensors - Working principle and characteristics: – Hall Effect Sensor – Thermistor – Piezo-Electric Sensor – Piezo-Resistive Sensors – Oxygen Concentration Sensor – Crankshaft Angular Position Sensor – Mass Air Flow (MAF) Rate – Manifold Absolute Pressure (MAP) – Throttle Plate Angular Position – Engine Oil Pressure Sensor – Vehicle Speed Sensor – Stepper Motors – Relays – Detonation Sensor – Emission Sensor.

UNIT III	**FUEL INJECTION AND IGNITION SYSTEM**	**9**

Introduction - Fuel system components - Electronic fuel system - fuel injection types: throttle body versus port injection - electronic control fuel injection:operation, types - fuel injectors - idle speed control continuous injection system - high pressure diesel fuel injection - MPFI system - Electronic ignition system : operation, types - Electronic spark timing control.

UNIT IV	**ENGINE CONTROL SYSTEM**	**9**

Control modes for fuel control - Engine control subsystems – ignition control methodologies – different ECU's used in the Engine management – Block diagram of the Engine management system. Vehicle networks: CAN standard, format of CAN standard – diagnostics systems in modern automobiles.

UNIT V	**VEHICLE INTELLIGENCE**	**9**

Introduction - Basic structure - vision based autonomous road vehicles - architecture for dynamic vision system - A visual control system using image processing and fuzzy theory - An application of mobile robot vision to a vehicle information system - object detection, collision warning and avoidance system - low tyre pressure warning system.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. William Ribbens, “Understanding Automotive Electronics: An Engineering Perspective”, Butterworth-Heinemann, Seventh Edition, 2013.
2. “Automotive Sensors Handbook”, 8th Edition, 2011, BOSCH
3. Crouse, W.H "Automobile Electrical Equipment", McGraw-Hill Book Co., Inc., New York, 3rd edition, reprint 2010

REFERENCES:

1. Tom Denton, “Automobile Electrical and Electronics Systems”, Butterworth- Heinemann, Fourth Edition, 2004.
2. Allan Bonnick, “Automotive Computer Controlled Systems” Taylor & Francis, Fifth Edition, 2001.
3. Robert Bosch GmbH, “Diesel-Engine Management”, John Wiley & Sons, Fourth Edition, 2006.
4. Robert Bosch GmbH and Horst Bauer, “Gasoline-Engine Management”, Bentley Publishers, Second Edition, 2006.
5. Hillier V.A.W, “Fundamentals of Automotive Electronics”, Nelson Thornes Limited, Sixth Edition, 2012.
6. Robert. N, Brady, “Automotive Computers and Digital Instrumentation”, Prentice Hall, First Edition, 1988.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the basic fundamentals of Automobile Engineering Electronics	2
CO2	Interpret the different types of sensors and actuators used in automobile Engineering	3
CO3	Illustrate the principles of operation of electronically operated fuel injection and ignition systems	3
CO4	Acquaint knowledge on various control and network systems in automotives	2
CO5	Analyse basic electronic devices for design of vehicle intelligence systems in automotive electronics	4
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	2	2	1	1	2	1	1	2	3	1
2.	3	3	3	3	2	2	1	1	2	1	1	2	3	1
3.	3	3	3	3	2	2	1	1	2	1	1	2	3	1
4.	3	3	3	3	2	2	1	1	2	1	1	2	3	1
5.	3	3	3	3	2	2	1	1	2	1	1	2	3	1
* 1 – Weak, 2 – Moderate, 3 – Strong														

OE22702	BIOMETRIC SYSTEM AND ITS APPLICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introducte the basics of biometrics and its functionalities.
- To understand the technologies of fingerprint recognition.
- To identify the issues in realistic evaluation of Face recognition biometrics systems.
- To acquire knowledge in building Iris recognition system and its performance evaluation.
- To develop applications with biometric based systems.

UNIT I	**INTRODUCTION TO BIOMETRICS**	**9**

Introduction to Biometric Systems- Person Recognition, Biometric Functionalities, Biometric System Errors, Performance measures, The Design Cycle of Biometric Systems, Applications of Biometric Systems, Security and Privacy Issues

UNIT II	**FINGERPRINT RECOGNITION**	**9**

Introduction, Friction Ridge Pattern, Fingerprint Acquisition, Feature Extraction, Matching, Fingerprint, Fingerprint Synthesis, Palmprint

UNIT III	**FACE RECOGNITION**	**9**

Psychology of face recognition, Image Acquisition, Face Detection - Viola-Jones face detector, Feature Extraction and Matching, Handling pose, illumination, and expression variations, Heterogeneous face recognition, Face modelling

UNIT IV	**IRIS RECOGNITION**	**9**

Design of an Iris Recognition System, Image Acquisition, Iris Segmentation, Generating iris masks, Iris Normalization, Iris Encoding and Matching, Iris Quality, Performance Evaluation

UNIT V	**APPLICATIONS: CASE STUDY**	**9**

Multibiometric Using Face and Ear, Biometric System Security, Application of Biometrics in the Government and Commercial Sector.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Anil K. Jain, Arun Ross, and Karthik Nandakumar, “Introduction to Biometrics”, Springer, 2011.

REFERENCES:

1. Anil K Jain, Patrick Flynn and Arun A Ross, “Handbook of Biometrics”, Springer, 2007. ISBN: 978-0-387-71040-2.
2. Nikolaos V Boulgouris, Konstantinos N Plataniotis and Evangelia Micheli Tzanakov,“Biometrics Theory, Methods and Applications”, IEEE & Wiley, 2009, ISBN: 978-0470-24782-2
2. John D Woodward, Nicholas M Orlans and Peter T Higgin, “Biometrics: The Ultimate Reference”, Dream Tech, 2009.
3. Guide to Biometrics, By: Ruud M. Bolle, Sharath Pankanti, Nalini K. Ratha, Andrew W. Senior, Jonathan H. Connell, Springer 2009.

4. https://archive.nptel.ac.in/content/syllabus_pdf/106104119.pdf

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Demonstrate fundamental principles underlying biometric systems.	2
CO2	Explore the feature extraction, segmentation and synthesis of finger, face and iris recognition systems.	3
CO3	Identify the multidisciplinary technologies for biometric applications	4
CO4	Apply data analytics and evaluate the performance metrics of biometric systems.	3
CO5	Designing and development of different identification/ verification systems to validate the user identity	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	2	2	-	-	1	1	1	2	3	3
2.	3	3	3	3	2	2	-	-	1	1	1	2	3	3
3.	3	3	3	3	2	2	-	-	1	1	1	2	3	3
4.	3	3	3	3	2	2	-	-	1	1	1	2	3	3
5.	3	3	3	3	2	2	-	-	1	1	1	2	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

OE22703	COMPUTER VISION AND ITS APPLICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To ascertain and describe the essentials of computer vision through mathematical interpretation.
- To acquire the knowledge of various image enhancement and image restoration techniques involved.
- To experiment the various image segmentation for a meaningful partition of objects and design the various basic feature extraction and object detection techniques for various image applications.
- To evaluate various motion analysis and tracking techniques for various aspects of image processing.
- To analyze and implement computer vision and image processing algorithms for various real-time applications.

UNIT I	**INTRODUCTION TO COMPUTER VISION**	**9**
Overview of computer vision and its applications, Camera models and calibration, Geometric transformations -homography, affine transformations, Image processing fundamentals.		
UNIT II	**IMAGE ENHANCEMENT AND RESTORATION**	**9**
Image enhancement techniques -contrast enhancement, histogram equalization, Noise reduction and restoration algorithms -filters, deconvolution		
UNIT III	**IMAGE SEGMENTATION, FEATURE EXTRACTION AND OBJECT DETECTION**	**9**
Segmentation methods -thresholding, edge detection, Feature extraction techniques -corner detection, Object detection methods -Haar cascades, HOG.		
UNIT IV	**MOTION ANALYSIS AND TRACKING**	**9**
Optical flow and motion estimation, Object tracking techniques -Kalman filters, tracking-by-detection,3D Computer Vision-Stereo vision and depth estimation.		
UNIT V	**APPLICATIONS OF COMPUTER VISION**	**9**
Medical Image segmentation, Motion Estimation and Object Tracking, Face recognition, Gesture recognition,		
	TOTAL: 45 PERIODS	

TEXT BOOKS:

1. Rafael C. Gonzalez, Richard E. Woods, “Digital Image Processing”, Pearson Education, Fourth Edition, 2018.
2. Richard Szeliski,“Computer Vision: Algorithms and Applications”,Springer, Second edition, ISBN-10: 1848829345, ISBN-13: 978-1848829343, 2022 ,http://szeliski.org/Book/
3. Manas Kamal Bhuyan Computer Vision and Image Processing Fundamentals and Applications,CRC Press,2020
4. S. Sridhar, “Digital Image Processing”, Second Edition, Oxford University, 2016.

REFERENCES:
1. Anil K. Jain "Fundamentals of Digital Image Processing", PHI, Learning Private Ltd, 2011. 2. https://onlinecourses.nptel.ac.in/noc21_ee23/ 3. David Marr, "Vision: A Computational Investigation into the Human Representation and Processing of Visual Information", The MIT Press,2010

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Demonstrate a deep understanding of the core principles, algorithms, and methodologies in computer vision, including image processing, and object recognition.	2
CO2	Apply various image enhancement techniques to improve image quality and perform advanced image analysis through segmentation, feature extraction, and object detection.	3
CO3	Utilize segmentation techniques to partition images into meaningful regions and extract relevant features, enabling effective analysis and understanding of visual data.	3
CO4	Understand motion analysis techniques such as optical flow and implement object tracking algorithms for dynamic visual data.	3
CO5	Investigate various applications of computer vision across domains	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	2	2	1	-	-	-	-	-	-	1	3	-
2.	3	2	2	2	1	-	-	-	-	-	-	1	3	-
3.	3	2	2	2	1	-	-	-	-	-	-	1	3	-
4.	3	2	2	2	1	-	-	-	-	-	-	1	3	-
5.	3	2	2	2	1	-	-	-	-	-	-	1	3	-
* 1 – Weak, 2 – Moderate, 3 – Strong														

OE22704	CONSUMER ELECTRONICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of consumer electronic devices
- To learn the working principle of different types of audio systems
- To study the operating principle of different types of display systems
- To describe the working of various house hold devices
- To identify various technologies involved in Smart home

UNIT I	**CONSUMER ELECTRONICS FUNDAMENTALS**	**9**

History of Electronic Devices - Vacuum Tubes, Transistors, Integrated Circuits- Moore's Law, Semiconductor Devices, Diodes, Rectifiers, Transistors, Logic Gates, Microprocessors and Microcontrollers in consumer electronics, Sensors: Motion Sensors, Thermal Sensors and Image Sensors, PIR, IR.

UNIT II	**AUDIO SYSTEMS**	**9**

Audio systems: Construction and working principle of : Microphone, Loud speaker, AM and FM receiver, stereo, 2.1 home theater, 5.1 home theater

UNIT III	**VIDEO SYSTEMS**	**9**

Display systems: CRT, LCD, LED and Graphics displays, Video Players : DVD and Blue RAY. Recording Systems: Digital Cameras and Camcorders, Smart Phones,Smart Watches

UNIT IV	**DOMESTIC APPLIANCES**	**9**

Home Enablement Systems: RFID Home, Automatic Cleaning Robots, Washing Machines, Kitchen Electronics- Microwave, Dishwasher, Induction Stoves, Smart Refrigerators, Smart alarms, Smart locks

UNIT V	**SMART HOME**	**9**

Introduction- Home Virtual Assistants- Alexa and Google Home - Home Security Systems - CCTV, Intruder Detection, Automated blinds, Water Level Indicator, Intelligent Building Perspective

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Thomas L Floyd "Electronic Devices" 10th Edition Pearson Education Asia 2018.
2. Philp Hoff "Consumer Electronics for Engineers" - Cambridge University Press.1998.
3. Jordan Frith, " Smartphones as Locative Media ", Wiley. 2014.
4. Dennis C Brewer, " Home Automation", Que Publishing 2013.
5. Thomas M. Coughlin, "Digital Storage in Consumer Electronics", Elsevier and Newness 2012.

REFERENCES:

1. M.L.Bushnell and V.D.Agrawal, “Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits”, Kluwer Academic Publishers, 2002.
2. A.L.Crouch, “Design Test for Digital IC’s and Embedded Core Systems”, Prentice Hall International, 2002.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Interpret the fundamentals of Electronic devices	2
CO2	Infer the technical specifications of various electronic audio systems	2
CO3	Infer the technical specifications of display and recording systems	2
CO4	Illustrate the functions of home appliances like Washing machine, Microwave oven etc.	3
CO5	Compare the technologies used in building a smart home	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	1	2	1	1	1	1	1	-	2	3	2
2.	3	3	3	2	2	1	1	1	1	2	1	2	3	2
3.	3	3	3	2	2	1	1	1	1	2	1	2	3	2
4.	3	3	3	2	2	1	1	1	1	2	1	2	3	2
5.	3	3	3	2	3	1	1	1	1	2	1	2	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

OE22705	EMBEDDED SYSTEMS AND ITS APPLICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the Embedded Systems Fundamentals
2. To comprehend Embedded System Components
3. To learn Embedded Hardware Design and Development
4. To know the different design approaches of Embedded Firmware
5. To design typical applications of Embedded Systems through case studies

UNIT I	**INTRODUCTION TO EMBEDDED SYSTEMS**	**9**

Introduction to Embedded Systems: Definition of Embedded System, Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification of Embedded Systems, Major application areas, Purpose of Embedded Systems, Characteristics and Quality attributes of Embedded Systems.

UNIT II	**A TYPICAL EMBEDDED SYSTEM**	**9**

Core of the Embedded System-Memory-Sensors and Actuators-Communication Interface - Embedded Firmware - Other System Components - PCB and Passive Components.

UNIT III	**EMBEDDED HARDWARE DESIGN AND DEVELOPMENT**	**9**

Analog Electronic Components, Digital Electronic Components, VLSI and Integrated Circuit Design, Electronic Design Automation (EDA) Tools, Use of OrCAD EDA Tool - Schematic Design using OrCAD Capture CIS, The PCB Layout Design, Printed Circuit Board (PCB) Fabrication.

UNIT IV	**EMBEDDED FIRMWARE DESIGN AND DEVELOPMENT**	**9**

Embedded Firmware Design Approaches- Super Loop Based Approach, Embedded Operating System (OS) Based Approach, Embedded Firmware Development Languages - Assembly Language based Development, High Level Language Based Development, Mixing Assembly and High-Level Language, Simple programming in Embedded C.

UNIT V	**CASE STUDY**	**9**

Smart Vending machine, Elevator Controller, Washing Machine -Application-Specific Embedded System, Model Train Controller, Automotive–Domain Specific Examples of Embedded System, Trends in embedded systems in industrial applications.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Shibu K V, “Introduction to Embedded Systems”, Second Edition, Mc Graw Hill, 2017.
2. Wayne Wolf, “Computers as components Principles of Embedded Computing System Design”, Second Edition, Morgan Kaufmann Publishers, 2008.
3. Raj Kamal, “Embedded Systems”, Fourth Edition, McGraw Hill, 2020.

REFERENCES:

1. Jonathan W.Valvano, “Embedded Microcomputer Systems Real Time Interfacing”, Third Edition Cengage Learning, 2012.

2. Sriram V Iyer, Pankaj Gupta, "Embedded Real Time Systems Programming", Tata McGrawHill, 2017.
3. Lyla B Das, "Embedded Systems"-Pearson Education, 2013.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the selection procedure of processors in the embedded domain.	1
CO2	Develop a comprehensive understanding of embedded systems	1
CO3	Design and develop Hardware embedded systems	3
CO4	Perform Firmware Design through programming using Embedded C	3
CO5	Design embedded applications for Real-World Scenarios	6
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	2	2	3	3	-	-	-	-	-	-	3	3
2.	3	1	3	3	3	3	-	-	-	-	-	-	3	3
3.	3	1	3	3	3	2	-	-	-	-	-	-	3	3
4.	3	1	3	3	3	2	-	-	-	-	-	-	3	3
5.	3	3	3	3	3	3	-	-	-	-	-	-	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

OE22706	FUNDAMENTALS OF ANALOG AND DIGITAL ICs	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study circuit configuration and introduce practical applications of linear integrated circuits.
- To introduce the concept of application of ADC and DAC in real time systems and Phase Locked Loop with applications.
- To introduce the design of various combinational digital circuits using logic gates and to analyze sequential circuits
- To acquire knowledge about various logic families.

UNIT I	**INTRODUCTION TO OPERATIONAL AMPLIFIER & ITS APPLICATIONS**	**9**

Ideal Operational Amplifier - General operational amplifier stages - Internal circuit diagrams of IC 741, DC and AC performance characteristics, slew rate, Applications: Adder, Subtractor, Instrumentation amplifier, Integrator, Differentiator, Logarithmic amplifier -Low pass Butterworth filter-Fundamentals of Monolithic IC technology

UNIT II	**ANALOG TO DIGITAL AND DIGITAL TO ANALOG CONVERTERS**	**9**

D/A converter – Weighted resistor type, R-2R Ladder type - IC Specifications - A/D Converters – Flash type - Successive Approximation type - IC Specifications.

UNIT III	**WAVEFORM GENERATORS AND SPECIAL FUNCTION ICS**	**9**

Timer IC 555, Voltage regulators - IC 723 - SMPS - Phase Locked Loop(PLL) -Basic principles - Voltage controlled oscillator, Monolithic PLL IC 565, Application of PLL: AM detection, Frequency multiplier

UNIT IV	**MSI ICs - COMBINATIONAL & SEQUENTIAL CIRCUITS**	**9**

Parallel binary adder/subtractor, Magnitude comparator, Decoder, Encoder, Boolean function Implementation using these IC's.- Flip Flops - Synchronous and Asynchronous Counters - 7490, 74161 Counter IC Specifications - Shift Registers - 74194 Shift Register IC Specifications

UNIT V	**LOGIC FAMILIES & PROGRAMMABLE LOGIC DEVICES**	**9**

Logic families- TTL, MOS, CMOS, HMOS, HCMOS, BiCMOS - Comparison of Logic families - PLDs - ROM, PLA, PAL - Implementation of combinational logic using standard ICs, ROM, PLA and PAL- Introduction to VLSI

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ramakant A. Gayakwad, "OP-AMP and Linear ICs", 4th Edition, Prentice Hall / Pearson Education, 2015
2. M. Morris Mano and Michael D.Ciletti, "Digital Design", Pearson, 5 th Edition, 2013

REFERENCES:

1. D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New Age International Pvt. Ltd., 2018, Fifth Edition

2. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 4th Edition, Tata Mc Graw-Hill, 2016
3. Charles H.Roth Jr., "Fundamentals of Logic Design" Thomson Learning,2013

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Ability to design analog linear circuits and develop linear IC based Systems.	4
CO2	Understand the concept of ADC and DAC in real time systems with applications	2
CO3	Apply the principles of Special function ICs in the design of real time systems.	3
CO4	Analyze various Combinational and Sequential digital circuits.	4
CO5	Understand the concept of various logic families and programmable logic devices.	2

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	2	-	-	-	-	-	-	3	3
2.	3	3	3	3	3	2	-	-	-	-	-	-	3	3
3.	3	3	3	3	3	2	-	-	-	-	-	-	3	3
4.	3	3	3	3	3	2	-	-	-	-	-	-	3	3
5.	3	3	3	3	3	2	-	-	-	-	-	-	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

OE22707	IOT AND SENSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the underlying principles and performance characteristics of important sensors.
- To infer the use of interface electronics.
- To familiarize the fundamentals of IoT
- To implement of Domain Specific IoT in real world
- To design and develop an IoT based application

UNIT I	**SENSORS**	**9**

Data Acquisition, Sensor Characteristics, Principles of sensing – Capacitance, Inductance, Resistance, Piezoelectric Effect, Hall Effect, Temperature and thermal effects, Lights, Optical Sensors.

UNIT II	**PROCESS MANAGEMENT INTERFACE ELECTRONIC CIRCUITS**	**9**

Introduction, Amplifiers, Excitation Circuits, Analog-to-Digital Converters, Direct Digitization, Bridge Circuits, Data Transmission, Noise in Sensors and circuits, Calibration, Batteries for low power sensors.

UNIT III	**TEMPERATURE AND CHEMICAL SENSORS**	**9**

Temperature Sensors: coupling with objects – temperature reference points – thermo resistive sensors – thermoelectric contact sensors – Chemical sensors: characteristics – classes of chemical sensors – biochemical sensors –multisensory arrays – electronic noses and tongues.

UNIT IV	**INTERNET OF THINGS**	**9**

Fundamentals of IoT, Physical Design, Logical Design, IoT Enabling Technologies, IoT Levels and Deployment Templates.

UNIT V	**IOT APPLICATIONS**	**9**

Home Automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health and Lifestyle.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Jacob Fraden, "Handbook of Modern Sensors: Physics, Designs, and Applications", Fifth Edition, Springer, 2016.
2. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.
3. Sudip Misra, Anandarup Mukherjee, Arijit Roy, "Introduction to IoT", Cambridge University Press, 2022.

REFERENCES:

1. Olivier Hersent, David Boswarthick, Omar Elloumi "The Internet of Things – Key applications and Protocols", Wiley, 2012.
2. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things – Introduction to a New Age of Intelligence", Elsevier, 2014.
3. Dieter Uckelmann, Mark Harrison, Michahelles and Florian (Eds) "Architecting the Internet of Things", Springer, 2011.
4. Rajkamal, "Internet of Things: Architecture, Design Principles And Applications", McGraw Hill Higher Education, 2017.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Identify sensor technologies for sensing real world entities.	2
CO2	Apply design concepts to interface sensors with various electronic components.	3
CO3	Differentiate various temperature and chemical sensors based on its applications.	2
CO4	Interpret the key enablers of IoT.	4
CO5	Interrelate real-world IOT Applications.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	2	-	-	3	-	-	-	-	-	3	3	3
2.	3	2	2	2	2	-	-	-	2	2	-	2	3	3
3.	3	2	2	2	2	2	-	-	-	2	-	2	3	3
4.	3	2	2	2	2	2	-	-	2	2	-	2	3	3
5.	3	2	2	2	2	2	-	-	-	2	-	2	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

OE22708	FUNDAMENTALS OF WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce various generations of wireless systems.
- To acquaint fundamentals of cellular systems design.
- To familiarize with various multiple access schemes used in wireless communication.
- To introduce mobile radio propagation·
- To provide basic knowledge of diversity and equalization techniques

UNIT I	**WIRELESS COMMUNICATION SYSTEMS**	**9**

Generation of wireless communication systems: Examples of wireless systems: Cordless, Paging Systems. Cellular Telephone System, Comparison of wireless systems, Personal Communication Systems, Call establishment in cellular systems.

UNIT II	**FUNDAMENTALS OF CELLULAR COMMUNICATION**	**9**

Frequency reuse, Handoff, Channel Assignment, Interference and system capacity, improving coverage and capacity in cellular systems: cell splitting, sectoring, repeaters for range extensions, microcell zone concept.

UNIT III	**MULTIPLE ACCESS TECHNIQUES**	**9**

Introduction to Multiple Access Techniques - FDMA, TDMA, Spread Spectrum Multiple Access - FHMA, CDMA, Basics of OFDM.

UNIT IV	**MOBILE RADIO PROPAGATION**	**9**

Introduction to Radio Wave Propagation - Large Scale Path Loss - Free Space Propagation Model - Propagation Mechanisms: Reflection, Diffraction, Scattering - Small Scale Multipath Propagation

UNIT V	**DIVERSITY TECHNIQUES**	**9**

Introduction to Diversity - Space Diversity - Selection Diversity - Feedback Diversity - Maximal Ratio Combining - Equal Gain Combining - Polarization Diversity - Frequency Diversity - Time Diversity

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Rappaport. T.S., “Wireless communications”, Pearson Education, Second edition updated, 3rd impression, 2024.
2. Vijay Garg, ―Wireless Communications and networking, First Edition, Elsevier 2008.

REFERENCES:

1. Jochen Schiller, “Mobile communications”, Pearson Education, 2nd Edition 2008.
2. Simon Haykin & Michael Moher, “Modern wireless Communication”, Pearson Education, 2007.
3. Andreas. F.Molisch, Wireless Communication”, John Wiley, 2006.
4. T. S. Rappaport, R. W. Heath Jr., R. C. Daniels, and J. M. Murdock,, Millimeter Wave Wireless Communication., Pearson Education, 2015.
5. M. Vaezi, Z. Ding, and H. V. Poor, Multiple Access Techniques for 5G Wireless

Networks and Beyond., Springer Nature, Switzerland, 2019.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	To be familiar with generations of wireless communication systems	2
CO2	To acquire insights into cellular architecture	3
CO3	To analyze various multiple-access techniques adopted in wireless applications	3
CO4	To understand the various wave propagation mechanisms and a propagation model	3
CO5	To analyze a multipath mitigation technique to retrieve signals under various channel conditions	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	2	3	1	-	-	-	1	2	-	2	2	2
2.	3	2	2	3	2	-	-	-	-	2	-	3	2	2
3.	3	2	2	3	2	-	-	-	-	2	-	3	2	2
4.	3	2	2	3	1	-	-	-	1	2	-	2	2	2
5.	3	3	3	3	3	-	-	-	1	1	-	1	2	1
* 1 – Weak, 2 – Moderate, 3 – Strong														

OE22709	INTRODUCTION TO SMART CITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the concept of smart city and associated challenges
- To understand process of nomadic service discovery of smart city
- To learn several fundamental enabling technologies
- To design and develop sustainable infrastructure for smart city applications
- To study various case studies of smart city

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

Trends in smart cities, Challenges of smart cities: Security, Fragmentation of standards, Scalability, Application of smart cities, Criteria for smart cities: Data Communications, Data Acquisition, Deployment: An economic point of view

UNIT II	**NOMADIC SERVICE DISCOVERY**	**9**

mDNS/DNS-SD Service Discovery: Operational modes, Strategies for responding to queries, support for context queries, Proxy support for sleeping nodes: Active Proxy and Passive Proxy delegation protocols, Reliability

UNIT III	**ENABLING TECHNOLOGIES**	**9**

Data plane challenges, Enabling Technologies for smart cities - Internet of Things, Smart Dust, Smartphones, Cloud Computing, Big Data and Open Data

UNIT IV	**SUSTAINABLE SMART CITIES**	**9**

Sustainability Assessment, Balanced Sustainability, Procedural Balance, Contextual and Temporal Balance, City Blocks as a Contextual Variable, Sustainability Information Modeling Platforms

UNIT V	**VEHICLE-TO-X (V2X) INFRASTRUCTURE**	**9**

Traffic Surveillance, Detecting Abnormal Events, Micro-mobility Data Communications, V2X Network Integration and Interoperability, Connected Cars, Green V2X Communications

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Houbing Song, Ravi Srinivasan, Tamim Sookoor, Smart Cities: Foundations, Principles, and Applications, Wiley, 2017
2. Mohammad S. Obaidat and Petros Nicopolitidis, Smart Cities and Homes, Morgan Kaufmann 2016.

REFERENCES:

1. Mohammad Ayoub Khan, Fahad Algarni, Mohammad Tabrez Quasim, Smart Cities: A Data Analytics Perspective, Springer, 2020.
2. Poonam Sharma, Swati Rajput, Sustainable Smart Cities in India, Springer 2019.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the basic concepts of a smart city.	2
CO2	Acquaint knowledge on service discovery of smart cities	2
CO3	Explore the latest technologies used in smart cities	2
CO4	Apply sustainable infrastructure modeling for designing Smart Cities	3
CO5	Analyze the various applications and case study of smart city	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	2	2	2	-	-	-	-	1	3	3	2
2.	3	3	3	3	2	2	-	-	-	-	1	3	3	2
3.	3	3	3	2	2	3	-	-	-	-	1	3	3	2
4.	3	3	3	3	3	3	-	-	-	-	1	3	3	3
5.	3	2	3	3	3	3	-	-	-	-	1	3	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

OE22710	MEDICAL IMAGING SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the basics of medical imaging and its functional modalities.
- To understand the principles and working of CT imaging technology.
- To Identify the clinical applications of ultrasound imaging technology.
- To impart in-depth knowledge of thermal imaging technology to diagnose diseases.
- To learn the working principles of the MRI technique.

UNIT I	**INTRODUCTION TO MEDICAL IMAGING**	**9**

The basic imaging principle, Imaging Modalities-Projection radiography, Computed Tomography,
Nuclear medicine, Ultrasound imaging, Magnetic Resonance Imaging.

UNIT II	**COMPUTED TOMOGRAPHY**	**9**

Conventional tomography-Introduction, CT Instrumentation, Generations of CT Machines—First, Second, Third, Fourth, Fifth, Sixth & Seventh, Dual-Energy CT, CT Detectors, Gantry, Slip Ring, and Patient Table, Image Formation: Line Integrals, Parallel Beam Reconstruction, Fan Beam
Reconstruction, Helical CT Reconstruction.

UNIT III	**ULTRASOUND IMAGING**	**9**

Acoustic propagation, Attenuation, Absorption and scattering Doppler effect, Ultrasonic transducers, Transducer Arrays, A mode, B mode, M mode scanners, Steering and Focusing-Transmit Steering and Focusing, Beamforming and Dynamic Focusing.

UNIT IV	**THERMAL IMAGING**	**9**

Medical Thermography-Infrared Radiation, Physical Factors, Infrared Detectors, Thermographic Equipment, Quantitative Medical Thermography-Digital Analysis of Thermograms, Pyroelectric Vidicon-based Thermographic Camera.

UNIT V	**MAGNETIC RESONANCE IMAGING**	**9**

Principles of NMR Imaging system, Basic NMR components, MRI Data Acquisition, Slice selection, Frequency encoding, Polar Scanning, Gradient Echoes, Phase Encoding Spin Echoes, Biological effects of magnetic field, Introduction to Functional MRI.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Jerry L Prince & Jonathan M Links, Medical Imaging Signals and Systems, Pearson Prentice Hall, Second Edition, 2022.
2. R S Khandpur, Handbook of Biomedical Instrumentation, Tata McGraw Hill Publication, Third Edition, 2014.

REFERENCES:

1. Dr. Bhumika Gupta, Dr. Devendra Singh, Dr. Rohit, and Ms. Pragya Baluni, Advancement in Healthcare Applications Using Biomedical Signal Processing, Book Rivers, 2024.
2. Ray H. Hashemi & William G. Bradley Jr., Lippincott Williams & Wilkins, Basics of MRI, Fourth Edition, 2017.
3. Joachim Hornegger, Vincent Christlein , Stefan Steidl, Medical Imaging Systems, 2020.
4. Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt, and John M. Boone, "The Essential Physics of Medical Imaging," LWW; Fourth, North American edition, 2020.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Exhibit the principles, components, and procedures of different imaging modalities.	4
CO2	Demonstrate the operation of CT imaging systems and their applications.	2
CO3	Analyze the Ultrasound imaging technique for a particular application.	4
CO4	Analyze the images obtained from the Thermal imaging technique for diagnosis and treatment.	4
CO5	Apply the knowledge of MRI and its types for clinical applications.	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	-	-	-	-	-	1	2	3	3
2.	3	3	2	3	3	2	-	-	2	1	1	2	3	2
3.	3	3	3	3	2	-	-	-	1	-	1	2	3	3
4.	3	3	2	3	3	-	-	-	2	1	1	2	3	2
5.	3	3	3	3	3	2	-	-	1	1	1	2	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

OE22711	NEURAL NETWORKS AND ITS APPLICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic ideas and principles of Neural Networks.
- To develop an understanding of the fundamentals of Convolutional Neural Networks.
- To study the basic concepts of recurrent neural networks.
- To impart knowledge in deep reinforcement algorithms.
- To explore the generative adversarial networks for various applications.

UNIT I	**INTRODUCTION TO NEURAL NETWORKS**	**9**

Overview of neural networks and their history, Biological inspiration: neurons and synapses, Basic structure and terminology of neural networks, Activation functions and their role - Types of machine learning: supervised, unsupervised, reinforcement, feed forward Neural Networks, Architecture and working of feed forward neural networks Forward propagation and back propagation algorithms,
Gradient descent and its variants, Implementation of a simple feed forward network.

UNIT II	**CONVOLUTIONAL NEURAL NETWORKS (CNNs)**	**9**

Introduction to deep learning and its motivations, Convolutional layers and their significance, Pooling layers, Filters, Parameter sharing, Regularization and reducing spatial dimensions Applications of CNNs in image classification.

UNIT III	**RECURRENT NEURAL NETWORKS (RNNs)**	**9**

Introduction to sequential data and RNNs, Bidirectional RNNs, Encoder-decoder sequence to sequence architectures, Long Short-Term Memory (LSTM) networks, Applications of RNNs in NLP: text generation, sentiment analysis

UNIT IV	**DEEP REINFORCEMENT LEARNING**	**9**

Stateless Algorithms: Multi-Armed Bandits, Bootstrapping for Value Function Learning, Monte Carlo Tree Search, Applications of Reinforcement Learning - Building Conversational Systems: Deep Learning for Chatbots, Self-Learning Robots, Self-Driving Cars.

UNIT V	**GENERATIVE ADVERSARIAL NETWORKS (GANs)**	**9**

Understanding GAN architecture, Training process: generator and discriminator, Applications of GANs: image generation, style transfer.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Charu C.Aggarwal, "Neural Networks and Deep Learning", Springer International Publishing AG, part of Springer Nature 2018.
2. Jakub Langr, Vladimir Bok, "GANs in Action Deep Learning with Generative Adversarial Networks" Manning Publications, 2019

REFERENCES:

1. Satish Kumar, “Neural Networks: A Classroom Approach”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2nd edition,2017.
2. Phil Kim, “MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence”, Apress , 2017.
3. Jon Krohn, Grant Beyleveld, Aglaé Bassens "Deep Learning Illustrated: A Visual, Interactive Guide to Artificial Intelligence", 1st edition Addison-Wesley Professional 2019.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Infer the concepts of neural networks and their applications	2
CO2	Apply appropriate convolutional neural network for image classification problems	3
CO3	Deploy RNN and LSTM in NLP and real world problems	3
CO4	Implement deep reinforcement learning techniques in various applications to improve their performance	3
CO5	Apply GAN model for data augmentation	3
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	-	-	-	-	-	-	-	-	1	3	1
2.	3	3	2	1	2	2	2	-	2	1	-	2	3	2
3.	3	3	2	1	2	2	2	-	2	1	-	2	3	2
4.	3	3	2	1	2	2	2	-	2	1	-	2	3	2
5.	3	3	2	1	2	2	2	2	2	1	-	2	3	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

OE22712	ROBOTIC SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The student should be exposed to:

- To understand robotics, automation and control technologies
- To explore various types of robotic sensors
- To comprehend robotic vision and machine learning
- To learn about actuators and robot programming
- To study various applications of robotics and its system in industry

UNIT I	**OVERVIEW OF ROBOTICS AND AUTOMATION**	**9**

Robotics: Definition, Origin, Different types, Various generations, Degrees of freedom; Anatomy of a robot, Classification of robots – Cartesian, Cylindrical, Spherical, Articulated, SCARA; Precision of robot movements – Accuracy, Resolution, Repeatability.

Automation: Basic elements of an automated system – Level of automation; Overview on controller and its types – PI, PD, PID

UNIT II	**SENSORS FOR ROBOTIC APPLICATIONS**	**9**

Sensor characteristics, Types of sensors – Tactile sensors, Touch sensors; Position sensors – Proximity sensors-Speed sensors– Velocity/motion sensors; Force/Pressure and torque sensors, Advanced Sensor Technology - Smart sensors, MEMS-based sensors; Sensor fusions

UNIT III	**ROBOTIC VISION SYSTEM**	**9**

Robotic vision systems – Image processing and analysis, Segmentation, Feature extraction, Object Recognition, Vision Sensors-Overview on Artificial Intelligence/Machine Learning for robotic vision

UNIT IV	**ACTUATORS AND ROBOT PROGRAMMING**	**9**

Actuators – Electric – Hydraulic – Pneumatic; End effectors – Grippers and Tools – Types, Design considerations in gripper selection; Robot programming, Introduction to robot languages-IPL

UNIT V	**ROBOTIC SYSTEMS IN INDUSTRY**	**9**

Industrial applications – Material transfers, Machine loading and unloading, Automatic assembly, Automatic inspection, Flexible Manufacturing Systems; Introduction to modern mobile robots: Swarm robots, cooperative and collaborative robots

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey, “Industrial Robotics”, Tata Mc Graw Hill, 2e, 2017.
2. Mittal R K, Nagrath I J, “Robotics and control”, Tata McGraw Hill, 2022.

REFERENCES:

1. Saeed B. Niku, "An Introduction to Robotics: Analysis, systems and applications", Pearson Education, 2009.
2. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics control, sensing, vision and intelligence", McGraw Hill Book co, 1987.
3. Mikell P. Groover, "Automation, Production systems and Computer Integrated Manufacturing", Prentice Hall India Pvt. Ltd., 2011.
4. Richard D Klafter, and Michael Negin, "Robotics Engineering", Prentice Hall, 2009.
5. Designing Autonomous Mobile Robots, John M Holland, Elsevier, 2004
6. D. Patranabis, Sensors and Transducers, PHI, 2nd Ed 2013
7. Jon S.Wilson, Sensor Technology Handbook, Elsevier, 2005

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Classify robotics systems, automation and control technologies.	3
CO2	Select appropriate sensors for certain applications.	3
CO3	Sketch various stages involved in computer vision for robotics.	3
CO4	Select required actuators, end effectors, robot programming languages for any given applications.	4
CO5	Illustrate recent industrial robotics and their applications.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	1	1	-	-	-	-	-	-	-	1	1	1
2.	3	2	1	1	-	-	-	-	-	-	-	1	1	1
3.	3	2	1	1	-	-	-	-	-	-	-	1	1	1
4.	3	3	1	2	-	-	-	-	-	-	-	1	1	1
5.	3	1	1	2	-	-	-	-	-	-	-	1	1	1

* 1 – Weak, 2 – Moderate, 3 – Strong

OE22713	SYSTEM DESIGN USING MICROCONTROLLERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study the Architecture, addressing modes & instruction set of PIC Microcontroller and develop skills in writing simple programs.
- To understand the concepts of Interrupts, timer and Serial ports
- To introduce commonly used peripheral interfacing ICs.
- To expose the students to the fundamentals of Arduino - based system design
- To study and understand the typical applications of microcontrollers

UNIT I	**INTRODUCTION TO MICROCONTROLLER**	**9**

Overview of PIC microcontroller - Architecture – Program Memory considerations – Register File
Structure - Instruction Set - Addressing modes – Assembly language Programming - Simple operations

UNIT II	**PORTS, TIMERS AND INTERRUPTS OF MICROCONTROLLER**	**9**

I/O ports register formats, Serial port register formats - Timer and Counter registers, PIC microcontroller Interrupts – Sources of PIC Interrupts

UNIT III	**PERIPHERALS AND INTERFACING**	**9**

Serial Communication – Universal Synchronous Asynchronous Receiver Transmitter (USART), Serial Peripheral Interface (SPI), Inter-Integrated Circuit (I2C), Analog to Digital Converter (ADC), Digital to Analog Converter (DAC) and Sensor Interfacing

UNIT IV	**INTRODUCTION TO ARDUINO**	**9**

Single-board microcontroller (Example-Arduino) – Types of Boards - Board breakdown – Power Supply – Microcontroller Shields; Sensors – Distance Ranging sensor, PIR motion sensor, light sensor, pressure sensor, proximity sensor, humidity and temperature sensor, Acceleration sensor, sound detecting sensor, RGB and Gesture sensor

UNIT V	**SYSTEM DESIGN – CASE STUDY**	**9**

Interfacing LCD Display – Keypad Interfacing – Stepper Motor Control - DC Motor Control - Controlling DC/ AC appliances – Simple programmable robotic arm using Single-board microcontroller (Example-Arduino)

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey 'PIC Microcontroller and Embedded Systems using Assembly and C for PIC18', Pearson Education 2008
2. Peatman, J. B., "Design with PIC Microcontrollers", Pearson Education, 3rd Edition, 2004.
3. Saurabh Chandrakar Nilesh Bhaskarrao Bahadure,"Microcontrollers and Embedded System Design", Wiley, 2019.

4. Arduino-For-Beginners.pdf (makerspaces.com)
5. Arduino Course for Absolute Beginners eBook Info - Programming Electronics Academy

REFERENCES:

1. Tim Wilmshurst, "Designing Embedded Systems with PIC Microcontrollers – Principles and Applications", Newness Publication, 2007
2. John Iovine, 'PIC Microcontroller Project Book', McGraw Hill 2000
3. Julio Sanchez Maria P. Canton, "Microcontroller Programming: The microchip PIC", CRC Press, Taylor & Francis Group, 2007.
4. Arduino Course for Absolute Beginners eBook Info - Programming Electronics Academy
5. Web Resource: https://www.udemy.com/course/arduino-for-beginners-complete-course

COURSE OUTCOMES: At the end of the course, learners will be able to		**RBT Level**
CO1	Interpret the PIC architecture and its assembly language programming.	2
CO2	Assess the viability of using the interrupts, timers, and I/O ports of the PIC microcontroller for real-time applications.	3
CO3	Identify the best commonly used interfaces of PIC microcontrollers such as USART, SPI, I2C and to develop applications based on DAC, ADC of PIC.	3
CO4	Identify suitable type of Arduino and sensors for an application	3
CO5	Examine the available case studies based on PIC and Arduino microcontroller to design an embedded system.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	2	-	-	-	-	-	3	2	3
2.	3	3	3	3	3	2	-	-	-	-	-	3	2	3
3.	3	3	3	3	3	2	-	-	-	-	-	3	2	3
4.	3	3	3	3	3	2	-	-	-	-	-	3	2	3
5.	3	3	3	3	3	2	-	-	-	-	-	3	2	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

VALUE ADDED COURSES

VD22701	5G AND 6G ANTENNA THEORY AND DESIGN	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To impart the knowledge about antenna arrays for 5G and 6G.
- To familiarize with conformal antenna array.
- To provide exposure on Leaky wave antennas.
- To get acquaintance with antenna technologies in 5G and 6G.
- To design antenna for 5G and 6G wireless communication.

UNIT I	**ANTENNA ARRAYS FOR 5G and 6G**	**6**

Introduction of the course, A Perspective of Antennas for 5G and 6G, 5G Requirements of Antenna Arrays, 6G and its Antenna Requirements.

UNIT II	**CONFORMAL ANTENNAS**	**6**

Conformal Transmit arrays, Challenges, Conformal Transmit arrays employing triple layer elements, Conformal arrays for 5G and beyond.

UNIT III	**LEAKY WAVE ANTENNAS**	**6**

Frequency Independent Beam Scanning Leaky Wave Antennas, Reconfigurable Fabry-Perot (FP) LWA, Period-Reconfigurable SIW Based LWA, Reconfigurable Composite Right/Left-Handed LWA.

UNIT IV	**5G AND 6G WIRELESS COMMUNICATIONS**	**6**

Introduction, key features-Modulation and Multiple Access techniques-millimeter wave communications, 5G Architectures -Antenna technologies used in 5G and 6G.

UNIT V	**ANTENNAS FOR 5G AND 6G WIRELESS COMMUNICATION**	**6**

Introduction to 5G and 6G antennas and arrays, Design of Antennas for 5G wireless communication, Sub-6 GHz antennas, and millimeter wave 5G antennas, Measurement techniques.

TOTAL: 30 PERIODS

TEXT BOOK:

1. Constantine.A.Balanis, "Antenna Theory Analysis and Design", 4th Edition Wiley Student Edition, 2016.
2. Rappaport, T.S., "Wireless Communications, Principles and Practice", 2nd Edition, Prentice Hall, NJ, 2002.
3. Ahmed El-Zooghby, Smart Antenna Engineering, Artech House Publishers,2005.
4. Y. Jay Guo, Richard W Ziolkowski, "Advanced Antenna Array Engineering for 6G and beyond wireless communications", online resource, Hoboken, New Jersey : Wiley-IEEE Press, 2022.

REFERENCES:

1. John D.Kraus," Antennas for all Applications", 5th Edition, Mc Graw Hill, 2017.
2. Afif Osseiran, Jose F Monserrat, Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016
3. Saad Z. Asif, "5G Mobile Communications Concepts and Technologies", CRC Press, Taylor

& Francis Group, First Edition, 2018

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the fundamentals of antenna arrays for 5 G and 6G.	2
CO2	Analyze conformal antenna systems and its applications.	4
CO3	Acquire knowledge about leaky-wave Antennas.	3
CO4	Articulate the principles of 5G and 6G wireless communication.	3
CO5	Utilize the commercial simulation software to design and analyze the antennas for 5G and 6G.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	2	-	-	-	-	1	1	1	3
2.	3	3	3	3	3	2	-	-	-	-	1	1	2	3
3.	3	3	3	3	3	2	-	-	-	-	1	1	2	3
4.	3	3	2	2	2	2	-	-	-	-	1	1	2	1
5.	3	2	2	2	3	2	-	-	-	-	1	1	1	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

VD22702	ARTIFICIAL NEURAL NETWORKS	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To understand the basic concepts of neural networks.
- To illustrate the different working principles of the back propagation network.
- To analyze the different types of neural networks.
- To introduce the advanced level networks.
- To apply artificial neural networks for real-time applications.

UNIT I	**INTRODUCTION**	**6**

Basic concepts of Neural Networks, Model of Artificial Neuron, Neural Network Architectures, Characteristics of neural networks, Learning Methods, Gradient Descent Rules, Perceptron Learning Algorithm-Back propagation Learning.

UNIT II	**LEARNING ALGORITHMS**	**6**

Back Propagation Network, Generalised Delta Rule, BPN Application, Associative Memory definition, Bidirectional AM, Hopfield Memory, Simulated Annealing – Boltzmann Machine.

UNIT III	**OTHER NEURAL NETWORKS**	**6**

Counter Propagation Network, Feature Counter Propagation Network, Feature Mapping, Self Organising Feature Maps, Adaptive Resonance Theory (ART) Network Descriptions.

UNIT IV	**ADVANCE NETWORKS**	**6**

Support Vector Machines, R B F Network, Neocognitron Evolving neural networks using GA.

UNIT V	**APPLICATIONS**	**6**

Speech Signal Processing, Handwritten Character Recognition, Signature Classification, Medical Application-Tumor Detection, Biomedical signal analysis and Medical image analysis.

TOTAL: 30 PERIODS

TEXT BOOKS:

1. Satish Kumar, “Neural Networks A Classroom Approach”, McGraw Hill Education (India) Pvt. Ltd, Second Edition, 2017.
2. Charu C.Aggarwal, “Neural Networks and Deep Learning”, Springer International Publishing AG, part of Springer Nature 2018.
3. Jakub Langr, Vladimir Bok, “GANs in Action Deep Learning with Generative Adversarial Networks” Manning Publications, 2019.

REFERENCES:

1. Phil Kim, “MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence”, Apress , 2017.
2. Jon Krohn, Grant Beyleveld, Aglaé Bassens "Deep Learning Illustrated: A Visual, Interactive Guide to Artificial Intelligence", 1st edition Addison-Wesley Professional 2019.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Demonstrate the basic principles of neural networks.	2
CO2	Implement various types of networks for back propagation models .	3
CO3	Understand the different types of neural networks.	3
CO4	Implement the optimization algorithm for neural networks.	3
CO5	Evaluate the given neural network application for latest technologies.	5
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	2	3	3	-	-	-	-	-	2	3	3	3
2.	3	3	2	3	3	-	-	-	-	-	2	3	3	3
3.	3	3	2	3	3	-	-	-	-	-	2	3	3	3
4.	3	3	3	3	3	-	-	-	-	-	2	2	3	3
5.	3	3	3	3	3	-	-	-	-	-	1	2	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

VD22703	DEEP LEARNING USING PYTHON	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To understand the theoretical foundations of machine learning models.
- To illustrate the different working principles of deep learning architectures.
- To analyze how to reduce the dimensions of high resolution data.
- To evaluate the generalizability of the optimized deep networks.
- To apply optimized deep networks for appropriate real-time applications.

UNIT I	**MACHINE LEARNING CONCEPTS**	**6**

Introduction to Machine Learning – ML terminologies – Linear Regression: Training and Loss – Loss Reduction techniques – Working with python (Tensorflow).

UNIT II	**CLASSIFICATION AND CLUSTERING**	**6**

Logistic regression – Generalization – Regularization - Classification – Clustering: Centroid-based Clustering - Density-based Clustering - Distribution-based Clustering - Hierarchical Clustering – Working with Python Tensorflow and Google's colab environment.

UNIT III	**DEEP NETWORKS**	**6**

Introduction to Neural networks – Terminology – Working with tensors – Pandas, numpy, matplotlib library – Feed forward networks – Convolutional Neural network – Recurrent neural networks and its variants – Long-Short Term memory.

UNIT IV	**DEVELOPING CONVOLUTIONAL NETWORKS AND SEQUENCE MODELING**	**6**

Digit Classification using MNIST - Image Classification with Fashion MNIST - Training an Image Classifier via Transfer Learning - Building a Text Classifier with TF-Hub – Image captioning.
Working with Google's Colab environment.

UNIT V	**DEEP GENERATIVE MODELS**	**6**

Restricted Boltzmann Machines – Deep Belief networks – Deep Boltzmann machine – Convolutional Boltzmann machine – Working with Python.

TOTAL: 30 PERIODS

TEXT BOOKS:

1. Deep Learning for Computer Vision by Rajalingappaa Shanmugamani , 2018
2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition. by Aurélien Géron. Released September 2019. Publisher- O'Reilly Media,
3. Yoshua Bengio and Ian J.Goodfellow and Aaron Courville, "Deep Learning", MIT Press, 2015

REFERENCES:

1. P. Flach, "Machine Learning: The art and science of algorithms that make sense of data", Cambridge University Press, 2012

2. Li Deng, Dong Yu, "Deep Learning: Methods and Applications", now publishers, 2014
3. K. P. Murphy, “Machine Learning: A probabilistic perspective”, MIT Press, 2012.
4. C. M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2007.

Extensive Reading:

• https://developers.google.com/machine-learning/crash-course/ml-intro
• https://www.tensorflow.org/tutorials/

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Demonstrate the basics of deep learning for a given context.	2
CO2	Implement various deep learning models for the given problem.	3
CO3	Realign high dimensional data using reduction techniques for the given problem.	3
CO4	Analyze optimization and generalization techniques of deep learning for the given problem.	4
CO5	Evaluate the given deep learning application and enhance by applying latest techniques	5
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
2.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
3.	3	3	3	3	3	2	-	-	-	-	1	1	3	3
4.	3	3	2	2	2	2	-	-	-	-	1	1	3	1
5.	3	2	2	2	3	2	-	-	-	-	1	1	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

VD22704	EMBEDDED SYSTEM SIMULATION	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To recollect the fundamental concepts of microcontroller-based systems and write embedded C coding.
- To make the students to know about the Arduino hardware, interfacing and also to provide the practical experience
- To understand Interfacing sensors and actuators through suitable communication modes.
- To explore basic concepts in android based mobile application control
- To be familiar with Wi-Fi technology associated with Embedded systems.

UNIT I	**INTRODUCTION OF EMBEDDED SYSTEM**	**6**
ASIC in latest technology, Basic microcontroller concept, Embedded system application, AVR microcontroller concept, Embedded C using basic microcontroller		
UNIT II	**ARDUINO WITH MACHINE LEARNING (EDGE AI)**	**6**
TinyML Overview: Introduction to TinyML and Machine Learning at the edge using TensorFlow Lite for Microcontrollers on Arduino ML Applications: Voice recognition using machine learning models on Arduino, Gesture recognition with accelerometers and gyroscopes. LoRa and Long-Range Communication: Using LoRa modules for long-distance communication Building IoT systems with low-power wide-area networks (LPWAN)		
UNIT III	**ARDUINO COMMUNICATION AND SENSOR INTEGRATION**	**6**
Basic serial communication and serial communication between two Arduinos, Bluetooth communication, Interface various sensors like ultrasonic sensor, LDR, Gas sensors, Pulse sensor, Water level, Flex sensor etc.		
UNIT IV	**ANDROID BASED APPS CONTROL**	**6**
Mobile app Handling, Interfacing app with hardware. Reading Sensor Data from Arduino and Displaying on an Android App via Wi-Fi, Controlling Arduino Outputs Using a Custom Android App		
UNIT V	**EMBEDDED WITH WI-FI TECHNOLOGY**	**6**
Introduction to wireless systems. Connecting Arduino to Wi-Fi module and Sending Data to a Web Server, creating a Wi-Fi Controlled LED, Building a Wi-Fi Data Logger with Arduino.		
	TOTAL: 30 PERIODS	

TEXT BOOKS:

1. Muhammad Ali Mazidi, Sepehr Naimi, Sarmad Naimi, “The AVR Microcontroller and Embedded systems Using Assembly and C”, Pearson Education International, Edition

2017
2. Scot Fitzgerald and Michael Shiloh, “THE ARDUINO PROJECTS BOOK”, printed and bound in Torino, Italy September 2012.
3. Wei-Meng Lee, "Beginning Android Application Development", Wiley Publishing, Inc., 2011.
4. Erwin Ouyang, "Hands-On IoT: Wi-Fi and Embedded Web Development".
5. Steven F. Barrett and Daniel J. Pack, “Arduino V: Machine Learning”, Springer Nature Switzerland, 2023.

REFERENCES:

1. https://www.microchip.com/en-us/products/microcontrollers-and-microprocessors/ 8- bit-mcus/avr-mcus
2. https://forum.arduino.cc/
3. https://developer.android.com/
4. Jakob Iversen, Michael Eierman, "Learning Mobile App Development", Pearson Education, Inc., 2014

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Apply basic microcontroller concept for building embedded system applications using embedded c coding.	3
CO2	Design interfacing applications based on Arduino and programming them.	4
CO3	Handle sensors and actuators interfacing through suitable communication modes.	4
CO4	Develop mobile applications and interface it with hardware.	5
CO5	Construct embedded systems using Wi-Fi technology.	5

Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	-	-	-	3	-	-	3	1	3
2.	3	3	3	3	3	-	-	-	3	-	2	3	1	3
3.	3	3	3	3	3	-	-	-	3	-	2	3	-	3
4.	3	3	3	3	3	1	1	1	3	1	2	3	-	3
5.	3	3	3	3	3	1	1	1	3	1	2	3	-	3

* 1 – Weak, 2 – Moderate, 3 – Strong

VD22705	HARDWARE MODELING AND ANALYSIS USING EDA TOOL	L	T	P	C
		2	0	0	2

OBJECTIVES:

- To introduce the Verilog Hardware Description Language
- To learn various Issues in Digital Circuit Modeling using Verilog
- To learn functional verification of the Hardware Model by writing test benches
- To analyze the area, power and delay of the hardware model using EDA tool

UNIT I	**HIERARCHICAL MODELING CONCEPTS**	**6**

Overview of Digital Design with Verilog HDL, Emergence of HDLs, Typical Design Flow, Importance of HDLs, Popularity of Verilog HDL, Trends in HDLs, Design Methodologies - Example: Half Adder, Full Adder, 4-bit Ripple Carry Adder, Modules, Instances. Components of a Simulation, Design Block, Stimulus Block, Example- Ripple Carry Adder, Basic Concepts, Lexical Conventions, Data Types, System Tasks and Compiler Directives.

UNIT II	**COMPONENTS OF VERILOG MODULE AND GATE-LEVEL MODELING**	**6**

Modules and Ports, Modules- Components of Verilog Module, Example: S-R Latch, Ports- List of ports – Port Declaration - Port Connection Rules- Connecting Ports to External Signals, Gate-Level Modeling - Gate Types- AND/OR Gates, BUF/NOT Gates, Array of instances, Examples: Gate-level multiplexer, decoder.

UNIT III	**DATAFLOW AND BEHAVIORAL MODELING**	**6**

Dataflow Modeling - Continuous Assignments, Delays, Expressions, Operators, and Operands, Operator Types, Examples: 4-to-1 Multiplexer, 4-bit Full Adder, Ripple Counter; Behavioral Modeling, Structured Procedures, Procedural Assignments, Conditional Statements, Multiway Branching, Loops, Sequential and Parallel Blocks, Examples: 4-to-1 Multiplexer, 4-bit Counter.

UNIT IV	**SWITCH-LEVEL MODELING**	**6**

Switch-Level Modeling, Switch-Modeling Elements- MOS switches, CMOS switches, Bi-directional switches, Power and Ground, Resistive Switches, Delay Specification on Switches, Examples: CMOS Inverter, CMOS NAND Gate, CMOS NOR Gate, 2-to-1 Multiplexer, Full Adder.

UNIT V	**FSM MODELING**	**6**

Modeling Delays – Modeling Conditional Operations – State Machine Modeling – Interacting state machine – Modeling Moore FSM – Modeling Mealy FSM - Traffic Light Controller, Vending Machine Controller.

	TOTAL: 30 PERIODS

TEXT BOOK:

1. Samir Palnitkar "Verilog HDL: A Guide to Digital Design and Synthesis", Second Edition.
2. Zainalabedin Navabi "Verilog Digital System Design".

REFERENCES:

1. Simon Monk "Programming FPGAs: Getting Started with Verilog".
2. Jayaram Bhasker "A Verilog HDL primer".

Web Resource:

https://www.udemy.com/course/system-design-using-verilog/

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Determine hierarchical hardware modeling techniques suitable for a digital design	4
CO2	Develop Gate Level Modeling for digital designs	3
CO3	Develop Dataflow Modeling and Behavioral Modeling for digital designs	3
CO4	Develop Switch-Level Modeling and User-Defined Primitives for digital designs	4
CO5	Use CADENCE software tool for Hardware Modeling, Functional verification, Simulation, Synthesize and Analyze the Area, Power and Delay for the digital designs	5
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**Pos**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	-	2	1	1	-	-	-	-	-	2	2
2.	3	3	3	-	2	1	1	-	-	-	-	-	2	2
3.	3	3	3	-	2	1	1	-	-	-	-	-	2	2
4.	3	3	3	-	2	2	1	-	-	-	-	-	2	2
5.	3	3	3	-	2	2	1	-	-	-	-	-	2	2
* 1 – Weak, 2 – Moderate, 3 – Strong														

VD22706	MIMO TECHNOLOGIES	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To introduce the concept of MIMO system
- To provide various techniques for MIMO signal processing
- To inculcate the knowledge of beamforming in MIMO systems
- To deliver estimation techniques for MIMO under various channel conditions
- To provide knowledge channel estimation techniques for an MIMO system

UNIT I	**INTRODUCTION**	**6**

Types of multi-antenna systems, MIMO vs. multiantenna systems. Diversity, exploiting multipath diversity, Transmit diversity, Space-time codes, The Alamouti scheme, Delay diversity, Cyclic delay diversity

UNIT II	**EQUALIZATION IN MIMO**	**6**

The generic MIMO problem, Singular Value Decomposition, Eigen values and eigenvectors, Equalising MIMO systems, Disadvantages of equalising MIMO systems, Predistortion in MIMO systems and its disadvantages.

UNIT III	**SIGNAL PROCESSING IN MIMO**	**6**

Pre-coding and combining in MIMO systems, Advantages of pre-coding and combining, Disadvantages of precoding and combining, Channel state information.

UNIT IV	**MIMO AND BEAMFORMING**	**6**

Beamforming principles, Switched beamformer, Adaptive beamformer, Narrowband beamformer, Wideband beamformer

UNIT V	**MIMO SIMULATION**	**6**

MIMO in LTE, Precoding for transmit diversity, Beamforming in LTE, Cyclic delay diversity-based pre-coding, MIMO channel models.

TOTAL: 30 PERIODS

TEXT BOOKS:

1. Claude Oestges, Bruno Clerckx, "MIMO Wireless Communications: From Real-world Propagation to Space-time Code Design", Academic Press, 1st edition, 2010.
2. Mohinder Janakiraman, “Space - Time Codes and MIMO Systems”, Artech House Publishers, 2004.

REFERENCES:

1. Howard Huang, Constantinos B. Papadias and Sivarama Venkatesan, “MIMO Communication for Cellular Networks”, Springer, 2011
2. Robert W. Heath Jr. and Angel Lozano, “Foundations of MIMO Communication”, Cambridge University Press, 2018

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Realize MIMO systems with various system consideration	2
CO2	Perform Equalization technique over MIMO system	3
CO3	Analyze the signal processing schemes in MIMO system	4
CO4	Apply appropriate beamforming techniques for MIMO system	3
CO5	Perform basic mathematical modelling of MIMO systems	3
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	2	1	1	-	-	-	-	1	3	3	3
2.	3	3	3	2	1	1	-	-	-	-	1	3	3	3
3.	3	3	3	2	2	1	-	-	-	-	2	3	3	3
4.	3	3	3	3	2	1	-	-	-	-	3	3	3	3
5.	3	3	3	3	2	1	-	-	-	-	3	3	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

VD22707	MIXED SIGNAL IC DESIGN	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To provide an overview of principles of Embedded System
- To study the Architecture, addressing modes & instruction set of PIC Microcontroller and develop skills in writing simple programs.
- To understand the concepts of Interrupts, timer and Serial ports
- To introduce commonly used peripheral interfacing ICs.
- To study and understand the typical applications of microcontrollers

UNIT I	**REFERENCE CIRCUITS**	**6**

Current Mirrors, Self Biased Current Reference, VBE based Current Reference, VT Based Current Reference, Band Gap Reference, Supply Independent Biasing, Temperature Independent Biasing, PTAT and CTAT Current Generation.

UNIT II	**LOW DROPOUT REGULATORS**	**6**

Shunt regulator, Error amplifier, AC Design, Stability, Internal and External Compensation, PSRR – Internal and External compensation circuits, NMOS vs. PMOS regulators.

UNIT III	**FREQUENCY SYNTHESIZERS**	**6**

Integer-N Phase Lock Loop (PLL), Fractional-N Phase Lock Loop, Delay-Lock Loop (DLL), multiplying-DLL, Injection-locked PLLs, and Sub-sampled PLLs.

UNIT IV	**ACTIVE FILTER DESIGN**	**6**

Butterworth Filter approximations, Chebyshev Filter approximations, Frequency Transformations, Continuous time filters- Biquad and Ladder based designs, Active RC and Gm-C Filters, Switch Capacitor Filters, Integrator realization and nonidealities

UNIT V	**CLOCK AND DATA RECOVERY CIRCUITS**	**6**

Channel characteristics-intersymbol interference, eye diagrams, Linear equalization at the transmitter and receiver; CDR Architectures, Transimpedance Amplifiers, Linear Half Rate CDR Circuits, Wide capture Range CDR Circuits.

TOTAL: 30 PERIODS

TEXT BOOKS:

1. Gabriel.A. Rincon-Mora, "Voltage references from diode to precision higher order bandgap circuits", John Wiley & Sons, Inc 2002.
2. Gabriel.A. Rincon-Mora, "Analog IC Design With Low-Dropout Regulators", McGraw-Hill Professional Pub, 2nd Edition, 2014
3. Floyd M. Gardner, "Phase Lock Techniques", John Wiley & Sons Inc, 2005

REFERENCES:

1. R. Best, Phase-Locked Loops: "Design, Simulation, and Applications", McGraw Hill, 2003.
2. Williams and Taylor, "Electronic Filter Design Handbook", McGraw-Hill, 3 rd Edition, 1995
3. Deliyannis, Sun, and Fidler, "Continuous-Time Active Filter Design", CRC Press 1998,
4. Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, Tata McGraw Hill, 2001

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Design Band gap reference circuits and Low Dropout regulator for a given specification.	3
CO2	Design of regulators and compensation circuits.	3
CO3	Design Frequency synthesizers meeting a given specification.	3
CO4	Choose active filter topology and design for a given specification.	3
CO5	Design clock generation circuits in the context of high speed I/Os, High speed BroadBand Communication circuits and Data Conversion Circuits.	3
Bloom’s Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	3	2	3	2	-	-	-	-	-	-	3	3
2.	3	3	3	3	3	2	-	-	-	-	-	-	3	3
3.	3	3	3	2	3	2	-	-	-	-	-	-	3	3
4.	3	3	3	3	3	2	-	-	-	-	-	-	3	3
5.	3	3	3	3	3	2	-	-	-	-	-	-	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

VD22708	PCB DESIGN USING EDA TOOL	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To introduce the basic electronics components.
- To learn the design rules for PCB circuits.
- To understand the need for PCB Design and the steps involved in the PCB Design process.
- To familiarize Schematic and layout design flow using Electronic Design Automation (EDA) Tools.
- To learn the basic circuit PCB design using EDA tool.

UNIT I	**INTRODUCTION TO PRINTED CIRCUIT BOARD**	**6**
Fundamental of Electronic Components - Basic Electronic Circuits - Basics of Printed Circuit Board Design: Layout Planning, general rules and parameters, Various PCB Materials.		
UNIT II	**DESIGN RULES FOR PCB**	**6**
Design rules for Digital circuit PCBs - Analog circuit PCBs - high-frequency applications – Power electronic applications.		
UNIT III	**PCB TECHNOLOGY TRENDS**	**6**
Multilayer PCBs - Multiwire PCB - Flexible PCBs - Surface mount PCBs - Reflow soldering.		
UNIT IV	**INTRODUCTION TO EDA TOOLS FOR PCB DESIGNING**	**6**
Introduction to PCB Design using EDA tool, PCB Designing Flow Chart-Schematic Entry-Net listing -PCB Layout Designing-Prototype Designing: Design Rule Check (DRC), Design for Manufacturing (DFM)- PCB Making: Printing, Etching, Drilling - Assembly of components, Creating report of design, creating manufacturing data (GERBER) for design.		
UNIT V	**PRACTICAL TRAINING ON PCB DESIGN**	**6**
Schematic and Layout Design: ON/OFF Switches Circuits, Full-wave Rectifier, Regulator circuit using 7805, Inverting Amplifier or Summing Amplifier using op-amp, Astable or Monostable multivibrator using IC555, Full-Adder using half-adders.		
	TOTAL: 30 PERIODS	

TEXT BOOKS:

1. R.S. Khandpur, Printed Circuit Board -Design, Fabrication, Assembly & Testing, TMH, 3rd Edition, 2017.
2. Walter C. Bosshart, Printed circuit Board - Design & Technology, TMH. Reprint 2008.
3. Simon Monk, "Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards (Electronics)" 2017.

REFERENCES:

1. Clyde F. Coombs, Jr., Printed Circuits Handbook, Sixth Edition, McGraw-Hill Education, 2016.
2. Kraig Mitzner Bob Doe Alexander Akulin Anton Suponin Dirk Müller, Complete PCB Design Using OrCAD Capture and PCB Editor, 2nd Edition 2009.

3. S. Yogesh, "OSCAD: An Open Source EDA Tool for Circuit Design, Simulation, Analysis and PCB Design", Shroff Publishers & Distributors Pvt. Ltd, 2013.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Understand the steps involved in the schematic, layout and assembly process of PCB design	2
CO2	Classify the design rules of Digital and analog circuit PCBs	2
CO3	Appreciate the necessity and evolution of PCB, types and classes of PCB.	2
CO4	Describe the PCB design and EDA tool.	3
CO5	Design (schematic and layout) PCB for analog circuits, digital circuits and mixed circuits.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	2	3	3	3	-	-	-	1	1	1	3	3	3
2.	3	2	3	3	3	-	-	-	1	1	1	3	3	3
3.	3	2	3	3	3	-	-	-	1	1	1	3	3	3
4.	3	2	3	3	3	-	-	-	1	1	1	3	3	3
5.	3	2	3	3	3	-	-	-	1	1	1	3	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

VD22709	RF CIRCUIT DESIGN – THEORY AND SIMULATION USING EM SIMULATION TOOLS	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To get insights about RF circuit design.
- To investigate the design of Microwave Circuits.
- To be familiar with the most popular antenna design.
- To design special antennas using simulation tools.
- To introduce the design and its simulation of Microstrip Antenna

UNIT I	**OVERVIEW OF RF CIRCUITS**	**6**

Introduction of the course, including an overview of applications and trends. Passive microwave circuits, covering transmission-line based circuits including impedance matching.

UNIT II	**DESIGN AND SIMULATION OF MICROWAVE COMPONENTS**	**6**

Design and simulation of Microwave amplifiers, oscillators, filters, couplers and dividers.

UNIT III	**ANTENNA THEORY AND SIMULATION**	**6**

Introduction of antennas concepts. Antenna characteristics (radiation pattern, directivity, gain, impedance, bandwidth, and polarization).Wire Antennas theory and simulation. Linear array theory and simulation.

UNIT IV	**DESIGN AND SIMULATION OF SPECIAL ANTENNAS**	**6**

Visualization of dipole, loop, parabolic reflector, Yagi-Uda and horn antennas using simulation tool.

UNIT V	**IMPLEMENTATION OF MICROSTRIP PATCH ANTENNAS**	**6**

Microstrip patch antenna fundamental and design. Simulation of microstrip patch antenna and array using simulation tool. Final project to design specific microstrip antenna.

TOTAL: 30 PERIODS

TEXT BOOK:

1. Reinhold Ludwig and Gene Bogdanov, “RF Circuit Design: Theory and Applications”, Pearson Education Inc., 2011.
2. Constantine.A.Balanis “Antenna Theory Analysis and Design”, 4th Edition Wiley Student Edition, 2016.
3. Ramesh Garg, Prakash Bhartia, Inder J. Bahl, A. Ittipiboon, "Microstrip Antenna Design Handbook, 2001, Artech House.

REFERENCES:

1. David M. Pozar, “Microwave Engineering”, 4th Edition, Wiley India (P) Ltd, New Delhi, 2013.
2. John D.Kraus,” Antennas for all Applications”, 5th Edition, Mc Graw Hill, 2017.

COURSE OUTCOMES: Upon successful completion of the course, students will able to:		**RBT Level**
CO1	Understand the fundamentals of RF circuits.	2
CO2	Utilize commercial simulation software to design and analyze the RF and Microwave circuits.	3
CO3	Articulate the principles of electromagnetic energy radiation in free space by antennas.	4
CO4	Design and simulate the special antennas.	3
CO5	Implement the microstrip patch antennas for specific applications	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	3	3	2	-	-	-	-	1	1	1	3
2.	3	3	3	3	3	2	-	-	-	-	1	1	2	3
3.	3	3	3	3	3	2	-	-	-	-	1	1	2	3
4.	3	3	2	2	2	2	-	-	-	-	1	1	2	1
5.	3	2	2	2	3	2	-	-	-	-	1	1	1	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

VD22710	SIMULATION OF COMMUNICATION NETWORKS	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To understand the concept of emerging topics in communication networks and systems
- To classify several simulation frameworks.
- To assess various open-source tools for simulating communication networks.
- To adopt suitable tools to model wireless networks.
- To build a simple network using open-source tools.

UNIT I	**NETWORK ARCHITECTURE**	**6**

Overview of Networks - Services and Protocols – Edge and Core – Packet Switching vs. Circuit Switching – Protocol Layers and Service Models - Client-Server and Peer-to-Peer architectures - Performance Metrics Delay – Loss – Throughput

UNIT II	**SIMULATION FRAMEWORKS**	**6**

Simulation models and tools - Event Driven simulation - Discrete Event simulation: Sequential discrete simulation, Spatial parallel simulation, Time parallel simulation - Process-oriented simulation - GPU-based simulation - Multi-agent-based simulation

UNIT III	**OPEN SOURCE TOOLS**	**6**

Network simulation issues - Simulation frameworks overview - Open Source network simulators: OMNET++, OPNET, CrowNet - OS-oriented tools: Tiny OS, Contiki, RiOT - Co-Simulation of wireless and mobile systems

UNIT IV	**NETWORK SIMULATOR**	**6**

Introduction to NS2 - Installation - Directories and Convention - Simulation of wireless local - personal and wide area networks using NS2 – Analysis of trace files and inferencing - Design a network topology - Implementation of TCP and UDP using NS2

UNIT V	**CASE STUDY ON OPEN SOURCE TOOLS**	**6**

Features of NS3 - Installation - Simulating the computer networks - Collision control for VANET application - Trust aware routing for MANET - Installation of OMNET++ - Configuration of Wireless Sensor Networks - Live monitoring and remote control application using OMNET++

TOTAL: 30 PERIODS

TEXT BOOKS:

1. Mohammad S. Obaidat, Faouzi Zarai, Petros Nicopolitidis, “Modeling and Simulation of Computer Networks and Systems: Methodologies and Applications”, Morgan Kaufmann, 2015
2. Klaus Wehrle, Mesut Günes, James Gross, “Modeling and Tools for Network Simulation”, Springer Berlin Heidelberg, 2010.
3. Behrouz A. Forouzan, “Data Communications and Networking”, Fifth Edition, McGraw-Hill, 2013.

REFERENCES:

1. Teerawat Issariyakul, Ekram Hossain, "Introduction to Network Simulator NS2", Second Edition, Springer, 2012.
2. Antonio Virdis, Michael Kirsche, "Recent Advances in Network Simulation: The OMNeT++ Environment and Its Ecosystem ", Springer , 2019.
3. Jack L. Burbank, "An Introduction to Network Simulator 3" John Wiley & Sons, Incorporated, 2018.

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Interpret the services and performance metrics of communication networks.	2
CO2	Describe the concepts of different simulation models and tools.	2
CO3	Organize the most appropriate open-source network simulators to build a reliable network.	3
CO4	Apply the network simulator as learning and practice tool for networking algorithms.	3
CO5	Implement various networking applications.	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	2	1	1	-	-	-	-	2	3	3	3
2.	3	3	3	2	1	1	-	-	-	-	2	3	3	3
3.	3	3	3	3	1	1	-	-	-	-	2	3	3	3
4.	3	3	3	3	2	1	-	-	-	-	3	3	3	3
5.	3	3	3	3	2	1	-	-	-	-	3	3	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														

VD22711	SMART IOT APPLICATIONS	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To understand the concept of IoT and its design procedures
- To introduce the several IoT-related enabling technologies and protocols
- To introduce various interfacing techniques for popular input devices including sensors, output devices and communication protocols.
- To study the IoT peripherals and its interfacing techniques
- To build a simple IoT application and to perform predictive analysis on gathered data.

UNIT I	**INTRODUCTION**	**6**

IoT - IoT impact- IoT challenges - Architecture - Core IoT functional Stack - IoT Data Management - Communication Technologies used in IoT - Smart Objects

UNIT II	**ENABLING TECHNOLOGIES AND PROTOCOLS**	**6**

Enabling Technologies: Wireless Sensor Networks, Cloud Computing - IoT Network protocol stack - IoT technology stack - Communication Protocols: Bluetooth, Zigbee, 6LowPAN

UNIT III	**IoT SYSTEM DESIGN**	**6**

Working principles of sensors – IoT deployment for Raspberry Pi /Arduino/Equivalent platform – Reading from Sensors, Communication: Connecting microcontroller with mobile devices – communication through Bluetooth, wifi and USB

UNIT IV	**PERIPHERAL CONTROL**	**6**

Working with LED, Switch, and Buzzer - ADC, DAC and, Motor - DC Motor Control using PWM Relay and Stepper Motor interfacing

UNIT V	**IoT PROJECTS**	**6**

Designing GUI for capturing and analyzing sensor data from IoT kit, Developing Video surveillance application using IoT, Set up cloud environment –Cloud access from sensors– Design and implementation of cloud-based smart home automation system, Smart industry protection system using IoT.

TOTAL: 30 PERIODS

TEXT BOOKS:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, “IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things”, Cisco Press, 2017
2. Kamlesh Lakhwani, Hemant Kumar Gianey, Joseph Kofi Wireko, “Internet of Things (IoT) Principles, Paradigms and Applications of IoT”, BPB Publications, 2020.
3. “Building Arduino Projects for the Internet of Things-Experiments with Real World Applications,” Adeel Javed, 2016, Apress.

REFERENCES:

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things :A hands on approach", First Edition, Universities Press, 2015.
2. Dieter Uckelmann Mark Harrison; Florian Michahelles, "Architecting the Internet of Things ", Springer, 2011.
3. "The Internet of Things-Do it Yourself at Home Projects for Arduino, Raspberry Pi and BeagleBone Black," Donald Norris, 2015, TMH

COURSE OUTCOMES: Upon successful completion of the course, students should be able to:		**RBT Level**
CO1	Elaborate the basic building blocks of the Internet of Things.	2
CO2	Describe the working of IoT network technologies, systems, and protocols.	2
CO3	Identify the most appropriate IoT devices and sensors to build real-time applications using IoT	3
CO4	Apply knowledge on interfacing various peripherals	3
CO5	Analyze the working of real-time applications	4
Bloom's Taxonomy (RBT) Level: Remember-1; Understand-2; Apply-3; Analyze-4; Evaluate-5; Create-6		

COURSE ARTICULATION MATRIX

***COs**	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1.	3	3	3	2	1	1	-	-	-	-	1	3	3	3
2.	3	3	3	2	1	1	-	-	-	-	1	3	3	3
3.	3	3	3	2	2	1	-	-	-	-	2	3	3	3
4.	3	3	3	3	2	1	-	-	-	-	3	3	3	3
5.	3	3	3	3	2	1	-	-	-	-	3	3	3	3
* 1 – Weak, 2 – Moderate, 3 – Strong														