REGULATIONS 2024
CHOICE BASED CREDIT SYSTEM

B.E. ELECTRONICS AND COMMUNICATION ENGINEERING

I. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

1. To provide the students with a strong foundation in the required sciences in order to pursue studies in Electronics and Communication Engineering.
2. To gain adequate knowledge to become good professional in Electronics and Communication Engineering associated industries, higher education and research.
3. To develop attitude in lifelong learning, applying and adapting new ideas and technologies as their field evolves.
4. To prepare students to critically analyze existing literature in an area of specialization and ethically develop innovative and research-oriented methodologies to solve the problems identified.
5. To inculcate in the students a professional and ethical attitude and an ability to visualize the engineering issues in a broader social context.

II. PROGRAM OUTCOMES (POs)

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

societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

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

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

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

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

III. PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Design, develop and analyze electronic systems through application of relevant electronics, mathematics and engineering principles
PSO2: Design, develop and analyze communication systems through application of fundamentals from communication principles, signal processing, and RF System Design & Electromagnetics.
PSO3: Adapt to emerging electronics and communication technologies and develop innovative solutions for existing and newer problems

PEOs (1 to 5) mapped with POs and PSOs

PEO	PO												PSO		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
I.	3	3	2	2	2	2	-	-	-	-	-	3	3	2	3
II.	3	3	3	3	2	-	-	-	2	1	2	3	3	3	3
III.	3	2	3	3	3	-	-	-	2	2	-	3	3	3	3
IV.	3	3	3	3	2	-	-	3	-	-	-	2	2	2	2
V.	-	-	-	-	2	2	2	2	-	-	-	-	1	1	1

1 - low, 2 - medium, 3 - high, '-' - no correlation

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CURRICULUM AND SYLLABI FOR SEMESTERS I TO VIII

SEMESTER – I

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
1.	24IP3151	Induction Programme	-	-	-	-	-	0
THEORY								
2.	24HS3152	Professional English -I	HSMC	3	0	0	3	3
3.	24MA3151	Matrices and Calculus	BSC	3	1	0	4	4
4.	24PH3151	Engineering Physics	BSC	3	0	0	3	3
5.	24CY3151	Engineering Chemistry	BSC	3	0	0	3	3
6.	24GE3151	Problem Solving and Python Programming	ESC	3	0	0	3	3
7.	24GE3151	தமிழர மரபு / Heritage of Tamils	HSMC	1	0	0	1	1
PRACTICALS								
8.	24GE3171	Problem Solving and Python Programming Laboratory	ESC	0	0	4	4	2
9.	24BS3171	Physics and Chemistry Laboratory	BSC	0	0	4	4	2
10	24GE3172	English Laboratory[$]	EEC	0	0	2	2	1
11	24TP3101	Skill Enhancement – I	EEC	0	0	2	2	0
			TOTAL	**16**	**1**	**12**	**29**	**22**

$ Skill Based Course

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SEMESTER – II

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	24HS3252	Professional English-II	HSMC	2	0	0	2	2
2.	24MA3251	Statistics and Numerical Methods	BSC	3	1	0	4	4
3.	24PH3254	Physics for Electronics Engineering	BSC	3	0	0	3	3
4.	24BE3254	Electrical and Instrumentation Engineering	ESC	3	0	0	3	3
5.	24GE3251	Engineering Graphics	ESC	2	0	4	6	4
6.	24EC3251	Circuit Analysis	PCC	3	1	0	4	4
7.	24GE3252	தமிழரும் தொழில்நுட்பமும் / Tamils and Technology	HSMC	1	0	0	1	1
8.		NCC Credit Course Level 1	ECR	0	0	0	2	0
PRACTICALS								
9.	24GE3271	Engineering Practices Laboratory	ESC	0	0	4	4	2
10.	24EC3271	Circuits Analysis Laboratory	PCC	0	0	2	2	1
11.	24GE3272	Communication Laboratory / Foreign Language $^{\$}$	EEC	0	0	4	4	2
12.	24TP3201	Skill Enhancement – II	EEC	0	0	2	2	0
			TOTAL	**17**	**2**	**16**	**37**	**26**

$ Skill Based Course

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SEMESTER – III

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	24MA3355	Random Processes and Linear Algebra	BSC	3	1	0	4	4
2.	24EC3301	Signals and Systems	PCC	3	1	0	4	4
3.	24EC3302	Control Systems	PCC	3	0	0	3	3
THEORY COURSE WITH PRACTICAL COMPONENTS								
4.	24EC3303	Digital Systems Design	PCC	3	0	2	5	4
5.	24EC3304	Electronic Devices and Circuits - I	PCC	3	0	2	5	4
6.	24CS3353	C Programming and Data Structures	ESC	2	0	2	4	3
VALUE ADDED COURSE								
7.	24TP3301	Skill Enhancement – III	EEC	0	0	2	2	1
			TOTAL	**17**	**2**	**8**	**27**	**23**

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SEMESTER – IV

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	24EC3401	Electromagnetic Fields & Transmission Lines	PCC	3	1	0	4	4
2.	24EC3402	Communication Systems	PCC	3	0	0	3	3
3.	24EC3403	Electronic Circuits - II	PCC	3	0	0	3	3
THEORY COURSE WITH PRACTICAL COMPONENTS								
4.	24EC3404	Networks and Security	PCC	2	0	2	4	3
5.	24EC3405	Linear Integrated Circuits	PCC	3	0	2	5	4
6.	24EC3406	Digital Signal Processing	PCC	3	0	2	5	4
PRACTICALS								
7.	24EC3411	Communication Systems Laboratory	PCC	0	0	3	3	1.5
8.	24EC3412	Circuits Design and Simulation Laboratory	PCC	0	0	3	3	1.5
VALUE ADDED COURSE								
9.	24TP3401	Skill Enhancement – IV	EEC	0	0	2	2	1
			TOTAL	**17**	**1**	**14**	**32**	**25**

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SEMESTER – V

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.		Professional Elective - I	PEC	3	0	0	3	3
2.		Open Elective-I	OEC	3	0	0	3	3
3.	24GE3501	Climate Change and Sustainability	HSMC	2	0	0	2	2
THEORY COURSE WITH PRACTICAL COMPONENTS								
4.	24EC3501	Microprocessor and Microcontroller	PCC	3	0	2	5	4
5.	24EC3502	VLSI and Chip Design	PCC	3	0	2	5	4
6.	24EC3503	Digital Communication	PCC	2	0	2	4	3
7.		Mandatory Course-I [&]	MC	3	0	0	3	0
PRACTICALS								
8.	24EC3511	Industry Oriented Course	EEC	0	0	2	2	1
VALUE ADDED COURSE								
9.	24TP3501	Skill Enhancement – V	EEC	0	0	2	2	1
			TOTAL	**19**	**0**	**10**	**29**	**21**

Mandatory Course- I is a Non-credit Course (Student shall select one course from the list given under Mandatory Course-I)

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SEMESTER – VI

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.		Professional Elective - II	PEC	3	0	0	3	3
2.		Professional Elective - III	PEC	3	0	0	3	3
3.		Open Elective-II	OEC	3	0	0	3	3
THEORY COURSE WITH PRACTICAL COMPONENTS								
4.	24EC3601	Wireless Communication	PCC	2	0	2	5	3
5.	24EC3602	Artificial Intelligence and Machine Learning	PCC	2	0	2	5	3
6.	24IC3401	Engineering Entrepreneurship Development	IC	2	0	2	4	3
7.		Mandatory Course-II &	MC	3	0	0	3	0
PRACTICALS								
8.	24EC3611	Mini Project	PCC	0	0	4	3	2
VALUE ADDED COURSE								
9.	24TP3601	Skill Enhancement – VI	EEC	1	0	2	1	1
			TOTAL	**19**	**0**	**12**	**30**	**21**

Mandatory Course-II is a Non-credit Course (Student shall select one course from the list given under Mandatory Course-II)

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SEMESTER – VII

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	24MG3701	Professional Ethics	HSMC	2	0	0	2	2
2.	24MG3702	Principles of Management	HSMC	2	0	0	2	2
3.		Professional Elective - IV	PEC	3	0	0	3	3
4.		Professional Elective - V	PEC	3	0	0	3	3
THEORY COURSE WITH PRACTICAL COMPONENTS								
5.	24EC3701	Antenna & Microwave Engineering	PCC	2	0	2	4	3
6.	24EC3702	Embedded Systems and IOT Design	PCC	2	0	2	4	3
PRACTICALS								
6.	24EC3711	Summer Internship	EEC	0	0	0	0	2
VALUE ADDED COURSE								
7.	24TP3701	Skill Enhancement – VII	EEC	2	0	2	1	1
			TOTAL	**16**	**0**	**6**	**19**	**19**

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SEMESTER – VIII

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
PRACTICALS								
1.	24EC3811	Project Work / Internship	EEC	0	0	20	20	10
			TOTAL	**0**	**0**	**20**	**20**	**10**

TOTAL CREDITS: 167

MANDATORY COURSES I

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
PRACTICALS								
1.	24MX3081	Introduction To Women And Gender Studies	MC	3	0	0	3	0
2.	24MX3082	Indian Knowledge Systems	MC	3	0	0	3	0
3.	24MX3083	Production And Operations Management For Entrepreneurs	MC	3	0	0	3	0
4.	24MX3084	Disaster Risk Reduction And Management	MC	3	0	0	3	0
5.	24MX3085	Well -Being With Traditional Practices-Yoga, Ayurveda And Siddha	MC	3	0	0	3	0

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MANDATORY COURSES II

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
PRACTICALS								
1	24MX3086	Environmental Sciences and Sustainability	MC	3	0	0	3	0
2	24MX3087	History of Science and Technology in India	MC	3	0	0	3	0
3	24MX3088	Political and Economic Thought for a Human Society	MC	3	0	0	3	0
4	24MX3089	State, Nation Building and Politics in India	MC	3	0	0	3	0
5	24MX3090	Industrial Safety	MC	3	0	0	3	0

PROFESSIONAL ELECTIVE COURSES: VERTICALS

LIST OF IDENTIFIED VERTICALS	
Vertical 1	**SEMICONDUCTOR CHIP DESIGN AND TESTING**
Vertical 2	**SIGNAL PROCESSING**
Vertical 3	**BIO MEDICAL TECHNOLOGIES**
Vertical 4	**HIGH SPEED COMMUNICATIONS**
Vertical 5	**EMERGING TECHNOLOGIES**
Vertical 6	**ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**

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Vertical I Semiconductor Chip Design and Testing	Vertical II Signal Processing	Vertical III Bio Medical Technologies	Vertical IV High Speed Communications	Vertical V Emerging Technologies	Vertical VI Artificial Intelligence and Machine Learning
Wide Bandgap Devices	Advanced Digital Signal Processing	Wearable Devices	Optical Communication & Networks	Remote Sensing	Knowledge Engineering
High Speed Semiconductor	Image Processing	Human Assist Devices	Wireless Broad Band Networks	Cyber Security	Soft Computing
Validation and Testing Technology	Speech Processing	Therapeutic Equipment	5G Communication Networks	Quantum Computing	Neural Networks and Deep Learning
Mixed Signal IC Design Testing	Software Defined Radio	Medical Imaging Systems	Software Defined Networks	Pattern Recognition	Text and Speech Analysis
Analog IC Design	DSP Architecture and Programming	Brain Computer Interface and Applications	Massive MIMO Networks	Network on Chip Design	Optimization Techniques
VLSI Technology	Computer Vision	Body Area Networks	Advanced Wireless Communication Techniques	Blockchain Technology	Game Theory
VLSI Signal Processing	Industrial IoT and Industry 4.0	Medical Electronics	Satellite Communication	3D Printing and Design	Cognitive Science
MEMS Design	IoT Based System Design	Biomedical Signal Processing	Wireless Sensor Network Design	Cryptography and Network Security	Ethics And AI

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Registration of Professional Elective Courses from Verticals:

Professional Elective Courses will be registered in Semesters V and VI. These courses are listed in groups called verticals that represent a particular area of specialization / diversified group. Students are permitted to choose all the Professional Electives from a particular vertical or from different verticals. Further, only one Professional Elective course shall be chosen in a semester horizontally (row-wise). However, two courses are permitted from the same row, provided one course is enrolled in Semester V and another in semester VI.

The registration of courses for B.E./B.Tech (Honors) or Minor degree shall be done from Semester V to VIII. The procedure for registration of courses explained above shall be followed for the courses of B.E/B.Tech (Honors) or Minor degree also. For more details on B.E./B.Tech (Honors) or Minor degree refer to the Regulations 2021, Clause 4.10 (Amendments).

PROFESSIONAL ELECTIVE COURSES: VERTICALS

VERTICAL 1: SEMICONDUCTOR CHIP DESIGN AND TESTING

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
1.	24CEC101	Wide Bandgap Devices	PEC	2	0	2	4	3
2.	24CEC102	High Speed Semiconductor Devices	PEC	2	0	2	4	3
3.	24CEC103	Low Power IC Design	PEC	2	0	2	4	3
4.	24CEC104	Mixed Signal IC Design Testing	PEC	2	0	2	4	3
5.	24CEC105	Analog IC Design	PEC	2	0	2	4	3
6.	24CEC106	VLSI Technology	PEC	3	0	0	3	3
7.	24CEC107	VLSI Signal Processing	PEC	3	0	0	3	3
8.	24CEC108	MEMS Design	PEC	2	0	2	4	3

VERTICAL 2: SIGNAL PROCESSING

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
1.	24CEC201	Advanced Digital Signal Processing	PEC	2	0	2	4	3
2.	24CEC202	Image Processing	PEC	3	0	0	3	3
3.	24CEC203	Speech Processing	PEC	2	0	2	4	3
4.	24CEC204	Software Defined Radio	PEC	2	0	2	4	3
5.	24CEC205	DSP Architecture and Programming	PEC	2	0	2	4	3
6.	24CEC206	Computer Vision	PEC	2	0	2	4	3
7.	24CEC207	Industrial IoT and Industry 4.0	PEC	2	0	2	4	3
8.	24CEC208	IoT Based System Design	PEC	3	0	0	3	3

VERTICAL 3: BIO MEDICAL TECHNOLOGIES

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
1.	24CBM301	Wearable Devices	PEC	3	0	0	3	3
2.	24CBM302	Human Assist Devices	PEC	3	0	0	3	3
3.	24CBM303	Therapeutic Equipment	PEC	3	0	0	3	3
4.	24CBM304	Medical Imaging Systems	PEC	3	0	0	3	3
5.	24CBM305	Brain Computer Interface and Applications	PEC	3	0	0	3	3
6.	24CBM306	Body Area Networks	PEC	3	0	0	3	3
7.	24CBM307	Medical Electronics	PEC	3	0	0	3	3
8.	24CBM308	Biomedical Signal Processing	PEC	3	0	0	3	3

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VERTICAL 4: HIGH SPEED COMMUNICATIONS

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
1.	24CEC401	Optical Communication & Networks	PEC	3	0	0	3	3
2.	24CEC402	Wireless Broad Band Networks	PEC	3	0	0	3	3
3.	24CEC403	5G Communication Networks	PEC	2	0	2	4	3
4.	24CEC404	Software Defined Networks	PEC	2	0	2	4	3
5.	24CEC405	Massive MIMO Networks	PEC	2	0	2	4	3
6.	24CEC406	Advanced Wireless Communication Techniques	PEC	3	0	0	3	3
7.	24CEC407	Satellite Communication	PEC	3	0	0	3	3
8.	24CEC408	Wireless Sensor Network Design	PEC	3	0	0	3	3

VERTICAL 5: EMERGING TECHNOLOGIES

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
1.	24CEC501	Remote Sensing	PEC	3	0	0	3	3
2.	24CEC502	Cyber Security	PEC	2	0	2	4	3
3.	24CEC503	Quantum Computing	PEC	2	0	2	4	3
4.	24CEC504	Pattern Recognition	PEC	3	0	0	3	3
5.	24CEC505	Network on Chip Design	PEC	3	0	0	3	3
6.	24CEC506	Blockchain Technology	PEC	3	0	0	3	3
7.	24CEC507	3D Printing and Design	PEC	2	0	2	4	3
8.	24CEC508	Cryptography and Network Security	PEC	3	0	0	3	3

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VERTICAL 6: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
1.	24CEC601	Knowledge Engineering	PEC	2	0	2	4	3
2.	24CEC602	Soft Computing	PEC	2	0	2	4	3
3.	24CEC603	Neural Networks and Deep Learning	PEC	2	0	2	4	3
4.	24CEC604	Text and Speech Analysis	PEC	2	0	2	4	3
5.	24CEC605	Optimization Techniques	PEC	2	0	2	4	3
6.	24CEC606	Game Theory	PEC	2	0	2	4	3
7.	24CEC607	Cognitive Science	PEC	2	0	2	4	3
8.	24CEC608	Ethics and AI	PEC	2	0	2	4	3

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OPEN ELECTIVES

(Students shall choose the open elective courses, such that the course contents are not similar to any other course contents/title under other course categories).

OPEN ELECTIVES – I

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
1.	24OEEE01	Semiconductor Memories	OEC	3	0	0	3	3
2.	24OEEE02	Electrical Safety and Safety Management	OEC	3	0	0	3	3
3.	24OEEC01	IoT Concepts and Applications	OEC	2	0	2	4	3
4.	24OEEC02	Drone Technologies	OEC	3	0	0	3	3
5.	24OECE01	Plastic and E-Waste Management	OEC	3	0	0	3	3
6.	24OECE02	Remote Sensing and GIS Applications in Environmental Management	OEC	3	0	0	3	3
7.	24OECS01	Advanced Java Technologies	OEC	3	0	0	3	3
8.	24OECS02	Machine Learning Paradigms	OEC	3	0	0	3	3
9	24OEME01	Fundamentals of Aeronautical Engineering	OEC	3	0	0	3	3
10	24OEME02	Energy Technology	OEC	3	0	0	3	3
11	24OEAD01	Artificial Intelligence and Machine Learning Fundamentals	OEC	3	0	0	3	3
12	24OEAD02	Business Intelligence and Its Applications	OEC	3	0	0	3	3

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OPEN ELECTIVES – II

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
1	24OEEE03	Energy Storage Systems	OEC	3	0	0	3	3
2	24OEEE04	Energy Management and Auditing	OEC	3	0	0	3	3
3	24OEEC03	Robotic Process Automation	OEC	2	0	2	4	3
4	24OEEC04	Fundamentals of Embedded Systems and IoT	OEC	2	0	2	4	3
5	24OECE03	Green Building Design	OEC	3	0	0	3	3
6	24OECE04	Safety in Construction	OEC	3	0	0	3	3
7	24OECS03	IoT And Edge Computing	OEC	3	0	0	3	3
8	24OECS04	IT In Agricultural System	OEC	3	0	0	3	3
9	24OEME03	Environmental Engineering and Pollution Control	OEC	3	0	0	3	3
10	24OEME04	Elements Of Marine Engineering	OEC	3	0	0	3	3
11	24OEAD03	Augmented Reality / Virtual Reality	OEC	3	0	0	3	3
12	24OEAD04	Digital Forensics	OEC	3	0	0	3	3

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OPEN ELECTIVES – III

Sl. No	Course Code	Course Name	Category	Periods per week			Total Contact Periods	Credits
				L	T	P		
1	24OEEE05	Electric Vehicles	OEC	3	0	0	3	3
2	24OEEE06	Green Energy Sources	OEC	3	0	0	3	3
3	24OEEC05	Consumer Electronics	OEC	3	0	0	3	3
4	24OEEC06	Sensors And Actuators	OEC	3	0	0	3	3
5	24OECE05	Urban Agriculture	OEC	3	0	0	3	3
6	24OECE06	Irrigation Engineering	OEC	3	0	0	3	3
7	24OECS05	Deep Learning Techniques	OEC	3	0	0	3	3
8	24OECS06	Ethical Hacking and Network Defense	OEC	3	0	0	3	3
9	24OEME05	Alternative Fuels and Energy Systems	OEC	3	0	0	3	3
10	24OEME06	Foundation of Robotics	OEC	3	0	0	3	3
11	24OEAD05	Block chain Architecture and Design	OEC	3	0	0	3	3
12	24OEAD06	Full Stack Development	OEC	3	0	0	3	3

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Name of the Programme: B.E. Electronics and Communication Engineering										
S.No	Subject Area	Credits per Semester								Total Credits
		I	II	III	IV	V	VI	VII/ VIII	VIII/ VII	
1	HSMC	4	3			2		4		13
2	BSC	12	7	4						23
3	ESC	5	9	3						17
4	PCC		5	15	24	11	8	6		69
5	PEC					3	6	6		15
6	OEC					3	3			6
7	EEC	1	2	1	1	2	1	3	10	21
8	Non-Credit / (Mandatory)					√	√			
9	IC						3			3
Total		22	26	23	25	21	21	19	10	167

SUMMARY

ENROLLMENT FOR B.E. / B. TECH. (HONOURS) / MINOR DEGREE (OPTIONAL)

A student can also optionally register for additional courses (18 credits) and become eligible for the award of B.E. / B. Tech. (Honours) or Minor Degree. For B.E. / B. Tech. (Honours), a student shall register for the additional courses (18 credits) from semester V onwards. These courses shall be from the same vertical or a combination of different verticals of the same programme of study only. For minor degree, a student shall register for the additional courses (18 credits) from semester V onwards. All these courses have to be in a particular vertical from any one of the other programmes, Moreover, for minor degree the student can register for courses from any one of the following verticals also.

Anna University Nominee **Academic Expert 1** **Academic Expert 2**

Industry Person **Alumni Member**

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SEMESTER III

24MA3355	RANDOM PROCESSES AND LINEAR ALGEBRA	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

- To introduce some standard distributions applicable to engineering which can de- scribe real life phenomenon.
- To understand the basic concepts of probability, one and two dimensional random variables
- To provide necessary basic concepts in probability and random processes for applications such as random signals, linear systems in communication engineering.
- To introduce the basic notions of vector spaces which will then be used to solve related problems.
- To understand the concepts of vector space, linear transformations, inner product spaces and orthogonalization.

UNIT I	PROBABILITY AND RANDOM VARIABLES	12

Axioms of probability – Conditional probability – Baye's theorem - Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential and Normal distributions.

UNIT II	TWO - DIMENSIONAL RANDOM VARIABLES	12

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and linear regression — Central limit theorem (for independent and identically distributed random variables).

UNIT III	RANDOM PROCESSES	12

Classification –Auto Correlation Function (Excluding properties and cross correlation)- Stationary processes (Excluding Ergodic Process) – Markov process - Discrete parameter Markov chain (Excluding classification of Markov chain)- Chapman Kolmogorov equations (Statement only) - Limiting distributions - Poisson process.

UNIT IV	VECTOR SPACES	12

Vector spaces – Subspaces – Linear combinations and linear system of equations – Linear independence and linear dependence – Bases and dimensions.

UNIT V	LINEAR TRANSFORMATION AND INNER PRODUCT SPACES	12

Linear transformation - Null spaces and ranges - Dimension theorem - Matrix representation of a linear transformations - Inner product - Norms - Gram Schmidt orthogonalization process - Adjoint of linear operations - Least square approximation.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Understand the fundamental concepts of probability with a thorough knowledge of standard distributions that can describe certain real-life phenomenon.

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CO2:	Understand the basic concepts of one and two dimensional random variables and apply them to model engineering problems.
CO3:	Apply the concept of random processes in engineering disciplines.
CO4:	Explain the fundamental concepts of advanced algebra and their role in modern mathematics and applied contexts.
CO5:	Demonstrate accurate and efficient use of advanced algebraic techniques.
TEXT BOOKS:	
1.	Gross, D., Shortle, J.F, Thompson, J.M and Harris. C.M., "Fundamentals of Queueing Theory", Wiley Student 4 th Edition, 2014.
2.	Ibe, O.C., "Fundamentals of Applied Probability and Random Processes", Elsvier,1st Indian Reprint, 2007.
REFERENCES:	
1.	Hsu, "Schaum's Outline of Theory and Problems of Probability, Random Variables and Random Processes", Tata McGraw Hill Edition, New Delhi, 2004. RPLA Notes
2.	Trivedi, K.S., "Probability and Statistics with Reliability, Queueing and Computer Science Applications", 2nd Edition, John Wiley and Sons, 2002.
3.	Yates, R.D. and Goodman. D. J., "Probability and Stochastic Processes", 2nd Edition, Wiley India Pvt. Ltd., Bangalore, 2012.
4.	Kolman. B. Hill. D.R., "Introductory Linear Algebra", Pearson Education, New Delhi, First Reprint, 2009.
5.	Kumaresan. S., "Linear Algebra – A Geometric Approach", Prentice – Hall of India, New Delhi, Reprint, 2010.

CO's-PO's & PSO's MAPPING

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
1	3	3	0	0	0	0	0	0	3	0	0	2	-	-	-
2	3	3	0	0	0	0	0	0	3	0	0	2	-	-	-
3	3	3	0	0	0	0	0	0	3	0	0	2	-	-	-
4	3	3	0	0	0	0	0	0	3	0	0	2	-	-	-
5	3	3	0	0	0	0	0	0	3	0	0	2	-	-	-
CO	**3**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**2**	—	—	—

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24EC3301	SIGNALS AND SYSTEMS	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

- To understand and analyze the basic properties of signals and systems
- To analyze continuous time signals and system in the Fourier and Laplace domain
- To apply and analyze the methods of characterization of LTI systems in time domain
- To analyze discrete time signals and system in the Fourier and Z transform domain
- To apply and analyze the methods of characterization of LTI systems in frequency domain

UNIT I	CLASSIFICATION OF SIGNALS AND SYSTEMS	12

Standard signals- Step, Ramp, Pulse, Impulse, Real and complex exponentials and Sinusoids - Classification of signals — Continuous time (CT) and Discrete Time (DT) signals, Periodic & Aperiodic signals, Deterministic & Random signals, Energy & Power signals — Classification of systems- CT systems and DT systems- — Linear & Nonlinear, Time-variant & Time-invariant, Causal & Non-causal, Stable & Unstable.

UNIT II	ANALYSIS OF CONTINUOUS TIME SIGNALS	12

Fourier series for periodic signals — Fourier Transform — properties- Laplace Transforms and properties.

UNIT III	LINEAR TIME INVARIANT CONTINUOUS TIME SYSTEMS	12

Impulse response — convolution integrals- Differential Equation- Fourier and Laplace transforms in Analysis of CT systems — Systems connected in series / parallel- Block diagram Realization.

UNIT IV	ANALYSIS OF DISCRETE TIME SIGNALS	12

Baseband signal Sampling — Fourier Transform of discrete time signals (DTFT) — Properties of DTFT — Z Transform & Properties.

UNIT V	LINEAR TIME INVARIANT-DISCRETE TIME SYSTEMS	12

Impulse response — Difference equations-Convolution sum- Discrete Fourier Transform and Z Transform Analysis of Recursive & Non-Recursive systems-DT systems connected in series and parallel- Block diagram Realization.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Determine if a given system is linear/causal/stable
CO2:	Determine the frequency components present in a deterministic signal.
CO3:	Characterize continuous LTI systems in the time domain and frequency domain.
CO4:	Characterize discrete LTI systems in the time domain and frequency domain.
CO5:	Compute the output of an LTI system in the time and frequency domains

TEXT BOOKS:

1.	Oppenheim, Willsky and Hamid, “Signals and Systems”, 2nd Edition, Pearson Education, New Delhi, 2015.(Units I - V)

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2.	Simon Haykin, Barry Van Veen, "Signals and Systems", 2nd Edition, Wiley, 2007.
REFERENCES:	
1.	B. P. Lathi, "Principles of Linear Systems and Signals", 2nd Edition, Oxford, 2009.
2.	M. J. Roberts, "Signals and Systems Analysis using Transform methods and MAT- LAB", McGraw- Hill Education, 2018.
3.	John Alan Stuller, "An Introduction to Signals and Systems", Thomson, 2007

CO's-PO's & PSO's MAPPING

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
1	3	3	3	-	3	2	2	-	1	-	1	3	2	3	2
2	3	3	3	-	3	2	1	-	1	-	1	3	2	3	2
3	3	3	-	-	3	2	3	-	1	-	1	3	2	3	2
4	3	3	-	-	3	2	2	-	1	-	1	3	2	3	2
5	3	3	-	3	3	2	1	-	1	-	1	3	2	3	2
CO	**3**	**3**	**3**	**3**	**3**	**2**	**2**	—	**1**	—	**1**	**3**	**2**	**3**	**1**

1 - low, 2 - medium, 3 - high, '-' - no correlation

24EC3302	**CONTROL SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To illustrate the components and the representation of control systems.
- To demonstrate various methods for analyzing the time response of the systems.
- To identify various methods for analyzing the frequency response the systems.
- To identify the methods for analyzing stability of the systems.
- To evaluate the various approach for the state variable analysis.

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

Control System: Terminology and Basic Structure-Feed forward and Feedback control theory-Electrical and Mechanical Transfer Function Models-Block Diagram Models- Signal flow graphs models-DC and AC servo Systems-Synchronous -Multivariable control system.

UNIT II	**TIME RESPONSE ANALYSIS**	**9**

Transient response-steady state response -Measures of performance of the standard first order and second order system-effect on an additional zero and an additional pole-steady error constant and system- type number-PID Control-Analytical design for PD, PI, PID control systems- Matlab programs

of second order systems.		
UNIT III	**FREQUENCY RESPONSE AND SYSTEM ANALYSIS**	**9**
Closed loop frequency response - Performance specification in frequency domain -Frequency response of standard second order system- Bode Plot - Polar Plot- Matlab programs- Design of compensators using Bode plots -Cascade Lead Compensation-Cascade lag compensation, Cascade lead-lag compensation.		
UNIT IV	**CONCEPTS OF STABILITY ANALYSIS**	**9**
Concept of stability - Bounded - Input Bounded - Output stability - Routh stability criterion- Relative stability - Root locus concept - Guidelines for sketching root locus-Nyquist stability criterion- Nyquist plot.		
UNIT V	**CONTROL SYSTEM ANALYSIS USING STATE VARIABLE METHODS**	**9**
State variable representation - Conversion of state variable models to transfer functions- Conversion of transfer functions to state variable models - Solution of state equations- Concepts of Controllability and Observability-Stability of linear systems - Equivalence be- tween transfer function and state variable representations - State variable analysis of digital control system - Digital control design using state feedback.		
		TOTAL:45 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Demonstrate the transfer function of different physical systems.	
CO2:	Illustrate the time domain specification and calculate the steady state error.	
CO3:	Develop the frequency response characteristics of open loop and closed loop system response.	
CO4:	Analyze the stability using Routh and root locus technique.	
CO5:	Determine the state space model of a physical system and discuss the concepts of sampled data control system.	
TEXT BOOKS:		
1.	M.Gopal,"Control System – Principles and Design", Tata McGraw Hill, 4th Edition, 2012.	
REFERENCES:		
1.	J.Nagrath and M.Gopal, "Control System Engineering", New Age International Publishers, 8th Edition, 2024.	
2.	K.Ogata, "Modern Control Engineering", PHI, 5th Edition, 2012.	
3.	S.K.Bhattacharya, "Control System Engineering", Pearson, 3rd Edition, 2013.	
4.	Benjamin.C.Kuo, "Automatic Control Systems", Prentice Hall of India, 9th Edition,2014.	

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CO's-PO's & PSO's MAPPING

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
1	3	3	3	2	2	2	-	-	-	-	2	3	3	3	3
2	3	3	3	3	2	3	-	-	-	-	2	2	3	3	3
3	3	2	3	3	2	2	-	-	-	-	2	3	2	2	3
4	3	3	3	2	2	2	-	-	-	-	2	2	3	3	3
5	2	2	3	3	2	3	-	-	-	-	2	3	2	2	3
CO	**3**	**3**	**3**	**3**	**2**	**2.4**	—	—	—	—	**2**	**3**	**3**	**2.6**	**3**

1 - low, 2 - medium, 3 - high, '-' - no correlation

24EC3303	DIGITAL SYSTEMS DESIGN	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- To recall the fundamentals of digital circuits and various simplification methods.
- To describe the principles of combinational circuits and their practical applications.
- To design synchronous sequential circuits using established procedures.
- To analyze asynchronous sequential circuits through systematic approaches.
- To identify the various semiconductor memory technologies and their use in digital systems.

UNIT I	BASIC CONCEPTS	9

Review of number systems-representation-conversions, Review of Boolean algebra- theorems, sum of product and product of sum simplification, canonical forms min term and max term, Simplification of Boolean expressions-Karnaugh map, completely and incompletely specified functions, Implementation of Boolean expressions using universal gates, Tabulation methods.

UNIT II	COMBINATIONAL LOGIC CIRCUITS	9

Problem formulation and design of combinational circuits - Code-Converters, Half and Full Adders, Binary Parallel Adder – Carry look ahead Adder, BCD Adder, Magnitude Comparator, Decoder, Encoder, Priority Encoder, Mux/ Demux, Case study: Digital trans-receiver / 8-bit Arithmetic and logic unit, Parity Generator/Checker, Seven Segment display decoder, Modeling of data path circuits using Verilog HDL.

UNIT III	SYNCHRONOUS SEQUENTIAL CIRCUITS	9

Latches, Flip flops – SR, JK, T, D, Master/Slave FF, Triggering of FF, Analysis and design of clocked sequential circuits – Design - Moore/Mealy models, state minimization, state assignment, lock - out condition circuit implementation - Counters, Ripple Counters, Ring Counters, Shift registers, Universal Shift Register. Model Development: Designing of rolling display/real time clock, Modeling of sequential logic circuits using Verilog HDL.

UNIT IV	ASYNCHRONOUS SEQUENTIAL CIRCUITS	9
Stable and Unstable states, output specifications, cycles and races, state reduction, race free assignments, Hazards, Essential Hazards, Fundamental and Pulse mode sequential circuits, Design of Hazard free circuits.		
UNIT V	**LOGIC FAMILIES AND PROGRAMMABLE LOGIC DEVICES**	**9**
Logic families- Propagation Delay, Fan - In and Fan - Out - Noise Margin - RTL, TTL, ECL, CMOS - Comparison of Logic families - Implementation of combinational logic/sequential logic design using standard ICs, PROM, PLA and PAL, basic memory, static ROM, PROM, EPROM, EEPROM EAPROM, CPLD, FPGA Generic Architecture.		
		TOTAL: 45 PERIODS
PRACTICAL EXERCISES:		**30 PERIODS**
1. Design of adders and subtractors & code converters.		
2. Design of Multiplexers & Demultiplexers.		
3. Design of Encoders and Decoders.		
4. Design of Magnitude Comparators.		
5. Simulation of Combinational Circuits (Exp 1 and 2).		
6. Implementation of Combinational Circuits using FPGA (Exp 1 and 2).		
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Use Boolean algebra and simplification procedures relevant to digital logic.	
CO2:	Design various combinational digital circuits using logic gates.	
CO3:	Analyze and design synchronous sequential circuits.	
CO4:	Analyze and design asynchronous sequential circuits.	
CO5:	Build logic gates and use programmable devices.	
		TOTAL: 75 PERIODS
TEXT BOOKS:		
1.	M. Morris Mano and Michael D. Ciletti, 'Digital Design', Pearson, 6th Edition, 2017. (Unit - I - V).	
REFERENCES:		
1.	Charles H. Roth, Jr, 'Fundamentals of Logic Design', Jaico Books, 4th Edition, 2002.	
2.	William I. Fletcher," An Engineering Approach to Digital Design", Prentice- Hall of India, 1990.	
3.	Floyd T.L.," Digital Fundamentals", Charles E. Merril publishing company,1982.	
4.	John. F. Wakerly," Digital Design Principles and Practices", Pearson Education, 4th Edition,2007.	
Requirements for a batch of 30 students:		
1.	Dual power supply/ single mode power supply - 15 Nos	

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2.	IC Trainer Kit - 15 Nos
3.	Bread Boards - 15 Nos
4.	Seven segment display -15 Nos
5.	Multimeter - 15 Nos
6.	ICs each 50 Nos 7400/ 7402 / 7404 / 7486 / 7408 / 7432 / 7483 / 74150 / 74151 / 74147 / 7445 / 7476/7491/ 555 / 7494 / 7447 / 74180 / 7485 / 7473 / 74138 / 7411 / 7474

CO's-PO's & PSO's MAPPING

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1	3	2	2	2	-	2	-	-	-	-	3	3	3	3	2
2	-	-	-	-	-	-	-	-	-	-	2	1	2	3	2
3	-	3	3	2	-	2	-	-	-	-	2	2	3	3	2
4	-	-	-	-	-	-	-	-	-	-	3	2	2	3	1
5	-	3	3	3	-	-	-	-	-	-	2	2	3	3	2
CO	**3**	**2.6**	**2.6**	**2.3**	—	**2**	—	—	—	—	**2**	**2**	**3**	**3**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

24EC3304	ELECTRONIC DEVICES AND CIRCUITS - I	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- To illustrate a comprehensive exposure to all types of devices and circuits constructed with discrete components.
- To design and analyze amplifiers circuits.
- To design and analyze small signal amplifiers.
- To analyze the frequency response of small signal amplifiers.
- To analyze, troubleshoot and fault analysis the regulated DC power supplies.

UNIT I	SEMICONDUCTOR DEVICES	9

PN junction diode, Zener diode, BJT, MOSFET–structure, operation and V-I characteristics, diffusion and transition capacitance, Zener as regulator, LED, Photodiode, Varactor diode and Schottky diode.

UNIT II	BJT AMPLIFIERS	9

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Load line and operating point (Q-point), biasing techniques for BJT and MOSFET BJT small signal model (Hybrid-π) - Analysis of CE amplifier –Miller effect - Cascade, Cascode configurations - Differential amplifier, Basic BJT differential pair – Small signal analysis and CMRR.		
UNIT III	**SINGLE STAGE FET, MOSFET AMPLIFIERS**	**9**
Small Signal Hybrid π equivalent circuit of FET and MOSFET - Analysis of CS, CD and CG amplifiers using Hybrid π equivalent circuits - Frequency response and bandwidth - JFET amplifiers -FET differential pair.		
UNIT IV	**FREQUENCY RESPONSE OF AMPLIFIER**	**9**
Frequency response of amplifiers – Effect of coupling and bypass capacitors - BJT frequency response, short-circuit current gain - Cut-off frequency – fα, fβ and unity gain bandwidth - High-frequency analysis of CE and CS amplifier - Transistor switching times and speed limitations.		
UNIT V	**POWER SUPPLIES AND ELECTRONIC DEVICE TESTING**	**9**
Power Supply Design – Linear power supplies - Rectifiers - Filters - Half-Wave Rectifier Power Supply - Full-Wave Rectifier - Linear voltage regulators (series and shunt) –Overvoltage and thermal protection – Introduction to Switching Regulators– SMPS: operation and advantages – BJT and MOSFET roles in power supply – Design and testing of regulated DC power supplies – Fault analysis and troubleshooting techniques.		
		45 PERIODS
PRACTICAL EXERCISES:		**30 PERIODS**
1. Characteristics of PN Junction Diode and Zener diode.		
2. Full Wave Rectifier with Filters.		
3. Design of Zener diode Regulator.		
4. Common Emitter input-output Characteristics - BJT		
5. MOSFET Drain current and Transfer Characteristics.		
6. Frequency response of CE, CB, CC and CS amplifiers.		
7. Frequency response of Cascode Amplifier		
8. CMRR measurement of Differential Amplifier		
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Explain the structure and working operation of basic electronic devices.	
CO2:	Acquire knowledge of Working principles, characteristics and applications of BJT.	
CO3:	Acquire knowledge of Working principles, characteristics and applications of FET.	
CO4:	Analyze the performance and frequency response of BJT and FET amplifiers.	
CO5:	Apply the knowledge gained in the design of Electronic circuits.	
		TOTAL: 75 PERIODS
TEXT BOOKS:		
1.	David A. Bell, "Electronic Devices and Circuits", Oxford Higher Education press, 5 th Edition, 2010.	
2.	Robert L. Boylestad and Louis Nasheresky, “Electronic Devices and Circuit Theory”, 10th	

BoS Chairman

	Edition, Pearson Education / PHI, 2008.
3.	Adel .S. Sedra, Kenneth C. Smith, "Micro Electronic Circuits", Oxford University Press, 7 th Edition, 2014.
REFERENCES:	
1.	Donald.A. Neamen, "Electronic Circuit Analysis and Design", Tata McGraw Hill, 3rd Edition, 2010.
2.	D.Schilling and C.Belove, "Electronic Circuits", McGraw Hill, 3rd Edition, 1989.
3.	Muhammad H.Rashid, "Power Electronics", Pearson Education / PHI , 2004.
Requirements for a batch of 30 students:	
1.	CRO/DSO (30MHz) – 15 Nos.
2.	Signal Generator /Function Generators (3 MHz) – 15 Nos
3.	Dual Regulated Power Supplies (0 – 30V) – 15 Nos.
4.	Standalone desktop PCs with SPICE software – 15 Nos.
5.	Transistor/FET (BJT-NPN-PNP and NMOS/PMOS) – 50 Nos
6.	Components and Accessories: Resistors, Capacitors, Inductors, diodes, Zener Diodes, Bread Boards, Transformers.

CO's-PO's & PSO's MAPPING

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
1	3	2	–	–	–	–	–	–	–	–	–	1	3	1	–
2	3	3	3	2	–	–	–	–	–	–	–	1	3	2	2
3	3	3	3	2	–	–	–	–	–	–	–	1	3	2	2
4	3	3	3	3	2	–	–	–	–	–	–	1	3	3	3
5	2	3	3	3	3	–	–	–	2	2	–	2	2	3	3
CO	**3**	**3**	**3**	**2.5**	**2.5**	**-**	**-**	**-**	**2**	**2**	**-**	**1**	**3**	**2**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

BoS Chairman

24CS3353	C PROGRAMMING AND DATA STRUCTURES	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To introduce the basics of C programming language.
- To learn the concepts of advanced features of C.
- To understand the concepts of ADTs and linear data structures.
- To know the concepts of non-linear data structure and hashing.
- To familiarize the concepts of sorting and searching techniques.

UNIT I	C PROGRAMMING FUNDAMENTALS	7

Data Types – Variables – Operations – Expressions and Statements – Conditional Statements – Functions – Recursive Functions – Arrays – Single and Multi-Dimensional Arrays.

UNIT II	C PROGRAMMING - ADVANCED FEATURES	7

Structures – Union – Pointers: Pointers to Variables, Arrays and Functions – File Handling – Preprocessor Directives.

UNIT III	LINEAR DATA STRUCTURES	7

Abstract Data Types (ADTs) – List ADT – Array-Based Implementation – Linked List Doubly- Linked Lists – Circular Linked List – Stack ADT – Implementation of Stack – Queue ADT – Queue Implementation.

UNIT IV	NON-LINEAR DATA STRUCTURES	7

Trees – Binary Trees – Tree Traversals – Expression Trees – Binary Search Tree – Hashing

- Hash Functions – Separate Chaining – Open Addressing – Linear Probing– Quadratic Probing.

UNIT V	SORTING AND SEARCHING TECHNIQUES	7

Insertion Sort – Quick Sort – Merge Sort –Linear Search – Binary Search. SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

TOTAL: 35 PERIODS

PRACTICAL EXERCISES: 25 PERIODS

1. Practice of C programming using statements, expressions, decision making and iterative statements
2. Practice of C programming using Functions and Arrays
3. Implement C programs using Pointers and Structures
4. Array implementation of List ADT
5. Implementation of Binary trees and operations of Binary tree
6. Implementation of searching techniques
7. Implementation of sorting Algorithms: insertion Sort, Quick sort, Merge Sort.

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Use different constructs of C and develop applications

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CO2:	Apply advanced features of C in solving problems.
CO3:	Write functions to implement linear and non-linear data structure operations
CO4:	Suggest and use the appropriate linear / non-linear data structure operations for solving a given problem
CO5:	Appropriately use Sort and search algorithms for a given application
	TOTAL: 60 PERIODS

TEXT BOOKS:

1.	Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", Second Edition, Pearson Education, 1997.
2.	Reema Thareja, "Programming in C", Second Edition, Oxford University Press, 2016.

REFERENCES:

1.	Brian W. Kernighan, Rob Pike, "The Practice of Programming", Pearson Education, 1999.
2.	Paul J. Deitel, Harvey Deitel, "C How to Program", Seventh Edition, Pearson Education, 2013.
3.	Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, "Data Structures and Algorithms", Pearson Education,1983.
4.	Ellis Horowitz, Sartaj Sahni and Susan Anderson, "Fundamentals of Data Structures", Galgotia, 2008.

CO's-PO's & PSO's MAPPING

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1	2	3	1	2	2	1	1	-	1	2	1	3	2	1	3
2	1	2	1	2	2	-	-	-	1	1	1	2	2	2	2
3	2	3	1	2	3	-	-	-	1	1	1	2	2	1	2
4	2	1	-	1	1	-	-	-	2	1	1	2	2	3	1
5	1	2	1	2	2	1	1	-	1	2	1	3	2	2	3
CO	**2**	**2**	**1**	**2**	**2**	**1**	**1**	—	**1**	**1**	**1**	**2**	**2**	**2**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

24TP3301	SKILL ENHANCEMENT - III	L	T	P	C
		0	**0**	**2**	**1**

COURSE OBJECTIVES:

- To educate and enrich the students on quantitative ability, reasoning ability, and verbal ability.
- Improve their quantitative ability.
- Improve the ability of arithmetic reasoning.
- Enhance their verbal ability through vocabulary building and grammar.

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● Equip with creative thinking and problem solving skills		
UNIT I	**QUANTITATIVE ABILITY – I**	**10**
Problems on Trains - Time and Distance - Height and Distance - Time and Work		
UNIT II	**QUANTITATIVE ABILITY – II**	**10**
Problems on Ages - Alligation or Mixture - Chain Rule - Simple Interest - Simple Equation- Theory of Equation.		
UNIT III	**REASONING ABILITY – I**	**8**
Analytical Reasoning - Pipes and Cistern - Logical Problems –Logical Games-Logical Deduction-Data Sufficiency-Arithmetic Reasoning.		
UNIT IV	**VERBAL ABILITY – I**	**10**
Idioms Phrases - Synonyms - Antonyms - Classification		
UNIT V	**CREATIVITY ABILITY – I**	**7**
Venn Diagrams -Cube and Cuboids - Dice - Cubes and Dice - Figure Matrix.		
		TOTAL: 45 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Solve real-time problems involving trains, time and distance, time and work, and height and distance using quantitative techniques.	
CO2:	Apply arithmetic concepts such as ages, mixtures, chain rule, interest, and equations to solve mathematical problems efficiently.	
CO3:	Analyze and solve logical and analytical reasoning problems, including pipes and cisterns, logical games, and data sufficiency.	
CO4:	Demonstrate improved verbal skills through the understanding and application of idioms, phrases, synonyms, antonyms, and classification techniques.	
CO5:	Apply creative and spatial thinking to solve problems involving Venn diagrams, cubes, dice, and figure matrices.	
		TOTAL: 60 PERIODS
TEXT BOOKS:		
1.	Quantitative Aptitude for Competitive Exams by R. S. Aggarwa	
2.	Quantum CAT by Sarvesh Verma	
3.	A Modern Approach to Logical Reasoning by R. S. Aggarwal	
4.	Verbal Ability and Reading Comprehension by Arun sharma	

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CO's-PO's & PSO's MAPPING

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
1	2	3	1	2	2	1	1	-	1	2	1	3	2	1	3
2	1	2	1	2	2	-	-	-	1	1	1	2	2	2	2
3	2	3	1	2	3	-	-	-	1	1	1	2	2	1	2
4	2	1	-	1	1	-	-	-	2	1	1	2	2	3	1
5	1	2	1	2	2	1	1	-	1	2	1	3	2	2	3
CO	**2**	**2**	**1**	**2**	**2**	**1**	**1**	—	**1**	**1**	**1**	**2**	**2**	**2**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

Anna University Nominee **Academic Expert 1** **Academic Expert 2**

Industry Person **Alumni Member**

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SEMESTER IV

24EC3401	ELECTROMAGNETIC FIELDS AND TRANSMISSION LINES	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

- To understand the fundamental concepts of electrostatics and electric field behavior.
- To analyze magnetostatic fields, flux, and magnetic material characteristics
- To apply Maxwell's equations to study time-varying fields and electromagnetic waves.
- To interpret transmission line parameters, propagation, distortion, and reflections.
- To evaluate high-frequency transmission line behavior and perform impedance matching using Smith charts.

UNIT I	ELECTROSTATICS	9

Review of Coordinate Systems, Coulomb's Law, Electric Field Intensity - Fields due to Different Charge Distributions, Electric Flux Density, Gauss Law and Applications, Electric Potential, Relations Between E and V, Capacitance: parallel, cylindrical and spherical capacitors, Boundary conditions, Electrostatic energy, Poisson's and Laplace's equations, Poisson's and Laplace's Equations Illustrative Problems.

UNIT II	MAGNETOSTATICS	9

Biot - Savart's Law, Magnetic field intensity for various current distributions, Magnetic flux density, Ampere's Circuital Law and Applications, Lorentz force equation, Magnetic Scalar and Vector Potentials, Magnetic circuits, Behaviour of magnetic materials, Boundary conditions, Inductance: Solenoid, toroid and coaxial cable.

UNIT III	TIME VARYING FIELDS AND MAXWELL'S EQUATIONS	9

Fundamental relations for Electrostatic and Magnetostatic fields, Faraday's law for Electromagnetic induction, Transformers, Motional Electromotive forces, Differential form of Maxwell's equations, Integral form of Maxwell's equations, Potential functions, Electromagnetic boundary conditions, Wave equations and their solutions, Electromagnetic power flow and Poynting vector, Poynting's theorem, Time harmonic fields.

UNIT IV	TRANSMISSION LINES	9

General theory of transmission lines, Types of transmission lines, Line Parameters, Primary & Secondary Constants, Expressions for Characteristics Impedance, Propagation Constant, Phase and Group Velocities, Infinite Line Concepts, Distortion - Condition for Distortion less Transmission and Minimum Attenuation, Line not terminated in Z0 — Reflection coefficient, reflection factor and reflection loss.

UNIT V	HIGH FREQUENCY TRANSMISSION LINES AND IMPEDANCE MATCHING	9

Transmission line equations at radio frequencies, Line constants for zero dissipation, Standing Waves, Nodes, Standing Wave Ratio, Input impedance of the dissipationless line-Open and short circuited lines, Impedance matching: Quarter wave transformer, Impedance matching by stubs — Single stub and double stub matching , Smith chart- Single and double stub matching using Smith chart.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Explain electrostatic laws, fields, potentials, capacitance and boundary conditions.
CO2:	Apply magnetostatic principles to determine magnetic fields, inductance, and magnetic properties.
CO3:	Interpret time-varying fields, derive Maxwell's equations, analyze EM waves & Poynting

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	theorem.
CO4:	Analyze transmission line parameters, distortion, reflections and propagation characteristics.
CO5:	Evaluate RF line behavior, calculate SWR, impedance, and design matching networks using Smith chart.
TEXT BOOKS:	
1.	M.N.O.Sadiku and S.V. Kulkarni, Principles of electromagnetics, 6th ed., Oxford(Asian Edition), 2015
2.	D.K. Cheng, Field and wave electromagnetics, 2nd ed., Pearson (India), 2014
3.	John D Ryder, "Networks lines and fields",Prentice Hall of India,New Delhi,2015.(Unit IV,V)
REFERENCES:	
1.	W.H. Hayt and J.A. Buck, Engineering electromagnetics, 7th ed., McGraw-Hill (India), 2006
2.	Edward C. Jordan & Keith G. Balmain,Electromagnetic waves and Radiating Systems, Second Edition, Prentice-Hall Electrical Engineering Series, 2012.
3	Electromagnetic Waves and Transmission Lines-Y Mallikarjuna Reddy, University Press, 2015
4.	Electromagnetic Fields Theory and Transmission Lines - G. Dashibhushana Rao, Wiley India, 2013.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	1	2	-	-	-	-	-	-	-	1	3	2	2
CO2	3	2	2	2	-	-	-	-	-	-	-	1	3	2	2
CO3	3	3	2	3	2	-	-	-	-	-	-	2	3	3	3
CO4	3	3	3	3	2	-	-	-	-	-	-	2	3	3	3
CO5	3	3	3	3	3	-	-	-	-	-	-	2	3	3	3
CO	3	3	2	3	1	-	-	-	-	-	-	2	3	3	3

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24EC3402	COMMUNICATION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamental principles of amplitude modulation and demodulation techniques
- To understand the concepts and mathematical models of phase and frequency modulation.
- To analyze random processes and noise in communication systems, including methods to improve the performance
- To understand the principles and techniques of pulse modulation schemes and their performance
- To analyze the fundamental principles of signal sampling and quantization, and their effects in communication systems.

UNIT I	AMPLITUDE MODULATION	9

Review of signals and systems, Time and Frequency domain representation of signals, Principles of Amplitude Modulation Systems- DSB, SSB and VSB modulations. Modulation index, Spectra, Power relations and Bandwidth – AM Generation – Square law and Switching modulator SSB Generation – Filter and Phase Shift Methods, Pre-envelope & complex envelope AM techniques, Superheterodyne Receiver.

UNIT II	ANGLE MODULATION	9

Phase and frequency modulation, Narrow Band and Wide band FM – Modulation index, Spectral characteristics of angle modulated signals, Power relations and Transmission Bandwidth - FM modulation – Direct and Indirect methods, FM Demodulation - FM to AM conversion, FM Discriminator - PLL as FM Demodulator.

UNIT III	RANDOM PROCESS & NOISE CONSIDERATIONS	9

Review of probability and random process. Gaussian and white noise characteristics, Noise in amplitude modulation systems, Noise in Frequency modulation systems, Noise sources – Noise figure, noise temperature and noise bandwidth – Noise in cascaded systems, Noise performance analysis in AM & FM systems Pre-emphasis and Deemphasis, Threshold effect in angle modulation

UNIT IV	PULSE MODULATION	9

PAM, PPM, PWM, PCM, Differential pulse code modulation. Delta modulation, Noise considerations in PCM – TDM, FDM.

UNIT V	SAMPLING & QUANTIZATION	9

Sampling Theorem– Aliasing- Signal Reconstruction-Quantization - Uniform & non-uniform quantization - quantization noise - Logarithmic Companding- Inter symbol Interference.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Describe various amplitude modulation techniques (DSB, SSB, VSB) in terms of bandwidth, power, and spectral characteristics.
CO2:	Demonstrate the principles and implementation of FM and PM generation.

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CO3:	Analyze the concepts of probability and random processes and noise performance in communication systems.
CO4:	Describe the basic concepts and differences among various pulse modulation techniques
CO5:	Explain the sampling theorem and quantization and its impact on signal quality.
TEXT BOOKS:	
1.	Simon Haykins," Communication Systems", Wiley, 5th Edition, 2009.(Unit I - V)
2.	B.P.Lathi, "Modern Digital and Analog Communication Systems", 4th Edition, Oxford University Press, 2011
3.	J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems", Pearson Education 2014.
REFERENCES:	
1.	Wayne Tomasi, Electronic Communication System, 5th edition, Pearson Education,2008.
2.	D.Roody, J.Coolen, Electronic Communications, 4th edition PHI 2008
3	A.Papoulis, "Probability, Random variables and Stochastic Processes", McGraw Hill, 4th edition, 2017.
4.	Couch.L., "Modern Communication Systems", Pearson, 2001
5.	H P Hsu, Schaum Outline Series - "Analog and Digital Communications" TMH 2006

CO's-PO's & PSO's MAPPING

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3	3	2	1	1	-	-	-	1	1	3	2	2
2	3	3	3	3	2	1	1	-	-	-	1	1	3	2	2
3	3	3	3	3	3	1	1	-	-	-	1	1	3	2	2
4	3	3	3	3	2	1	1	-	-	-	1	1	3	2	2
5	3	3	3	3	2	1	1	-	-	-	1	1	3	2	2
CO	**3**	**3**	**3**	**3**	**2**	**1**	**1**	—	—	—	**1**	**1**	**3**	**2**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24EC3403	ELECTRONIC CIRCUITS - II	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the principles and types of feedback amplifiers
- To design different types of oscillator circuits.
- To analyze the performance of tuned amplifiers.
- To apply wave-shaping techniques and construct multivibrator circuits
- To understand and analyze power amplifiers and DC-DC converters.

UNIT I	FEEDBACK AMPLIFIERS AND STABILITY	9

Feedback Concepts – gain with feedback – effect of feedback on gain stability, distortion, bandwidth, input and output impedances; topologies of feedback amplifiers – analysis of series-series, shunt-shunt and shunt-series feedback amplifiers-stability problem – Gain and Phase-margins-Frequency compensation.

UNIT II	OSCILLATORS	9

Barkhausen criterion for oscillation – phase shift, Wien bridge - Hartley & Colpitt's oscillators – Clapp oscillator - Ring oscillators and crystal oscillators – oscillator amplitude stabilization.

UNIT III	TUNED AMPLIFIERS	9

Coil losses, unloaded and loaded Q of tank circuits, small signal tuned amplifiers – Analysis of capacitor coupled single tuned amplifier – double tuned amplifier - effect of cascading single tuned and double tuned amplifiers on bandwidth – Stagger tuned amplifiers - Stability of tuned amplifiers – Neutralization - Hazeltine neutralization method.

UNIT IV	WAVE SHAPING AND MULTIVIBRATOR CIRCUITS	9

Pulse circuits – attenuators – RC integrator and differentiator circuits – diode clampers and clippers – Multivibrators - Schmitt Trigger- UJT Oscillator.

UNIT V	POWER AMPLIFIERS AND DC CONVERTERS	9

Power amplifiers- class A-Class B-Class AB - Class C -Power MOSFET-Temperature Effect - Class AB Power amplifier using MOSFET – DC/DC convertors – Buck, Boost, Buck-Boost analysis and design

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Understand the concept and effects of feedback in amplifiers
CO2:	Design different types of oscillator circuits.
CO3:	Analyze the working and performance of tuned amplifiers
CO4:	Apply wave-shaping methods and build multivibrator circuits.
CO5:	Understand the operation and design of power amplifiers and DC-DC converters.

TEXT BOOKS:

1.	Sedra and Smith, "Micro Electronic Circuits"; Eighth Edition, Oxford University Press, 2020. (UNIT I, III, IV, V)
2.	Jacob Millman, 'Microelectronics', McGraw Hill, 2nd Edition, Reprinted, 2017. (UNIT I, II, IV, V)
REFERENCES:	
1.	Robert L. Boylestad and Louis Nasheresky, "Electronic Devices and Circuit Theory", 11th Edition, Pearson Education/ PHI, 2015.
2.	David A. Bell, "Electronic Devices and Circuits", 5th Edition, Oxford University Press, 2008.
3	Millman J. and Taub H, Pulse Digital and Switching Waveforms, TMH, 2000.
4.	Millman and Halkias. C., Integrated Electronics, 2nd Edition, TMH, 2017.

CO's-PO's & PSO's MAPPING

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	1	-	-	-	-	-	-	-	-	1	3	1	2
2	3	2	1	3	2	-	-	-	-	-	-	1	3	1	3
3	3	3	2	-	-	-	-	-	-	-	-	1	3	-	3
4	3	2	2	2	2	-	-	-	-	-	-	1	2	2	2
5	3	2	2	2	2	-	-	-	1	-	1	2	3	3	3
AVG.	**3**	**2.2**	**1.6**	**1.4**	**1.2**	—	—	—	**0.2**	—	**0.2**	**1**	**2.8**	**1.4**	**2.6**

1 - low, 2 - medium, 3 - high, '-' - no correlation

24EC3404	**NETWORKS AND SECURITY**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- To learn the Network Models and datalink layer functions
- To understand routing in the Network Layer
- To explore methods of communication and congestion control by the Transport Layer.
- To gain knowledge on the Network Security Mechanisms
- To learn various hardware security attacks and their countermeasures.

UNIT I	**NETWORK MODELS AND DATALINK LAYER**	**6**

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

UNIT II	**NETWORK LAYER PROTOCOLS**	**6**

Network Layer – IPv4 Addressing – Network Layer Protocols (IP,ICMP and Mobile IP) Unicast and Multicast Routing – Intradomain and Interdomain Routing Protocols – IPv6 Addresses – IPv6 – Datagram Format - Transition from IPv4 to IPv6.		
UNIT III	**TRANSPORT AND APPLICATION LAYERS**	**6**
Transport Layer Protocols – UDP and TCP Connection and State Transition Diagram - Congestion Control and Avoidance (DEC bit, RED)- QoS - Application Layer Paradigms – Client – Server Programming – Domain Name System – World Wide Web, HTTP, Electronic Mail.		
UNIT IV	**NETWORK SECURITY**	**6**
OSI Security Architecture – Attacks – Security Services and Mechanisms – Encryption –Advanced Encryption Standard – Public Key Cryptosystems – RSA Algorithm – Hash Functions – Secure Hash Algorithm – Digital Signature Algorithm.		
UNIT V	**HARDWARE SECURITY**	**6**
Introduction to hardware security, Hardware Trojans, Side – Channel Attacks – Physical Attacks and Countermeasures – Design for Security. Introduction to Blockchain Technology		
		TOTAL: 30 PERIODS
		30 PERIODS
LIST OF EXPERIMENTS: (ANY 5)		
Experiments using C		
1. Implement the Data Link Layer framing methods, i) Bit stuffing, (ii) Character stuffing.		
2. Implementation of Error Detection / Correction Techniques i) LRC, (ii) CRC, (iii) Hamming code.		
3. Implementation of Stop and Wait, and Sliding Window Protocols.		
4. Implementation of Go back-N and Selective Repeat Protocols.		
5. Implementation of Distance Vector Routing algorithm (Routing Information Protocol) (Bellman-Ford).		
6.Implementation of Link State Routing algorithm (Open Shortest Path First) with 5 nodes (Dijkstra's).		
7.Data encryption and decryption using Data Encryption Standard algorithm.		
8.Data encryption and decryption using RSA (Rivest, Shamir and Adleman) algorithm.		
9.Implement Client Server model using FTP protocol.		
Experiments using Tool Command Language		
1. Implement and realize the Network Topology - Star, Bus and Ring using NS2.		
2. Implement and perform the operation of CSMA/CD and CSMA/CA using NS2		
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Explain the Network Models, layers and functions	
CO2:	Categorize and classify the routing protocols.	

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CO3:	List the functions of the transport and application layer.
CO4:	Evaluate and choose the network security mechanisms
CO5:	Discuss the hardware security attacks and countermeasures.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS
SOFTWARE
C / Python / Java / Equivalent Compiler
MATLAB SOFTWARE (Few experiments can be practiced with MATLAB)
Standard LAN Trainer Kits 4 Nos
Network simulator like NS2/ NS3 / Glomosim/OPNET/ 30 Equivalent
HARDWARE
Standalone Desktops 30 Nos

TEXT BOOKS:	
1.	Behrouz.A.Forouzan, Data Communication and Networking, Fifth Edition, TMH, 2017.(Unit – I,II,III)
2.	William Stallings, Cryptography and Network Security, Seventh Edition, Pearson Education, 2017(Unit- IV)
3.	Bhunia Swarup, Hardware Security –A Hands On Approach, Morgan Kaufmann, First edition, 2018.(Unit – V)
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.

CO's-PO's & PSO's MAPPING

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	-	3	-	3	2	2	-	1	-	1	3	2	3	2
2	3	-	3	-	3	2	1	-	1	-	1	3	2	3	2
3	3	3	-	-	3	2	3	-	1	-	1	3	2	3	2
4	3	3	-	-	3	2	2	-	1	-	1	3	2	3	2
5	3	3	-	3	3	2	1	-	1	-	1	3	2	3	2
CO	**3**	**1.8**	**1**	**1**	**3**	**2**	**1.8**	—	**1**	—	**1**	**3**	**2**	**3**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24EC3405	LINEAR INTEGRATED CIRCUITS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- To understand the basic building blocks of linear integrated circuits.
- To analyse the linear and non-linear applications of operational amplifiers
- To understand the theory and applications of analog multipliers and PLL.
- To analyse the theory of ADC and DAC.
- To understand the concepts of waveform generation and introduce some special function ICs.

UNIT I	BASICS OF OPERATIONAL AMPLIFIERS	9

Current mirror and current sources, Current sources as active loads, Voltage sources, Voltage References, BJT Differential amplifier with active loads, Basic information about op-amps – Ideal Operational Amplifier - General operational amplifier stages and internal circuit diagrams of IC 741, DC and AC performance characteristics, slew rate, Open and closed loop configurations – MOSFET Operational Amplifiers – CA3130A

UNIT II	APPLICATIONS OF OPERATIONAL AMPLIFIERS	9

Basic Op-Amp circuits: Inverting and Non-inverting voltage amplifiers - Voltage follower, summing amplifier - Linear Applications: Instrumentation Amplifiers, V-to-I and I-to-V converters, Differentiators, and Integrators - Non-linear Applications: Precision Rectifiers, Isolation amplifier, V to F and F to V converters, Sample and Hold circuit, Schmitt trigger.

UNIT III	ANALOG MULTIPLIER AND PHASE- LOCKED LOOP (PLL)	9

Analog Multiplier using Emitter Coupled Transistor Pair - Gilbert Multiplier cell – Variable transconductance technique, analog multiplier ICs and their applications, Operation of the basic PLL, Closed loop analysis, Voltage controlled oscillator, Monolithic PLL IC 565, application of PLL for AM detection, FM detection, FSK modulation and demodulation.

UNIT IV	ANALOG TO DIGITAL AND DIGITAL TO ANALOG CONVERTERS	9

Analog and Digital Data Conversions, D/A converter – specifications - weighted resistor type, R-2R Ladder type- switches for D/A converters, high speed sample-and-hold circuits, A/D Converters – specifications - Flash type - Successive Approximation type - Single Slope type – Dual Slope type - A/D Converter using Voltage-to-Time Conversion - Over-sampling A/D Converters, Sigma – Delta converters.

UNIT V	WAVEFORM GENERATORS AND SPECIAL FUNCTION ICS	9

Triangular wave generator, Saw-tooth wave generator, ICL8038 function generator, Timer IC 555, IC Voltage regulators – Three terminal fixed and adjustable voltage regulators - IC 723 general purpose regulator - Monolithic switching regulator, Low Drop – Out(LDO) Regulators - Switched capacitor filter.

TOTAL: 45 PERIODS

PRACTICAL EXERCISES: 30 PERIODS

Design and Analysis of the following Circuits:

1. Series and Shunt feedback amplifiers-Frequency response, Input and output impedance
2. RC Integrator and Differentiator circuits using Op-Amp
3. Instrumentation amplifier

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4. Active low-pass, High-pass and band-pass filters.	
5. RC Phase shift and Wien bridge oscillators using Op-amp.	
6. R-2R Ladder Type D-A Converter using Op-amp.	
SIMULATION USING SPICE:	
7. Tuned Collector Oscillator	
8. Schmitt Trigger circuit with Predictable hysteresis	
9. Analysis of power amplifier	
TOTAL: 75 PERIODS	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Design linear and nonlinear applications of OP –AMPS
CO2:	Design applications using analog multiplier and PLL
CO3:	Design ADC and DAC using OP – AMPS
CO4:	Generate waveforms using OP – AMP Circuits
CO5:	Analyze special function ICs.
LAB REQUIREMENT FOR A BATCH OF 30 STUDENTS / 2 STUDENTS PER EXPERIMENT:	
EQUIPMENTS:	
1. CRO/DSO (Min 30MHz) -- 15 Nos	
2. Signal Generator /Function Generators (2 MHz) – 15 Nos	
3. Dual Regulated Power Supplies (0 – 30V) -- 15 Nos	
4. Digital Multimeter -- 15 Nos	
5. IC Tester -- 5 Nos	
6. Standalone desktops PC -- 15 Nos	
7. Components and Accessories – 50 Nos	
Components and Accessories:	
Transistors, Resistors, Capacitors, diodes, Zener diodes, Bread Boards, Transformers, wires, Power transistors, Potentiometer, A/D and D/A convertors, LEDs .	
Note:	
Op-Amps uA741, LM 301, LM311, LM 324, LM317, LM723, 7805, 7812, 2N3524, 2N3525, 2N3391, AD 633, LM 555, LM 565 may be used.	
TEXT BOOKS:	
1.	D.Roy Choudhry, Shail Jain, ―Linear Integrated Circuits‖, New Age International Pvt. Ltd., 2022, Sixth Edition. (Unit I – V).
2.	Sergio Franco, ―Design with Operational Amplifiers and Analog Integrated Circuits‖, 4th Edition, Tata Mc Graw-Hill, 2016 (Unit I – V)
REFERENCES:	

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1.	Ramakant A. Gayakwad, ―OP-AMP and Linear ICs 4th Edition, Prentice Hall / Pearson Education, revised 4th Edition 2021.
2.	Robert F.Coughlin, Frederick F.Driscoll, ―Operational Amplifiers and Linear Integrated Circuits‖, Sixth Edition, PHI, 2001.
3.	B.S.Sonde, ―System design using Integrated Circuits‖ , 2nd Edition, New Age Pub, 2001
4.	Gray and Meyer, ―Analysis and Design of Analog Integrated Circuits‖, Wiley International,5th Edition, 2009.
5.	William D.Stanley, ―Operational Amplifiers with Linear Integrated Circuits‖, Pearson Education,4th Edition,2001.
6.	S.Salivahanan & V.S. Kanchana Bhaskaran, ―Linear Integrated Circuits‖, TMH,2nd Edition, 4th Reprint, 2016.

CO's-PO's & PSO's MAPPING

	PO												PSO		
CO	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2	1	1	-	-	-	-	-	-	-	3	3	3
2	3	3	3	2	2	-	-	-	-	-	-	-	3	3	3
3	3	2	3	2	2	-	-	-	-	-	-	-	2	2	3
4	3	2	2	1	2	-	-	-	-	-	-	-	3	3	3
5	3	2	3	1	2	-	-	-	-	-	-	-	2	2	3
CO	**3**	**2**	**3**	**1**	**2**	-	-	-	-	-	-	-	**3**	**3**	**3**

1 - low, 2 - medium, 3 - high, '-' - no correlation

24EC3406	**DIGITAL SIGNAL PROCESSING**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

COURSE OBJECTIVES:

- To learn DFT, properties of DFT, FFT and its application to linear filtering
- To understand the characteristics and structures of digital IIR and FIR filters and apply these filters to filter undesirable signals in various frequency bands.
- To understand the quantization errors and the effects of finite precision representation on digital filters.
- To understand the fundamentals of multi rate signal processing and its applications
- To introduce the concepts of adaptive filters, its application and DSP architecture.

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

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Concept of frequency in discrete-time signals, frequency domain sampling, Discrete Fourier transform (DFT) - deriving DFT from DTFT, properties of DFT - periodicity, symmetry, linearity, time reversal, circular convolution, multiplication, Linear filtering using DFT, Filtering long data sequences - overlap save and overlap add method, Fast computation of DFT - Radix-2 Decimation-in-time (DIT) Fast Fourier transform (FFT), Decimation-in-frequency (DIF) Fast Fourier transform (FFT), Linear filtering using FFT.

UNIT II	**INFINITE IMPULSE RESPONSE FILTERS**	**9**

Characteristics of practical frequency selective filters, Analog filter design- Butterworth filters. Design of IIR filters from analog filters (LPF, HPF, BPF, BRF) - Approximation of derivatives, Impulse invariance method, Bilinear transformation. Structure of IIR filter - direct form I, direct form II, Cascade, parallel realizations.

UNIT III	**FINITE IMPULSE RESPONSE FILTERS**	**9**

Design of FIR filters - symmetric and Anti-symmetric FIR filters - design of linear phase FIR filters using Fourier series method - FIR filter design using windows (Rectangular, Hamming and Hanning window), Frequency sampling method. FIR filter structures - linear phase structure, direct form realizations.

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

Fixed point and floating point number representation - ADC - quantization - truncation and rounding - quantization noise - input / output quantization - coefficient quantization error - product quantization error - overflow error - limit cycle oscillations due to product quantization and summation - scaling to prevent overflow.

UNIT V	**DSP APPLICATIONS**	**9**

Multirate signal processing: Decimation, Interpolation, Sampling rate conversion by a rational factor – Adaptive Filters: Introduction, Applications of adaptive filtering to equalization-DSP Architecture - TMS320C50 architecture- addressing modes-Instruction set-programming.

45 PERIODS

PRACTICAL EXERCISES:	**30 PERIODS**

MATLAB / EQUIVALENT SOFTWARE PACKAGE/ DSP PROCESSOR BASED IMPLEMENTATION

1. Generation of elementary Discrete-Time sequences.
2. Linear and Circular convolutions
3. Auto correlation and Cross Correlation
4. Frequency Analysis using DFT
5. Design of FIR filters (LPF/HPF/BPF/BSF) and demonstrates the filtering operation
6. Design of Butterworth and Chebyshev IIR filters (LPF/HPF/BPF/BSF) and demonstrate the filtering operations
7. Study of architecture of Digital Signal Processor
8. Perform MAC operation using various addressing modes.
9. Generation of various signals and random noise.
10. Design and demonstration of FIR Filter for Low pass, High pass, Band pass and Band stop filtering.

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11. Design and demonstration of Butter worth and Chebyshev IIR Filters for Low pass, High pass, Band pass and Band stop filtering.	
12. Implement an Up-sampling and Down-sampling operation in DSP Processor.	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Apply the DFT, its properties and FFT for the analysis of signals and systems.
CO2:	Deduce both analog and digital IIR filters.
CO3:	Illustrate FIR filters using window techniques
CO4:	Analyze the errors and characterize finite word length effects.
CO5:	Discriminate Digital signal processors architecture and apply adaptive filters in communication systems.
	TOTAL: 75 PERIODS
TEXT BOOKS:	
1.	John G. Proakis and Dimitris G.Manolakis, Digital Signal Processing – Principles, Algorithms and Applications, Fourth Edition, Pearson Education / Prentice Hall, 2007.
2.	A. V. Oppenheim, R.W. Schafer and J.R. Buck, ―Discrete-Time Signal Processing", Third Edition, Pearson, 2009.
REFERENCES:	
1.	Emmanuel C. Ifeachor & Barrie. W. Jervis, "Digital Signal Processing", Second Edition, Pearson Education / Prentice Hall, 2002.
2.	Sanjit K. Mitra, "Digital Signal Processing – A Computer Based Approach", Fourth Edition, Tata Mc Graw Hill, 2013.
3.	Andreas Antoniou, "Digital Signal Processing", Tata Mc Graw Hill, 2006.
Requirements for a batch of 30 students:	
1.PCs with Fixed/Floating point DSP Processors (Kit/Add-on cards)- 15 Nos	
2.Matlab with Simulink and Signal Processing Toolbox or Equivalent software in desktop systems- 15 Nos	
3. Signal Generators (1MHz)-20	
4.CRO /DSO (20 MHz)-20	

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CO's-PO's & PSO's MAPPING

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1	3	3	3	3	2	2	-	-	-	-	1	1	3	3	2
2	3	3	3	3	2	2	-	-	-	-	1	1	2	2	2
3	3	3	**2**	2	2	2	-	-	-	-	1	1	1	2	2
4	3	3	2	2	3	1	-	-	-	-	1	1	2	2	3
5	3	2	2	2	3	2	-	-	-	-	1	1	2	2	1
CO	**3**	**3**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**1**	**1**	**2**	**2**	**2**

24EC3411	**COMMUNICATION SYSTEMS LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

- To study the AM Modulation and Demodulation.
- To study the FM Modulation and Demodulation.
- To learn and realize the effects of sampling.
- To understand Pulse modulation schemes and Delta modulation.
- To learn and realize the effects of TDM.

LIST OF EXPERIMENTS:

1. AM- Modulator and Demodulator
2. FM - Modulator and Demodulator
3. Pre-Emphasis and De-Emphasis.
4. Signal sampling.
5. Pulse Code Modulation and Demodulation.
6. Pulse Amplitude Modulation and Demodulation.
7. Pulse Position Modulation and Demodulation.
8. Pulse Width Modulation and Demodulation.
9. Delta Modulation and Demodulation.
10. TDM.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Design AM Modulators and Demodulators for specific applications.
CO2:	Design FM Modulators and Demodulators for specific applications.

BoS Chairman

CO3:	Understanding the effects of sampling.
CO4:	Gain knowledge about different Pulse modulation schemes and Delta modulation.
CO5:	Applying their knowledge of TDM in communication systems.

LAB Requirements for a Batch of 30 students (3 students per experiment):

i) Kits for Signal Sampling, TDM, AM, FM, PCM, DM and Line Coding Schemes

ii) CROs/DSOs – 15 Nos, Function Generators – 15 Nos.

iii) MATLAB or equivalent software package for simulation experiments

iv) PCs - 15 Nos

CO's-PO's & PSO's MAPPING

	PO												PSO		
CO	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3	3	3	3	-	-	-	1	1	1	3	2	2
2	3	3	3	3	3	2	-	-	-	1	1	1	3	2	2
3	3	3	3	3	3	2	-	-	-	1	1	1	3	2	2
4	3	3	3	3	3	3	-	-	-	1	1	1	3	2	2
5	3	3	3	3	3	2	-	-	-	1	1	1	3	2	2
CO	3	3	3	3	3	*2*	—	—	-	1	1	1	3	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24EC3412	**CIRCUITS DESIGN AND SIMULATION LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

- To gain hands on experience in designing electronic circuits
- To learn simulation software used in circuit design
- To learn the fundamental principles of amplifier circuits
- To differentiate feedback amplifiers and oscillators
- To differentiate the operation of various multivibrators

LIST OF EXPERIMENTS:

1. Series and Shunt feedback amplifiers-Frequency response, Input and output impedance
2. RC Phase shift oscillator and Wien Bridge Oscillator
3. Hartley Oscillator and Colpitts Oscillator

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4. Single Tuned Amplifier
5. RC Integrator and Differentiator circuits
6. Astable and Monostable multivibrators
7. Clippers and Clampers
SIMULATION USING SPICE
1. Tuned Collector Oscillator
2. Twin -T Oscillator / Wein Bridge Oscillator
3. Double and Stagger tuned Amplifiers
4. Bistable Multivibrator
5. Schmitt Trigger circuit with Predictable hysteresis
6. Analysis of power amplifier
TOTAL: 45 PERIODS
COURSE OUTCOMES:
At the end of the course, the students will be able to:

CO1:	Analyze various types of feedback amplifiers
CO2:	Design oscillators, tuned amplifiers, wave-shaping circuits and multivibrators
CO3:	Design and simulate feedback amplifiers, oscillators, tuned amplifiers, wave- shaping circuits and multivibrators, filters using SPICE Tool.
CO4:	Design amplifiers, oscillators, D-A converters using operational amplifiers.
CO5:	Design filters using op-amp and perform an experiment on frequency response

LAB Requirements for a Batch of 30 students (3 students per experiment):
1. CRO/DSO (Min 30MHz) - 15 Nos
2. Signal Generator /Function Generators (2 MHz) – 15 Nos
3. Dual Regulated Power Supplies (0 – 30V) - 15 Nos
4. Digital Multimeter - 15 Nos
5. Standalone desktops PC - 15 Nos
6. Transistor/FET (BJT-NPN-PNP and NMOS/PMOS) - 50 Nos
LAB REQUIREMENT FOR A BATCH OF 30 STUDENTS / 2 STUDENTS PER EXPERIMENT:
Components and Accessories:
Transistors, Resistors, Capacitors, Inductors, diodes, Zener Diodes, Bread Boards, Transformers
SPICE Circuit Simulation Software: (any public domain)

CO's-PO's & PSO's MAPPING

	PO												PSO		
CO	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	2	3	3	3	-	-	-	-	-	-	1	1	3	2	2
2	2	3	3	3	-	-	-	-	-	-	1	1	3	2	2
3	2	3	3	3	-	-	-	-	-	-	1	1	3	2	2
4	2	3	3	3	2	-	-	-	-	-	-	-	3	2	2
5	-	-	-	-	-	-	-	-	-	-	1	1	3	2	2
CO	2	3	3	3	1	-	—	—	-	-	1	1	3	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

BoS Chairman

24TP3401	SKILL ENHNACEMENT - IV	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- Improve their quantitative ability
- Improve their reasoning ability.
- Enhance their verbal ability through vocabulary building and grammar
- Equip with creative thinking and problem-solving skills.

UNIT I	QUANTITATIVE ABILITY – III	6

Compound Interest - Profit and Loss - Partnership - Percentage - Set Theory

UNIT II	QUANTITATIVE ABILITY – IV	6

True Discount - Ratio and Proportion - Simplification - Problems on H.C.F and L.C.M: Solenoid, toroid and coaxial cable.

UNIT III	REASONING ABILITY – II	6

Course of Action - Cause and Effect - Statement and Conclusion - Statement and Argument - Data Sufficiency (DS) - Statement and Assumption - Making Assumptions.

UNIT IV	VERBAL ABILITY – II	6

Change of Voice - Change of Speech - Letter and Symbol Series - Essential Part - Verbal Reasoning - Analyzing Arguments

UNIT V	CREATIVITY ABILITY – II	6

Seating Arrangement - Direction Sense Test - Character Puzzles – Missing

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Solve advanced quantitative aptitude problems involving compound interest, profit loss, percentages, ratios, and set theory with accuracy and efficiency.
CO2:	Apply logical reasoning to evaluate arguments, draw conclusions, identify assumptions, and determine cause-effect relationships.
CO3:	Demonstrate proficiency in complex verbal reasoning tasks such as voice/speech transformation, symbol series, and argument analysis
CO4:	Develop creative problem-solving skills through puzzles, direction tests, and seating arrangements using analytical approaches.
CO5:	Enhance critical thinking and decision-making abilities necessary for success in competitive exams and professional assessment.

TEXT BOOKS:

1.	M.N.O.Sadiku and S.V. Kulkarni, Principles of electromagnetics, 6th ed., Oxford(Asian Edition), 2015
2.	D.K. Cheng, Field and wave electromagnetics, 2nd ed., Pearson (India), 2014
3.	John D Ryder, “Networks lines and fields”,Prentice Hall of India,New Delhi,2015.(Unit IV,V)

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REFERENCES:	
1.	Aggarwal, R. S. Quantitative Aptitude: For competitive Examinations. S Chand, 2017
2.	Aggarwal, R. S. A Modern Approach to Verbal & Non-Verbal Reasoning. Chand, 2000.
3	Wren, Percival Christopher. High school English grammar and composition. 1973
4.	Arihant A new approach to reasoning verbal, non-verbal & analytical by B S Sijwali and Indu Sijwali
5.	Objective General English by S. P. Bakshi · 2014

CO's-PO's & PSO's MAPPING

	PO												PSO		
CO	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	1	1	2	1	-	-	-	-	3	1	3	2	3	3	1
2	1	1	2	2	2	-	-	-	2	2	3	2	3	1	1
3	1	1	3	1	1	-	-	-	2	3	1	1	2	3	1
4	2	3	1	3	1	-	-	-	3	3	3	3	3	2	2
5	2	1	1	1	2	-	-	-	3	3	1	3	2	2	1
CO	**1**	**1**	**2**	**2**	**2**	—	—	—	**3**	**2**	**2**	**2**	**3**	**2**	**1**

1 - low, 2 - medium, 3 - high, '-' - no correlation

Anna University Nominee **Academic Expert 1** **Academic Expert 2**

Industry Person **Alumni Member**

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SEMESTER V

24EC3501	MICROPROCESSOR AND MICROCONTROLLER	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- To understand the architecture of 8086 microprocessor
- To learn the design aspects of I/O and Memory Interfacing circuits.
- To interface microprocessors with supporting chips.
- To study the architecture of 8051 microcontroller
- To design a microcontroller based system.

UNIT I	THE 8086 MICROPROCESSOR	6

Introduction to 8086 – Microprocessor architecture – Addressing modes - Instruction set – Assembly language programming – Modular Programming - Linking and Relocation - Stacks - Procedures – Macros – Interrupts and interrupt service routines.

UNIT II	8086 SYSTEM BUS STRUCTURE	6

8086 signals – Basic configurations – System bus timing – I/O programming – Introduction to Multiprogramming – Multiprocessor configurations – Coprocessor, Closely coupled and loosely Coupled configurations.

UNIT III	I/O INTERFACING	6

Memory Interfacing and I/O interfacing - Parallel communication interface – Serial communication interface – D/A and A/D Interface – Interrupt controller – Programming and applications Case studies: Traffic Light control, LED display and LCD display.

UNIT IV	MICROCONTROLLER	6

Architecture of 8051 – Special Function Registers(SFRs) - I/O Pins Ports and Circuits - Instruction set - Addressing modes - Assembly language programming.

UNIT V	INTERFACING MICROCONTROLLER	6

Programming 8051 Timers - Serial Port Programming - Interrupts Programming – LCD & Keyboard Interfacing - ADC, DAC & Sensor Interfacing - Stepper Motor and Waveform generation.

30 PERIODS

PRACTICAL EXPERIMENTS:

Experiments using 8086

1.	Basic arithmetic and logical operations
2.	Move a data block without overlap
3.	Code conversion.

Experiments with peripherals and Interfacing

4.	Keyboard Display Controller
5.	Parallel Interface
6.	A/D and D/A interface and Waveform Generation

Experiments using 8051

7.	Basic arithmetic and logical operations
8	2’s complement of a number

30 PERIODS

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:	
CO1:	Explains the basic concepts of Microprocessors, addressing modes and instruction set of 8086.
CO2:	Illustrate the detailed hardware and software structure of the microprocessor.
CO3:	Analyze how peripherals (8255, 8253, etc.) are interconnected with the microprocessor
CO4:	Interpret the overview of the internal architecture and various operating modes of a typical microcontroller.
CO5:	Develop assembly language programs for interrupts, subroutines, macros, peripheral devices, and interfaces in the 8086 and 8051 architectures.
TEXT BOOKS:	
1.	Yu-Cheng Liu, Glenn A.Gibson, "Microcomputer Systems: The 8086 / 8088 Family - Architecture, Programming and Design", Second Edition, Prentice Hall of India, 2007. (Unit IIII)
2.	Mohamed Ali Mazidi, Janice Gillispie Mazidi, Rolin McKinlay, "The 8051 Microcontroller and Embedded Systems: Using Assembly and C", Second Edition, Pearson education, 2011. (Unit IV-V)
REFERENCES:	
1.	Doughlas V.Hall, "Microprocessors and Interfacing, Programming and Hardware",TMH,2012
2.	A.K.Ray,K.M.Bhurchandi, "Advanced Microprocessors and Peripherals" Third Edition, Tata McGraw Hill, 2012
3	Krishna Kant, "Microprocessors and Microcontrollers", Prentice Hall of India, 2013
4.	V. Udayashankara, M.S. Mallikajunaswamy, "8051 Microcontroller Hardware, Software and Applications", McGraw-Hill, 2017
5.	K.Uma Rao, Andhe Pallavi, "The 8051 and MSP430 Microcontrollers, Architecture and Programming and Applications", Wiley, 2019.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2	2	2	1	1	-	-	-	1	-	2	2	2	2	1
CO2	2	2	2	1	1	-	-	-	1	-	2	2	2	2	1
CO3	2	2	2	1	1	-	-	-	1	-	2	2	2	2	1
CO4	2	2	2	1	1	-	-	-	1	-	2	2	2	2	1
CO5	2	2	2	1	1	-	-	-	1	-	2	2	2	2	1
CO	2	2	2	1	1	-	-	-	1	-	2	2	2	2	1

1 - low, 2 - medium, 3 - high, '-' - no correlation

BoS Chairman

24EC3502	VLSI AND CHIP DESIGN	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- To learn the basics of IC technology, MOS devices, and the working of digital and analog VLSI circuits.
- To design basic combinational and sequential circuits using digital design principles and HDL (Verilog/VHDL).
- To develop and test digital systems such as adders, multipliers, counters, registers, and memories using HDL and FPGA tools.
- To understand the ASIC design process and the use of EDA tools for building VLSI circuits.
- To gain practical experience in digital and analog circuit simulation, including CMOS amplifier design, using Xilinx/Altera and other design platforms.

UNIT I	MOS TRANSISTOR PRINCIPLES	9

MOS logic families (NMOS, PMOS and CMOS), Ideal and Non-Ideal IV Characteristics, CMOS devices. C-V Characteristics, DC Transfer characteristics, Technology Scaling.

UNIT II	COMBINATIONAL LOGIC CIRCUITS	9

Delay estimation, stick diagram, Layout diagrams, Examples of combinational logic design, Static Logic Gates, Dynamic Logic Gates, Pass Transistor Logic, Power consumption and Power Dissipation, Low Power Design principles.

UNIT III	SEQUENTIAL LOGIC CIRCUITS AND CLOCKING STRATEGIES	9

Static Latches and Registers, Dynamic Latches and Registers, Pipelines, Nonbistable Sequential Circuits. Timing classification of Digital Systems, Synchronous Design, Self-Timed Circuit Design.

UNIT IV	INTERCONNECT, MEMORY ARCHITECTURE AND ARITHMETIC CIRCUITS	9

Interconnect Parameters – Capacitance, Resistance, and Inductance, Electrical Wire Models, Sequential digital circuits: adders (Carry look ahead adder, Carry bypass adder), multipliers (Wallace Tree Multiplier, Booth Multiplier), comparators, shift registers. Logic Implementation using Programmable Devices (ROM, PLA, FPGA), Memory Architecture and Building Blocks, Memory Core and Memory Peripherals Circuitry.

UNIT V	ASIC DESIGN AND TESTING	9

Introduction to wafer to chip fabrication process flow. Microchip design process & issues in test and verification of complex chips, embedded cores and SOCs, Fault models, Test coding. ASIC Design Flow, Introduction to ASICs, Introduction to test benches, Writing test benches in Verilog HDL, Automatic test pattern generation, Design for testability, Scan design: Test interface and boundary scan.

TOTAL: 45 PERIODS

PRACTICAL EXERCISES: **30 PERIODS**

1. Design of basic combinational and sequential (Flip-flops) circuits using HDL. Simulate it using Xilinx/Altera Software and implement by Xilinx/Altera FPGA.
2. Design an Adder; Multiplier (Min 8 Bit) using HDL. Simulate it using Xilinx/Altera Software and implement by Xilinx/Altera FPGA
3. Design and implement Universal Shift Register using HDL. Simulate it using Xilinx/Altera Software

4.	Design Memories using HDL. Simulate it using Xilinx/Altera Software and implement by Xilinx/Altera FPGA.
5.	Design 3-bit synchronous up/down counter using HDL. Simulate it using Xilinx/Altera Software and implement by Xilinx/Altera FPGA.
6.	Design and simulate a CMOS Inverting Amplifier.
	TOTAL: 75 PERIODS
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Understand MOS technology, digital circuit fundamentals, and VLSI design concepts.
CO2:	Analyze and design combinational and sequential logic circuits using standard design principles.
CO3:	Develop HDL code for digital circuits and implement the designs on FPGA boards.
CO4:	Use EDA tools to simulate, synthesize, place & route, and create layouts for digital and analog IC blocks.
CO5:	Test and verify VLSI circuits through simulation, FPGA implementation, and standard verification methods.
TEXT BOOKS:	
1.	Jan D Rabaey, Anantha Chandrakasan, "Digital Integrated Circuits: A Design Perspective", PHI, 2016. (Units II, III and IV).
2.	Neil H E Weste, Kamran Eshranghian, "Principles of CMOS VLSI Design: A System Perspective," Addison Wesley, 2009. (Units - I, IV).
3.	Michael J Smith," Application Specific Integrated Circuits, Addison Wesley, (Unit - V)
4.	Samir Palnitkar," Verilog HDL: A guide to Digital Design and Synthesis", Second Edition, Pearson Education,2003. (Unit - V)
5.	Parag K.Lala, "Digital Circuit Testing and Testability", Academic Press, 1997, (Unit - V)
REFERENCES:	
1.	Vikram Arkalgud Chandrasetty, "VLSI Design -A practical Guide for FPGA and ASIC Implementations, Springer, University of South Australia, 2011.
2.	Vaibbhav Taraate, "Digital Design from the VLSI perspective: Concepts for VLSI beginners", Springer nature, 2022.
3.	Sneh Saurabh, "Introduction to VLSI Design Flow", Cambridge University Press, 2023.
4.	Sung-Mo kang, Yusuf Leblebici, Chulwoo Kim "CMOS Digital Integrated Circuits: Analysis& Design", Fourth edition, McGraw Hill Education, 2013.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	1	-	-	-	-	-	-	-	-	-	-	3	3	3
CO2	3	2	3	2	-	-	-	-	-	-	-	1	3	3	3
CO3	2	3	2	3	1	1	-	-	-	-	-	2	3	2	3
CO4	-	-	1	1	-	-	-	-	-	-	-	3	3	3	2
CO5	-	-	-	-	-	2	-	-	-	-	1	-	3	2	2
CO	**2**	**2**	**2**	**2**	**1**	**1.5**	**-**	**-**	**-**	**-**	**1**	**2**	**3**	**3**	**3**

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24EC3503	DIGITAL COMMUNICATION	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To study the limits set by Information Theory.
- To study the various waveform coding schemes.
- To learn the various baseband transmission schemes.
- To understand the various band pass signaling schemes.
- To know the fundamentals of channel coding.

UNIT I	INFORMATION THEORY	6

Discrete Memoryless source, Information, Entropy, Mutual Information - Discrete Memoryless channels – Binary Symmetric Channel, Channel Capacity - Hartley - Shannon law - Source coding theorem - Shannon - Fano & Huffman codes.

UNIT II	WAVEFORM CODING & REPRESENTATION	6

Basics of Digital Communication - Prediction filtering and DPCM - Delta Modulation - ADPCM & ADM principles-Linear Predictive Coding- Properties of Line codes- Power Spectral Density of Unipolar / Polar RZ & NRZ – Bipolar NRZ – Manchester.

UNIT III	BASEBAND TRANSMISSION & RECEPTION	6

ISI – Nyquist criterion for distortion less transmission – Pulse shaping - Raised Cosine filter – Correlative coding: Duobinary signalling - Eye pattern – Receiving Filters: Matched Filter, Correlation receiver, Adaptive Equalization.

UNIT IV	DIGITAL MODULATION SCHEME	6

Geometric Representation of signals - Generation, detection, PSD & BER of Coherent BPSK, BFSK & QPSK - QAM - Carrier Synchronization - Structure of Non-coherent Receivers - Principle of DPSK.

UNIT V	ERROR CONTROL CODING	6

Channel coding theorem - Linear Block codes - Hamming codes - Cyclic codes - Convolutional codes - Viterbi Decoder - Error detection and correction capability of codes – Code rate and coding gain (conceptual) – Performance measures of coded systems – Applications of error control coding in digital communication systems.

TOTAL: 30 PERIODS

PRACTICAL EXERCISES: **TOTAL: 30 PERIODS**

1. Line coding schemes
2. Simulation of ASK, FSK, and BPSK generation and detection schemes
3. Simulation of DPSK, QPSK and QAM generation and detection schemes
4. Simulation of Linear Block and Cyclic error control coding schemes
5. Simulation of Convolutional coding scheme
6. Communication link simulation

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Understand and compute entropy, mutual information, and channel capacity.
CO2:	Explain and distinguish key waveform-coding and line-coding techniques.
CO3:	Analyze ISI and apply Nyquist criteria with matched-filter receiver concepts.

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CO4:	Evaluate digital modulation schemes using PSD and BER performance.
CO5:	Apply block, cyclic, and convolutional codes for reliable communication.
TEXT BOOKS:	
1.	S. Haykin, "Digital Communications", John Wiley, 2005 (Unit I –V)
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.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	-	2	-	-	-	-	-	-	-	1	3	-	2
CO2	3	2	-	1	2	-	-	-	-	-	-	1	3	-	2
CO3	3	3	3	3	1	-	-	-	-	-	-	1	3	-	2
CO4	3	3	-	1	3	-	-	-	-	-	-	1	3	-	2
CO5	3	3	2	1	-	-	-	-	-	-	-	1	3	2	3
CO	3	2.8	1	1.6	1.2	-	-	-	-	-	-	1	3	0.4	2.2

1 - low, 2 - medium, 3 - high, '-' - no correlation

BoS Chairman

24GE3501	CLIMATE CHANGE AND SUSTAINABILITY	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To understand the fundamental concepts of climate, weather, and factors influencing climate.
- To analyze the causes and impacts of climate change and global warming.
- To study urbanization issues and principles of sustainable development.
- To learn adaptation and mitigation strategies for combating climate change.
- To understand sustainability mechanisms, Kyoto protocol tools, and climate-related case studies.

UNIT I	CLIMATE	9

Climate and weather, Meteorology and climatology, Composition and structure of atmosphere. Factors influencing Climate-Insolation, Temperature, Humidity, Pressure, Wind, Precipitation, Topography. Atmospheric stability, Lapse rate, Inversions, Types of inversions. Cyclones and Anticyclones.

UNIT II	CLIMATE CHANGE	9

Climate change, anthropogenic drivers of climate change, Global warming, Greenhouse effect, Air pollution, carbon foot print, Impact of climate change on water cycle, agriculture, forest, water resources, urban areas, biodiversity, human health. Carbon sequestration, vulnerability index.

UNIT III	URBANISATION AND SUSTAINABLE DEVELOPMENT	9

Urbanisation and Industrialization, Urbanisation, problems of urbanisation, Urban sprawl, Urban heat islands, causes, mitigation measures. Urban flooding, water conservation and ecological aspects. Urban Planning, Zoning of Land Use , Pillars of Sustainable development**,** Sustainability indicators, Life cycle analysis, Material flow analysis, Green energy, Waste management, 3R concepts, Sustainable cities, Sustainable Urbanisation

UNIT IV	ADAPTATION AND MITIGATION STRATEGIES	9

Green Engineering, Design for Engineering, Green technologies, Circular economy. Planning of cities as climate resilient, Climate change and infrastructure planning, Climate resilient infrastructure, nature based solutions in disaster management, adaptation strategies for combating climate change

UNIT V	CLIMATE AND SUSTAINABILITY	9

Sustainability Engineering, Kyoto mechanisms to reduce GHG emission- Clean Development Mechanism, Joint Implementation, Emission trading, Case studies on Kyoto mechanism, Case studies on climate change and climate change risk reduction.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Explain the fundamental concepts of climate and its influencing factors
CO2:	Explain the factors affecting climate change and the harmful impacts due to climate change
CO3:	Discuss the problems due to urbanization and the need for sustainable development
CO4:	Demonstrate the various adaptation and mitigation techniques for combating climate change
CO5:	Discuss multilateral agreements on climate change, Case studies on Climate change

TEXT BOOKS:

1.	Jonathan Tomkin, Tom Theis, "Sustainability - A Comprehensive Foundation", 12th Media Services, 2018

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2.	John T. Hardy, Jean Ponce, “Climate Change - Causes, Effects, and Solutions”, Wiley Publications, 2003
3.	Karthik Karuppu, "Green Building Guidance: The Ultimate Guide for IGBC Accredited Professional Examination Book", NVICO Notion Press, 2019
REFERENCES:	
1.	Keith D. Alverson, ZintaZommers, "Resilience : The science of adaptation to climate change", Elsevier, 2018
2.	Lal, DS, “Climatology”, Published by Sharda Pustak Bhawan, ISBN8186204121
3.	Leal Filho, W., Azul, A.M., Brandli, L., Özuyar, P.G., Wall, T. (Eds.), “Sustainable Cities and Communities” Springer ,2020

CO’s-PO’s & PSO’s MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	-	-	-	-	-	-	-	-	-	-	-	3	3	1
CO2	-	2	-	2	-	-	2	-	-	-	-	-	2	3	2
CO3	-	3	-	3	-	-	2	-	-	-	-	-	1	3	1
CO4	2	-	-	-	-	-	3	-	-	-	-	-	2	3	1
CO5	-	-	-	-	-	-	2	-	-	-	-	-	2	3	2
CO	3	3	3	2	2.4	1.6	-	-	-	-	-	1.8	2	3	1.4

1 - low, 2 - medium, 3 - high, ’-’ - no correlation

24TP3501	SKILL ENHANCEMENT – V	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To promote self-discovery and personal grooming for overall personality enhancement.
- To develop effective communication skills for academic and professional environments.
- To encourage a positive attitude, confidence, and creative thinking in students.
- To build strong professional etiquette and workplace readiness.
- To enhance digital productivity skills essential for career success

UNIT I	QUANTITATIVE ABILITY	6

Probability Applications in Hiring Assessments-Number System (Advanced problem types)-Statistics: Distribution types, Outliers, Skewness-Variance & Standard Deviation for real-world analytics-Area & Mensuration – Industry case-based problems. Activities: Solve 20 industry-based quantitative aptitude problems-Perform variance & standard deviation calculation using real datasets

UNIT II	VERBAL ABILITY	6

Direct & Indirect Speech – advanced contextual usage-Active–Passive Voice transformations in professional writing-Applied Tenses for workplace & technical communication-Vocabulary Building – domain-based wo

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banks (IT, business, HR) Activities: Convert informal statements into formal business email language-Rewri 10 sentences using proper tense & voice transformation		
UNIT III	**REASONING ABILITY**	**6**
Blood Relations – symbolic & coded-Logical Arrangement & Ranking-Direction-based reasoning-Data Interpretation – charts & tables used in placements Activities: Reasoning test (Blood relations, Directions, Ranking)-Solve logical arrangement puzzles		
UNIT IV	**EMPLOYABILITY APTITUDE**	**6**
Error spotting in professional communication-Reading & interpreting English passages-Word usage in business contexts-Grammar application in real-time scenarios-Pattern-based language solving Activities: Peer-review: Correct real-world grammatical errors in office communication-Comprehension practice (short business passages)		
UNIT V	**WORKPLACE COMMUNICATION & CAREER READINESS**	**6**
Foundations of workplace messaging-Business email writing (formal tone, agenda clarity)-Resume fundamentals – first resume creation-Skills mapping & achievement recording-LinkedIn basics – headline, skills, visibility-Identifying internship opportunities-Digital learning platforms—Coursera/Udemy/TCS iON credential showcasing Activities: Create first professional resume (mandatory)-Draft 3 internship-request emails-Build LinkedIn headline & about section		
		TOTAL: 30 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Apply quantitative and statistical methods to solve aptitude-based problems.	
CO2:	Use refined grammar and vocabulary to improve written communication.	
CO3:	Solve reasoning-based analytical problems accurately.	
CO4:	Interpret and correct language errors in contextual usage.	
CO5:	Prepare internship-oriented resumes and build an initial LinkedIn presence for career readiness.	
TEXT BOOKS:		
1.	Aggarwal, R. S., Quantitative Aptitude for Competitive Examinations, S. Chand Publishing, 2022.	
2.	Aggarwal, R. S., A Modern Approach to Verbal & Non-Verbal Reasoning, S. Chand Publishing, 2021	
REFERENCES:		
1.	Raman, M. and Sharma, S., Technical Communication: Principles and Practice, Oxford University Press, 2019.	
2.	Guffey, M. E. and Loewy, D., Business Communication: Process and Product, Cengage Learning, 2018	
3	Yate, M., Knock ’em Dead Resumes: A Killer Resume Gets More Job Interviews!, Adams Media, 2016	

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	0	2	1	0	0	0	2	0	0	2	3	2	3
CO2	0	0	0	0	2	0	0	0	3	3	1	2	–	1	2
CO3	3	3	0	2	0	0	0	0	2	0	0	2	1	3	2
CO4	0	0	0	0	3	0	0	0	2	3	2	2	–	1	1
CO5	0	0	0	0	3	0	0	0	3	2	3	3	–	–	3
CO	3	3	0	2	2.5	0	0	0	2.7	2.5	2.4	2.5	2.4	2.3	2.4

Anna University Nominee **Academic Expert 1** **Academic Expert 2**

Industry Person **Alumni Member**

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SEMESTER VI

24EC3601	WIRELESS COMMUNICATION	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To study and understand the concepts and design of a Cellular System
- To Study And Understand Mobile Radio Propagation And Various Digital Modulation Techniques.
- To Understand The Concepts Of Multiple Access Techniques And Wireless Networks

UNIT I	THE CELLULAR CONCEPT-SYSTEM DESIGN FUNDAMENTALS	9

Introduction-Frequency Reuse-Channel Assignment Strategies-Handoff Strategies: Prioritizing Handoffs, Practical Handoff Considerations. Interference And System Capacity: Co-Channel Interference And System Capacity-Channel Planning for Wireless Systems, Adjacent Channel Interference, Power Control For Reducing Interference, Trunking and Grade Of Service. Improving Coverage And Capacity In Cellular Systems: Cell Splitting, Sectoring

UNIT II	MOBILE RADIO PROPAGATION	9

Large Scale Path Loss: Introduction To Radio Wave Propagation - Free Space Propagation Model – Three Basic Propagation Mechanism: Reflection – Brewster Angle- Diffraction- Scattering. Small Scale Fading And Multipath: Small Scale Multipath Propagation, Factors Influencing Small-Scale Fading, Doppler Shift, Coherence Bandwidth, Doppler Spread And Coherence Time. Types Of Small- Scale Fading: Fading Effects Due To Multipath Time Delay Spread, Fading Effects Due To Doppler Spread.

UNIT III	MODULATION TECHNIQUES AND EQUALIZATION AND DIVERSITY	9

Digital Modulation – An Overview: Factors That Influence The Choice Of Digital Modulation, Linear Modulation Techniques: Minimum Shift Keying (MSK), Gaussian Minimum Shift Keying(GMSK), Spread Spectrum Modulation Techniques: Pseudo- Noise (PN) Sequences, Direct Sequence Spread Spectrum (DS-SS)- Modulation Performance In Fading And Multipath Channels- Equalization, Diversity And Channel Coding: Introduction-Fundamentals Of Equalization- Diversity Techniques: Practical Space Diversity Considerations, Polarization Diversity, Frequency Diversity, Time Diversity.

UNIT IV	MULTIPLE ACCESS TECHNIQUES	9

Introduction: Introduction To Multiple Access- Frequency Division Multiple Access(FDMA)- Time Division Multiple Access(TDMA)- Spread Spectrum Multiple Access-Code Division Multiple Access(CDMA)- Space Division Multiple Access(SDMA)- Capacity Of Cellular Systems: Capacity Of Cellular CDMA, Capacity Of CDMA With Multiple Cells.

UNIT V	WIRELESS NETWORKING	9

Introduction: Difference Between Wireless And Fixed Telephone Networks, The Public Switched Telephone Network(PSTN), Evolution Of Wireless Networks, Traffic Routing In Wireless Networks: Circuit Switching, Packet Switching- Personal Communication Services/ Networks(PCS/PCNs):Packet Vs Circuit Switching For PCN, Cellular Packet- Switched Architecture- Packet Reservation Multiple Access(PRMA)- Network Databases: Distributed Database For Mobility Management- Universal Mobile Telecommunication Systems(UMTS).

45 PERIODS

PRACTICAL EXERCISES:	30 PERIODS

1.Modeling of wireless communication systems using Matlab (Two ray channel and Okumura –Hata model)

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2.Modeling and simulation of Multipath fading channel
3.Design, analyze and test Wireless standards and evaluate the performance measurements such as BER, PER, BLER, throughput, capacity, ACLR, EVM for 4G and 5G using Matlab
4.Modulation: Spread Spectrum – DSSS Modulation & Demodulation
5.Wireless Channel equalization: Zero-Forcing Equalizer (ZFE),MMSE Equalizer(MMSEE),Adaptive Equalizer (ADE),Decision Feedback Equalizer (DFE)
6.Modeling and simulation of TDMA, FDMA and CDMA for wireless communication
TOTAL: 75 PERIODS

COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Understand The Concept And Design Of A Cellular System.
CO2:	Understand Mobile Radio Propagation And Various Digital Modulation Techniques
CO3:	Understand The Concepts Of Multiple Access Techniques And Wireless Networks
CO4:	Characterize a wireless channel and evolve the system design specifications
CO5:	Design a cellular system based on resource availability and traffic demands.
TEXT BOOKS:	
1.	Rappaport,T.S.,-Wireless communications", Pearson Education, Second Edition, 2010.
REFERENCES:	
1.	Wireless Communication –Andrea Goldsmith, Cambridge University Press, 2011
2.	Van Nee, R. and Ramji Prasad, ―OFDM for wireless multimedia communications, Artech House, 2000.
3	David Tse and Pramod Viswanath, ―Fundamentals of Wireless Communication, Cambridge University Press, 2005.
4.	Upena Dalal, ―Wireless Communication", Oxford University Press, 2009.
5.	Andreas.F. Molisch, ―Wireless Communications", John Wiley – India, 2006.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	2	3	3	1	-	-	-	-	-	1	3	1	1
CO2	3	3	2	1	3	2	-	-	-	-	-	-	3	1	2
CO3	3	3	3	3	2	2	-	-	-	-	-	1	3	1	2
CO4	2	3	2	2	2	2	-	-	-	-	-	1	2	1	1
CO5	2	-	3	3	2	1	-	-	-	-	-	1	2	2	2
CO	**3**	**3**	**2**	**2**	**2**	**2**	-	-	-	-	-	**1**	**3**	**1**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24EC3602	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- Learn about uninformed and Heuristic search techniques.
- Understand the techniques for reasoning under uncertainty.
- Introduce Machine Learning and supervised learning algorithms.
- Study about ensembling and unsupervised learning algorithms.
- Learn the basics of deep learning using neural networks.

UNIT I	PROBLEM SOLVING	9

Introduction to AI - AI Applications - Problem solving agents – search algorithms – uninformed search strategies – Game Playing Techniques: Minimax algorithm and Alpha–Beta pruning - Heuristic search strategies: Greedy Best – First Search – A* Search – Local search and optimization problems – adversarial search – constraint satisfaction problems (CSP).

UNIT II	PROBABILISTIC REASONING	9

Acting under uncertainty – Bayesian inference – naïve bayes models. Probabilistic reasoning – Bayesian networks – exact inference in BN – approximate inference in BN – causal networks.

UNIT III	SUPERVISED LEARNING	9

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

UNIT IV	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 V	NEURAL NETWORKS	9

Perceptron - 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- Convolutional Neural Networks (CNNs) – Architecture and applications.

45 PERIODS

PRACTICAL EXERCISES: **30 PERIODS**

1. Implementation of Uninformed search algorithms (BFS, DFS)
2. Implementation of Informed search algorithms (A*, memory-bounded A*)

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3. Implement naïve Bayes models	
4. Implement Bayesian Networks	
5. Build Regression models	
6. Build decision trees and random forests	
7. Build SVM models	
8. Implement ensembling techniques	
9. Implement clustering algorithms	
10. Implement EM for Bayesian networks	
11. Build simple NN models	
12. Build deep learning NN models	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Identify appropriate search algorithms for problem solving.
CO2:	Apply reasoning under uncertainty
CO3:	Construct supervised learning models.
CO4:	Develop ensembling and unsupervised models.
CO5:	Build deep learning neural network models.
TOTAL :75 PERIODS	
TEXT BOOKS:	
1.	Stuart Russell and Peter Norvig, "Artificial Intelligence – A Modern Approach", Fourth Edition, Pearson Education, 2021.
2.	Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Fourth Edition, 2020.
REFERENCES:	
1.	Dan W. Patterson, "Introduction to AI and ES", Pearson Education,2007
2.	Kevin Night, Elaine Rich, and Nair B., "Artificial Intelligence", McGraw Hill, 2008
3.	Patrick H. Winston, "Artificial Intelligence", Third Edition, Pearson Education, 2006
4.	Deepak Khemani, "Artificial Intelligence", Tata McGraw Hill Education, 2013 (http://nptel.ac.in/)
5.	Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006
6.	Tom Mitchell, "Machine Learning", McGraw Hill, 3rd Edition,1997.
7.	Charu C. Aggarwal, "Data Classification Algorithms and Applications", CRC Press, 2014

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8.	Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, "Foundations of Machine Learning", MIT Press, 2012.
9.	Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2016

CO's-PO's & PSO's MAPPING

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
1	3	2	2	3	1	3	2	-	-	-	-	1	3	3	3
2	3	2	2	3	1	3	2	-	-	-	-	1	3	3	3
3	1	2	1	3	2	3	2	-	-	-	-	1	3	3	3
4	1	2	3	1	3	3	2	-	-	-	-	1	3	3	3
5	2	2	2	-	3	3	2	-	-	-	-	1	3	3	3
CO	**2**	**2**	**2**	**2**	**2**	**3**	**2**	-	-	-	-	**1**	3	3	3

1 - low, 2 - medium, 3 - high, '-' - no correlation

24IC3401	ENGINEERING ENTREPRENEURSHIP DEVELOPMENT	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- Learn basic concepts in entrepreneurship, develop mind-set and skills necessary to explore entrepreneurship
- Apply process of problem - opportunity identification and validation through human centered approach to design thinking in building solutions as part of engineering projects
- Analyse market types, conduct market estimation, identify customers, create customer persona, develop the skills to create a compelling value proposition and build a Minimum Viable Product
- Explore business models, create business plan, conduct financial analysis and feasibility analysis to assess the financial viability of a venture ideas & solutions built with domain expertise
- Prepare and present an investible pitch deck of their practice venture to attract stakeholders

UNIT I	ENTREPRENEURIAL MINDSET	6

Introduction to Entrepreneurship: Definition – Types of Entrepreneurs – Emerging Economies, Developing and Understanding an Entrepreneurial Mindset – Importance of Technology Entrepreneurship – Benefits to the Society.

Case Analysis: Study cases of successful & failed engineering entrepreneurs - Foster Creative Thinking: Engage in a series of Problem-Identification and Problem-Solving tasks

UNIT II	OPPORTUNITIES	6

Problems and Opportunities – Ideas and Opportunities – Identifying problems in society Creation of opportunities – Exploring Market Types – Estimating the Market Size- Knowing the Customer and Consumer - Customer Segmentation - Identifying niche markets – Customer discovery and validation; Market research techniques, tools for validation of ideas and opportunities Activity Session: Identify emerging sectors / potential opportunities in existing markets - Customer Interviews: Conduct preliminary interviews with potential customers for Opportunity Validation - Analyse feedback to refine the opportunity.		
UNIT III	**PROTOTYPING & ITERATION**	**6**
Prototyping – Importance in entrepreneurial process – Types of Prototypes - Different methods – Tools & Techniques. Hands-on sessions on prototyping tools (3D printing, electronics, software), Develop a prototype based on identified opportunities; Receive feedback and iterate on the proto- types.		
UNIT IV	**BUSINESS MODELS & PITCHING**	**6**
Business Model and Types - Lean Approach - 9 block Lean Canvas Model - Riskiest Assumptions in Business Model Design – Using Business Model Canvas as a Tool – Pitching Techniques: Importance of pitching - Types of pitches - crafting a compelling pitch – pitch presentation skills - using storytelling to gain investor/customer attention. Activity Session: Develop a business model canvas for the prototype; present and receive feedback from peers and mentors - Prepare and practice pitching the business ideas- Participate in a Pitching Competition and present to a panel of judges - receive & reflect feedback		
UNIT V	**ENTREPRENEURIAL ECOSYSTEM**	**6**
Understanding the Entrepreneurial Ecosystem – Components: Angels, Venture Capitalists, Maker Spaces, Incubators, Accelerators, Investors. Financing models – equity, debt, crowdfunding, etc, Support from the government and corporates. Navigating Ecosystem Support: Searching & Identifying the Right Ecosystem Partner – Leveraging the Ecosystem- Building the right stakeholder network. Activity Session: Arrangement of Guest Speaker Sessions by successful entrepreneurs and entrepreneurial ecosystem leaders (incubation managers, angels, etc), Visit one or two entrepreneurial ecosystem players (Travel and visit a research park or incubator or makerspace or interact with startup founders).		
		30 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Develop an Entrepreneurial Mind-set and Understand the Entrepreneurial Ecosystem Components and Funding types	
CO2:	Comprehend the process of opportunity identification through design thinking, identify market potential and customers	
CO3:	Generate and develop creative ideas through ideation techniques	

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CO4:	Create prototypes to materialize design concepts and conduct testing to gather feedback and refine prototypes to build a validated MVP
CO5:	Analyse and refine business models to ensure sustainability and profitability Prepare and deliver an investible pitch deck of their practice venture to attract stakeholders.

TEXT BOOKS:

1.	Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, Sabyasachi Sinha (2020). Entrepreneurship, McGrawHill, 11th Edition
2.	Bill Aulet (2024). Disciplined Entrepreneurship: 24 Steps to a Successful Startup. John Wiley & Sons.
3.	Bill Aulet (2017). Disciplined Entrepreneurship Workbook. John Wiley & Sons
4.	Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business
5.	Blank, S. G., & Dorf, B. (2012). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. K&S Ranch
6.	Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons
7.	Marc Gruber & Sharon Tal (2019). Where to Play: 3 Steps for Discovering Your Most Valuable Market Opportunities. Pearson

CO's-PO's & PSO's MAPPING

	PO												PSO		
CO	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2	2	-	2	-	-	-	-	3	3	3	3	2
2	-	-	-	-	-	-	-	-	-	-	2	1	2	3	2
3	-	3	3	2	-	2	-	-	-	-	2	2	3	3	2
4	-	-	-	-	-	-	-	-	-	-	3	2	2	3	1
5	-	3	3	3	-	-	-	-	-	-	2	2	3	3	2
CO	**3**	**2.6**	**2.6**	**2.3**	—	**2**	—	—	—	—	**2**	**2**	**3**	**3**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24TP3601	SKILL ENHANCEMENT – VI	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To enhance advanced quantitative reasoning skills
- To improve verbal and logical reasoning competencies
- To develop professional communication skills
- To equip students with strong resume, cover letter, and portfolio development skills
- To foster professional readiness and career engagement abilities

UNIT I	QUANTITATIVE ABILITY	6

Permutation & Combination (combinatorial thinking)-Surds & Indices (exponent simplification)-Geometry – advanced property-based problems-Trigonometry – identities & applications in engineering-Activities: Solve previous-year national-level aptitude tests (TCS NQT / AMCAT / Co Cubes)

UNIT II	VERBAL ABILITY	6

One-word substitution-Sentence completion -Data-arrangement in language contexts-Vocabulary expansion – roots, etymology, prefixes/suffixes **Activities:** Build a vocabulary bank using root-based technique-Practice one-word substitution exercises

UNIT III	REASONING ABILITY	6

Critical reasoning arguments-Clock reasoning-Calendar reasoning -Puzzle Tests (seating, floor, distribution, multi-layer constraints) Activities: Solve 10 advanced puzzles (including clock & calendar reasoning)-Floor/seating arrangement puzzle-solving worksheets

UNIT IV	CREATIVE & ANALYTICAL ABILITY	6

Para-jumbles-Vocabulary analytics – semantic clusters-Image analysis -Grouping & visual recognition-Pattern identification problems-Activities: Perform visual pattern recognition tasks-Semantic-cluster vocabulary mapping

UNIT V	ADVANCED CAREER READINESS SKILLS	6

Advanced Resume tailoring (role-focused, ATS-optimized)-STAR storytelling for experience & achievements-Professional cover letters-Specialized internship/job-oriented emails-GitHub portfolio creation-Showcasing project repositories-Presentation & articulation for interviews-PPT design for final-year project reviews-Activities: Create a role-specific ATS-optimized resume-Prepare a PPT for final-year project presentation-Draft a professional cover letter

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Apply advanced quantitative concepts to solve complex aptitude assessments.
CO2:	Improve verbal reasoning & structured language use.
CO3:	Solve multi-layer logical puzzles and analytical reasoning tasks
CO4:	Demonstrate enhanced creative, linguistic & visual reasoning.
CO5:	Develop advanced resumes, personal branding, GitHub & professional presentations.

TEXT BOOKS:

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1.	Aggarwal, R. S., Objective Mathematics for Competitive Examinations, S. Chand Publishing, 2020
2.	Thorpe, E., Test of Reasoning, McGraw Hill Education, 2016.
REFERENCES:	
1.	Norman Lewis, Word Power Made Easy, Goyal Publishers, 2014.
2.	Guffey, M. E. and Loewy, D., Essentials of Business Communication, Cengage Learning, 2019.
3	Yate, M., Knock 'em Dead Resumes: A Killer Resume Gets More Job Interviews!, Adams Media, 2017.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	0	2	1	0	0	0	2	0	0	2	3	2	3
CO2	0	0	0	0	2	0	0	0	3	3	1	2	–	1	2
CO3	3	3	0	2	0	0	0	0	2	0	0	2	1	3	2
CO4	0	0	0	0	3	0	0	0	2	3	2	2	–	1	1
CO5	0	0	0	0	3	0	0	0	3	2	3	3	–	–	3
CO	3	3	0	2	2.5	0	0	0	2.7	2.5	2.4	2.5	2.4	2.3	2.4

1 - low, 2 - medium, 3 - high, '-' - no correlation

Anna University Nominee **Academic Expert 1** **Academic Expert 2**

Industry Person **Alumni Member**

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MANDATORY COURSES I

24MX3081	INTRODUCTION TO WOMEN AND GENDER STUDIES	L	T	P	C
		3	0	0	0

COURSE OBJECTIVES:

- To understand what gender means and why it is important
- To learn about the problems and challenges faced by women.
- To know how society, family, school, and media shape gender roles.
- To become aware of gender inequality and discrimination
- To develop respect, fairness, and equality towards all genders

UNIT I	GROWTH OF WOMEN'S STUDIES / GENDER STUDIES	9

Objectives and scope of Women's Studies – Need for Women's Studies Introducing Women's Studies in Higher Education - Role of Women's Studies Centre – Women Studies Programme in India – UGC initiatives – Women's Studies in Tamil Nadu – Case Studies.

UNIT II	GENDER SOCIALIZATION	9

Stages – Agencies of socialization – Social Construction of Gender Sex and Gender – Gender Discrimination Gender Stereotyping – Gender Sensitivity - Gender Roles – Gender Perspective – Gender Analysis – Gender Auditing – Gender Budgeting Gender Equity – Gender Equality - Gender Mainstreaming – Role Play.

UNIT III	ISSUES RELATED TO FEMALE CHILDREN	9

Female feticide – Female infanticide – Child Marriage – Prostitution – Transgender and juvenile Girls HIV positive children – Differently abled Children – COVID19 Pandemic and girl child

UNIT IV	WOMEN AND INSTITUTIONS OF SOCIAL SYSTEM	9

Family – types – Marriage – types of marriage – Multiple roles of women – Caste – Class- Culture Religion and Social system – Initiatives for minorities empowerment – Evaluation

UNIT V	STATUS OF WOMEN	9

Status – Concept – Meaning – Definition – Types of status – Achieved and Ascribed status – factors and indicators of status of women-Status of women in Indian Society – Emerging trends in Women's Studies-Women Empowerment

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	To understand the need and significance of Gender Studies.
CO2:	To gain knowledge of key concepts and theories related to gender.
CO3:	To develop awareness of issues concerning female children.
CO4:	To evaluate the role of social institutions in shaping and perpetuating gender discrimination.
CO5:	To understand the contemporary status and challenges faced by women in the present scenario.

REFERENCES:

1.	L. Ayu Saraswati, Barbara L. Shaw, and Heather Rellihan 2020 "Introduction to Women's, Gender and Sexuality Studies" ISBN: 9780190084806
2.	Melissa J. Gillis, Andrew T. Jacobs 2019 "Introduction to Women's and Gender Studies: An Interdisciplinary Approach"

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3	Eliza Long, 2022 “Introduction to Gender Studies” Social Sciences, ISBN9781641726917, Larsen and Keller Education
4.	Maithreyi Krishna Raj, 1986, Women Studies in India – Some Perspectives, Popular Prakasham, Bombay
5.	P Chakrabarti, "Optical Fiber Communication”, McGraw Hill Education (India)Private Limited, 2016

CO’s-PO’s & PSO’s MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	-	-	-	-	-	1	1	1	3	3	-	3	3	2	2
CO2	-	-	-	-	-	1	1	1	3	3	-	3	3	3	2
CO3	-	-	-	-	-	1	1	1	3	3	-	3	3	3	2
CO4	-	-	-	-	-	1	1	1	3	3	-	3	2	2	3
CO5	-	-	-	-	-	1	1	1	3	3	-	3	2	2	3
CO	-	-	-	-	-	1	1	1	3	3	-	3	2	2	3

1 - low, 2 - medium, 3 - high, ’-’ - no correlation

24MX3082	INDIAN KNOWLEDGE SYSTEMS	L	T	P	C
		3	0	0	0

COURSE OBJECTIVES:

- The course introduces India’s traditional knowledge systems and shows their importance in today’s world.
- It explains how knowledge was created and used in fields like philosophy, science, medicine, arts, agriculture, and architecture.
- Students learn the basic principles of IKS, focusing on holistic thinking, sustainability, and harmony between humans, society, and nature.
- The course compares classical texts and indigenous practices with modern scientific ideas to encourage critical understanding
- It highlights how IKS can help solve current issues such as environmental protection, health, community welfare, and sustainable development.

UNIT I	INTRODUCTION TO IKS	9

Definition and characteristics of Indian Knowledge Systems - Historical evolution from ancient times to the 18th century CE - Impact of colonial education policies and the need for revisiting traditional Knowledge - Traditional educational institutions: Gurukuls, Pathshalas, Takshashila, and Nalanda - Local heritage sites and their relevance

UNIT II	INTRODUCTION TO ANCIENT INDIAN MATHEMATICS AND ASTRONOMY	9

Mathematics: Ancient numeral systems and mathematical concepts - Logic: Indian logic systems and epistemology - Overview of Indian astronomy; celestial coordinate systems and calendar systems - Astronomical Instruments (Yantras)- Application of Physics and Chemistry

UNIT III	INTRODUCTION TO HEALTH AND MEDICINE	9

In-depth study of Ayurveda, its diagnostic methods, and therapeutic practices - Understanding the holistic approach to health encompassing physical, mental, and spiritual well-being - Application of Ayurveda principles in contemporary healthcare systems - Ayurvedic perspectives on health, including dietary regimes, disease management, elements of wellness—and their intersections with botany and medical science		
UNIT IV	**INTRODUCTION TO ANCIENT GOVERNANCE AND PUBLIC ADMINISTRATION**	**9**
Analysis of ancient Indian governance models and administrative structures - Insights from texts like Arthashastra on statecraft and economics - Relevance of traditional governance principles in modern administrative Practices - Concept of Kingship; duties and responsibilities of a monarch - Three-tier political system: Dharmadanda, Rajdanda, Nyāyadanda - Law & administration, crime suppression, defence systems, foreign policy - Concept of wealth, ownership, and distribution - Kautilya's "Saptanga" model (seven sources of income) - Taxation, savings, and expenditure in ancient Indian economy		
UNIT V	**INTRODUCTION TO ANCIENT ARTS AND CULTURE**	**9**
Study of traditional Indian art forms, including sculpture, dance, and music - Understanding the cultural significance and philosophical underpinnings of these art forms - Promotion of cultural heritage through education and practice - Temple architecture overview - Cave and monolithic architecture - Architectural styles: Chalukya, Pallava, Chola, Hoysala, Mauryan, Vijayanagara. Buddhist and Jain art & architectural heritage.		
		TOTAL: 45 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Design and implement the various protocols in wireless networks.	
CO2:	Learn basic ideas of ancient Indian mathematics and astronomy.	
CO3:	Understand the principles of Ayurveda and holistic health.	
CO4:	Learn how ancient Indian governance and administration worked.	
CO5:	Understand traditional Indian art, architecture, and cultural heritage.	
TEXT BOOKS:		
1.	Kaveh Pahlavan, "Principles of wireless networks", Prentice-Hall of India, 2008	
REFERENCES:		
1.	Introduction to Indian Knowledge System: Concepts and Applications by B. Mahadevan	
2.	Indian Knowledge System by Kapil Kapoor and Avadhesh Kumar Singh	
3	Traditional Knowledge System in India by Amit Jha.	

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	2	-	-	-	-	-	1	-	-	2	2	-	-
CO2	3	3	2	2	-	-	-	-	1	-	-	2	3	-	-
CO3	2	2	1	-	-	-	-	-	1	-	-	3	2	2	-
CO4	2	3	2	1	-	-	-	-	2	-	-	2	-	-	-
CO5	1	2	1	-	-	-	-	-	1	-	-	2	2	2	-
CO	2	2	2	1		-	-	-	1	-		2	2	1	

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24MX3083	PRODUCTION AND OPERATIONS MANAGEMENT FOR ENTREPRENEURS	L	T	P	C
		3	0	0	0

COURSE OBJECTIVES:

- To know the basic concept and function of Production and Operation Management for entrepreneurship
- To understand the Production process and planning.
- To understand the Production and Operations Management Control for business owners.
- To understand the Production and Management process
- To understand the process of Controlling Productions..

UNIT I	INTRODUCTION TO PRODUCTION AND OPERATIONS MANGEMENT	9

Functions of Production Management - Relationship between production and other functions – Production management and operations management, Characteristics of modern production and operation management, organization of production function, recent trends in production /operations management - production as an organizational function, decision making in production Operations research

UNIT II	PRODUCTION & OPERATION SYSTEMS	9

Production Systems- principles – Models - CAD and CAM- Automation in Production - Functions and significance- Capacity and Facility Planning: Importance of capacity planning- Capacity measurement – Capacity Requirement Planning (CRP) process for manufacturing and service industry

UNIT III	PRODUCTION & OPERATIONS PLANNING	9

Facility Planning – Location of facilities – Location flexibility – Facility design process and techniques – Location break even analysis-Production Process Planning: Characteristic of production process systems – Steps for production process- Production Planning Control Functions – Planning phase- Action phase- Control phase - Aggregate production planning

UNIT IV	PRODUCTION & OPERATIONS MANAGEMENT PROCESS	9

Process selection with PLC phases- Process simulation tools- Work Study – Significance – Methods, evolution of normal/ standard time – Job design and rating - Value Analysis - Plant Layout: meaning – characters –- Plant location techniques - Types- MRP and Layout Design - Optimisation and Theory of Constraints (TOC)– Critical Chain Project Management (CCPM)- REL (Relationship) Chart – Assembly line balancing- – Plant design optimisation -Forecasting methods.

UNIT V	CONTROLING PRODUCTION & OPERATIONS MANAGEMENT	9

Material requirement planning (MRP)- Concept- Process and control - Inventory control systems and techniques – JIT and Lean manufacturing - Network techniques - Quality Management: Preventive Vs Breakdown maintenance for Quality – Techniques for measuring quality - Control Chart (X , R , p , np and C chart) - Cost of Quality, Continuous improvement (Kaizen) - Quality awards - Supply Chain Management - Total Quality Management - 6 Sigma approach and Zero Defect Manufacturing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	To understand the basics and functions of Production and Operation Management for business owners.
CO2:	To learn about the Production & Operation Systems
CO3:	To acquaint on the Production & Operations Planning Techniques followed by entrepreneurs

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	in Industries
CO4:	To know about the Production & Operations Management Processes in organisations.
CO5:	To comprehend the techniques of controlling , Production and Operations in industries.

REFERENCES:

1.	Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson, 2007
2.	Adam Jr. Ebert, Production and Operations Management, PHI Publication, 1992
3.	Amitabh Raturi, Production and Inventory Management, 2008.
4.	Muhlemann, Okland and Lockyer, Production and Operation Management, Macmillan India,1992.
5.	Chary S.N, Production and Operations Management, TMH Publications, 2010

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	2	2	3	-	-	-	-	2	2	-	-	3	2	2
CO2	3	2	2	3	-	-	-	-	2	1	-	-	3	3	2
CO3	2	3	2	3	-	-	-	-	2	2	-	-	2	3	2
CO4	2	2	2	3	-	-	-	-	2	1	-	-	2	2	3
CO5	3	3	3	3	-	-	-	-	2	2	-	-	3	3	3
CO	2	2	2	3	-	-	-	-	2	2	-	-	3	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24MX3084	**DISASTER RISK REDUCTION AND MANAGEMENT**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**0**

COURSE OBJECTIVES:

- To impart knowledge on concepts related to disaster, disaster risk reduction, disaster management
- To acquaint with the skills for planning and organizing disaster response
- To understand the types, causes, and impacts of natural and man-made disasters.
- To develop the skills to plan, respond to, and manage disaster situations effectively
- To learn strategies and methods for disaster prevention, preparedness, and mitigation.

UNIT I **HAZRADS, VULNERABILITY AND DISASTER RISKS** **9**

Definition: Disaster, Hazard, Vulnerability, Resilience, Risks – Types of Disasters: Natural, Human induced, Climate change induced –Earthquake, Landslide, Flood, Drought, Fire etc – Technological disasters- Structural collapse, Industrial accidents, oil spills -Causes, Impacts including social, Economic, political, environmental, health, psychosocial, etc.- Disaster vulnerability profile of India and Tamil Nadu - Global trends in disasters: urban disasters, pandemics, Complex emergencies, - -, Inter relations between Disasters and Sustainable development Goals

UNIT II **DISASTER RISK REDUCTION (DRR)** **9**

Sendai Framework for Disaster Risk Reduction, Disaster cycle - Phases, Culture of safety, prevention, mitigation and preparedness community Based DRR, Structural- nonstructural measures, Roles and

responsibilities of- community, Panchayati Raj Institutions / Urban Local Bodies (PRIs/ULBs), States, Centre, and other stakeholders- Early Warning System – Advisories from Appropriate Agencies.- Relevance of indigenous Knowledge, appropriate technology and Local resources		
UNIT III	**DISASTER MANAGEMENT**	**9**
Components of Disaster Management – Preparedness of rescue and relief, mitigation, rehabilitation and reconstruction- Disaster Risk Management and post disaster management – Compensation and Insurance- Disaster Management Act (2005) and Policy - Other related policies, plans, programmers and legislation - Institutional Processes and Framework at State and Central Level- (NDMA –SDMA-DDMA-NRDF- Civic Volunteers)		
UNIT IV	**TOOLS AND TECHNOLOGY FOR DISASTER MANAGEMENT**	**9**
Early warning systems -Components of Disaster Relief: Water, Food, Sanitation, Shelter, Health, Waste Management, Institutional arrangements (Mitigation, Response and Preparedness, – Role of GIS and Information Technology Components in Preparedness, Risk Assessment, Response and Recovery Phases of Disaster – Disaster Damage Assessment. - Elements of Climate Resilient Development –Standard operation Procedure for disaster response – Financial planning for disaster Management		
UNIT V	**DISASTER MANAGEMENT: CASE STUDIES**	**9**
Discussion on selected case studies to analyse the potential impacts and actions in the contest of disasters- Landslide Hazard Zonation: Earthquake Vulnerability Assessment of Buildings and Infrastructure: Case Studies, Drought Assessment: Case Studies, Coastal Flooding: Storm Surge Assessment, Floods: Fluvial and Pluvial Flooding: Case Studies; Forest Fire: Case Studies, Man Made disasters: Case Studies, Space Based Inputs for Disaster Mitigation and Management and field works related to disaster management.- Field work-Mock drill		
		TOTAL: 45 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	To impart knowledge on the concepts of Disaster, Vulnerability and Disaster Risk reduction (DRR)	
CO2:	To enhance understanding on Hazards, Vulnerability and Disaster Risk Assessment prevention and risk reduction.	
CO3:	To develop disaster response skills by adopting relevant tools and technology	
CO4:	Enhance awareness of institutional processes for Disaster response in the country	
CO5:	Develop rudimentary ability to respond to their surroundings with potential Disaster response in areas where they live, with due sensitivity	
TEXT BOOKS:		
1.	Taimpo (2016), Disaster Management and Preparedness, CRC Publications	
2.	Singh R (2017), Disaster Management Guidelines for earthquakes, Landslides, Avalanches and tsunami, Horizon Press Publications	
3.	Singhal J.P. “Disaster Management”, Laxmi Publications, 2010. ISBN-10: 9380386427 ISBN-13: 978-9380386423	
4.	Tushar Bhattacharya, “Disaster Science and Management”, McGraw Hill India Education Pvt. Ltd., 2012. ISBN-10: 1259007367, ISBN-13: 978-1259007361]	
REFERENCES:		
1.	Govt. of India: Disaster Management Act, Government of India, New Delhi, 2005.	
2.	Government of India, National Disaster Management Policy, 2009.	
3.	Shaw R (2016), Community based Disaster risk reduction, Oxford University Press	

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CO's-PO's & PSO's MAPPING:

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	3	-	-	1	1	2	2	-	-	2	-	1
CO2	3	3	3	3	-	-	1	1	2	1	-	-	2	-	1
CO3	3	3	3	3	-	-	1	1	2	2	-	-	2	-	1
CO4	3	3	2	3	-	-	1	1	2	1	-	-	2	-	1
CO5	3	3	2	3	-	-	1	1	2	2	-	-	3	-	1
CO	3	3	2	3	-	-	1	1	2	2	-	-	2	-	1

1 - low, 2 - medium, 3 - high, '-' - no correlation

24MX3085	WELL-BEING WITH TRADITIONAL PRACTICES-YOGA, AYURVEDA AND SIDDHA	L	T	P	C
		3	0	0	0

COURSE OBJECTIVES:

- To enjoy life happily with fun filled new style activities that help to maintain health
- To adapt a few lifestyle changes that will prevent many health disorders
- To be cool and handbill every emotion very smoothly in every walk of life
- To learn to eat cost effective but healthy foods that are rich in essential nutrients
- To develop immunity naturally that will improve resistance against many health disorders

UNIT I **HEALTH AND ITS IMPORTANCE** **9**

Health: Definition - Importance of maintaining health - More importance on prevention than treatment - Ten types of health one has to maintain - Physical health - Mental health - Social health - Financial health - Emotional health - Spiritual health - Intellectual health - Relationship health - Environmental health - Occupational/Professional heath.

Present health status - The life expectancy-present status - mortality rate - dreadful diseases - Non-communicable diseases (NCDs) the leading cause of death - 60% - heart disease – cancer – diabetes - chronic pulmonary diseases - risk factors – tobacco – alcohol - unhealthy diet - lack of physical activities.

Types of diseases and disorders - Lifestyle disorders – Obesity – Diabetes - Cardiovascular diseases – Cancer – Strokes – COPD - Arthritis - Mental health issues.

Causes of the above diseases / disorders - Importance of prevention of illness - Takes care of health - Improves quality of life - Reduces absenteeism - Increase satisfaction - Saves time

Simple lifestyle modifications to maintain health - Healthy Eating habits (Balanced diet according to age) Physical Activities (Stretching exercise, aerobics, resisting exercise) - Maintaining BMI-Importance and actions to be taken

UNIT II **DIET** **9**

Role of diet in maintaining health - energy one needs to keep active throughout the day - nutrients one needs for growth and repair - helps one to stay strong and healthy - helps to prevent diet-related illness, such as some cancers - keeps active and - helps one to maintain a healthy weight - helps to reduce risk of developing lifestyle disorders like diabetes – arthritis – hypertension – PCOD – infertility – ADHD – sleeplessness -helps to reduce the risk of heart diseases - keeps the teeth and bones strong.

Balanced Diet and its 7 Components - Carbohydrates – Proteins – Fats – Vitamins – Minerals - Fibre and Water.

Food additives and their merits & demerits - Effects of food additives - Types of food additives - Food additives and processed foods - Food additives and their reactions

Definition of BMI and maintaining it with diet -Importance - Consequences of not maintaining BMI - different steps to maintain optimal BM

Common cooking mistakes- Different cooking methods, merits and demerits of each method

UNIT III	**ROLE OF AYURVEDA & SIDDHA SYSTEMS IN MAINTAINING HEALTH**	**9**

AYUSH systems and their role in maintaining health - preventive aspect of AYUSH - AYUSH as a soft therapy.

Secrets of traditional healthy living - Traditional Diet and Nutrition - Regimen of Personal and Social Hygiene - Daily routine (Dinacharya) - Seasonal regimens (Ritucharya) - basic sanitation and healthy living environment - Sadvritta (good conduct) - for conducive social life.

Principles of Siddha & Ayurveda systems - Macrocosm and Microcosm theory - Pancheekarana Theory / **(**Five Element Theory) 96 fundamental Principles - Uyir Thathukkal **(**Tri-Dosha Theory) - Udal Thathukkal

Prevention of illness with our traditional system of medicine

Primary Prevention - To decrease the number of new cases of a disorder or illness - Health promotion/education, and - Specific protective measures - Secondary Prevention - To lower the rate of established cases of a disorder or illness in the population (prevalence) - Tertiary Prevention - To decrease the amount of disability associated with an existing disorder.

UNIT IV	**MENTAL WELLNESS**	**9**

Emotional health - Definition and types - Three key elements: the subjective experience - the physiological response - the behavioral response - Importance of maintaining emotional health - Role of emotions in daily life -Short term and long term effects of emotional disturbances - Leading a healthy life with emotions - Practices for emotional health - Recognize how thoughts influence emotions - Cultivate positive thoughts - Practice self-compassion - Expressing a full range of emotions.

Stress management - Stress definition - Stress in daily life - How stress affects one's life - Identifying the cause of stress - Symptoms of stress - Managing stress (habits, tools, training, professional help) - Complications of stress mismanagement.

Sleep - Sleep and its importance for mental wellness - Sleep and digestion.

Immunity - Types and importance - Ways to develop immunity		
UNIT V	**YOGA**	**9**
Definition and importance of yoga - Types of yoga - How to Choose the Right Kind for individuals according to their age - The Eight Limbs of Yoga - Simple yogasanas for cure and prevention of health disorders - What yoga can bring to our life.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Learn the importance of different components of health
CO2:	Gain confidence to lead a healthy life
CO3:	Learn new techniques to prevent lifestyle health disorders
CO4:	Understand the importance of diet and workouts in maintaining health
CO5:	Understand the importance of yoga and physical fitness.
TEXT BOOKS:	
1.	Nutrition and Dietetics - Ashley Martin, Published by White Word Publications, New York, NY 10001, USA
2.	Yoga for Beginners_ 35 Simple Yoga Poses to Calm Your Mind and Strengthen Your Body, by Cory Martin, Copyright © 2015 by Althea Press, Berkeley, California
REFERENCES:	
1.	What we know about emotional intelligence How It Affects Learning, Work, Relationships, and Our Mental Health, by Moshe Zeidner, Gerald Matthews, and Richard D. Roberts
2.	A Bradford Book, The MIT Press, Cambridge, Massachusetts, London, England The Mindful Self-Compassion Workbook, Kristin Neff, Ph.D Christopher Germer, Ph.D, Published by The Guilford Press A Division of Guilford Publications, Inc.370 Seventh Avenue, Suite 1200, New York, NY 10001

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	2	-	-	-	-	-	-	1	-	1	-	-	-
CO2	3	2	2	-	-	-	-	-	-	1	-	1	-	-	-
CO3	2	1	2	-	-	-	-	-	-	2	1	1	-	-	-
CO4	1	-	2	-	-	-	-	-	-	2	1	2	-	-	-
CO5	2	1	1	-	-	-	-	-	-	1	1	2	-	-	-
CO	2	1	2	-	-	-	-	-	-	1	1	1	-	-	-

1 - low, 2 - medium, 3 - high, '-' - no correlation

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MANDATORY COURSES II

24MX3086	ENVIRONMENTAL SCIENCES AND SUSTAINABILITY	L	T	P	C
		3	0	0	0

COURSE OBJECTIVES:

- To introduce the basic concepts of environment, ecosystems and biodiversity and emphasize on the biodiversity of India and its conservation.
- To impart knowledge on the causes, effects and control or prevention measures of environmental pollution and natural disasters.
- To facilitate the understanding of global and Indian scenario of renewable and nonrenewable resources, causes of their degradation and measures to preserve them.
- To familiarize the concept of sustainable development goals and appreciate the interdependence of economic and social aspects of sustainability, recognize and analyze climate changes, concept of carbon credit and the challenges of environmental management.
- To inculcate and embrace sustainability practices and develop a broader understanding on green materials, 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– ecological succession. Types of biodiversity: genetic, species and ecosystem diversity– values of biodiversity, India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ.

UNIT II	ENVIRONMENTAL POLLUTION	9

Causes, Effects and Preventive measures of Water, Soil, Air and Noise Pollutions. Solid, Hazardous and E-Waste management. Case studies on Occupational Health and Safety Management system (OHASMS). Environmental protection, Environmental protection acts .

UNIT III	RENEWABLE SOURCES OF ENERGY	9

Energy management and conservation, New Energy Sources: Need of new sources. Different types new energy sources. Applications of- Hydrogen energy, Ocean energy resources, Tidal energy conversion. Concept, origin and power plants of geothermal 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 Climate change- Global, Regional and local environmental issues and possible solutions-case studies. 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 14000 Series, Material Life cycle assessment, Environmental Impact Assessment. Sustainable habitat: Green buildings, Green materials, Energy efficiency, Sustainable transports. Sustainable energy: Non-conventional Sources, Energy Cycles carbon cycle, emission and sequestration, Green Engineering: Sustainable urbanization- Socio economical and technological change.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	To recognize and understand the functions of environment, ecosystems and biodiversity and their conservation.

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CO2:	To identify the causes, effects of environmental pollution and natural disasters and contribute to the preventive measures in the society.
CO3:	To identify and apply the understanding of renewable and non-renewable resources and contribute to the sustainable measures to preserve them for future generations.
CO4:	To recognize the different goals of sustainable development and apply them for suitable technological advancement and societal development.
CO5:	To demonstrate the knowledge of sustainability practices and identify green materials, energy cycles and the role of sustainable urbanization.
TEXT BOOKS:	
1.	Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers ,2018.
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.
REFERENCES:	
1.	R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38 . edition 2010.
2.	Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3.	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, Third Edition, 2015.
5.	ErachBharucha "Textbook of Environmental Studies for Undergraduate Courses" Orient Blackswan Pvt. Ltd. 2013.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	1	-	-	-	2	3	-	-	-	-	2	-	-	-
CO2	3	2	-	-	-	3	3	-	-	-	-	2	-	-	-
CO3	3	-	1	-	-	2	2	-	-	-	-	2	-	-	-
CO4	3	2	1	1	-	2	2	-	-	-	-	2	-	-	-
CO5	3	2	1	-	-	2	2	-	-	-	-	1	-	-	-

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24MX3087	HISTORY OF SCIENCE AND TECHNOLOGY IN INDIA	L	T	P	C
		3	0	0	0

COURSE OBJECTIVES:

- To understand the basic concepts of history and science in India.
- To learn about important historians of science and technology.
- To study science and technology in ancient India.
- To study science and technology in medieval India.
- To learn about science and technology in colonial and modern India.

UNIT I	CONCEPTS AND PERSPECTIVES	9

Meaning of History Objectivity, Determinism, Relativism, Causation, Generalization in History; Moral judgment in history Extent of subjectivity, contrast with physical sciences, interpretation and speculation, causation verses evidence, concept of historical inevitability, Historical Positivism. Science and Technology- Meaning, Scope and Importance, Interaction of science, technology & society, Sources of history on science and technology in India.

UNIT II	HISTORIOGRAPHY OF SCIENCE AND TECHNOLOGY IN INDIA	9

Introduction to the works of D.D. Kosambi, Dharmpal, Debiprasad Chattopadhyay, Rehman, S. Irfan Habib, Deepak Kumar, Dhruv Raina, and others.

UNIT III	SCIENCE AND TECHNOLOGY IN ANCIENT INDIA	9

Technology in pre-historic period Beginning of agriculture and its impact on technology Science and Technology during Vedic and Later Vedic times Science and technology from 1st century AD to C-1200.

UNIT IV	SCIENCE AND TECHNOLOGY IN MEDIEVAL INDIA	9

Legacy of technology in Medieval India, Interactions with Arabs Development in medical knowledge, interaction between Unani and Ayurveda and alchemy Astronomy and Mathematics: interaction with Arabic Sciences Science and Technology on the eve of British conquest

UNIT V	SCIENCE AND TECHNOLOGY IN COLONIAL INDIA AND POST-INDEPENDENT INDIA	9

Science and the Empire Indian response to Western Science Growth of techno-scientific institutions- Science, Technology and Development discourse Shaping of the Science and Technology Policy Developments in the field of Science and Technology Science and technology in globalizing India Social implications of new technologies like the Information Technology and Biotechnology.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Understand the relationship between history, science, and society in India.
CO2:	Recognize contributions of major historians of science.
CO3:	Explain scientific and technological developments in ancient India.
CO4:	Describe science and technology during medieval India.
CO5:	Understand modern science and technology and their social impact in India.

REFERENCES:

1.	History of Science and Technology in India by Dr. Binod Bihari Satpathy
2.	R. Parthasarathy, Paths of Innovators In Science, Engineering and Technology, EastWest Books (Madras) Pvt. Ltd, 2000.
3.	Glimpses of India‘s Statistical Heritage, Edited by: J.K. Ghosh, S.K. Mitra, K.R. Parthasarathy, Wiley Eastern Limited, 1992.

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4.	Jagjit Singh, Some Eminent Indian Scientists, Publications Division, Ministry of Information and Broadcasting, Government of India, 1991.
5.	B.C. Berndt and R.A. Rankin, Ramanujan: Essays and Surveys, Hindustan Book Agency, 2003.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	-	-	-	-	-	3	2	2	-	2	1	3	-	-	-
CO2	-	-	-	-	-	3	2	2	-	2	1	3	-	-	-
CO3	-	-	-	-	-	3	2	2	-	2	1	3	-	-	-
CO4	-	-	-	-	-	3	2	2	-	2	1	3	-	-	-
CO5	-	-	-	-	-	3	2	3	-	2	1	3	-	-	-

1 - low, 2 - medium, 3 - high, '-' - no correlation

24MX3088	POLITICAL AND ECONOMIC THOUGHT FOR A HUMAN SOCIETY	L	T	P	C
		3	0	0	0

COURSE OBJECTIVES:

- To introduce students to human needs, desires, and the evolution of political and economic systems aimed at fulfilling them.
- To examine and critically analyse major political and economic systems, including capitalism, communism, fascism, welfare state, and liberal democracy.
- To explore Gandhian thought and Indian civilisational perspectives as models for a humane and just society.
- To understand the role of technology, education, and social transformation in shaping human welfare and societal progress.
- To enable students to evaluate and propose alternative political-economic frameworks that promote equity, sustainability, and human well-being.

UNIT I	FOUNDATIONS OF A HUMANE SOCIETY	9

Considerations for a humane society – Holistic thought – Human being's desires – Harmony in the self – Harmony in human relationships – Harmony in society and nature – Introduction to societal systems.

UNIT II	CAPITALISM, FASCISM & TOTALITARIAN SYSTEMS	9

Capitalism: Free Markets, Demand–Supply, Perfect Competition, Laissez-Faire, Monopolies, Imperialism – Liberal Democracy. Fascism & Totalitarianism – World War I & II – Cold War.

UNIT III	COMMUNISM & WELFARE STATE	9

Communism: Mode of production – Theory of labour – Surplus value – Class struggle – Dialectical materialism – Historical materialism – Russian and Chinese models. Welfare State: relation with human desires – Empowered human beings – Satisfaction and well-being.

UNIT IV	GANDHIAN THOUGHT & INDIAN CIVILISATION	9

Gandhian thought: Swaraj – Decentralized economy and polity – Community life – Control over one's life – Relationship with nature. Essential elements of Indian civilisation – Cultural, ethical and social foundations.

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UNIT V	TECHNOLOGY, EDUCATION & FUTURE DIRECTIONS	9
Technology as a driver of society – Technology and human relationships – Role of education in shaping society – Social transformation – Future directions for a humane society – Conclusion.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Understand the relationship between human needs, desires, and the evolution of political and economic systems.
CO2:	Analyse and compare different political-economic systems, including capitalism, communism, fascism, welfare state, and liberal democracy, in terms of human welfare and social justice.
CO3:	Evaluate Gandhian thought and Indian civilisational perspectives as approaches to building a humane and equitable society.
CO4:	Assess the role of technology, education, and social transformation in shaping society and promoting human well-being.
CO5:	Apply political-economic theories and perspectives to contemporary issues and propose pathways for a sustainable and humane society.
REFERENCES:	
1.	M.K. Gandhi, Hind Swaraj, Navajivan Publishing House
2.	Adam Smith, The Wealth of Nations, Oxford University Press
3.	Karl Marx, Selected Writings, Oxford University Press
4.	E.F. Schumacher, Small Is Beautiful: Economics as if People Mattered, Harper & Row

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	2	1	-	-	-	-	-	-	-	-	1	-	-	-
CO2	3	3	2	2	-	-	-	-	1	-	-	2	-	-	-
CO3	3	2	2	1	-	-	-	-	2	1	-	2	-	-	-
CO4	2	2	2	3	2	-	-	-	2	1	1	2	-	-	-
CO5	3	3	2	2	2	-	-	-	3	2	1	2	-	-	-

1 - low, 2 - medium, 3 - high, '-' - no correlation

24MX3089	STATE, NATION BUILDING AND POLITICS IN INDIA	L	T	P	C
		3	0	0	0

COURSE OBJECTIVES:
● To provide an understanding of the State, its functions, and the working of its main organs.
● To explain the primacy of politics, political processes, and the concept of sovereignty, including its changing nature in a globalized world.
● To acquaint students with the major developments and legacies of the Indian national movement and constitutional evolution.
● To analyse the rationale for adopting a Parliamentary–Federal system in India and understand the broad philosophy underlying the Indian Constitution.

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● To examine the challenges of national integration and nation-building, and to encourage students to envision future pathways for a more inclusive and better India.		
UNIT I	**STATE, SOVEREIGNTY AND POLITICAL SYSTEM**	**9**
Understanding the Need and Role of the State – Meaning and Scope of Politics – Development of the Nation-State – Concept of Sovereignty – Types and Features of Sovereignty – Sovereignty in a Globalized World – Organs of the State: Executive, Legislature, Judiciary – Functions of Each Organ – Separation of Powers – Forms of Government: Unitary and Federal; Presidential and Parliamentary Systems.		
UNIT II	**IDEA OF INDIA AND THE NATIONAL MOVEMENT**	**9**
The Idea of India – 1857 and the National Awakening – Emergence of National Consciousness – Formation of the Indian National Congress (1885) – Phases of the National Movement – Legacies of the Freedom Struggle – Constitution Making Process – Constituent Assembly Debates – Goals, Objectives and Philosophy of the Indian Constitution.		
UNIT III	**FEDERALISM, NATIONAL INTEGRATION AND NATION-BUILDING**	**9**
Why a Federal System? – Features of Indian Federalism – Centre–State Relations – National Integration: Meaning, Need and Challenges – Nation-Building: Issues of Identity, Diversity and Unity – Challenges of Nation-Building – Rajni Kothari's "State Against Democracy" – Democracy, Pluralism and Integration.		
UNIT IV	**SOCIAL MOVEMENTS AND POLITICAL TRANSFORMATION**	**9**
New Social Movements – Women's Movements – Farmers' Movements – Dalit Movements – Environmental Movements – Human Rights Movements – Civil Society and People's Initiatives – Role of Social Mobilization in Nation-Building – Political Participation and Citizenship.		
UNIT V	**CONTEMPORARY INDIAN POLITICAL SYSTEM AND FUTURE DIRECTIONS**	**9**
The Changing Nature of the Indian Political System – Shifts in Party Systems – Electoral Behaviour – Governance Challenges – Role of Media and Public Opinion – Political Reforms – Future Scenario of Indian Democracy – What Can We Do? – Strengthening Participation, Accountability and Democratic Governance.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1	Explain the theoretical foundations of the State, its organs, and their functioning within the political system.
CO2	Describe the historical background, philosophy and evolution of the Indian political system and constitutional framework.
CO3	Analyse the major streams, issues and challenges related to national integration and nation-building in India.
CO4	Evaluate the functioning of India's political processes and governance mechanisms from an informed and critical perspective.
CO5	Propose constructive ways for effective citizen participation aimed at strengthening governance, democratic delivery systems, and societal well-being.

REFERENCES:	
1.	Sunil Khilnani, The Idea of India. Penguin India Ltd., New Delhi.
2.	Madhav Khosla, The Indian Constitution, Oxford University Press. New Delhi, 2012.
3.	Brij Kishore Sharma, Introduction to the Indian Constitution, PHI, New Delhi, latest edition.
4.	Sumantra Bose, Transforming India: Challenges to the World's Largest Democracy, Picador India, 2013.

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5.	AtulKohli, Democracy and Discontent: India's Growing Crisis of Governability, Cambridge University Press, Cambridge, U. K., 1991.
6.	M. P. Singh and RekhaSaxena, Indian Politics: Contemporary Issues and Concerns, PHI, New Delhi, 2008, latest edition.
7.	Rajni Kothari, Rethinking Democracy, Orient Longman, New Delhi, 2005.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	2	-	2	-	3	2	2	2	2	-	3	3	-	-
CO2	2	2	-	2	-	2	2	2	1	2	-	3	3	-	-
CO3	2	3	-	3	-	3	3	2	2	2	-	3	3	2	2
CO4	2	3	2	3	-	3	3	2	2	3	-	3	3	2	2
CO5	2	2	2	3	-	3	3	2	3	3	2	3	3	3	3

1 - low, 2 - medium, 3 - high, '-' - no correlation

24MX3090	INDUSTRIAL SAFETY	L	T	P	C
		3	0	0	0

COURSE OBJECTIVES:

- To understand the Introduction and basic Terminologies safety.
- To enable the students to learn about the Important Statutory Regulations and standards.
- To enable students to Conduct and participate the various Safety activities in the industry.
- To have knowledge about Workplace Exposures and Hazards.
- To assess the various Hazards and consequences through various Risk Assessment Techniques.

UNIT I	SAFETY TERMINOLOGIES	9

Hazard-Types of Hazard- Risk-Hierarchy of Hazards Control Measures-Lead indicators- lag Indicators-Flammability- Toxicity Time-weighted Average (TWA) - Threshold LimitValue (TLV) - Short Term Exposure Limit (STEL)- Immediately dangerous to life or health (IDLH)- acute and chronic Effects- Routes of Chemical Entry-Personnel Protective Equipment- Health and Safety Policy-Material Safety Data Sheet MSDS

UNIT II	STANDARDS AND REGULATIONS	9

Indian Factories Act-1948- Health- Safety- Hazardous materials and Welfare- ISO 45001:2018 occupational health and safety (OH&S) - Occupational Safety and Health Audit IS14489:1998- Hazard Identification and Risk Analysis- code of practice IS 15656:2006

UNIT III	SAFETY ACTIVITIES	9

Toolbox Talk- Role of safety Committee- Responsibilities of Safety Officers and Safety Representatives-Safety Training and Safety Incentives- Mock Drills- On-site Emergency Action Plan- Off-site Emergency Action Plan- Safety poster and Display- Human Error Assessment

UNIT IV	WORKPLACE HEALTH AND SAFETY	9

Noise hazard- Particulate matter- musculoskeletal disorder improper sitting poster and lifting Ergonomics RULE & REBA- Unsafe act & Unsafe Condition- Electrical Hazards- Crane Safety- Toxic gas Release		
UNIT V	**HAZARD IDENTIFICATION TECHNIQUES**	**9**
Job Safety Analysis-Preliminary Hazard Analysis-Failure mode and Effects Analysis- Hazard and Operability- Fault Tree Analysis- Event Tree Analysis Qualitative and Quantitative Risk Assessment- Checklist Analysis- Root cause analysis- What-If Analysis- and Hazard Identification and Risk Assessment.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Understand the basic concept of safety.
CO2:	Obtain knowledge of Statutory Regulations and standards.
CO3:	Know about the safety Activities of the Working Place.
CO4:	Analyze on the impact of Occupational Exposures and their Remedies
CO5:	Obtain knowledge of Risk Assessment Techniques.
TEXT BOOKS	
1	R.K. Jain and Prof. Sunil S. Rao Industrial Safety, Health and Environment Management Systems KHANNA PUBLISHER
2	L. M. Deshmukh Industrial Safety Management: Hazard Identification and Risk Control McGraw-Hill Education
REFERENCES:	
1.	Frank Lees (2012) 'Lees' Loss Prevention in Process Industries.Butterworth-Heinemann publications, UK, 4th Edition.
2.	John Ridley & John Channing (2008)Safety at Work: Routledge, 7th Edition.
3.	Dan Petersen (2003) Techniques of Safety Management: A System Approach.
4.	Alan Waring.(1996).Safety management system: Chapman &Hall,England
5.	Society of Safety Engineers, USA

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	1	1	3	2	2	3	3	1	3	3	3	3
CO2	2	3	2	2	1	3	2	3	3	2	1	3	3	3	3
CO3	2	2	2	2	1	2	2	2	3	2	1	2	3	3	3
CO4	3	3	3	2	2	3	2	2	3	2	1	3	3	3	3
CO5	3	2	3	2	2	3	2	2	3	2	2	3	3	3	3

1 - low, 2 - medium, 3 - high, '-' - no correlation

Anna University Nominee **Academic Expert 1** **Academic Expert 2**

Industry Person **Alumni Member**

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PROFESSIONAL ELECTIVE COURSES: VERTICALS

VERTICAL 1: SEMICONDUCTOR CHIP DESIGN AND TESTING

24CEC101	WIDE BANDGAP DEVICES	L	T		P	C
		2	0		2	3

COURSE OBJECTIVES:

- To Introduce the concept of wide band gap (WBG) devices and its application in real world
- To understand the advantages and disadvantages of WBG devices
- To Provide an introduction to basic operation of WBG power devices
- To Learn Design principles of modern power devices
- To Learn high frequency design complexity

UNIT I	WBG DEVICES AND THEIR APPLICATION IN REAL WORLD	6

Review of semiconductor basics, Operation and characteristics of the SiC Schottky Barrier Diode, SiC DMOSFET and GaN HEMT, Review of Wide bandgap semiconductor technology -Advantages and disadvantages

UNIT II	SWITCHING CHARACTERIZATION OF WBG	6

Turn-on and Turn-off characteristics of the device, Hard switching loss analysis, Double pulse test set-up

UNIT III	DRIVERS FOR WIDE BAND GAP DEVICES	6

Gate driver, Impact of gate resistance, Gate drivers for wide bandgap power devices .Transient immunity integrated gate drivers

UNIT IV	HIGH FREQUENCY DESIGN COMPLEXITY AND PCB DESIGNING	6

Effects of parasitic inductance, Effects of parasitic capacitance, EMI filter design for high frequency power converters High frequency PCB design, Conventional power loop design, High frequency power loop optimization, Separation of power from signal PCB

UNIT V	APPLICATIONS OF WIDE BANDGAP DEVICES	6

Consumer electronics applications, Wireless power transfer applications, Electric vehicle applications , Renewable energy sources applications

PRACTICAL EXERCISES:

1. Conduct switching loss and Magnetic loss on Low side

2. Conduct Double pulse test (DPT) and learn IEC 60747 -8/9 standards

3. Conduct experiments for Diode reverse recovery on High side

4. Conduct Power analysis and harmonic measurement

5. Measure Turn on /off delay. Calculate recovery softness factor , measure reverse recovery energy.

TOTAL: 30+30=60 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Students master design principles of power devices
CO2:	Students become familiar with reliability issues and testing methods
CO3:	An ability to design and conduct experiments, as well as to analyze and interpret data
CO4:	Student to get real life experience and to know practical applications of WBG
CO5:	In-depth knowledge on practical usage of this technology

TEXT BOOKS:

1.	A. Lidow, J. Strydom, M. D. Rooij, D. Reusch, GaN Transistors for Efficient Power Convertion, Wiley, 2014, ISBN-13: 978-1118844762
2.	G. Meneghesso, M. Meneghini, E. Zanoni, “Gallium Nitride-enabled High Frequency and High Efficiency Power Conversion,” Springer International Publishing, 2018, ISBN: 978-3319-77993-5

REFERENCES:

1.	F. Wang, Z. Zhang and E. A. Jones, Characterization of Wide Bandgap Power Semiconductor Devices, IET, ISBN-13: 978-1785614910 (2018).
2.	B.J.Baliga, “Gallium Nitride and Silicon Carbide Power Devices,” World Scientific Publishing Company (3 Feb. 2017).
3	L. Corradini, D. Maksimovic, P. Mattavelli, R. Zane, “Digital Control of High Frequency Switched-Mode Power Converters”, Wiley, ISBN-13: 978-1118935101 (9th June, 2015)

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	3	3	2	3	2	-	-	-	-	-	1	1	3	2
CO2	3	3	3	2	2	2	-	-	-	-	-	-	3	1	2
CO3	3	3	3	3	2	2	-	-	-	-	-	1	3	1	2
CO4	2	3	2	2	2	2	-	-	-	-	-	1	2	1	1
CO5	2	-	3	3	2	1	-	-	-	-	-	1	2	2	2
CO	**3**	**3**	**2**	**2**	**2**	**2**	-	-	-	-	-	**1**	**3**	**1**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC102	**HIGH SPEED SEMICONDUCTOR DEVICES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand the basic factors that affect the speed of semiconductor devices and circuits.
- To understand the working of high-speed silicon-based MOSFET and BJT circuits and their
- limitations.
- To introduce different semiconductor materials used for high-speed device applications.
- To understand MIS and MOS devices and their interface characteristics.

UNIT I	**HIGH SPEED PERFORMANCE OF DEVICES AND CIRCUITS**	**9**

Transit time of charge carriers, junction capacitances, ON-resistances, carrier mobility, doping concentration and temperature. Contact resistance and interconnection/interlayer capacitances in the Integrated Electronic Circuits. Silicon based MOSFET and BJT circuits for high-speed operation and their limitations: Emitter coupled Logic (ECL) and CMOS Logic circuits with scaled down devices.

UNIT II	**MATERIALS FOR HIGH-SPEED DEVICES AND CIRCUITS**	**9**

Merits of III –V binary and ternary compound semiconductors (GaAs, InP, InGaAs, AlGaAs, SiC, GaN etc.), different SiC structures, silicon-germanium alloys and silicon carbide for high-speed devices,outline of the crystal structure, dopants, Band diagrams, homo and hetro junctions, electrostatic calculations, Band gap engineering

UNIT III	**METAL INSULATOR SEMICONDUCTOR AND METAL OXIDE SEMICONDUCTOR DEVICES**	**9**
Introduction to Metal Insulator and Metal Oxide Semiconductor Materials-Compound semiconductors for MOS devices-Interface state density related issues. Metal semiconductor contacts, Schottky barrier diode. Thermionic Emission model for current transport and V-I characteristics. Effect of interface states and interfacial thin electric layer on the Schottky barrier height.		
UNIT IV	**METAL SEMICONDUCTOR FIELD EFFECT TRANSISTORS (MESFETS)**	**9**
Pinch off voltage and threshold voltage of MESFETs. D.C. characteristics and analysis of drain current. Velocity overshoot effects and the related advantages of GaAs, InP and GaN based devices for high-speed operation. Short channel effects and the performance of scaled down devices		
UNIT V	**HIGH ELECTRON MOBILITY TRANSISTORS (HEMTs)**	**9**
Implementation of electron gases induced by spontaneous and piezoelectric polarization in undoped and doped AlGaN/GaN heterostructures- Design and Characterization of 2DEG Structure of a Gallium Nitride HEMT.		
	TOTAL: 45 PERIODS	
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Identify and explain the parameters that limit the speed of electronic devices and circuits.	
CO2:	Describe the operation of high-speed CMOS, ECL, MOSFET, and BJT circuits.	
CO3:	Compare silicon and compound semiconductor materials for high-speed applications.	
CO4:	Explain the behavior of metal–semiconductor contacts, Schottky diodes, and MOS structures.	
CO5:	Understand the working principles and performance of MESFET and HEMT devices used in high-speed electronics.	
TEXT BOOKS:		
1.	C.Y. Chang, F. Kai, GaAs High-Speed Devices: Physics, Technology and Circuit Applications,Wiley, 1994.	
2.	S.M. Sze, High Speed Semiconductor Devices, Wiley (1990) ISBN 0-471-62307-5.	
REFERENCES:		
1.	Ambacher, O., Foutz, B., Smart, J., Shealy, J.R., Weimann, N.G., Chu, K., Murphy, M., Sierakowski, A.J., Schaff, W.J., Eastman, L.F. and Dimitrov, R., 2000. Two-dimensional	

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	electron gases induced by spontaneous and piezoelectric polarization in undoped and doped AlGaN/GaN heterostructures. Journal of applied physics, 87(1), pp.334-344.
2.	David K. Ferry, Ed., Gallium Arsenide Technology, Howard W. Sams & Co.,1985. Avishay Katz, Indium Phosphide and Related materials: Processing,Technology and Devices, Artech House, 1992.
3	Etienne Sicard, Sonia Delmas Bendhia, "Basics of CMOS Cell Design", TMH, EEE, 2005

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	2	2	1	-	-	-	2	2	3	2	3
CO2	2	3	3	3	2	1	1	-	-	-	2	2	3	3	2
CO3	3	2	2	3	2	3	3	-	-	-	3	2	2	2	2
CO4	3	3	2	3	2	3	3	-	-	-	2	2	1	2	1
CO5	3	2	3	3	3	3	2	-	-	-	2	2	1	2	1
CO	2.8	2.6	2.6	3	2.2	2.4	2	-	-	-	2	2	2	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC103	VALIDATION AND TESTING TECHNOLOGY	L	T	P	C
		2	0	2	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 different design approaches
- To develop the low power low voltage memories
- To Provide fundamental knowledge on the need for silicon validation and testing in VLSI design flow.

UNIT I	TECHNOLOGY INTRODUCTION	6

Introduction to IC Technology – MOS, PMOS, NMOS, CMOS & BiCMOS Technologies. VLSI Fabrication, Oxidation, Lithography, Diffusion, Ion Implantation, Metallization, Integrated Resistors and Capacitors.		
UNIT II	**MOS THEORY ANALYSIS-I**	**6**
Basic Electrical Properties of MOS Circuits: Ids-Vds Relationships, MOS Transistor Threshold Voltage Vth, gm, gds, Figure of Merit ωo, Short Channel and Narrow Channel Width Effects		
UNIT III	**MOS THEORY ANALYSIS- II**	**6**
Pass Transistor, Transmission Gate, NMOS Inverter, Various Pull-ups, CMOS Inverter Analysis and Design, Bi-CMOS Inverters, Latch up in CMOS Circuits.		
UNIT IV	**CMOS CIRCUIT CHARACTERISATION AND PERFORMANCE ESTIMATION**	**6**
Sheet Resistance RS, conductivity and its Concept to MOS, Area Capacitance Units, Calculations - Delays, Driving Large Capacitive Loads, Delay Estimation, Logical Effort and Transistor Sizing, Power Dissipation, Reliability.		
UNIT V	**BASIC OF SILICON VALIDATION**	**6**
Need for Testing, Testing at Various Levels, Objectives of Testing - VLSI Test process and Test Equipment - Types of Testing: Functionality Tests, Silicon Debug, Manufacturing Tests, Defect during manufacturing - Fault Modelling, Observability and Controllability, Fault Coverage, Fault Sampling - ATE, Test economics		
PRACTICAL EXERCISES: 1.MOS TESTING for Ids-Vds Relationships 2.MOSFET testing for threshold voltage like Vth, gate breakdown voltage. 3.Sheet resistivity measurement. 4.Conductivity measurement. 5.Inverter testing 6.Designing of CMOS inverter/ logic gate and testing of delay estimation.		
TOTAL: 30+30=60 PERIODS		
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Complete overview to CMOS fabrication process.	
CO2:	Understand the fundamental concept of MOS FET and testing.	
CO3:	Explain the concept of MOS theory and analysis.	

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CO4:	To give the student an understanding of CMOS performance testing and estimation.
CO5:	Explain the need for VLSI testing and validation across different development stages.
TEXT BOOKS:	
1.	Kamran Ehraghian, Dauglas A. Pucknell and Sholeh Eshraghiam, "Essentials of VLSI Circuits and Systems" – PHI, EEE, 2005 Edition.
2.	Neil H. E. Weste and David. Harris Ayan Banerjee,, "CMOS VLSI Design" - Pearson Education, 1999.
REFERENCES:	
1.	M.L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers, 2004
2.	N.K. Jha and S.G. Gupta, "Testing of Digital Systems", Cambridge University Press, 2003
3	Etienne Sicard, Sonia Delmas Bendhia, "Basics of CMOS Cell Design", TMH, EEE, 2005

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	3	2	2	1	-	-	-	2	2	3	2	3
CO2	2	3	3	3	2	1	1	-	-	-	2	2	3	3	2
CO3	3	2	2	3	2	3	3	-	-	-	3	2	2	2	2
CO4	3	3	2	3	2	3	3	-	-	-	2	2	1	2	1
CO5	3	2	3	3	3	3	2	-	-	-	2	2	1	2	1
CO	2.8	2.6	2.6	3	2.2	2.4	2	-	-	-	2	2	2	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24CEC104	MIXED SIGNAL IC DESIGN TESTING	L	T	P	C
		2	0	2	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	6

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 Equipments – Wafer Probers – Handlers – E-Beam Probers – Focused Ion Beam Equipments – Forced –Temperature

UNIT II	YIELD, MEASUREMENT ACCURACY, AND TEST TIME	6

Yield - Measurement Terminology - Repeatability, Bias, and Accuracy - Calibrations and Checkers - Tester Specifications - Reducing Measurement Error with Greater Measurement Time – Guardbands - Effects of Measurement Variability on Test Yield - Effects of Reproducibilty and Process Variation on Yield - Statistical Process Control

UNIT III	DAC TESTING	6

Memory Test -Memory fault models, Functional architecture as applicable to test, Test of memories, Test of logic around memories, BIST controller configuration, Test of logic around memories, DFT and architecture enhancements, Algorithmic optimisations; Test Interfaces-Test control requirements, Test interfaces - 1500, JTAG, Hierarchical, serial control, Module / IP test, SOC test, Board test, System test, Boundary scan.

UNIT IV	ADC TESTING	6

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 AND SERIAL DATA COMMUNICATIONS CHANNEL MEASUREMENT	6

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.

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PRACTICAL EXERCISES:

DESIGN AND TESTING OF THE FOLLOWING CIRCUITS

1. PLL characteristics and its use as Frequency Multiplier, Clock synchronization
2. R-2R Ladder Type and Flash Type ADC.
3. DC power supply using LM317 and LM723.
4. Design of asynchronous counter
5. Design of synchronous counter
6. Implementation and Testing of RS Latch and Flip-flops

TOTAL: 30 +30=60 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Learn the fundamentals of mixed signal circuits.
CO2:	Define the various measurement terminologies.
CO3:	Acquire knowledge of Analog to Digital Converters
CO4:	Learn testing of Analog to Digital Converters.
CO5:	Comprehend the attributes of a clock signal

TEXT BOOKS:

1.	Gordon W.Roberts, Friedrich Taenzler, Mark Burns, "An Introduction to Mixed-signal IC Test and Measurement" Oxford University Press, Inc.2012 (Unit I - V)
2.	M.L.Bushnell and V.D.Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers, 2002. (Unit - III)
3.	BapirajuVinnakota, "Analog and mixed-signal test", Prentice Hall, 1998.(Unit - II)

REFERENCES:

1.	Digital and Analogue Instrumentation: Testing and Measurement by NihalKularatna

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	2	2	-	-	-	-	-	2	3	3	3
CO2	3	3	2	2	1	2	-	-	-	-	-	2	3	2	3
CO3	3	3	2	2	2	2	-	-	-	-	-	2	3	2	3
CO4	3	3	3	2	2	1	-	-	-	-	-	2	1	2	2
CO5	3	3	3	2	2	2	-	-	-	-	-	3	2	1	2
CO	3	3	2.8	2.2	1.8	1.8	-	-	-	-	-	2.2	3	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC105	ANALOG IC DESIGN	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To study the basics of MOS Circuits.
- To analyse the noise characteristics of amplifiers
- To study the performance parameters of amplifiers
- To comprehend the compensation techniques
- To understand the detection and testing of faults

UNIT I	SINGLE STAGE AMPLIFIERS	6

Basic MOS physics and equivalent circuits and models, CS, CG and Source Follower, differential amplifier with active load, Cascode and Folded Cascode configurations with active load, design of Differential and Cascode Amplifiers – to meet specified SR, noise, gain, BW, ICMR and power dissipation, voltage swing, high gain amplifier structures.

UNIT II	HIGH FREQUENCY AND NOISE CHARACTERISTICS OF AMPLIFIERS	6

Miller effect, association of poles with nodes, frequency response of CS, CG and Source Follower, Cascode and Differential Amplifier stages, statistical characteristics of noise, noise in Single Stage amplifiers, noise in Differential Amplifiers.

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UNIT III	**FEEDBACK AND SINGLE STAGE OPERATIONAL AMPLIFIERS**	**6**
Properties and types of negative feedback circuits, effect of loading in feedback networks, operational amplifier performance parameters, single stage Op Amps, two-stage Op Amps, input range limitations, gain boosting, slew rate, power supply rejection, noise in Op Amps.		
UNIT IV	**STABILITY , FREQUENCY COMPENSATION**	**6**
Multipole Systems, Phase Margin, Frequency Compensation, Compensation Of Two Stage Op Amps, Slewing In Two Stage Op Amps, Other Compensation Techniques.		
UNIT V	**LOGIC CIRCUIT TESTING**	**6**
Faults in Logic Circuits- Basic Concepts of Fault Detection- Design for Testability- Ad Hoc Techniques, Level-Sensitive Scan Design, Partial Scan, Built-in Self-Test		
PRACTICAL EXERCISES: 1. Design a CMOS inverter and analyze its characteristics. 2. Design a Common source amplifier and analyze its performance. 3. Design a Common drain amplifier and analyze its performance. 4. Design a Common gate amplifier and analyze its performance. 5. Design a differential amplifier with resistive load using transistors. 6. Design three stage and five stage ring oscillator circuit and compare its frequencies.		
		TOTAL: 30 +30=60 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Design amplifiers to meet user specifications.	
CO2:	Analyse the frequency and noise performance of amplifiers.	
CO3:	Design and analyse feedback amplifiers and one stage op amps .	
CO4:	Analyse stability of op amp	
CO5:	Testing experience of logic circuits.	
TEXT BOOKS:		
1.	Behzad Razavi, “Design Of Analog Cmos Integrated Circuits”, Tata Mcgraw Hill, 2001.(Unit –I,II,III,IV)	

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2.	Parag K.Lala, “An Introduction to Logic Circuit Testing”,Morgan & Claypool Publishers,2009.(Unit V)
REFERENCES:	
1.	Willey M.C. Sansen, “Analog Design Essentials”, Springer, 2006. 2. 3 4.
2.	. Grebene, “Bipolar And Mos Analog Integrated Circuit Design”, John Wiley & Sons,Inc.,2003. Phillip E.Allen, Douglas R .Holberg, “Cmos Analog Circuit Design”, Oxford University Press, 2nd Edition, 2002
3.	Recorded Lecture Available at http://www.ee.iitm.ac.in/vlsi/courses/ee5320_2021/start
4.	Jacob Baker “CMOS: Circuit Design, Layout, And Simulation, Wiley IEEE Press, 3rd Edition, 2010

CO’s-PO’s & PSO’s MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	3	2	2	-	-	-	-	-	2	3	3	3
CO2	3	3	2	2	1	2	-	-	-	-	-	2	3	2	3
CO3	3	3	2	2	2	2	-	-	-	-	-	2	3	2	3
CO4	3	3	3	2	2	1	-	-	-	-	-	2	1	2	2
CO5	3	3	3	2	2	2	-	-	-	-	-	3	2	1	2
CO	3	3	2.6	2.2	1.8	1.8	-	-	-	-	-	2.2	2.4	2	2

1 - low, 2 - medium, 3 - high, ’-’ - no correlation

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24CEC106	VLSI TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Understand various IC technology.
- Learn MOS theory and testing
- Learn CMOS circuit theory and testing
- Getting expertise on CMOS characterization
- Explore circuit and device level testing methods

UNIT I	SEMICONDUCTOR FUNDAMENTALS & CRYSTAL GROWTH	6

Introduction to VLSI Technology: Scaling trends, IC generations, Moore's Law-Silicon crystal structure & material properties-Impurities, doping, Fermi levels, carrier concentration-Crystal growth techniques: Czochralski (CZ), Float zone (FZ), Epitaxy-Silicon wafer preparation & cleaning-Introduction to GaAs, SiC, GaN, SOI materials

UNIT II	OXIDATION, LITHOGRAPHY & ETCHING	6

Thermal oxidation: Dry & wet oxidation, Deal-Grove model-Lithography: Optical lithography, Electron-beam lithography, Mask materials-Photoresists, pattern resolution, alignment & overlay-Etching: Wet chemical etching, Plasma etching.

UNIT III	DIFFUSION, ION IMPLANTATION & ANNEALING	6

Diffusion fundamentals, Fick's laws, dopant profiles-Diffusion furnaces & oxidation-diffusion coupling-Ion implantation: Process physics, Range theory, Channeling effect-Annealing techniques: RTA, laser annealing, defect removal-Junction depth, sheet resistance & process control

UNIT IV	THIN FILM DEPOSITION & METALLIZATION	6

Physical Vapor Deposition (PVD): Sputtering, evaporation-Chemical Vapor Deposition (CVD): LPCVD, PECVD, ALD-Polysilicon gate technology-Metallization: Al, Cu, W, barrier metals, damascene process-Interconnects: RC delays, electromigration, low-k dielectrics-CMP – Planarization techniques

UNIT V	MOSFET FABRICATION & PROCESS INTEGRATION	6

Overview of CMOS VLSI process flow-Well formation, isolation techniques (LOCOS, STI)-Gate stack engineering: High-k dielectric, metal gate-Source/Drain extensions, LDD, Halo implants-FinFET and advanced transistor nodes (Gate-all-around concept)-Process defects & yield enhancement

TOTAL: 30 PERIODS

COURSE OUTCOMES:

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At the end of the course, the students will be able to:	
CO1:	Understand semiconductor material properties, wafer preparation and epitaxial technologies
CO2:	Explain oxidation, photolithography and etching technologies used in IC fabrication
CO3:	Analyze dopant distribution, junction formation using diffusion and ion implantation
CO4:	Compare various deposition methods and metal interconnect schemes for VLSI devices
CO5:	Describe complete CMOS process flow including advanced transistor technologies & reliability concerns
TEXT BOOKS:	
1.	The "VLSI Technology" text by S. M. Sze remains the standard; its 2nd Edition is the widely referenced version in academic courses.
2.	The "Basic VLSI Design" book by Pucknell & Eshraghian — many courses currently use the 3rd Edition by PHI (or Prentice-Hall)
REFERENCES:	
1.	R. Jacob Baker, CMOS: Circuit Design, Layout, and Simulation

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	-	-	-	-	-	-	-	-	-	3	3	2	3
CO2	2	3	3	-	-	-	-	-	-	-	-	2	3	3	2
CO3	3	2	2	3	-	-	-	-	-	-	-	2	2	2	2
CO4	3	3	2	3	2	-	-	-	-	-	-	2	1	2	1
CO5	3	2	3	3	3	-	2	-	-	-	2	2	1	2	1
CO	2.8	2.6	2.6	3	2.2	2.4	2	-	-	-	2	2	2	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24CEC107	VLSI SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To Understand the fundamentals of DSP hardware architecture and FPGA implementation requirements.
- To Learn techniques for reducing critical path and optimizing performance in arithmetic units.
- To Explore algorithmic strength reduction strategies for digital filters, especially IIR structures.
- To Design high-performance pipelined digital filters considering arithmetic constraints and noise.
- To Analyze synchronous and asynchronous pipelining approaches for low-power and high-performance DSP architectures.

UNIT I	INTRODUCTION	9

Overview of DSP-FPGA Technology-DSP Technology requirements -Design Implementation

UNIT II	METHODS OF CRITICAL PATH REDUCTION	9

Binary Adders-Binary Multipliers-Multiply-Accumulator (MAC) and Sum of Product (SOP)-Pipelining and Parallel Processing-Retiming-Unfolding-Systolic Architecture Design

UNIT III	ALGORITHMIC STRENGTH REDUCTION METHODS AND RECURSIVE FILTER DESIGN	9

Fast Convolution-Pipelined and Parallel Processing of Recursive and Adaptive Filters-Fast IIR Filters Design

UNIT IV	DESIGN OF PIPELINED DIGITAL FILTERS	9

Designing FIR Filters-Digital Lattice Filter Structures-Bit-Level Arithmetic Architecture-Redundant Arithmetic-Scaling and Round-off Noise

UNIT V	SYNCHRONOUS ASYNCHRONOUS PIPELINING AND PROGRAMMABLE DSP	9

Numeric Strength Reduction-Synchronous, Wave and Asynchronous Pipelines-Low Power Design-Programmable DSPs-DSP Architectural Features / Alternatives for High Performance and Low Power.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Identify architectural features and implementation issues in DSP systems

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CO2:	Apply critical path reduction techniques like pipelining, retiming, unfolding in VLSI DSP circuits
CO3:	Evaluate algorithmic strength reduction techniques for recursive filters
CO4:	Design pipelined FIR/IIR digital filters with efficient arithmetic structures
CO5:	Compare synchronous, wave and asynchronous pipelining strategies in programmable DSP processors for low-power operation
TEXT BOOKS:	
1.	Keshab K. Parhi, "VLSI Digital Signal Processing Systems, Design and Implementation", John Wiley, Indian Reprint, 2007.
REFERENCES:	
1.	U. Meyer-Baese, "Digital Signal Processing with Field Programmable Arrays", Springer, Second Edition, Indian Reprint, 2007.
2.	S.Y. Kuang, H.J. Whitehouse, T. Kailath, "VLSI and Modern Signal Processing", Prentice Hall.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	1	2	-	-	-	-	-	1	-	2	2	2
CO2	3	3	2	2	3	-	-	-	-	-	1	-	3	2	2
CO3	3	3	2	3	2	-	-	-	-	-	1	-	2	2	2
CO4	3	3	3	3	3	-	-	-	-	-	2	-	3	2	3
CO5	2	3	2	3	3	-	-	-	-	-	2	-	3	2	3
CO	2.8	2.8	2.4	2.4	2.4	2.4	2.3	-	-	-	2.1	-	2.8	2	2.1

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC108	MEMS DESIGN	L	T	P	C
		2	0	2	3
COURSE OBJECTIVES:					
• To understand the basic electrical and mechanical concepts of MEMS design					

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• To understand the design aspects of electrostatic sensors and actuators
• To understand the design aspects of thermal sensors and actuators
• To understand the design aspects of piezoelectric sensors and actuators
• To understand the design aspects of magnetic sensors and actuators

UNIT I	**ESSENTIAL ELECTRIC AND MECHANICAL CONCEPTS**	**6**
Conductivity of semiconductors, Crystal planes and orientations, stress and strain, flexural beam bending analysis under simple loading conditions, Dynamic system, resonant frequency and quality factor		
UNIT II	**ELECTRO STATIC SESNING AND ACTUATION**	**6**
Parallel plate capacitor, Applications of parallel plate capacitors- inertial sensor, pressure sensor, flow sensor, tactile sensor, parallel plate actuators, interdigitated finger capacitors, applications of comb drive devices.		
UNIT III	**THERMAL SENSING AND ACTUATION**	**6**
Fundamentals of thermal transfer, Sensors and actuators based on thermal expansion, Thermal couples, Thermal resistors, Applications- Body temperature monitoring devices**,** Thermal sensing in household appliances		
UNIT IV	**PIEZOELECTRIC SENSING AND ACTUATION**	**6**
Mathematical description of piezoelectric effects, Cantilever piezoelectric actuator model, properties of piezoelectric materials –Quartz, PZT, PVDF, ZnO, Applications – Acoustic sensors, Tactile sensors		
UNIT V	**MAGNETIC SENSING AND ACTUATION**	**6**
Concepts and principles- magnetization and nomenclatures, principles of micromagnetic actuators, fabrication of micro magnetic components- deposition, design and fabrication of magnetic coil, MEMS magnetic actuators.		
PRACTICAL EXERCISES: 1. Design and simulation of piezoelectric cantilever 2. Design and simulation of thermocouples 3. Design and simulation of comb drive actuators 4. Design and simulation of MEMS Pressure Sensor 5. Design a microheater and analyse temperature distribution, power consumption, and thermal efficiency.		
TOTAL: 30+30=60 PERIODS		
COURSE OUTCOMES:		

At the end of the course, the students will be able to:	
CO1:	Understand the basics of MEMS design aspects.
CO2:	Apply the knowledge in the development of electro static sensors and actuators.
CO3:	Apply the knowledge in the development of thermal sensors and actuators
CO4:	Apply the knowledge in the development of piezoelectric sensors and actuators
CO5:	Apply the knowledge in the development of magnetic sensors and actuators
TEXT BOOKS:	
1.	Chang Liu, "Foundations of MEMS", Pearson education India limited, 2006.
REFERENCES:	
1.	Murty B.S, Shankar P, Raj B, Rath, B.B, Murday J, Textbook of Nanoscience and Nanotechnology, Springer publishing, 2013.
2.	Sergey Edward Lyshevski, "MEMS and NEMS: Systems, Devices, and Structures" , CRC Press, 2002
3.	Tai Ran Hsu, MEMS and Microsystems Design and Manufacture, Tata Mcgraw Hill, 2002
4.	Vinod Kumar Khanna Nanosensors: Physical, Chemical, and Biological, CRC press,2012.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	2	2	2	2	-	-	-	-	-	1	3	2	2
CO2	3	3	3	2	2	2	-	-	-	-	-	2	3	2	2
CO3	3	3	3	2	2	2	-	-	-	-	-	2	3	2	2
CO4	3	3	3	2	2	2	-	-	-	-	-	2	3	2	2
CO5	3	3	3	2	2	2	-	-	-	-	-	2	3	2	2
CO	**2.8**	**2.6**	**2.6**	**3**	**2.2**	**2.4**	**2**	**-**	**-**	**-**	**2**	**2**	**2**	**2**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

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VERTICAL 2: SIGNAL PROCESSING

24CEC201	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To introduce the concepts of discrete time random signal processing
- To know about multirate signal processing and its applications
- To learn the concept of prediction theory
- To learn about adaptive filtering
- To understand the spectrum estimation techniques

UNIT I	MULTIRATE SIGNAL PROCESSING	6

Review of Convolution, DFT and ZT, Multirate Signal Processing - Decimation, Interpolation, Sampling Rate Conversion by a rational factor – digital filter banks, sub band coding, Quadrature Mirror Filter.

UNIT II	DISCRETE TIME RANDOM PROCESSES	6

Stationary random processes, Autocorrelation, Rational Power Spectra, Filters for generating random Processes from white noise and inverse filter – AR, MA and ARMA processes – relationship between autocorrelation and the filter parameters.

UNIT III	LINEAR PREDICTION AND FILTERING	6

Linear Prediction – Forward and Backward - Wiener filters for filtering and prediction – FIR Wiener Filter – IIR Wiener Filter – Kalman Filter, Applications of Linear Prediction.

UNIT IV	ADAPTIVE FILTERING	6

FIR adaptive filters – adaptive filters based on steepest descent method – LMS algorithm – Variants of LMS algorithm – adaptive echo cancellation – adaptive channel equalization – RLS Algorithm.

UNIT V	SPECTRUM ESTIMATION	6

Estimation of power spectra from finite duration observations of signals – Non parametric methods of spectrum estimation – the Bartlett and the Welch method – Parametric spectrum estimation – AR, MA and ARMA.

30 PERIODS

PRACTICAL EXERCISES: **30 PERIODS**

1. Study of autocorrelation and Cross Correlation of random signals
2. Design and Implementation of Multirate Systems.
3. Design and Implementation of Wiener Filter

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4. Design and Implementation of FIR Linear Predictor	
5. Design of adaptive filters using LMS algorithm	
6. Spectrum Estimation using Bartlett and Welch Methods	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Comprehend multirate signal processing and demonstrate its applications
CO2:	Demonstrate an understanding of the power spectral density and apply to discrete random signals and systems.
CO3:	Apply linear prediction and filtering techniques to discrete random signals for signal detection and estimation.
CO4:	Analyze adaptive filtering problems and demonstrate its application.
CO5:	Apply power spectrum estimation techniques to random signals.
	TOTAL: 60 PERIODS
TEXT BOOKS:	
1.	John G. Proakis & Dimitris G.Manolakis, ―Digital Signal Processing – Principles, Algorithms & Applications, Fourth Edition, Pearson Education / Prentice Hall, 2007.
2.	P. Vaidyanathan, "Multirate systems and filter banks", Prentice Hall Inc. 1993.
REFERENCES:	
1.	Monson H. Hayes, "Statistical digital signal processing and modeling", John Wiley and Sons Inc. New York, Indian reprint 2008.
2.	Haykin, Adaptive Filter Theory, 4th Edition, Pearson Education, New Delhi, 2006.
3	Sophoncles J. Orfanidis, “Optimum Signal Processing “, McGraw Hill, 2000.

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	2	2	2	-	-	-	-	-	1	2	3	3
CO2	3	3	3	2	2	2	-	-	-	-	-	2	3	2	2
CO3	3	3	3	2	2	2	-	-	-	-	-	2	2	2	1
CO4	3	3	3	2	2	2	-	-	-	-	-	2	3	2	2
CO5	3	3	2	2	1	1	-	-	-	-	-	1	2	3	1
CO	3	3	3	2	2	2	-	-	-	-	-	2	3	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC202	IMAGE PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To become familiar with digital image fundamentals
- To get exposed to simple image enhancement techniques in Spatial and Frequency domain.
- To learn concepts of degradation function and restoration techniques.
- To study the image segmentation and representation techniques.
- To become familiar with image compression and recognition methods

UNIT I	DIGITAL IMAGE FUNDAMENTALS	9

Steps in Digital Image Processing – Components – Elements of Visual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels - Color image fundamentals - RGB, HSI models, Two-dimensional mathematical preliminaries, 2D transforms - DFT, DCT.

UNIT II	IMAGE ENHANCEMENT	9

Spatial Domain: Gray level transformations – Histogram processing – Basics of Spatial Filtering– Smoothing and Sharpening Spatial Filtering, Frequency Domain: Introduction to Fourier Transform– Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters, Homomorphic filtering, Color image enhancement.

UNIT III	IMAGE RESTORATION	9

Image Restoration - degradation model, Properties, Noise models – Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener filtering		
UNIT IV	**IMAGE SEGMENTATION**	**9**
Edge detection, Edge linking via Hough transform – Thresholding - Region based segmentation – Region growing – Region splitting and merging – Morphological processing- erosion and dilation, Segmentation by morphological watersheds – basic concepts – Dam construction – Watershed segmentation algorithm.		
UNIT V	**IMAGE COMPRESSION AND RECOGNITION**	**9**
Need for data compression, Huffman, Run Length Encoding, Shift codes, Arithmetic coding, JPEG standard, MPEG. Boundary representation, Boundary description, Fourier Descriptor, Regional Descriptors – Topological feature, Texture - Patterns and Pattern classes - Recognition based on matching, Machine Learning Approaches to Image Recognition.		
		TOTAL:45 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Know and understand the basics and fundamentals of digital image processing, such as digitization, sampling, quantization, and 2D-transforms.	
CO2:	Operate on images using the techniques of smoothing, sharpening and enhancement.	
CO3:	Understand the restoration concepts and filtering techniques.	
CO4:	Learn the basics of segmentation, features extraction, compression and recognition methods for color models.	
CO5:	Comprehend image compression concepts.	
TEXT BOOKS:		
1.	Rafael C. Gonzalez, Richard E. Woods, ‘Digital Image Processing’, Pearson, Third Edition,2010.	
2.	Anil K. Jain, ‘Fundamentals of Digital Image Processing’, Pearson, 2002.	
REFERENCES:		
1.	Kenneth R. Castleman, ‘Digital Image Processing’, Pearson, 2006.	
2.	Rafael C. Gonzalez, Richard E. Woods, Steven Eddins, ‘Digital Image Processing using MATLAB’, Pearson Education, Inc., 2011.	
3.	D.E. Dudgeon and RM. Mersereau, ‘Multidimensional Digital Signal Processing’, Prentice Hall Professional Technical Reference, 1990.	

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4.	William K. Pratt, 'Digital Image Processing', John Wiley, New York, 2002
5.	Milan Sonka et al 'Image processing, analysis and machine vision', Brookes/Cole, Vikas Publishing House, 2nd edition, 1999.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	2	2	2	-	-	-	-	-	3	2	3	2
CO2	3	3	3	2	2	2	-	-	-	-	-	2	2	3	2
CO3	3	3	2	2	2	2	-	-	-	-	-	2	2	2	1
CO4	3	3	3	2	2	2	-	-	-	-	-	2	2	2	1
CO5	3	3	3	3	2	2	-	-	-	-	-	2	2	2	1
CO	3	3	3	2	2	2	-	-	-	-	-	2	2	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC203	SPEECH PROCESSING	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- Study the fundamentals of speech signal and extracs various speech features
- Understand different speech coding techniques for speech compression applications
- Use speech coding techniques.
- Learn to build speech enhancement system.
- Learn to develop text-to-speech synthesis system

UNIT I	FUNDAMENTALS OF SPEECH	6

The Human speech production mechanism, Discrete-Time model of speech production, Speech perception - human auditory system, Phonetics - articulatory phonetics, acoustic phonetics, and auditory phonetics, Categorization of speech sounds, Spectrographic analysis of speech sounds, Pitch frequency, Pitch period

measurement using spectral and cepstral domain, Formants, Evaluation of Formants for voiced and unvoiced speech.		
UNIT II	**SPEECH FEATURES AND DISTORTION MEASURES**	**6**
Significance of speech features in speech-based applications, Speech Features – Cepstral Coefficients, Mel Frequency Cepstral Coefficients (MFCCs), Perceptual Linear Prediction (PLP), Log Frequency Power Coefficients (LFPCs), Speech distortion measures–Simplified distance measure, LPC-based distance measure, Spectral distortion measure, Perceptual distortion measure.		
UNIT III	**SPEECH CODING**	**6**
Need for speech coding, Waveform coding of speech – PCM, Adaptive PCM, DPCM, ADPCM, Delta Modulation, Adaptive Delta Modulation, G.726 Standard for ADPCM, Parametric Speech Coding – Channel Vocoders, Linear Prediction Based Vocoders, Code Excited Linear Prediction (CELP) based Vocoders, Sinusoidal speech coding techniques, Hybrid coder, Transform domain coding of speech		
UNIT IV	**SPEECH ENHANCEMENT**	**6**
Classes of Speech Enhancement Algorithms, Spectral-Subtractive Algorithms - Multiband Spectral Subtraction, MMSE Spectral Subtraction Algorithm, Spectral Subtraction Based on Perceptual Properties, Wiener Filtering - Wiener Filters in the Time Domain, Wiener Filters in the Frequency Domain, Wiener Filters for Noise Reduction, Maximum-Likelihood Estimators, Bayesian Estimators, MMSE and Log-MMSE Estimator, Subspace Algorithms.		
UNIT V	**SPEECH SYNTHESIS AND APPLICATION**	**6**
A Text-to-Speech systems (TTS), Synthesizers technologies – Concatenative synthesis, Use of Formants for concatenative synthesis, Use of LPC for concatenative synthesis, HMM-based synthesis, Sinewave synthesis, Speech transformations, Watermarking for authentication of a speech, Emotion recognition from speech, Neural Network–Based Speech Synthesis.		
		30 PERIODS
PRACTICAL EXERCISES:		**30 PERIODS**
1. Write a MATLAB Program to classify voiced and unvoiced segment of speech using various time- domain measures		
2. Write a MATLAB Program to calculate the MFCC for a speech signal		
3. Implement ITU-T G.722 Speech encoder in MATLAB		
4. Write a MATLAB Program to implement Wiener Filters for Noise Reduction		
5. Design a speech emotion recognition system using DCT and WPT in MATLAB		
HARDWARE & SOFTWARE SUPPORT TOOLS:		
Personal Computer with MATLAB		
Microphone and Speakers		

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COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Understand the fundamentals of speech.
CO2:	Extract various speech features for speech related applications
CO3:	Choose an appropriate speech coder for a given application.
CO4:	Build a speech enhancement system.
CO5:	Build a text-to-speech synthesis system for various applications
	TOTAL: 60 PERIODS
TEXT BOOKS:	
1.	Shaila D. Apte, Speech and Audio Processing, Wiley India (P) Ltd, New Delhi, 2012
2.	Philipos C. Loizou, Speech Enhancement Theory and Practice, Second Edition, CRC Press, Inc., United States, 2013
REFERENCES:	
1.	Rabiner L. R. and Juang B. H, Fundamentals of speech recognition, Pearson Education, 2003
2.	Thomas F. Quatieri, Discrete-time speech signal processing - Principles and practice, Pearson, 2012.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	2	1	1	2	1	-	-	-	-	-	2	3	3	3
CO2	1	2	1	1	2	1	-	-	-	-	-	2	2	2	2
CO3	1	2	1	1	2	1	-	-	-	-	-	1	1	2	2
CO4	3	-	3	3	-	3	-	-	-	-	-	2	2	3	3
CO5	3	-	3	3	-	3	-	-	-	-	-	2	2	2	2
CO	1.8	2	1.8	1.8	2	1.8						1.8	2	2.4	2.4

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24CEC204	SOFTWARE DEFINED RADIO	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To introduce the concepts of software radios
- To know about RF implementation challenges for software defined radios
- To understand the digital generation of signals
- To learn the smart antennas.
- To learn the software and hardware requirements for software defined radios.

UNIT I	INTRODUCTION TO SOFTWARE RADIO	6

The Need for Software Radios. Characteristics and Benefits of a Software Radio. Design Principles of a Software Radio.

UNIT II	RF IMPLEMENTATION	6

Purpose of RF front – end, Dynamic range, RF receiver front – end topologies, Enhanced flexibility of the RF chain with software radios, Importance of the components to overall performance, Transmitter architectures and their issues, Noise and distortion in the RF chain, Hybrid DDS – PLL systems, Applications of Direct Digital Synthesis.

UNIT III	DIGITAL GENERATION OF SIGNALS	6

Comparison of direct digital synthesis with analog signal synthesis, Approaches to direct digital synthesis, Analysis of spurious signals, Performance of direct digital synthesis systems, Applications of direct digital synthesis.

UNIT IV	SMART ANTENNAS	6

Benefits of smart antennas, Structures for beamforming systems, Smart antenna algorithms, Adaptive Beamforming Algorithms, Hardware implementation of smart antennas, Digital Hardware Choices-Key hardware elements.

UNIT V	HARDWARE AND SOFTWARE FOR SDR & CASE STUDIES	6

DSP Processors, FPGA, ASICs. Trade-offs, Object oriented programming, Object Brokers, GNU Radio-USRP. Case Studies: SPEAK easy, JRTS, SDR-3000.

TOTAL:30 PERIODS

PRACTICAL EXERCISES:	30 PERIODS

1. Study of SDR hardware kit

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2. Design and Implementation of digital modulation schemes using SDR	
3. Implementation of synchronization techniques using SDR	
4. Channel Coding Techniques using SDR	
5. Study of channel estimation techniques using SDR	
6. Study of MIMO concepts using SDR	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Demonstrate an understanding in the evolving paradigm of Software defined radio and technologies for its implementation.
CO2:	Analyse Radio frequency implementation issues
CO3:	Implement Smart antenna techniques for software defined radio.
CO4:	Compare various digital synthesis procedures.
CO5:	Comprehend various hardware and software requirements for software defined radios.
	TOTAL: 60 PERIODS
TEXT BOOKS:	
1.	Jeffrey Hugh Reed, "Software Radio: A Modern Approach to Radio Engineering," Prentice Hall Professional, 2002.
2.	Tony J Rouphael, "RF and DSP for SDR," Elsevier Newnes Press, 2008.
REFERENCES:	
1.	P. Kenington, "RF and Baseband Techniques for Software Defined Radio," Artech House, 2005.
2.	Paul Burns, "Software Defined Radio for 3G," Artech House, 2002.
3.	Behrouz. F. Bourjney" Signal Processing for Software defined Radios", Lulu 2008.

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	2	2	2	-	-	-	1	-	3	3	2	2
CO2	3	3	3	2	2	2	-	-	-	1	-	2	3	2	2
CO3	3	3	3	2	2	2	-	-	-	1	-	2	3	2	3
CO4	3	3	3	2	2	2	-	-	-	1	-	2	2	2	2
CO5	3	3	3	3	2	2	-	-	-	1	-	2	2	2	2
CO	3	3	3	2	2	2	-	-	-	1	-	2	2	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC205	DSP ARCHITECTURE AND PROGRAMMING	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- Study the architecture of programmable DSP processors
- Learn to implement various standard DSP algorithms in DSP Processors
- Use the Programmable DSP Processors to build real-time DSP systems
- Use DSP algorithms in various applications.
- Study the applications of DSP processors.

UNIT I	ARCHITECTURES FOR PROGRAMMABLE DSP PROCESSORS	6

Basic Architectural features, DSP Computational building blocks, Bus architecture and memory, Data addressing capabilities, Address generation Unit, Programmability and program execution, Speed issues, Features for external interfacing.

UNIT II	TMS320C5X PROGRAMMABLE DSP PROCESSOR	6

Architecture of TMS320C54xx DSP processors, Addressing modes – Assembly language Instructions - Memory space, interrupts, and pipeline operation of TMS320C54xx DSP Processor, On-Chip peripherals, Block Diagram of TMS320C54xx DSP starter kit.

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UNIT III	TMS320C6X PROGRAMMABLE DSP PROCESSOR	6

Commercial TI DSP processors, Architecture of TMS320C6x DSP Processor, Linear and Circular addressing modes, TMS320C6x Instruction Set, Assembler directives, Linear Assembly, Interrupts, Multichannel buffered serial ports, Block diagram of TMS320C67xx DSP Starter Kit and Support Tools.

UNIT IV	IMPLEMENTATION OF DSP ALGORITHMS	6

DSP Development system, On-chip, and On-board peripherals of C54xx and C67xx DSP development boards, Code Composer Studio (CCS) and support files, Implementation of Conventional FIR, IIR, and Adaptive filters in TMS320C54xx/TMS320C67xx DSP processors for real-time DSP applications, Implementation of FFT algorithm for frequency analysis in real-time.

UNIT V	APPLICATIONS OF DSP PROCESSORS	6

Voice scrambling using filtering and modulation, Voice detection and reverse playback, Audio effects, Graphic Equalizer, Adaptive noise cancellation, DTMF signal detection, Speech thesis using LPC, Automatic speaker recognition, DSP in Wireless Communication Systems.

30 PERIODS

PRACTICAL EXERCISES: **30 PERIODS**

1. Real-Time Sine Wave Generation
2. Programming examples using C, Assembly and linear assembly
3. Implementation of moving average filter
4. FIR implementation with a Pseudorandom noise sequence as input to a filter
5. Fixed point implementation of IIR filter
6. FFT of Real-Time input signal

HARDWARE & SOFTWARE SUPPORT TOOLS:

- TMS320C54xx/TMS320C67xx DSP Development board
- Code Composer Studio (CCS)
- Function Generator and Digital Storage Oscilloscope
- Microphone and speaker

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Understand the architectural features of DSP Processors.
CO2:	Comprehend the organization of TMS320C54xx DSP processors.
CO3:	Build solutions using TMS320C6x DSP Processor.
CO4:	Implement DSP Algorithms.

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CO5:	Study the applications of DSP Processors.
	TOTAL: 60 PERIODS
TEXT BOOKS:	
1.	Avtar Singh and S. Srinivasan, Digital Signal Processing – Implementations using DSP Microprocessors with Examples from TMS320C54xx, Cengage Learning India Private Limited, Delhi 2012
2.	Rulph Chassaing and Donald Reay, Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK, Second Edition, Wiley India (P) Ltd, New Delhi, 2008
REFERENCES:	
1.	B.Venkataramani and M.Bhaskar, "Digital Signal Processors – Architecture, Programming and Applications", Tata McGraw – Hill Publishing Company Limited. New Delhi, 2003.
2.	TMS320C5416/6713 DSK user manual at https://www.ti.com

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	2	2	2	-	-	-	1	-	3	3	3	3
CO2	3	3	2	2	2	2	-	-	-	1	-	2	3	3	3
CO3	3	3	3	2	2	2	-	-	-	1	-	2	2	2	2
CO4	3	3	3	3	2	2	-	-	-	1	-	2	2	3	2
CO5	3	3	3	2	2	2	-	-	-	1	-	2	2	3	2
CO	3	3	3	2	2	2	-	-	-	1	-	2	2	3	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC206	**COMPUTER VISION**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**
COURSE OBJECTIVES:					
● To understand the fundamental concepts related to Image formation and processing.					

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- To learn feature detection, matching and detection
- To become familiar with feature based alignment and motion estimation
- To develop skills on 3D reconstruction
- To understand image based rendering and recognition

UNIT I	**INTRODUCTION TO IMAGE FORMATION AND PROCESSING**	**6**

Computer Vision - Geometric primitives and transformations - Photometric image formation - The digital camera - Point operators - Linear filtering - More neighborhood operators - Fourier transforms- Pyramids and wavelets - Geometric transformations - Global optimization.

UNIT II	**FEATURE DETECTION, MATCHING AND SEGMENTATION**	**6**

Points and patches - Edges - Lines - Segmentation - Active contours - Split and merge - Mean shift and mode finding - Normalized cuts - Graph cuts and energy-based methods.

UNIT III	**FEATURE-BASED ALIGNMENT & MOTION ESTIMATION**	**6**

2D and 3D feature-based alignment - Pose estimation - Geometric intrinsic calibration - Triangulation - Two-frame structure from motion - Factorization - Bundle adjustment - Constrained structure and motion - Translational alignment - Parametric motion - Spline-based motion - Optical flow - Layered motion.

UNIT IV	**3D RECONSTRUCTION**	**6**

Shape from X - Active rangefinding - Surface representations - Point-based representations- Volumetric representations - Model-based reconstruction - Recovering texture maps and albedosos.

UNIT V	**IMAGE-BASED RENDERING AND RECOGNITION**	**6**

View interpolation Layered depth images - Light fields and Lumigraphs - Environment mattes - Video-based rendering-Object detection - Face recognition - Instance recognition - Category recognition - Context and scene understanding- Recognition databases and test sets, Performance Evaluation Metrics.

30 PERIODS

PRACTICAL EXERCISES: **30 PERIODS**

Software needed: OpenCV computer vision Library for OpenCV in Python / PyCharm or C++ / Visual Studio or or equivalent

1. OpenCV Installation and working with Python
2. Basic Image Processing - loading images, Cropping, Resizing, Thresholding, Contour analysis, Bolb detection

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3. Image Annotation – Drawing lines, text circle, rectangle, ellipse on images
4. Image Enhancement - Understanding Color spaces, color space conversion, Histogram equialization, Convolution, Image smoothing, Gradients, Edge Detection
5. Image Features and Image Alignment – Image transforms – Fourier, Hough, Extract ORB Image features, Feature matching, cloning, Feature matching based image alignment
6. Image segmentation using Graphcut / Grabcut
7. Camera Calibration with circular grid
8. Pose Estimation
9. 3D Reconstruction – Creating Depth map from stereo images
10. Object Detection and Tracking using Kalman Filter, Camshift
11. docs.opencv.org
12. https://opencv.org/opencv-free-course/

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	To understand basic knowledge, theories and methods in image processing and computer vision.
CO2:	To implement basic and some advanced image processing techniques in OpenCV.
CO3:	To apply 2D a feature-based based image alignment, segmentation and motion estimations.
CO4:	To apply 3D image reconstruction techniques
CO5:	To design and develop innovative image processing and computer vision applications.

TOTAL :60 PERIODS

TEXT BOOKS:

1.	Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer- Texts in Computer Science, Second Edition, 2022.
2.	Computer Vision: A Modern Approach, D. A. Forsyth, J. Ponce, Pearson Education, Second Edition, 2015.

REFERENCES:

1.	Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, March 2004.
2.	Christopher M. Bishop; Pattern Recognition and Machine Learning, Springer, 2006
3.	E. R. Davies, Computer and Machine Vision, Fourth Edition, Academic Press, 2012.

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	1	1	1	-	-	-	2	1	3	2	2	1	1
CO2	3	3	3	2	3	-	1	-	2	1	2	2	3	1	2
CO3	3	3	2	2	3	-	-	-	1	1	2	2	3	2	2
CO4	2	3	3	2	3	-	-	-	2	1	2	3	2	2	3
CO5	2	3	3	2	2	2	-	-	3	1	2	3	3	3	3
CO	2.6	2.6	2.4	1.8	2.4	0.4	0.25	0	2	1	2.2	2.4	2.6	1.8	2.2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC207	INDUSTRIAL IOT AND INDUSTRY 4.0	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To understand IoT Nodes & Sensors
- To gain knowledge on IoT Gateways
- To acquire knowledge on IoT Cloud Systems
- To get exposed in IoT Cloud Dashboards
- To understand the challenges in IoT system design- hardware and software

UNIT I	UNDERSTANDING IOT CONCEPT AND DEVELOPMENT PLATFORM	6

IOT Definition, Importance of IoT, Applications of IOT, IoT architecture, Understanding working of Sensors, Actuators, Sensor calibration, Study of Different sensors and their characteristics.

UNIT II	ANALYZING & DECODING OF COMMUNICATION PROTOCOL USED IN IOT DEVELOPMENT PLATFORM	6

UART Communication Protocol, I2C Protocol device interfacing and decoding of signal, SPI Protocol device interfacing and decoding of signal, WIFI and Router interfacing, Ethernet Configuration, Bluetooth study and analysis of data flow, Zigbee Interfacing and study of signal flow.

UNIT III	IOT PHYSICAL DEVICES AND ENDPOINTS AND CONTROLLING HARDWARE AND SENSORS	6

IoT Physical Devices and Endpoints- Installation, Interfaces (serial, SPI, I2C), Programming – Python program with Raspberry PI with focus on interfacing external gadgets, controlling output, reading input from pins.Controlling Hardware- Connecting LED, Buzzer, Switching High Power devices with transistors, Controlling AC Power devices with Relays, Controlling servo motor, speed control of DC Motor, unipolar and bipolar Stepper motors; Sensors in IoT.

UNIT IV	**CLOUD SERVICES USED IN IOT DEVELOPMENT PLATFORM**	**6**

Configuration of the cloud platform, Sending data from the IOT nodes to the gateways using different communication options; Transferring data from gateway to the cloud; Exploring the web services like mail, Messaging (SMS) and Twitter etc.; Tracking of cloud data as per the requirement; Google Cloud service architect; AWS clod Services architect; Microsoft Azure cloud services Architect; OEN source Cloud Services; Initial State IoT Dashboard & Cloud Services.

UNIT V	**CHALLENGES IN IOT SYSTEM DESIGN – HARDWARE & SOFTWARE**	**6**

Antenna design and placement, Chip-package system development, Power electronics, electromagnetic interference/compatibility (EMI/EMC), Electronics reliability; Battery simulation, IoT case studies.

30 PERIODS

PRACTICAL EXERCISES:	**30 PERIODS**

Study and Program different Sensors for IoT applications

- LDR sensor, IR sensor, Temperature Sensor, Ultrasound Sensor, Gas sensor
- Write a program using IR sensor for working morning alarm and night la
- Write a program using Temperature sensor for detecting heat / fire
- Write a program using Gas sensor for detecting LPG gas leak
- Write a program using Ultrasound sensor for range detection
- Write a program using sensors for carparking assist
- Write a program using sensors for water level indicator and overflow detection

Designing and debugging complex mixed signal devices (analog, digital, and RF)

- Write a program to interface Bluetooth and implement DC Motor.
- Write a program to control LEDs using Alexa Echo Dot.
- Write a program to control Buzzer using Alexa Echo Dot.
- Write a program to control DC motor using Google Assistance.
- Write a program to control Stepper motor using Google Assistance
- Studying and decoding Computer Bus (RS-232, UART).
- Studying Bluetooth analysis and measurement of Signals
- studying WLAN analysis of 802.11a/b/g/j/p, 802.11n, 802.11ac Signals

Understanding battery requirements

- Determining ultra-low deep sleep current of Node
- Measuring Transmit and Receive current signals of Node
- Capturing short transients and fast transients signals of node

- Recording Device(node) operations over extended states.
- Create stable low noise voltage supply for every state of your IOT devices, from sleep to transmit.
- Record and Generate Battery sources with the battery simulation options

Understanding Modulation techniques

- Understanding of ASK, FSK Modulation and measurement
- Capturing the live ASK Signal and decoding it.
- Understanding the BPSK, QPSK & QAM Modulation Techniques and analysis.
- Understanding the APSK & APCO modulation & analysis.

List of equipment for a batch of 30 students (3 in a bench):

- Real time Spectrum Analyser upto atleast 6.2GHz and 40MHz bandwidth – Qty #1
- DC Power supply - 120W with Battery simulation – Qty #1
- Graphical Digital Multimeter with built-in digitizer and datalogging for 20 channels – Qty #1
- 200MHz 6 channel scope with Serial trigger & decode capability for I2C, SPI, RS-232/422/485/UART buses, and built-in 50MHz AFG and 8 digital channel analysis – Qty #1
- AI Node with pre-configured SSD, USB Camera, USB Hub, USB Mouse, and USB Keyboard. – Qty 1no
- Sensor IOT Application Board with built-in 7 sensors (LDR #2, IR #2, Temperature #1, Ultrasound #1 and LPG Gas sensors #1); Embedded uC mother board, LCD display, Buzzer, Power supply (12V,1A) with adaptor and PCB Base plate; - Qty 5 nos
- All in One General Purpose Board
- IOT Gateway – Qty 1no
- Bluetooth Module– Qty 1no
- Router – Qty 1no
- Portable Sensor Kit – Qty 1no
- IOT sensor kit – Qty 1no
- RFID Module – Qty 1no
- Finger Print Module – Qty 1no
- Stepper Motor – Qty 1no
- DC Motor – Qty 1no
- Amazon Echo device – Qty 2nos

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Understand the building blocks of IoT technology and explore the vast spectrum of IoT applications.
CO2:	Use processors & peripherals to design & build IoT hardware
CO3:	Assess, select and customize technologies for IoT applications

CO4:	Connect numerous IOT applications with the physical world of humans and real life problem solving.
CO5:	Design and implement IOT applications that manage big data
	TOTAL : 60 PERIODS
TEXT BOOKS:	
1.	Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547
2.	Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759
REFERENCES:	
1.	Raspberry Pi Cookbook, Software and Hardware Problems and solutions, Simon Monk, O'Reilly (SPD), 2016, ISBN 7989352133895
2.	N. Ida, Sensors, Actuators and Their Interfaces, SciTech Publishers, 2014.
3.	Peter Waher, 'Learning Internet of Things', Packt Publishing, 2015 3. Editors Ovidiu Vermesan.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	2	2	1	2	-	-	-	-	-	2	3	2	2
CO2	3	2	2	2	1	2	-	-	-	-	-	2	3	3	2
CO3	3	2	2	2	2	2	-	-	-	-	-	2	3	3	2
CO4	3	2	3	2	3	2	-	-	-	-	-	2	3	3	2
CO5	3	3	3	3	3	3	-	-	-	-	-	1	3	2	3
CO	3	2.25	2.4	2.2	2	2.2	-	-	-	-	-	1.8	3	2.6	2.2

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24CEC208	IOT BASED SYSTEMS DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basics of IoT.
- To get knowledge about the various services provided by IoT.
- To familiarize themselves with various communication techniques and networking.
- To know the implementation of IoT with different tools.
- To understand the various applications in IoT.

UNIT I	INTRODUCTION TO INTERNET OF THINGS	9

Rise of the machines – Evolution of IoT – Web 3.0 view of IoT – Definition and characteristics of IoT – IoT Enabling Technologies – IoT Architecture -– Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors, Actuators, Smart Objects and Connecting Smart Objects - IoT levels and deployment templates – A panaromic view of IoT applications.

UNIT II	MIDDLEWARE AND PROTOCOLS OF IOT	9

Middleware technologies for IoT system (IoT Ecosystem Overview – Horizontal Architecture Approach for IoT Systems – SOA based IoT Middleware) Middleware architecture of RFID,WSN,SCADA,M2M – Interoperability challenges of IoT-Protocols for RFID,WSN,SCADA,M2M- Zigbee, KNX,BACNet,MODBUS - Challenges Introduced by 5G in IoT Middleware(Technological Requirements of 5G Systems - Perspectives and a Middleware Approach Toward 5G (COMPaaS Middleware) – Resource management in IoT.

UNIT III	COMMUNICATION AND NETWORKING	9

IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks – Application Transport Methods: Supervisory Control and Data Acquisition –Application Layer Protocols: CoAP and MQTT- Data aggregation & dissemination.

UNIT IV	IOT IMPLEMENTATION TOOLS	9

Introduction to Python, Introduction to different IoTtools, 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

Home automations - Smart cities – Environment – Energy – Retail – Logistics – Agriculture – Industry - Health and life style - Smart Healthcare Applications – Case study.

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	45 PERIODS
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Articulate the main concepts, key technologies, strength and limitations of IoT.
CO2:	Identify the architecture, infrastructure models of IoT
CO3:	Analyze the networking and how the sensors are communicated in IoT.
CO4:	Analyze and design different models for IoT implementation.
CO5:	Identify and design the new models for market strategic interaction.
	TOTAL :60 PERIODS
TEXT BOOKS:	
1.	Honbo Zhou, "Internet of Things in the cloud:A middleware perspective", CRC press, 2012.
2.	Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-onApproach)", VPT, 1st Edition, 2014.
REFERENCES:	
1.	Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.
2.	Constandinos X. Mavromoustakis, George Mastorakis, Jordi MongayBatalla, "Internet of Things (IoT) in 5G Mobile Technologies" Springer International Publishing Switzerland 2016
3.	Dieter Uckelmann, Mark Harrison, Florian Michahelles, "Architecting the Internet of Things" Springer-Verlag Berlin Heidelberg, 2011.

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	2	2	1	3	-	-	-	-	2	3	3	3	3
CO2	3	3	2	2	1	-	-	-	-	-	1	2	3	3	3
CO3	3	3	3	2	1	2	-	-	-	-	3	2	3	2	3
CO4	3	3	2	2	3	-	-	-	-	-	-	1	3	3	2
CO5	3	2	3	3	2	1	-	-	-	-	2	1	3	2	2
CO	3	2.8	2.4	2.2	1.6	2	-	-	-	-	2	1.8	3	2.6	2.6

1 - low, 2 - medium, 3 - high, '-' - no correlation

BoS Chairman

VERTICAL 3: BIO MEDICAL TECHNOLOGIES

24CBM301	WEARABLE DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the basic concepts, components, and sensor technologies of wearable systems.
- To explain signal processing needs and energy-harvesting techniques for wearable devices.
- To describe wireless health monitoring systems and Body Area Network (BAN) architecture.
- To familiarize students with smart textiles and their fabrication methods.
- To outline major healthcare and diagnostic applications of wearable systems

UNIT I	INTRODUCTION TO WEARABLE SYSTEMS AND SENSORS	9

Wearable Systems- Introduction, Need for Wearable Systems, Drawbacks of Conventional Systems for Wearable Monitoring, Applications of Wearable Systems, Types of Wearable Systems, Components of wearable Systems. Sensors for wearable systems-Inertia movement sensors, Respiration activity sensor, Inductive plethysmography, Impedance plethysmography, pneumography, Wearable ground reaction force sensor.

UNIT II	SIGNAL PROCESSING AND ENERGY HARVESTING FOR WEARABLE DEVICES	9

Wearability issues -physical shape and placement of sensor, Technical challenges - sensor design, signal acquisition, sampling frequency for reduced energy consumption, Rejection of irrelevant information. Power Requirements- Solar cell, Vibration based, Thermal based, Human body as a heat source for power generation, Hybrid thermoelectric photovoltaic energy harvests, Thermopiles.

UNIT III	WIRELESS HEALTH SYSTEMS	9

Need for wireless monitoring, Definition of Body area network, BAN and Healthcare, Technical Challenges- System security and reliability, BAN Architecture – Introduction, Wireless communication Techniques.

UNIT IV	SMART TEXTILE	9

Introduction to smart textile-Passive smart textile, active smart textile. Fabrication Techniques- Conductive Fibres, Treated Conductive Fibres, Conductive Fabrics, Conductive Inks. Case study- smart fabric for monitoring biological parameters - ECG, respiration, Smart Textile Standards and Reliability Issues.

UNIT V	APPLICATIONS OF WEARABLE SYSTEMS	9

Medical Diagnostics, Medical Monitoring-Patients with chronic disease, Hospital patients, Elderly patients, neural recording, Gait analysis, Sports Medicine. Role of AI and Machine Learning in Wearable Health Applications.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Describe the concepts of wearable system
CO2:	Explain the energy harvestings in wearable device.
CO3:	Use the concepts of BAN in health care.
CO4:	Illustrate the concept of smart textile
CO5:	Compare the various wearable devices in healthcare system
TEXT BOOKS:	
1.	Annalisa Bonfiglo and Danilo De Rossi, Wearable Monitoring Systems, Springer, 2011
2.	Zhang and Yuan-Ting, Wearable Medical Sensors and Systems,Springer, 2013
3.	Edward Sazonov and Micheal R Neuman, Wearable Sensors: Fundamentals, Implementation and Applications, Elsevier, 2014
4.	Mehmet R. Yuce and JamilY.Khan, Wireless Body Area Networks Technology, Implementation applications,Pan Stanford Publishing Pte.Ltd, Singapore, 2012
REFERENCES:	
1.	Sandeep K.S, Gupta, Tridib Mukherjee and Krishna Kumar Venkatasubramanian, Body Area Networks Safety, Security, and Sustainability, Cambridge University Press, 2013.
2.	Guang-Zhong Yang, Body Sensor Networks, Springer, 2006.

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	1	2	-	-	1	-	-	-	-	1	-	1
CO2	3	2	1	1	2	-	-	1	-	-	-	-	1	-	1
CO3	3	2	1	1	2	-	-	1	-	-	-	-	1	-	1
CO4	3	2	1	1	2	-	-	1	-	-	-	-	1	-	1
CO5	3	2	1	1	2	-	-	1	-	-	-	-	1	-	1
CO	3	2	1	1	2	-	-	1	-	-	-	-	1	-	1

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CBM302	HUMAN ASSIST DEVICES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the principles and functional requirements of heart–lung machines and artificial hearts.
- To explain various cardiac assist devices and their therapeutic mechanisms.
- To describe the working principles and components of artificial kidneys and dialysis systems.
- To familiarize students with respiratory aids, ventilators, and hearing-aid technologies.
- To expose learners to recent trends such as TENS, biofeedback systems, and point-of-care diagnostic platforms.

UNIT I	HEART LUNG MACHINE AND ARTIFICIAL HEART	9

Condition to be satisfied by the H/L System. Different types of Oxygenators, Pumps, Pulsatile and Continuous Types, Monitoring Process, Shunting, The Indication for Cardiac Transplant, Driving Mechanism, Blood Handling System, Functioning and different types of Artificial Heart, Schematic for temporary bypass of left ventricle.

UNIT II	CARDIAC ASSIST DEVICES	9

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Assisted through Respiration, Right and left Ventricular Bypass Pump, Auxiliary ventricle, Open Chest and Closed Chest type, Intra Aortic Balloon Pumping, Prosthetic Cardiac valves, Principle of External Counter pulsation techniques.		
UNIT III	**ARTIFICIAL KIDNEY**	**9**
Indication and Principle of Haemodialysis, Membrane, Dialysate, types of filter and membranes, Different types of hemodialyzers, Monitoring Systems, Wearable Artificial Kidney, Implanting Type.		
UNIT IV	**RESPIRATORY AND HEARING AIDS**	**9**
Ventilator and its types-Intermittent positive pressure, Breathing Apparatus Operating Sequence, Electronic IPPB unit with monitoring for all respiratory parameters. Types of Deafness, Hearing Aids, SISI, masking techniques, wearable devices for hearing correction.		
UNIT V	**RECENT TRENDS**	**9**
Transcutaneous electrical nerve stimulator, bio-feedback, Diagnostic and point-of-care platforms. Telemedicine and IoT-based assistive devices, Regulatory, ethical, and safety Aspects of Human Assist Devices.		
	TOTAL: 45 PERIODS	
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Explain the principles and construction of artificial heart	
CO2:	Understand various mechanical techniques that improve therapeutic technology	
CO3:	Explain the functioning of the membrane or filter that cleanses the blood.	
CO4:	Describe the tests to assess the hearing loss and development of wearable devices for the same.	
CO5:	Analyze and research on electrical stimulation and biofeedback techniques in rehabilitation and physiotherapy.	
TEXT BOOKS:		
1.	Gray E Wnek, Gray L Browlin – Encyclopedia of Biomaterials and Biomedical Engineering – Marcel Dekker Inc New York,second edition, 2008.	
2.	John. G . Webster – Bioinstrumentation - John Wiley & Sons (Asia) Pvt Ltd - 2004	
3.	Joseph D.Bronzino, The Biomedical Engineering Handbook, Third Edition: Three Volume Set, CRC Press, 2006	
REFERENCES:		

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1.	Andreas.F. Von racum, “Hand book of bio material evaluation”, Mc-Millan publishers, Third edition, 2014
2.	D.S. Sunder, “Rehabilitation Medicine”, 3rd Edition, Jaypee Medical Publication, 2010.

CO’s-PO’s & PSO’s MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	3	2	-	-	-	-	-	3	3	1	2
CO2	3	3	3	2	2	3	-	-	-	-	-	2	2	2	2
CO3	3	3	3	3	3	2	-	-	-	-	-	3	3	3	2
CO4	3	3	1	1	3	2	-	-	-	-	-	2	3	1	3
CO5	3	3	3	3	3	3	-	-	-	-	-	2	3	3	2
CO	3	3	2.6	2.4	2.8	2.4	-	-	-	-	-	2.4	2.8	2	2.2

1 - low, 2 - medium, 3 - high, ‘-' - no correlation

24CBM303	THERAPEUTIC EQUIPMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the principles, components, and functional requirements of cardiac and respiratory therapeutic equipment.
- To explain the operation and clinical significance of biomechanical therapeutic devices such as stimulators and traction units
- To describe the principles, mechanisms, and applications of dialysis equipment and various body-care therapeutic systems.
- To familiarize students with dental care equipment, radiographic units, and associated pneumatic and vacuum technologies.
- To explore heat- and photon-based therapeutic modalities including diathermy, ultrasound, lithotripsy, and biomedical lasers.

UNIT I	CARDIAC AND RESPIRATORY THERAPY EQUIPMENT	9

Cardiac Pacemaker: Internal and External Pacemaker– Programmable pacemakers. Cardiac Defibrillators: AC and DC Defibrillator- Internal and External Defibrillators - Protection Circuit, Defibrillator analyzers. Cardiac ablation catheter. Types of Ventilators – Pressure, Volume, and Time controlled. Basic principles of electromechanical, pneumatic and electronic ventilators, Patient Cycle Ventilators, Ventilator testing. Humidifiers, Nebulizers, Inhalators.

UNIT II	**BIOMECHANICAL THERAPEUTIC EQUIPMENT**	**9**

Electrodiagnosis, Therapeutic radiation, Electrotherapy, Electrodes, Stimulators for Nerve and Muscle, Functional Electrical Stimulation. peripheral nerve stimulator, ultrasonic stimulators, Stimulators for pain and relief - Inferential Therapy Unit, TENS. GAIT Assessment and Therapy. Continuous Passive Motion unit, Cervical / Lumber Traction Machine -Traction Table

UNIT III	**BODY CARE EQUIPMENT**	**9**

Indication and Principle of Haemodialysis, Membrane, Dialysate, types of filter and membranes, Different types Skin Treatment: Ultrasonic spot remove, vacuum therapy unit, Skin tightening, Wrinkle Reduction, Facial and Rejuvenation. Laser hair therapy machine. Body Slimmer/Shaper – Deep Heat Therapy, Massager, Fitness – Treadmill, Bike.

UNIT IV	**DENTAL CARE EQUIPMENT**	**9**

Dental Chair - Dental Hand pieces and Accessories: Evolution of rotary equipment, Low-speed handpiece, High-speed handpiece, Hand piece maintenance. Vacuum and Pneumatic techniques: Vacuum techniques, Oral evacuation systems, Vacuum pump, Pneumatic techniques, Dental compressor. Decontamination Unit and constant fumigation unit. Dental Radiography: Dental X-ray Machine, Radiation Safety and Quality Assurance in Dental Radiography.

UNIT V	**HEAT & PHOTON THERAPY EQUIPMENT**	**9**

High frequency heat therapy, Principle, Short wave diathermy, Microwave diathermy, Ultrasonic therapy, High-Intensity Focused Ultrasound (HIFU) Therapy , Lithotripsy. Therapeutic UV and IR Lamps. Basic principles of Biomedical , LASERS: Applications of lasers in medicine, CO2laser, He-Ne laser, Nd-YAG and Ruby laser

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Explain the principles and operation of cardiac and respiratory therapeutic equipment
CO2:	Understand and compare biomechanical therapeutic devices used in rehabilitation
CO3:	Describe the working mechanisms of dialysis and body-care therapeutic systems
CO4:	Demonstrate knowledge of dental care equipment and radiographic systems
CO5:	Analyze heat-based and laser-based therapeutic technologies used in clinical practice

TEXT BOOKS:	
1.	Khandpur. R.S.,"Handbook of Biomedical Instrumentation". Second Edition. Tata McGrawHill Pub. Co., Ltd. 2003.
2.	John.G.Webster. "Medical Instrumentation, Application and Design". Fourth Edition. Wiley &sons, Inc., NewYork. 2010.
REFERENCES:	
1.	Leslie Cromwell, Fred. J. Weibell & Erich. A.Pfeiffer. "Biomedical Instrumentation and Measurements". Second Edition. Prentice Hall Inc.2000.
2.	John Low & Ann Reed. "Electrotherapy Explained, Principles and Practice". Third Edition. Butterworth Heinemann Ltd. 2000.
3.	Joseph. J. Carr, John Michael Brown, "Introduction to Biomedical Equipment Technology", Prentice Hall and Technology, fourth edition, 2008.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	2	3	2	-	-	-	-	2	3	3	3
CO2	3	3	3	3	2	3	2	-	-	-	-	2	3	2	2
CO3	3	3	3	3	2	3	2	-	-	-	-	2	3	2	2
CO4	3	2	2	3	2	3	2	-	-	-	-	2	2	3	2
CO5	3	3	2	3	2	3	2	-	-	-	-	2	2	3	3
CO	3	2.8	2.6	3	2	3	2	-	-	-	-	2	2.6	2.6	2.4

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24CBM304	MEDICAL IMAGING SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the principles and components of X-ray imaging systems
- To explain the fundamentals and reconstruction techniques of CT imaging
- To describe MRI physics, system components, and signal generation methods
- To familiarize students with nuclear imaging modalities such as SPECT and PET
- To analyze the radiation therapy techniques and radiation safety principles

UNIT I	X RAYS	9

Nature of X-rays- X-Ray absorption – Tissue contrast. X- Ray Equipment (Block Diagram) – X-Ray Tube, the collimator, Bucky Grid, power supply, Digital Radiography - discrete digital detectors, storage phosphor and film scanning, X-ray Image Intensifier tubes – Fluoroscopy – Digital Fluoroscopy. Angiography, cine Angiography. Digital subtraction Angiography. Mammography.

UNIT II	COMPUTED TOMOGRAPHY	9

Principles of tomography, CT Generations, X- Ray sources- collimation- X- Ray detectors – Viewing systems – spiral CT scanning – Ultra fast CT scanners. Image reconstruction techniques – back projection and iterative method.

UNIT III	MAGNETIC RESONANCE IMAGING	9

Fundamentals of magnetic resonance- properties of electromagnetic waves : speed , amplitude, phase, orientation and waves in matter - Interaction of Nuclei with static magnetic field and Radio frequency wave- rotation and precession – Induction of magnetic resonance signals – bulk magnetization – Relaxation processes T1 and T2. Block Diagram approach of MRI system – system magnet (Permanent, Electromagnet and Superconductors), generations of gradient magnetic fields, Radio Frequency coils (sending and receiving), shim coils, Electronic components, fMRI.

UNIT IV	NUCLEAR IMAGING	9

Radioisotopes- alpha, beta, and gamma radiations. Radio Pharmaceuticals. Radiation detectors – gas filled, ionization chambers, proportional counter, GM counter and scintillation Detectors, Gamma camera – Principle of operation, collimator, photomultiplier tube, X-Y positioning circuit, pulse height analyzer. Principles of SPECT and PET

UNIT V	RADIATION THERAPY AND RADIATION SAFETY	9

Radiation therapy – linear accelerator, Telegamma Machine. SRS – SRT – Recent Techniques in radiation therapy – 3D CRT – IMRT – IGRT and Cyber knife – radiation measuring instruments Dosimeter, film

badges, Thermo Luminescent dosimeters – electronic dosimeter – Radiation protection in medicine – radiation protection principles, Treatment Planning Systems (TPS) and Quality Assurance in Radiotherapy	
TOTAL: 45 PERIODS	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Explain the principles and operation of X-ray imaging and fluoroscopy systems
CO2:	Describe CT scanner generations, detectors, and image reconstruction methods
CO3:	Explain MRI system components, magnetics, and relaxation mechanisms
CO4:	Apply the principles of nuclear imaging using gamma cameras, SPECT, and PET
CO5:	Analyze radiation therapy systems and evaluate radiation protection methods
TEXT BOOKS:	
1.	Isaac Bankman, I. N. Bankman , Handbook Of Medical Imaging: Processing and Analysis(Biomedical Engineering),Academic Press,2000
2.	Jacob Beutel (Editor), M. Sonka (Editor), Handbook of Medical Imaging, Volume 2. Medical Image Processing and Analysis , SPIE Press 2000
3.	Khin Wee Lai, DyahEkashantiOctorinaDewi “Medical Imaging Technology”, Springer Singapore, 2015
REFERENCES:	
1.	Khandpur R.S, “Handbook of Biomedical Instrumentation”, Tata McGraw – Hill, New Delhi, 2003
2.	Dougherty, Geoff (Ed.), “Medical Image Processing - Techniques and Applications “,Springer-Verlag New York, 2011

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	2	2	2	-	-	-	-	-	3	2	3	2
CO2	3	3	3	2	2	1	-	-	-	-	-	2	2	3	2
CO3	3	3	2	2	2	2	-	-	-	-	-	2	2	2	1
CO4	3	3	3	2	2	1	-	-	-	-	-	2	2	2	1
CO5	3	3	3	3	2	2	-	-	-	-	-	1	2	2	1
CO	3	3	2.8	2.2	2	1.6	-	-	-	-	-	2	2	2.4	1.4

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CBM305	BRAIN COMPUTER INTERFACE AND APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the fundamentals, structure, and types of Brain-Computer Interface systems
- To explain electrophysiological sources such as ERP, P300, and neural activity
- To describe feature extraction techniques used for EEG signal processing
- To explain machine-learning based feature translation methods for BCI
- To analyze BCI applications in neuroprosthesis and external device control

UNIT I	INTRODUCTION TO BCI	9

Fundamentals of BCI – Structure of BCI system – Classification of BCI – Invasive, Non-invasive and Partially invasive BCI – EEG signal acquisition - Signal Preprocessing – Artifacts removal.

UNIT II	ELECTROPHYSIOLOGICAL SOURCES	9

Sensorimotor activity – Mu rhythm, Movement Related Potentials – Slow Cortical Potentials-P300 - Visual Evoked Potential - Activity of Neural Cells - Multiple Neuromechanisms.

UNIT III	FEATURE EXTRACTION METHODS	9

Time/Space Methods – Fourier Transform, PSD – Wavelets – Parametric Methods – AR,MA,ARMA models – PCA – Linear and Non-Linear Features.		
UNIT IV	**FEATURE TRANSLATION METHODS**	**9**
Linear Discriminant Analysis – Support Vector Machines - Regression – Vector Quantization– Gaussian Mixture Modeling – Hidden Markov Modeling – Neural Networks.		
UNIT V	**APPLICATIONS OF BCI**	**9**
Functional restoration using Neuroprosthesis - Functional Electrical Stimulation, Visual Feedback and control - External device control, Case studies: BCI for Smart Home Automation, Neurofeedback-Based Cognitive Training		
		TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Explain the fundamentals, structure, and signal acquisition methods used in BCI systems
CO2:	Describe electrophysiological rhythms and potentials involved in neural activity
CO3:	Explain suitable feature extraction techniques for EEG signals in BCI
CO4:	Use classification and translation algorithms to convert brain signals into commands
CO5:	Analyze BCI applications in neuroprosthesis, assistive devices, and robotic control

TEXT BOOKS:

1.	Bernhard Graimann, Brendan Allison, Gert Pfurtscheller, “Brain-Computer Interfaces: Revolutionizing Human-Computer Interaction”, Springer, 2010.
2.	R. Spehlmann, “EEG Primer”, Elsevier Biomedical Press, Third edition,1999

REFERENCES:

1.	Arnon Kohen, "Biomedical Signal Processing Vol 2: Compression and Automatic Recognition" (1st ed., 2019).
2.	Bishop C.M., “Neural Networks for Pattern Recognition”, Oxford, Clarendon Press, 1995.

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	2	2	2	-	-	-	-	-	2	3	3	3
CO2	3	3	3	2	2	1	-	-	-	-	-	2	2	2	2
CO3	3	3	3	2	2	1	-	-	-	-	-	1	1	2	2
CO4	3	3	3	3	3	2	-	-	-	-	-	2	2	3	3
CO5	3	3	3	3	3	2	-	-	-	-	-	2	2	2	2
CO	3	3	3	2	2.4	1.6	-	-	-	-	-	1.8	2	2.4	2.4

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CBM306	BODY AREA NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the fundamentals, architecture, and components of Body Area Networks
- To explain sensor design issues, biocompatibility, and energy constraints in BAN systems
- To describe wireless communication mechanisms and network protocols used in BAN
- To discuss coexistence challenges, interference mitigation, and security aspects in BAN
- To outline healthcare and clinical applications enabled through Body Area Networks

UNIT I	INTRODUCTION	9

Definition, BAN and Healthcare, Technical Challenges- Sensor design, biocompatibility, Energy Supply, optimal node placement, number of nodes, System security and reliability, BAN Architecture – Introduction.

UNIT II	HARDWARE FOR BAN	9

Processor-Low Power MCUs, Mobile Computing MCUs ,Integrated processor with radio transceiver, Memory ,Antenna-PCB antenna, Wire antenna, Ceramic antenna, External antenna, Sensor Interface, Power sources- Batteries and fuel cells for sensor nodes.

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UNIT III	**WIRELESS COMMUNICATION AND NETWORK**	**9**
RF communication in Body, Antenna design and testing, Propagation, Base Station-Network topology-Stand –Alone BAN, Wireless personal Area Network Technologies-IEEE 802.15.1,IEEE P802.15.13, IEEE 802.15.14, Zigbee..		
UNIT IV	**COEXISTENCE ISSUES WITH BAN**	**9**
Interferences – Intrinsic - Extrinsic, Effect on transmission, Counter measures- on physical layer and data link layer, Regulatory issues-Medical Device regulation in USA and Asia, Security and Self-protection-Bacterial attacks, Virus infection, Secured protocols, Self-protection		
UNIT V	**APPLICATIONS OF BAN**	**9**
Mental health monitoring, Rehabilitation and Assistive Systems, Post-Surgical Recovery Monitoring, Maternal and Fetal Health Monitoring, Environmental Interaction and Safety Monitoring, Electronic pill.		
	TOTAL: 45 PERIODS	
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Explain BAN fundamentals, architecture, and signal acquisition methods	
CO2:	Describe electrophysiological sources, rhythms, and sensor characteristics used in BAN	
CO3:	Choose suitable hardware and feature extraction techniques for BAN systems	
CO4:	Use wireless protocols and interference mitigation strategies for BAN communication	
CO5:	Analyze BAN applications in patient monitoring, sports, and clinical diagnosis	
TEXT BOOKS:		
1.	Sandeep K.S. Gupta,Tridib Mukherjee, Krishna Kumar Venkata Subramanian, “Body Area Networks Safety, Security, and Sustainability’’, Cambridge University Press, 2013	
2.	Mehmet R. Yuce, Jamil Y.Khan, “Wireless Body Area Networks Technology, Implementation, and Applications”, Pan Stanford Publishing Pte. Ltd., Singapore, 2012	
REFERENCES:		
1.	Zhang, Yuan-Ting, “Wearable Medical Sensors and Systems’’, Springer, 2013	
2.	Guang-Zhong Yang(Ed.), “Body Sensor Networks’’, Springer, second edition 2014.	
3.	Annalisa Bonfiglio, Danilo De Rossi, "Wearable Monitoring Systems", Springer, 2011.	

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	2	1	1	1	1	1	-	-	-	-	1	3	3	3
CO2	3	3	3	3	1	2	2	-	-	-	-	1	3	3	3
CO3	3	2	1	1	1	1	1	-	-	-	-	1	3	3	3
CO4	2	2	1	1	1	1	1	-	-	-	-	1	3	3	3
CO5	2	2	1	1	1	2	2	-	-	-	-	1	3	3	3
CO	2.4	2.2	1.4	1.4	1	1.4	1.4	-	-	-	-	1	3	3	3

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CBM307	MEDICAL ELECTRONICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the fundamentals of electrophysiology and bio-potential recording
- To explain biochemical and non-electrical measurement techniques used in medical instrumentation
- To describe the working principles of assist devices such as pacemakers, defibrillators, and ventilators
- To discuss diathermy techniques and biotelemetry systems used in physical medicine
- To outline recent trends in medical instrumentation such as telemedicine and lab-on-chip devices.

UNIT I	ELECTRO-PHYSIOLOGY AND BIO-POTENTIAL RECORDING	9

Sources of bio medical signals, Bio-potentials, Biopotential electrodes, biological amplifiers, ECG,EEG, EMG, PCG, typical waveforms and signal characteristics.

UNIT II	BIO-CHEMICAL AND NON ELECTRICAL PARAMETER MEASUREMENT	9

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pH, PO2, PCO2, Colorimeter, Blood flow meter, Cardiac output, respiratory, blood pressure, temperature and pulse measurement, Continuous Glucose Monitoring (CGM) Systems, Blood Cell Counters.		
UNIT III	**ASSIST DEVICES**	**9**
Cardiac pacemakers, DC Defibrillator, Dialyser, Ventilators, Magnetic Resonance Imaging Systems, Ultrasonic Imaging Systems.		
UNIT IV	**PHYSICAL MEDICINE AND BIOTELEMETRY**	**9**
Diathermies- Shortwave, ultrasonic and microwave type and their applications, Surgical Diathermy, Biotelemetry.		
UNIT V	**RECENT TRENDS IN MEDICAL INSTRUMENTATION**	**9**
Telemedicine, Insulin Pumps, Radio pill, Endomicroscopy, Brain machine interface, Lab on a chip.		
		TOTAL: 45 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Explain electrophysiological signal sources and bio-potential recording methods.	
CO2:	Describe biochemical parameters and non-electrical measurement techniques used in healthcare.	
CO3:	Interpret the various assist devices used in the hospitals viz. pacemakers, defibrillators, dialyzers and ventilators	
CO4:	Comprehend physical medicine methods like ultrasonic, shortwave, microwave surgical diathermies , and bio-telemetry	
CO5:	Analyze advanced medical technologies such as telemedicine, BMI, and minimally invasive systems.	
TEXT BOOKS:		
1.	Leslie Cromwell, “Biomedical Instrumentation and Measurement”, Prentice Hall of India, New Delhi, 2007. (UNIT I – V)	
2.	Khandpur, R.S., “Handbook of Biomedical Instrumentation”, TATA Mc Graw-Hill, New Delhi,2003.	
REFERENCES:		
1.	John.G.Webster. “Medical Instrumentation, Application and Design”. Fourth Edition. Wiley &sons, Inc., NewYork. 2010.	

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2.	Joseph. J. Carr, John Michael Brown, “Introduction to Biomedical Equipment Technology”, Prentice Hall and Technology, fourth edition, 2008.

CO’s-PO’s & PSO’s MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	2	1	2	1	1	1	-	-	-	-	1	1	1	1
CO2	2	2	3	2	1	2	2	-	-	-	-	1	2	1	2
CO3	2	2	1	2	1	1	1	-	-	-	-	1	1	1	1
CO4	2	2	1	2	1	1	1	-	-	-	-	1	1	1	1
CO5	2	2	1	2	1	2	2	-	-	-	-	1	2	1	2
CO	2	2	1.4	2	1	1.4	1.4	-	-	-	-	1	1.4	1	1.4

1 - low, 2 - medium, 3 - high, ‘-' - no correlation

24CBM308	BIOMEDICAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide an understanding of various biomedical signal types and their inherent properties.
- To impart knowledge on adaptive filtering and modeling techniques for processing physiological signals
- To introduce analytical methods for interpreting ECG, EEG, EMG, and other clinical signals.
- To discuss wavelet-based time–frequency analysis for biomedical signals.
- To expose learners to real-time applications of biosignal processing in medical diagnostics and healthcare systems.

UNIT I	BIOMEDICAL SIGNAL AND SPECTRAL CHARACTERISTICS	9

Characteristics of biomedical signals, Stationary and Non stationary signals, Noises- random, structured and physiological noises, Spectral characteristics, Power spectrum estimation, Filtering for removal of artifacts- Time domain filters, Frequency domain filters, Optimal Filter- Wiener filter.

UNIT II	**ADAPTIVE FILTERS AND MODELING**	**9**
Adaptive filter- Least Mean square filter, Recursive Least square filter, Applications- Removal of artifact in ECG and EEG signals, Elimination of Maternal ECG in Fetal ECG, Autoregressive Modeling, PCA, ICA.		
UNIT III	**ANALYSIS OF BIOMEDICAL SIGNALS**	**9**
QRS detection in ECG signal, Heart rate variability, Analysis of EEG signal- EEG Frequency band separation, Visual evoked potential, Synchronous Averaging, Event related potential, Analysis of EMG signals- Feature extraction.		
UNIT IV	**WAVELET ANALYSIS**	**9**
Time frequency Representation, Short time Fourier transform, Wavelets- Multiresolution analysis, Continuous wavelet transform, Discrete wavelet transform, Wavelet Packets, Wavelet denoising.		
UNIT V	**APPLICATIONS**	**9**
Denoising of Biosignals , Arrhythmia detection, Epileptic seizure detection, Emotion recognition, Case studies: Sleep Stage Classification Using EEG Signals, Real-Time Cardiac Event Monitoring and Prediction.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Explain the characteristics, spectrum, and filtering techniques used for biomedical signals.
CO2:	Demonstrate the use of adaptive filters and signal modeling techniques for processing physiological data
CO3:	Analyze ECG, EEG, and EMG signals using suitable detection and feature extraction methods.
CO4:	Apply wavelet transforms and time–frequency analysis for biomedical signal interpretation.
CO5:	Evaluate biomedical signal processing applications such as denoising, arrhythmia detection, and seizure detection

TEXT BOOKS:

1.	Arnon Cohen, “Bio-Medical Signal Processing Vol I and Vol II”, CRC Press Inc., 2021.
2.	Rangaraj M. Rangayyan, “Biomedical Signal Analysis-A case study approach”, Wiley, 2nd Edition, 2016.
3.	Raghuveer M. Rao and Ajith S.Bopardikar, “Wavelets transform – Introduction to theory and its applications”, Pearson Education, India, 2000.

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REFERENCES:	
1.	Emmanuel C. Ifeachor, Barrie W.Jervis, “Digital Signal processing- A Practical Approach’’, Pearson education Ltd., 2004.
2.	John L.Semmlow, “Biosignal and Biomedical Image Processing Matlab Based applications’’, Taylor& Francis Inc, 2004.
3.	Kayvan Najarian and Robert Splerstor, “Biomedical signals and Image processing’’, CRC – Taylor and Francis, New York, 2nd Edition, 2012.

CO’s-PO’s & PSO’s MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	2	2	2	-	-	-	-	-	2	3	3	1
CO2	3	3	3	2	2	1	-	-	-	-	-	2	2	3	2
CO3	3	3	3	2	2	1	-	-	-	-	-	1	1	3	1
CO4	3	3	3	3	3	2	-	-	-	-	-	2	2	3	1
CO5	3	3	3	3	3	2	-	-	-	-	-	2	2	3	2
CO	3	3	3	2	2.4	1.6	-	-	-	-	-	1.8	2	3	1.4

1 - low, 2 - medium, 3 - high, ‘-' - no correlation

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VERTICAL 4: HIGH SPEED COMMUNICATIONS

24CEC401	OPTICAL COMMUNICATION & NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study about the various optical fiber modes, configuration of optical fibers
- To study transmission characteristics of optical fibers.
- To learn about the various optical sources, detectors and transmission techniques.
- To explore various idea about optical fiber measurements and various coupling techniques
- To enrich the knowledge about optical communication systems and networks

UNIT I	INTRODUCTION TO OPTICAL FIBER COMMUNICATION	9

Introduction - The General Systems - Advantages of Optical Fiber Communication- Ray Theory Transmission : Total Internal Reflection, Acceptance Angle, Numerical Aperture, Skew Rays - Electromagnetic Mode Theory for Optical Propagation: Modes in a Planar Guide, Phase and group velocity - Cylindrical Fiber: Step index fibers, Graded index fibers - Single mode fibers: Cutoff wavelength.

UNIT II	TRANSMISSION CHARACTERISTICS OF OPTICAL FIBERS	9

Attenuation - Material absorption losses in silica glass fibers: Intrinsic absorption, Extrinsic absorption - Linear scattering losses: Rayleigh Scattering, Mie Scattering -Nonlinear scattering losses: Stimulated Brillouin Scattering, Stimulated Raman Scattering – Fiber Bend Loss – Dispersion- Chromatic dispersion: Material dispersion, Waveguide dispersion- Intermodal dispersion : Multimode step index fiber, Multimode graded index fiber.

UNIT III	OPTICAL SOURCES AND OPTICAL DETECTORS	9

The laser : Introduction - Basic concepts: Absorption and emission of radiation, Population inversion , Optical feedback and laser oscillation, Threshold condition for laser oscillation- Optical emission from semiconductors: The PN junction, Spontaneous emission, Carrier recombination, Stimulated emission and lasing, Hetero junctions- LED: Introduction- Power and Efficiency - LED structures: Planar LED, Dome LED, Surface emitter LED, Edge emitter LED- LED Characteristics. Optical Detectors: Introduction ,Optical Detection Principles, Quantum Efficiency, Responsivity, P-N Photodiode ,P-I-N Photo Diode and Avalanche Photodiode.

UNIT IV	OPTICAL FIBER MEASUREMENTS	9

Introduction- Total Fiber Attenuation Measurement, Fiber Dispersion Measurements In Time Domain and Frequency Domain, Fiber Cut off Wavelength Measurements, Numerical Aperture Measurements. Fiber Diameter Measurements, Reflectance and Optical Return Loss, Field Measurements

UNIT V	OPTICAL NETWORKS	9

System design consideration Point – to –Point link design –Link power budget –rise time budget, WDM – Passive DWDM Components- DWDM in High-Capacity Optical Backbone Networks- Elements of optical networks-SONET/SDH Optical Interfaces-SONET/SDH Rings and Networks-High speed light wave Links-OADM configuration-Optical ETHERNET-Soliton,	
TOTAL: 45 PERIODS	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1	Explains the basic elements in optical fibers, different modes and configurations
CO2	Analyze the transmission characteristics associated with dispersion and polarization techniques.
CO3	Design optical sources and detectors with their use in optical communication system.
CO4	Construct fiber optic receiver systems, measurements and techniques.
CO5	Design optical communication systems and its networks.
TEXT BOOKS:	
1.	John M. Senior, “Optical Fiber Communication”, Pearson Education, Fourth Edition.2010.
REFERENCES:	
1.	Gred Keiser, "Optical Fiber Communication”, McGraw Hill Education (India) Private Limited. Fifth Edition, Reprint 2013.
2.	Govind P. Agrawal, “Fiber-Optic Communication Systems”, Third Edition, John Wiley & Sons, 2004.
3	J. Gower, “Optical Communication System”, Prentice Hall Of India, 2001
4.	Rajiv Rama swami, “Optical Networks “ , Second Edition, Elsevier , 2004.
5.	P Chakrabarti, "Optical Fiber Communication”, McGraw Hill Education (India)Private Limited, 2016

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	3	3	-	-	-	1	-	1	2	2	1	2
CO2	3	3	2	2	3	-	-	-	1	-	2	2	2	2	2
CO3	3	3	3	3	3	-	-	-	1	-	1	2	2	1	2
CO4	3	3	3	3	2	-	-	-	1	-	1	2	2	2	2
CO5	3	3	3	3	2	-	-	-	1	-	2	2	2	2	2
CO	3	3	3	3	3	-	-	-	1	-	1	2	2	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC402	WIRELESS BROAD BAND NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study the various network layer and transport layer protocols for wireless networks
- To study the architecture and interference mitigation techniques in 3G standards
- To learn about 4G technologies and LTE-A in mobile cellular network.
- To learn about the layer level functionalities in interconnecting networks
- To study the emerging techniques in 5G network.

UNIT I	WIRELESS PROTOCOLS	9

Mobile network layer- Fundamentals of Mobile IP, data forwarding procedures in mobile IP, IPv4, IPv6, IP mobility management, IP addressing - DHCP, Mobile transport layer-Traditional TCP, congestion control, slow start, fast recovery/fast retransmission, classical TCP improvements Indirect TCP, snooping TCP, Mobile TC.

UNIT II	3G EVOLUTION	9

IMT-2000 - W-CDMA, CDMA 2000 - radio & network components, network structure, packet-data transport process flow, Channel Allocation, core network, interference-mitigation techniques, UMTS-

services, air interface, network architecture of 3GPP, UTRAN – architecture, High Speed Packet Data-HSDPA, HSUPA.		
UNIT III	**4G EVOLUTION**	**9**
Introduction to LTE-A – Requirements and Challenges, network architectures – EPC, E- UTRAN architecture - mobility management, resource management, services, channel -logical and transport channel mapping, downlink/uplink data transfer, MAC control element, PDU packet formats, scheduling services, random access procedure, LTE for high-speed mobile broadband and real-time applications		
UNIT IV	**LAYER-LEVEL FUNCTIONS**	**9**
Characteristics of wireless channels - downlink physical layer, uplink physical layer, MAC scheme - frame structure, resource structure, mapping, synchronization, reference signals and channel estimation, SC-FDMA, interference cancellation – CoMP, Carrier aggregation, Services - multimedia broadcast/multicast, location-based services		
UNIT V	**5G EVOLUTION**	**9**
5G Roadmap - Pillars of 5G - 5G Architecture, The 5G internet - IoT and context awareness - Networking reconfiguration and virtualization support - Mobility QoS control - emerging approach for resource over provisioning, Small cells for 5G mobile networks- capacity limits and achievable gains with densification - Mobile data demand, Demand Vs Capacity, Small cell challenges, conclusion and future directions.		
		TOTAL: 45 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1	Design and implement the various protocols in wireless networks.	
CO2	Analyze the architecture of 3G network standards.	
CO3	Analyze the difference of LTE-A network design from 4G standard	
CO4	Design the interconnecting network functionalities by layer level functions	
CO5	Explore the current generation (5G) network architecture.	
TEXT BOOKS:		
1.	Kaveh Pahlavan, “Principles of wireless networks”, Prentice-Hall of India, 2008	
REFERENCES:		
1.	Vijay K.Garg, “Wireless Network Evolution - 2G & 3G”. Prentice Hall, 2008	
2.	Clint Smith,P.E, Dannel Collins, “3G Wireless Networks” Tata McGraw- Hill, 2nd Edition, 2011.	

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3	Jonathan Rodriguez, "Fundamentals of 5G Mobile networks", John Wiley, 2015.
4.	Sassan Ahmadi, “LTE-Advanced – A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies”, Elsevier, 2014.

CO’s-PO’s & PSO’s MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	3	3	-	-	-	1	-	1	3	3	1	1
CO2	3	3	2	2	3	-	-	-	1	-	2	3	3	2	2
CO3	3	3	3	3	2	-	-	-	1	-	1	3	3	2	2
CO4	2	3	3	3	2	-	-	-	1	-	1	3	2	1	2
CO5	2	2	3	3	2	-	-	-	1	-	2	3	2	2	1
CO	3	3	3	3	2	-	-	-	1	-	1	3	3	2	2

1 - low, 2 - medium, 3 - high, ‘-' - no correlation

24CEC403	5G COMMUNICATION NETWORKS	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To learn the evolution of wireless networks
- To get acquainted with the fundamentals of 5G networks.
- To study the processes associated with 5G architecture.
- To study spectrum sharing and spectrum trading
- To learn the security features in 5G networks.

UNIT I	EVOLUTION OF WIRELESS NETWORKS	6

Networks evolution: 2G,3G,4G, evolution of radio access networks, need for 5G. 4G versus 5G, Next Generation core (NG-core), visualized Evolved Packet core(vEPC).

UNIT II	5G CONCEPTS AND CHALLENGES	6

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Fundamentals of 5G technologies, overview of 5G core network architecture,5G new radio and cloud technologies, Radio Access Technologies (RATs), EPC for 5G ,5G New Radio and cloud-based core network		
UNIT III	**NETWORK ARCHITECTURE AND THE PROCESSES**	**6**
5G architecture and core, network slicing, multi access edge computing (MEC)visualization of 5G components, end-to-end system architecture, service continuity, relation to EPC, and edge computing. 5G protocols: 5G NAS, NGAP, GTP-U, IP Sec and GRE		
UNIT IV	**DYNAMIC SPECTRUM MANAGEMENT AND MM-WAVES**	**6**
Mobility management, Command and control, spectrum sharing and spectrum trading, cognitive radio based on 5G, millimeter waves...		
UNIT V	**SECURITY IN 5G NETWORKS**	**6**
Security features in 5G networks, network domain security, user domain security, flow based QoS framework, mitigating the threats in 5G.		
		30 PERIODS
PRACTICAL EXPERIMENTS:		
Simulation Using MATLAB		
7.	5G-Compliant waveform generation and testing	
8.	Modeling of 5G Synchronization signal blocks and bursts	
9.	Channel modeling in 5G networks	
4.	Multiband OFDM demodulation	
5.	Perfect Channel estimation	
6.	Development of 5G New Radio Polar Coding	
		30 PERIODS
		TOTAL: 60 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1	Explains the evolution of wireless networks.	
CO2	Illustrate the concepts of 5G networks.	
CO3	Analyze the 5G architecture and protocols	

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CO4	Interpret the concepts of dynamic spectrum management.
CO5	Examines the security aspects in 5G networks
TEXT BOOKS:	
1.	5G Core networks: Powering Digitalization , Stephen Rommer, Academic Press,2019
2.	An Introduction to 5G Wireless Networks : Technology, Concepts and Use cases, Saro Velrajan,First Edition, 2020.
REFERENCES:	
1.	5G Simplified: ABCs of Advanced Mobile Communications Jyrki. T.J.Penttinen, Copyrighted Material
2.	5G system Design: An end to end Perspective , Wan Lee Anthony, Springer Publications,2019.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	3	2	-	-	-	1	-	1	2	1	1	3
CO2	3	3	2	2	2	-	-	-	1	-	1	2	1	1	2
CO3	3	3	3	2	2	-	-	-	1	-	1	2	2	2	2
CO4	3	3	2	3	2	-	-	-	1	-	1	2	3	2	2
CO5	3	2	3	3	2	-	-	-	1	-	1	2	2	2	2
CO	3	3	3	3	2	-	-	-	1	-	1	2	2	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC404	**SOFTWARE DEFINED NETWORKS**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- To understand the need for SDN and its data plane operations
- To understand the functions of control plane
- To comprehend the migration of networking functions to SDN environment.

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● To explore various techniques of network function virtualization		
● To comprehend the concepts behind network virtualization		
UNIT I	**SDN: BACKGROUND AND DATA PLANE**	**6**
Evolving Network Requirements – The SDN Approach – SDN and NFV-Related Standards – SDN Data Plane – OpenFlow Logical Network Device – OpenFlow Protocol.		
UNIT II	**SDN CONTROL PLANE**	**6**
SDN Control Plane Architecture: Southbound Interface, Northbound Interface – Control Plane Functions – ITU-T Model – Open Daylight – REST – Cooperation and Coordination among Controllers.		
UNIT III	**SDN APPLICATION PLANE**	**6**
SDN Application Plane Architecture – Network Services Abstraction Layer – Traffic Engineering – Measurement and Monitoring – Security – Data Center Networking -- -Mobility and Wireless – Information-centric Networking- Case studies- SDN-based traffic engineering.		
UNIT IV	**NETWORK FUNCTION VIRTUALIZATION**	**6**
NFV Concepts – Benefits and Requirements – Reference Architecture – NFV Infrastructure – Virtualized Network Functions – NFV Management and Orchestration – NFV Use cases – SDN and NFV		
UNIT V	**NETWORK VIRTUALIZATION**	**6**
Virtual LANs – OpenFlow VLAN Support – Virtual Private Networks – Network Virtualization – Open Daylight's Virtual Tenant Network – CoSoftware -Defined Infrastructure,Virtualized network functions		
30 PERIODS		
PRACTICAL EXERCISES:		
1.	Installing Mininet simulator	
2.	Creating a 1 controller, 3 node topology, POX controller	
3.	Ability to view, read/write Flow table rules (for different applications - say firewall, Learning switch etc.), POX, Open v Switch	
4.	Building a SDN based application	
30 PERIODS		
TOTAL: 60 PERIODS		

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COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Describe the motivation behind SDN and its data plane
CO2:	Identify the functions of control plane.
CO3:	Apply SDN to networking applications
CO4:	Apply various operations of network function virtualization.
CO5:	Explain various use cases of SDN
TEXT BOOKS:	
1.	Fei Hu, "Network Innovation through OpenFlow and SDN: Principles and Design", 1st Edition, CRC Press, 2014..
2.	Thomas D Nadeau, Ken Gray, "SDN: Software Defined Networks", O'Reilly Media, 2013.
REFERENCES:	
1.	5G Simplified: ABCs of Advanced Mobile Communications Jyrki. T.J.Penttinen,Copyrighted Material
2.	Paul Goransson, Chuck Black Timothy Culver, "Software Defined Networks: A Comprehensive Approach", 2nd Edition, Morgan Kaufmann Press, 2016
3.	Oswald Coker, Siamak Azodolmolky, "Software-Defined Networking with OpenFlow", 2nd Edition, O'Reilly Media, 2017.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	2	2	2	2	-	-	-	1	-	3	3	2	2
CO2	3	3	3	2	2	2	-	-	-	1	-	2	3	2	2
CO3	3	3	3	2	2	2	-	-	-	1	-	2	3	2	3
CO4	3	3	3	2	2	2	-	-	-	1	-	2	2	2	2
CO5	3	3	3	3	2	2	-	-	-	1	-	2	2	2	2
CO	3	3	3	2	2	2	-	-	-	1	-	2	2	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24CEC405	MASSIVE MIMO NETWORKS	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To gain knowledge about massive MIMO networks
- To understand the massive MIMO propagation channels
- To learn about channel estimation in single cell and multicell massive MIMO systems.
- To comprehend the concepts of massive MIMO deployment in the context of single cell and multicell deployment.

UNIT I	MASSIVE MIMO NETWORKS	6

Definition of Massive MIMO, Correlated Rayleigh Fading, System Model for Uplink and Downlink, Basic Impact of Spatial Channel Correlation, Channel Hardening and Favourable Propagation, Local Scattering Spatial Correlation Model.

UNIT II	THE MASSIVE MIMO PROPAGATION CHANNEL	6

Favorable Propagation and Deterministic Channels-Capacity Upper Bound-Distance from Favorable Propagation-Favorable Propagation and Linear Processing-Singular Values and Favorable Propagation, Favorable Propagation and Random Channels-Independent Rayleigh Fading-Uniformly Random Line-of-Sight (UR-LoS)-Independent Rayleigh Fading versus UR-LoS - Finite-Dimensional Channels.

UNIT III	SINGLE-CELL SYSTEMS	6

Uplink Pilots and Channel Estimation - Orthogonal Pilots- De-Spreading of the Received Pilot Signal-MMSE Channel Estimation, Uplink Data Transmission - Zero-Forcing -Maximum-Ratio, Downlink Data Transmission-Linear Precoding-Zero-Forcing-Maximum-Ratio, Discussion Interpretation of the Effective SINR Expressions-Implications for Power Control-Scaling Laws and Upper Bounds on the SINR - Near-Optimality of Linear Processing when M >> K - Net Spectral Efficiency - Limiting Factors: Number of Antennas and Mobility

UNIT IV	MULTI-CELL SYSTEMS	6

Uplink Pilots and Channel Estimation, Uplink Data Transmission - Zero-Forcing -Maximum-Ratio, Downlink Data Transmission -Zero-Forcing - Maximum-Ratio, Discussion -Asymptotic Limits with Infinite Numbers of Base Station Antennas - The Effects of Pilot Contamination - Non-Synchronous Pilot Interference, Mitigation of pilot contamination

UNIT V	CASE STUDIES	6

Single-Cell Deployment Example: Fixed Broadband Access in Rural Area, Multi-Cell Deployment: Preliminaries and Algorithms, Multi-Cell Deployment Examples: Mobile Access - Dense Urban 178

Scenario - Suburban Scenario - Minimum Per-Terminal Throughput Performance -Additional Observations - Comparison of Power Control Policies	
30 PERIODS	
PRACTICAL EXERCISES:	
1.	Massive MIMO hybrid beamforming
2.	Single cell massive MIMO downlink communications
3.	Multicell massive MIMO downlink communications
4.	Precoding in massive MIMO single cell and multicell downlink communications
5.	Channel estimation in massive MIMO system
30 PERIODS	
TOTAL: 60 PERIODS	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Understand and explain massive MIMO networks.
CO2:	Analyze massive MIMO propagation channels and their capacity bounds
CO3:	Examine channel estimation techniques for single cell system
CO4:	Analyze channel estimation techniques for multi cell system.
CO5:	Explain the concepts underlining the deployment of single and multicell massive MIMO systems.
TEXT BOOKS:	
1.	Thomas L. Marzetta, Erik G. Larsson, Hong Yang, Hien Quoc Ngo, “Fundamentals of Massive MIMO”, Cambridge University Press 2016. (UNITS II-V)
2.	Emil Björnson, Jakob Hoydis and Luca Sanguinetti (2017), “Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency”, Foundations and Trends, Now, 2017. (UNIT I)
REFERENCES:	
1.	Long Zhao, Hui Zhao, Kan Zheng, “Wei Xiang Massive MIMO in 5G Networks: Selected Applications”, Springer 2018.
2.	Leibo Liu, Guiqiang Peng, Shaojun Wei, “Massive MIMO Detection Algorithm and VLSI Architecture”, Springer 2019.

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3.	Shahid Mumtaz, Jonathan Rodriguez, Linglong Dai, "mmWave Massive MIMO A Paradigm for 5G", Elsevier, 2017

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	1	1	2	2	-	-		-		2	3	1	2
CO2	3	3	2	2	2	2	-	-		-		1	2	2	1
CO3	3	2	2	2	2	2	-	-		-		1	3	3	3
CO4	2	3	2	2	2	2	-	-		-		2	3	1	2
CO5	3	2	2	2	2	2	-	-		-		2	3	3	2
CO	3	3	2	2	2	2	-	-		-		2	3	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC406	ADVANCED WIRELESS COMMUNICATION TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the evolving paradigm of cooperative communication
- To understand concepts related to green wireless communication
- To enable the student to understand the different power saving strategies and energy efficient signal, system and network design.
- To expose the student to the energy saving techniques adopted in existing wireless components
- To provide understanding on protocols and networks related to green future wireless communication technologies.

UNIT I	COOPERATIVE COMMUNICATIONS AND GREEN CONCEPTS	9

Network architectures and research issues in cooperative cellular wireless networks ; Cooperative communications in OFDM and MIMO cellular relay networks: issues and approaches; Fundamental trade-offs on the design of green radio networks, Green modulation and coding schemes..

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UNIT II	**COOPERATIVE TECHNIQUES**	**9**
Cooperative techniques for energy efficiency, Cooperative base station techniques for cellular wireless networks; Turbo base stations; Antenna architectures for cooperation; Cooperative communications in 3GPP LTE-Advanced, Partial information relaying and Coordinated multi-point transmission in LTE-Advanced.		
UNIT III	**RELAY-BASED COOPERATIVE CELLULAR NETWORKS**	**9**
Distributed space-time block codes ; Collaborative relaying in downlink cellular systems ; Radio resource optimization; Adaptive resource allocation ; Cross-layer scheduling design for cooperative wireless two-way relay networks ; Network coding in relay-based networks,Relay-assisted communication with network coding		
UNIT IV	**GREEN RADIO NETWORKS**	**9**
Base Station Power-Management Techniques- Opportunistic spectrum and load management, Energy-saving techniques in cellular wireless base stations , Power-management for base stations in smart grid environment, Cooperative multi cell processing techniques for energy-efficient cellular wireless communications.		
UNIT V	**ACCESS TECHNIQUES FOR GREEN RADIO NETWORKS**	**9**
Cross-layer design of adaptive packet scheduling for green radio networks; Energy-efficient relaying for cooperative cellular wireless networks ; Energy performance in TDD-CDMA multihop cellular networks ; Resource allocation for green communication in relay-based cellular networks ; Green Radio Test-Beds and Standardization Activities.		
		TOTAL: 45 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Appraise the necessity and the design aspects of cooperative communication	
CO2:	Appraise the necessity and the design aspects of green wireless communication..	
CO3:	Evolve new techniques in wireless communication	
CO4:	Demonstrate the feasibility of using mathematical models using simulation tools.	
CO5:	Demonstrate the impact of the green engineering solutions in a global, economic, environmental and societal context..	
TEXT BOOKS:		
1.	Ekram Hossain, Dong In Kim, Vijay K. Bhargava , “Cooperative Cellular Wireless Networks”,Cambridge University Press, 2011	

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2.	Ekram Hossain, Vijay K. Bhargava(Editor), Gerhard P. Fettweis (Editor), "Green Radio Communication Networks", Cambridge University Press, 2012.
REFERENCES:	
1.	F. Richard Yu, Yu, Zhang and Victor C. M. Leung "Green Communications and Networking", CRC press, 2012.
2.	Ramjee Prasad and Shingo Ohmori, Dina Simunic, "Towards Green ICT", River Publishers,2010..
3	Jinsong Wu, Sundeep Rangan and Honggang Zhang, "Green Communications: Theoretical Fundamentals, Algorithms and Applications", CRC Press, 2012.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	2	1	1	-	-		-		2	3	3	3
CO2	3	3	3	2	2	1	-	-		-		2	3	2	3
CO3	3	2	2	1	2	1	-	-		-		2	2	1	1
CO4	3	3	3	3	1	1	-	-		-		2	3	1	2
CO5	3	3	3	2	1	2	-	-		-		2	2	3	1
CO	3	3	3	2	2	1	-	-		-		2	3	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC407	SATELLITE COMMUNICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basics of satellite orbits.
- To understand the satellite and earth segments.
- To understand Link Power budget calculation
- To understand the various satellite access and coding technology

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● To understand the applications of satellite.		
UNIT I	**SATELLITE ORBITS**	**9**
Kepler's Laws, Newton's law, orbital parameters, orbital perturbations, station keeping, geo stationary and non Geo-stationary orbits – Look Angle Determination- Limits of visibility – eclipseSub satellite point – Sun transit outage-Launching Procedures - launch vehicles and propulsion		
UNIT II	**SPACE SEGMENT**	**9**
Spacecraft Technology- Structure, Primary power, Attitude and Orbit control, Thermal control and Propulsion, communication Payload and supporting subsystems, Telemetry, Tracking and command- Transponders Antenna Subsystem.		
UNIT III	**SATELLITE LINK DESIGN**	**9**
Basic link analysis, Uplink and Downlink Design equation, Free space loss-Atmospheric effects, Ionospheric scintillation, Rain induced attenuation and interference, system noise temperature, Link Design with and without frequency reuse.		
UNIT IV	**SATELLITE ACCESS AND CODING TECHNIQUES**	**9**
Modulation and Multiplexing: Voice, Data, Video, Analog – digital transmission system, Digital video Broadcast, multiple access: FDMA, TDMA, CDMA, PAMA and DAMA Assignment Methods, compression – encryption, Coding Schemes.		
UNIT V	**SATELLITE APPLICATIONS**	**9**
INTELSAT Series, INSAT, VSAT, Mobile satellite services: GSM, GPS, LEO, MEO, Satellite Navigational System. GPS-Position Location Principles, Differential GPS, Direct Broadcast satellites (DBS/DTH). Case studies with GPS and Differential GPS		
		TOTAL: 45 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Identify the satellite orbits	
CO2:	Analyze the satellite subsystems	
CO3:	Evaluate the satellite link power budget.	
CO4:	Identify access technology for satellite	
CO5:	Design various satellite applications	
TEXT BOOKS:		

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1.	Dennis Roddy, “Satellite Communication”, Fourth Edition, Mc Graw Hill International, 2017. (Unit I-IV)
2.	Timothy, Pratt, Charles,W.Bostain, Jeremy E.Allnutt, "SatelliteCommunication”,Third Edition, Wiley Publications, 2021 (Unit V).
REFERENCES:	
1.	Wilbur L.Pritchard, Hendri G. Suyderhoud, Robert A. Nelson, “Satellite Communication Systems Engineering”, Second Edition, Prentice Hall/Pearson, 2013.
2.	M.Richharia, “Mobile Satellite Communications :Principles and Trends”, Wiley publishers 2014
3	Tri T. Ha, “Digital Satellite Communications”, Second Edition, Mc Graw Hill education, 2017.
4.	Brian Ackroyd, “World Satellite Communication and earth station Design”, BSP professional Books, 1990
5.	Bruce R. Elbert, “The Satellite Communication Applications”, Hand Book, Artech House Bostan London, 2003.

CO’s-PO’s & PSO’s MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	2	2	1	1	-	-	-	1	-	1	2	2	-	1
CO2	2	2	2	1	1	-	-	-	1	-	1	2	2	-	1
CO3	2	2	2	1	1	-	-	-	1	-	1	2	2	-	1
CO4	2	2	2	1	1	-	-	-	1	-	1	2	2	-	1
CO5	2	2	2	1	1	-	-	-	1	-	1	2	2	-	1
CO	2	2	2	1	1	-	-	-	1	-	1	2	2	-	1

1 - low, 2 - medium, 3 - high, ‘-' - no correlation

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24CEC408	WIRELESS SENSOR NETWORK DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of wireless sensor network
- To gain knowledge on the MAC and Routing Protocols of WSN
- To get exposed to 6LOWPAN technology.
- To acquire knowledge on the protocols required for developing real time applications using WSN and 6LOWPAN.
- To gain knowledge about operating system related to WSN and 6LOWPAN.

UNIT I	INTRODUCTION	9

Principle of Wireless Sensor Network -Introduction to wireless sensor networks- Challenges, Comparison with ad hoc network, Node architecture and Network architecture, design principles, Service interfaces, Gateway, Short range radio communication standards-IEEE 802.15.4, Zigbee and Bluetooth. Physical layer and transceiver design considerations.

UNIT II	MAC AND ROUTING PROTOCOLS	9

MAC protocols – fundamentals, low duty cycle protocols and wakeup concepts, contention and Schedule-based protocols - SMAC, BMAC, TRAMA, Routing protocols – Requirements, Classification -SPIN, Directed Diffusion, COUGAR, ACQUIRE, LEACH, PEGASIS

UNIT III	6LOWPAN	9

6LoWPAN Architecture - protocol stack, Adaptation Layer, Link layers – Addressing, Routing - Mesh Under - Route-Over, Header Compression - Stateless header compression - Context- based header compression, Fragmentation and Reassembly , Mobility – types, Mobile IPv6,Proxy Home Agent, Proxy MIPv6, NEMO –Routing – MANET, ROLL, Border routing.

UNIT IV	APPLICATION	9

Design Issues, Protocol Paradigms -End-to-end, Real-time streaming and sessions, Publish/subscribe, Web service paradigms, Common Protocols -Web service protocols, MQ telemetry transport for sensor networks (MQTT-S), ZigBee compact application protocol (CAP),Service discovery, Simple network management protocol (SNMP), Real-time transport and sessions, Industry- Specific protocols.

UNIT V	TOOLS	9

TinyOS – Introduction, NesC, Interfaces, modules, configuration, Programming in TinyOS using NesC, TOSSIM, Contiki – Structure, Communication Stack, Simulation environment – Cooja simulator, Programming.

	TOTAL: 45 PERIODS
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1	Design solutions for WSNs applications
CO2	Develop efficient MAC and Routing Protocols
CO3	Design solutions for 6LOWPAN applications
CO4	Develop efficient layered protocols in 6LOWPAN.
CO5	Examine Tiny OS and Contiki OS in WSNs and 6LOWPAN applications
TEXT BOOKS:	
1.	Anna Forster, "Introduction to Wireless Sensor Networks", Wiley, 2017.
REFERENCES:	
1.	Holger Karl , Andreas willig, "Protocol and Architecture for Wireless Sensor Networks", John Wiley Publication, 2006.
2.	Zach Shelby Sensinode and Carsten Bormann, " 6LoWPAN: The Wireless Embedded Internet" John Wiley and Sons, Ltd, Publication, 2009.
3	Philip Levis, "TinyOS Programming", 2006 –www.tinyos.net.
4.	The Contiki Operating System.http://www.sics.se/contiki.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	2	2	1	-	-		-	2	2	3	1	1
CO2	3	3	2	2	2	1	-	-		-	2	2	3	2	2
CO3	3	2	3	2	2	1	-	-		-	2	3	2	2	2
CO4	3	3	3	3	2	2	-	-		-	2	2	3	1	2
CO5	2	2	1	1	3	2	-	-		-	2	2	2	2	1
CO	3	3	2	2	2	1	-	-		-	2	2	3	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

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VERTICAL 5: EMERGING TECHNOLOGIES

24CEC501	REMOTE SENSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the fundamental principles of remote sensing and the role of electromagnetic radiation in data acquisition.
- To explain the interaction of electromagnetic radiation with the atmosphere and Earth surface materials to support interpretation of remote-sensing data.
- To provide knowledge on satellite orbits, sensors, and remote-sensing platforms used for Earth observation.
- To develop understanding of various sensing techniques, sensor characteristics, and data acquisition methods used in remote-sensing applications.
- To enable students to learn image products, interpretation techniques, and basic digital image processing methods for remote-sensing data analysis.

UNIT I	REMOTE SENSING AND ELECTROMAGNETIC RADIATION	9

Definition and components of remote sensing; history of remote sensing; merits and demerits of conventional vs remote-sensing data collection; electromagnetic spectrum; radiation principles (wave theory, Planck's law, Wien's displacement law, Stefan–Boltzmann law, Kirchhoff's law); radiation sources: active & passive; radiation quantities.

UNIT II	EMR INTERACTION WITH ATMOSPHERE AND EARTH MATERIALS	9

Standard atmospheric profile; main atmospheric regions and their characteristics; interaction of radiation with atmosphere: scattering, absorption, refraction; atmospheric windows; specular and diffuse reflectors; spectral reflectance & emittance; concept of spectral signature; typical spectral reflectance curves for vegetation, soil, water; solid-surface scattering in microwave region.

UNIT III	ORBITS AND PLATFORMS	9

Motions of planets and satellites – Newton's law of gravitation - Gravitational field and potential - Escape velocity - Kepler's law of planetary motion - Orbit elements and types – Orbital perturbations and maneuvers – Types of remote sensing platforms - Ground based, Airborne platforms and Space borne platforms – Classification of satellites – Sun synchronous and Geosynchronous satellites – Lagrange Orbit.

UNIT IV	SENSING TECHNIQUES	9

Classification of remote sensors – Resolution concept: spatial, spectral, radiometric and temporal resolutions – Scanners – Along-track and across-track scanners – Optical–infrared sensors – Thermal sensors – Microwave sensors – Calibration of sensors – High-resolution sensors – LiDAR and UAV-based remote sensing – Orbital and sensor characteristics of live Indian Earth observation satellites – Active and passive

remote sensing principles – Multispectral and hyperspectral sensing concepts – Applications of sensing techniques in agriculture, disaster management and urban studies.		
UNIT V	**DATA PRODUCTS AND INTERPRETATION**	**9**
Photographic and digital products – Types, levels and open-source satellite data products – Selection and procurement of data – Visual interpretation: basic elements and interpretation keys – Digital interpretation – Concepts of image rectification – Image enhancement – Image classification – Accuracy assessment and validation of classified images – Introduction to GIS integration and thematic map generation – Applications of interpreted data in land use, environmental and disaster studies.		
		TOTAL: 45 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Understand the concepts and laws related to remote sensing.	
CO2:	Understand the interaction of electromagnetic radiation with atmosphere and Earth materials.	
CO3:	Acquire knowledge about satellite orbits and different types of satellites/platforms.	
CO4:	Understand different types of remote sensors and sensing techniques.	
CO5:	Gain knowledge about the concepts of interpretation of satellite imagery	
TEXT BOOKS:		
1.	Thomas M.Lillesand, Ralph W. Kiefer and Jonathan W. Chipman, Remote Sensing and Image interpretation, John Wiley and Sons, Inc, New York,2015.	
2.	George Joseph and C Jeganathan, Fundamentals of Remote Sensing,Third Edition Universities Press (India) Private limited, Hyderabad, 2018	
REFERENCES:		
1.	Janza, F.Z., Blue H.M. and Johnson,J.E. Manual of Remote Sensing. Vol.1, AmericanSociety of Photogrametry, Virginia, USA, 2002	
2.	Verbyla, David, Satellite Remote Sensing of Natural Resources. CRC Press, 1995	
3.	Paul Curran P.J. Principles of Remote Sensing. Longman, RLBS, 1988.	
4.	Introduction to Physics and Techniques of Remote Sensing , Charles Elachi and JacobVan Zyl, 2006 Edition II, Wiley Publication.	
5.	Basudeb Bhatta, Remote Sensing and GIS, Oxford University Press, 2011	
6.	Jensen, John R., Introductory Digital Image Processing: A Remote Sensing Perspective, 4th Edition, Pearson Education, 2016.	

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	2	1	-	-	-	-	1	-	2	3	1	2
CO2	3	3	1	2	2	-	-	1	-	1	-	2	3	2	2
CO3	3	3	2	3	3	-	-	1	-	2	-	2	3	2	3
CO4	3	3	2	3	3	1	1	1	-	2	1	2	3	2	3
CO5	2	2	3	3	3	1	2	1	2	3	2	3	3	2	3
CO	2.8	2.6	1.8	2.6	2.4	0.4	0.6	0.8	0.4	1.8	0.6	2.2	3	1.8	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC502	CYBER SECURITY	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To learn cybercrime and cyberlaw.
- To understand the cyber attacks and tools for mitigating them.
- To understand information gathering.
- To learn how to detect a cyber attack
- To learn how to prevent a cyber attack.

UNIT I	INTRODUCTION	6

Cyber Security – History of Internet – Impact of Internet – CIA Triad; Reason for Cyber Crime – Need for Cyber Security – History of Cyber Crime; Cybercriminals – Classification of Cybercrimes – A Global Perspective on Cyber Crimes; Cyber Laws – The Indian IT Act – Cybercrime and Punishment.

UNIT II	ATTACKS AND COUNTERMEASURES	6

OSWAP; Malicious Attack Threats and Vulnerabilities: Scope of Cyber-Attacks – Security Breach – Types of Malicious Attacks – Malicious Software – Common Attack Vectors – Social engineering Attack – Wireless Network Attack – Web Application Attack – Attack Tools – Countermeasures.		
UNIT III	**RECONNAISSANCE**	**6**
Harvester – Whois – Netcraft – Host – Extracting Information from DNS – Extracting Information from E-mail Servers – Social Engineering Reconnaissance; Scanning – Port Scanning – Network Scanning and Vulnerability Scanning – Scanning Methodology – Ping Sweer Techniques – Nmap Command Switches – SYN – Stealth – XMAS – NULL – IDLE – FIN Scans – Banner Grabbing and OS Finger printing Techniques.		
UNIT IV	**INTRUSION DETECTION**	**6**
Host -Based Intrusion Detection – Network -Based Intrusion Detection – Distributed or Hybrid Intrusion Detection – Intrusion Detection Exchange Format – Honeypots – Example System Snort.		
UNIT V	**INTRUSION PREVENTION**	**6**
Firewalls and Intrusion Prevention Systems – Need for firewalls – Firewall characteristics and access policy – Types of firewalls – Firewall basing – Firewall location and configurations – Intrusion Prevention Systems (IPS) – Signature-based and anomaly-based intrusion prevention – Host-based and network-based IPS – Unified Threat Management (UTM) products – Basic concepts of next-generation firewalls – Role of intrusion prevention in enterprise security architecture.		
		TOTAL: 30 PERIODS
PRACTICAL EXERCISES:		**TOTAL: 30 PERIODS**
1. Install Kali Linux on Virtual box		
2. Explore Kali Linux and bash scripting		
3. Perform open source intelligence gathering using Netcraft, Whois Lookups, DNS Reconnaissance, Harvester and Maltego		
4. Understand the nmap command d and scan a target using nmap		
5. Install metasploitable2 on the virtual box and search for unpatched vulnerabilities		
6. Use Metasploit to exploit an unpatched vulnerability		
7. Install Linus server on the virtual box and install ssh		
8. Use Fail2banto scan log files and ban Ips that show the malicious signs		
9. Launch brute-force attacks on the Linux server using Hydra		
10. Perform real-time network traffic analysis and data pocket logging using Snort		
COURSE OUTCOMES:		

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At the end of the course, the students will be able to:	
CO1:	Explain the basics of cyber security, cyber crime and cyber law (K2)
CO2:	Classify various types of attacks and learn the tools to launch the attacks (K2).
CO3:	Apply various tools to perform information gathering (K3)
CO4:	Apply intrusion techniques to detect intrusion (K3)
CO5:	Apply intrusion prevention techniques to prevent intrusion (K3)
TEXT BOOKS:	
1.	Anand Shinde, "Introduction to Cyber Security Guide to the World of Cyber Security", Notion Press, 2021 (Unit 1)
2.	Nina Godbole, Sunit Belapure, "Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives", Wiley Publishers, 2011 (Unit 1)
3.	Scarfone, Karen and Mell, Peter, *Guide to Intrusion Detection and Prevention Systems (IDPS)*, NIST Special Publication 800-94, National Institute of Standards and Technology, 2007.
4.	https://owasp.org/www-project-top-ten/
REFERENCES:	
1.	David Kim, Michael G. Solomon, "Fundamentals of Information Systems Security", Jones & Bartlett Learning Publishers, 2013 (Unit 2)
2.	Patrick Engebretson, "The Basics of Hacking and Penetration Testing: Ethical Hacking and Penetration Testing Made easy", Elsevier, 2011 (Unit 3)
3.	Kimberly Graves, "CEH Official Certified Ethical hacker Review Guide", Wiley Publishers, 2007 (Unit 3)
4.	William Stallings, Lawrie Brown, "Computer Security Principles and Practice", Third Edition, Pearson Education, 2015 (Units 4 and 5)
5.	Georgia Weidman, "Penetration Testing: A Hands-On Introduction to Hacking", No Starch Press, 2014 (Lab)

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	1	1	1	1	-	1	-	-	1	-	1	-	2	2	2
CO2	1	3	1	3	2	1	-	-	-	-	-	-	2	2	1
CO3	2	1	1	1	-	1	-	-	-	-	1	-	2	2	2
CO4	3	3	2	2	2	1	-	-	-	-	-	-	2	2	3
CO5	3	2	1	1	1	1	-	1	-	-	1	-	2	2	2
CO	2	2	1.2	1.6	1	1	0	0.2	0	0	0.6	0	2	2	2

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC503	QUANTUM COMPUTING	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To know the background of classical computing and quantum computing.
- To learn the fundamental concepts behind quantum computation.
- To study the details of quantum mechanics and its relation to Computer Science.
- To gain knowledge about the basic hardware and mathematical models of quantum computation
- To learn the basics of quantum information and the theory behind it.

UNIT I	QUANTUM COMPUTING BASIC CONCEPTS	6

Complex Numbers - Linear Algebra - Matrices and Operators - Global Perspectives Postulates of Quantum Mechanics – Quantum Bits - Representations of Qubits – Superpositions

UNIT II	QUANTUM GATES AND CIRCUITS	6

Universal logic gates - Basic single qubit gates - Multiple qubit gates - Circuit development - Quantum error correction

UNIT III	QUANTUM ALGORITHMS	6

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Quantum parallelism - Deutsch's algorithm - The Deutsch–Jozsa algorithm - Quantum Fourier transform and its applications - Quantum Search Algorithms: Grover's Algorithm		
UNIT IV	**QUANTUM INFORMATION THEORY**	**6**
Data compression – Shannon's noiseless channel coding theorem – Schumacher's quantum noiseless channel coding theorem – Classical information transmission over noisy quantum channels – Basic concepts of quantum entropy – Quantum mutual information – Quantum channel capacity (conceptual) – Limitations and challenges in quantum information transmission.		
UNIT V	**QUANTUM CRYPTOGRAPHY**	**6**
Classical cryptography basic concepts – Private key cryptography – Shor's factoring algorithm – Quantum key distribution (QKD) – BB84 protocol – Ekert-91 protocol – Basic concepts of public key cryptography (review) – Security motivation for quantum cryptography – Comparison of classical and quantum cryptographic approaches – Practical challenges and limitations of quantum cryptography.		
		TOTAL: 30 PERIODS
PRACTICAL EXERCISES:		**TOTAL: 30 PERIODS**
1. Single qubit gate simulation - Quantum Composer		
2. Multiple qubit gate simulation - Quantum Composer		
3. Composing simple quantum circuits with q-gates and measuring the output into classical bits		
4. IBM Qiskit Platform Introduction		
5. Implementation of Shor's Algorithms		
6. Implementation of Grover's Algorithm		
7. Implementation of Deutsch's Algorithm		
8. Implementation of Deutsch-Jozsa's Algorithm		
9. Integer factorization using Shor's Algorithm		
10. QKD Simulation		
11. Mini Project such as implementing an API for efficient search using Grover's Algorithms		
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Understand the basics of quantum computing.	
CO2:	Understand the background of Quantum Mechanics.	

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CO3:	Analyze the computation models.
CO4:	Model the circuits using quantum computation. environments and frameworks.
CO5:	Understand the quantum operations such as noise and error–correction.
TEXT BOOKS:	
1.	Parag K Lala, Mc Graw Hill Education, “Quantum Computing, A Beginners Introduction”, First edition (1 November 2020).
2.	Michael A. Nielsen, Issac L. Chuang, “Quantum Computation and Quantum Information”, Tenth Edition, Cambridge University Press, 2010.
3.	Chris Bernhardt, The MIT Press; Reprint edition (8 September 2020), “Quantum Computing for Everyone”.
REFERENCES:	
1.	Scott Aaronson, “Quantum Computing Since Democritus”, Cambridge University Press, 2013.
2.	N. David Mermin, “Quantum Computer Science: An Introduction”, Cambridge University Press, 2007.
3.	Stallings, William, “Cryptography and Network Security: Principles and Practice”, 7th Edition, Pearson Education, 2017.

CO’s-PO’s & PSO’s MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	2	2	-	-	-	-	2	-	-	-	2	3	2
CO2	3	2	2	2	-	-	-	-	2	-	-	-	2	3	1
CO3	3	3	3	3	2	-	-	-	3	-	-	-	3	2	2
CO4	3	2	3	3	3	-	-	-	3	-	-	-	1	3	2
CO5	3	3	2	3	-	-	-	-	2	-	-	-	1	3	3
CO	3	2.6	2.4	2.6	1	-	-	-	2.4	-	-	-	1.8	2.8	2

1 - low, 2 - medium, 3 - high, ‘-' - no correlation

BoS Chairman

24CEC504	PATTERN RECOGNITION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide basic knowledge about the fundamentals of pattern recognition and its applications.
- To understand about unsupervised algorithms suitable for pattern classification.
- To familiarize with the feature selection algorithms and methods of implementing them in applications.
- To learn about the basis of algorithms used for training and testing the dataset.
- To learn basic fuzzy system and neural network architectures, for applications in pattern recognition, image processing, and computer vision.

UNIT I	PATTERN CLASSIFIER	9

Overview of Pattern Recognition – Discriminant Functions – Supervised Learning – Parametric Estimation – Maximum Likelihood Estimation – Bayes Theorem – Bayesian Belief Network, Naive Bayesian Classifier.

UNIT II	CLUSTERING	9

Clustering Concept – Hierarchical Clustering Procedures – Partitional Clustering – Clustering of Large Data Sets – EM Algorithm – Grid Based Clustering – Density Based Clustering.

UNIT III	FEATURE EXTRACTION AND SELECTION	9

Entropy Minimization – Karhunen Loeve Transformation – Feature Selection Through Functions Approximation – Binary Feature Selection – K-NN.

UNIT IV	HIDDEN MARKOV MODELS AND SUPPORT VECTOR MACHINES	9

State Machines – Hidden Markov Models: Maximum Likelihood for the HMM, The Forward and Backward Algorithm, Sum-Product Algorithm for the HMM, Scaling Factors, The Viterbi Algorithm, Extensions Of The Hidden Markov Model – Support Vector Machines: Maximum Margin Classifiers, Relevance Vector Machines.

UNIT V	RECENT ADVANCES	9

Fuzzy classification: Fuzzy set theory – Fuzzy and crisp classification – Fuzzy clustering – Fuzzy pattern recognition – Introduction to neural networks – Elementary neural networks for pattern recognition – Hebb net – Perceptron – ADALINE – Back propagation algorithm – Limitations of classical neural networks – Brief introduction to deep learning concepts for pattern recognition – Applications of fuzzy and neural techniques in real-world pattern recognition problems.

TOTAL: 45 PERIODS

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COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Understand the basics of pattern classifiers and statistical decision-making.
CO2:	Apply clustering algorithms for effective unsupervised pattern classification.
CO3:	Perform feature extraction and selection using standard dimensionality-reduction methods.
CO4:	Use HMM and SVM techniques for sequential and discriminative pattern recognition.
CO5:	Apply fuzzy and neural approaches in solving real-world pattern recognition problems.
TEXT BOOKS:	
1.	Andrew Webb, "Statistical Pattern Recognition", Arnold publishers, London, 1999.
REFERENCES:	
1.	C. M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006
2.	R. O. Duda, P. E. Hart, D. G. Stork, "Pattern Classification", John Wiley, 2001.
3.	M. Narasimha Murthy, V. Susheela Devi, "Pattern Recognition", Springer 2011.
4.	Menahem Friedman, Abraham Kandel, "Introduction to Pattern Recognition Statistical, Structural, Neural and Fuzzy Logic Approaches", World Scientific publishing Co. Ltd, 2000.
5.	Robert J. Schalkoff, "Pattern Recognition Statistical, Structural and Neural Approaches", John Wiley & Sons Inc., 1992.
6.	S. Theodoridis, K. Koutroumbas, "Pattern Recognition", Fourth Edition, Academic Press, 2009.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	1	2	1	-	-	-	-	1	-	2	3	1	2
CO2	3	3	1	3	2	-	-	-	-	1	-	2	3	1	2
CO3	2	3	1	2	2	1	-	1	-	2	-	2	3	2	2
CO4	3	2	2	3	3	1	1	1	-	2	2	2	3	2	3
CO5	2	3	3	3	3	1	2	1	2	3	2	3	3	2	3
CO	2.6	2.6	1.6	2.6	2.2	0.6	0.6	0.6	0.4	1.8	0.8	2.2	3	1.6	2.4

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24CEC505	NETWORK ON CHIP DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the need for Network-on-Chip and limitations of traditional SoC interconnects.
- To learn NoC architectures and components, including topologies, routers, and flow control.
- To study routing algorithms and communication techniques used in NoC systems.
- To analyze design issues related to performance, power, reliability, and scalability.
- To explore advanced NoC trends, such as 3D NoC and emerging interconnect technologies.

UNIT I	INTRODUCTION TO NOC	9

Introduction to NOC – OSI Layer Rules in NOC - Interconnection Networks in Network-On-Chip Network Topologies - Switching Techniques - Routing Strategies - Flow Control Protocol Quality of-Service Support

UNIT II	ARCHITECTURE DESIGN	9

Switching techniques and packet format – Asynchronous FIFO design – GALS style of communication – Wormhole router architecture design – Virtual channel (VC) router architecture design – Adaptive router architecture design – Basic flow control mechanisms in NoC routers – Deadlock and congestion issues in NoC architectures (conceptual) – Performance parameters of NoC architectures.

UNIT III	ROUTING ALGORITHM	9

Packet Routing-QOS, Congestion Control and Flow Control – Router Design – Network Link Design – Efficient and Deadlock-Free Tree-Based Multicast Routing Methods - Path-Based Multicast Routing For 2D and 3D Mesh Networks- Fault-Tolerant Routing Algorithms - Reliable and Adaptive Routing Algorithms

UNIT IV	TEST AND FAULT TOLERANCE OF NOC	9

Design security in Networks-on-Chip – Formal verification of communication in Networks-on-Chip – Test and fault tolerance for Networks-on-Chip infrastructures – Fault models in NoC architectures (conceptual) – Error detection and recovery mechanisms in NoC – Monitoring services for Networks-on-Chip – Reliability and availability considerations in NoC-based systems.

UNIT V	THREE-DIMENSIONAL INTEGRATION OF NETWORK-ON-CHIP	9

Three-Dimensional Networks-On-Chips Architectures – A Novel Dimensionally-Decomposed Router for On-Chip Communication in 3D Architectures - Resource Allocation For QOS On-Chip Communication – Networks-On-Chip Protocols-On-Chip Processor Traffic Modeling For NetworksOn-Chip.

TOTAL: 45 PERIODS

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COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Compare different architecture design
CO2:	Discuss different routing algorithms
CO3:	Explain three dimensional Networks on Chip architectures
CO4:	Test and design fault tolerant NOC
CO5:	Design three dimensional architectures of NOC
REFERENCES:	
1.	ChrysostoMOSnicopoulos, Vijaykrishnan Narayanan, Chita R.Das" Networks-On - Chip " Architectures Holistic Design Exploration", Springer.
2.	Fayezgebali, Haythamelmiligi, Hqhahedwatheq E1-Kharashi "Networks-On-Chips Theory and Practice CRC Press
3.	Konstantinos Tatas and Kostas Siozios "Designing 2D and 3D Network-On-Chip Architectures" 2013
4.	Palesi, Maurizio, Daneshtalab, Masoud "Routing Algorithms in Networks-On-Chip" 2014.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	1	-	1	-	-	-	-	-	-	2	3	-	-
CO2	3	2	1	-	3	-	-	-	-	-	-	2	3	-	-
CO3	3	3	2	3	2	-	-	-	-	-	1	2	3	1	2
CO4	3	2	2	1	1	2	3	2	-	-	1	2	2	3	2
CO5	2	1	1	-	2	1	2	-	-	1	1	3	2	2	3
CO	2.8	2	1.4	0.8	1.8	0.6	1	0.4	-	0.2	0.6	2.2	1.6	1.2	1.4

1 - low, 2 - medium, 3 - high, '-' - no correlation

BoS Chairman

24CEC506	BLOCK CHAIN TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand Blockchain's fundamental components, and examine decentralization using blockchain.
- To explain how cryptocurrency works, from when a transaction is created to when it is considered part of the Blockchain.
- To explain the components of Ethereum and Programming Languages for Ethereum.
- To study the basics of Hyperledger and Web3
- To know about alternative Blockchains and Blockchain projects in different domains.

UNIT I	INTRODUCTION TO BLOCKCHAIN	9

History of Blockchain – Types of Blockchain – Consensus – Decentralization using Blockchain – Blockchain and Full Ecosystem Decentralization – Platforms for Decentralization.

UNIT II	INTRODUCTION TO CRYPTOCURRENCY	9

Bitcoin – Digital Keys and Addresses – Transactions – Mining – Bitcoin Networks and Payments – Wallets – Alternative Coins – Theoretical Limitations – Bitcoin limitations – Name coin – Prime coin – Zcash – Smart Contracts – Ricardian Contracts.

UNIT III	ETHEREUM	9

The Ethereum Network – Components of Ethereum Ecosystem – Ethereum Programming Languages: Runtime Byte Code, Blocks and Blockchain, Fee Schedule – Supporting Protocols – Solidity Language.

UNIT IV	WEB3 AND HYPERLEDGER	9

Introduction to Web3 – Contract Deployment – POST Requests – Development Frameworks – Hyperledger as a Protocol – The Reference Architecture – Hyperledger Fabric – Distributed Ledger – Corda.

UNIT V	ALTERNATIVE BLOCKCHAINS AND NEXT EMERGING TRENDS	9

Kadena – Ripple – Rootstock – Quorum – Tendermint – Scalability – Privacy – Other Challenges – Blockchain Research – Notable Projects – Miscellaneous Tools, Interoperability between blockchain networks (conceptual) – Enterprise and permissioned blockchain trends – Future directions and emerging trends in blockchain technology.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Understand the technology components of Blockchain and how it works behind the scenes
CO2:	Understand Bitcoin and its limitations by comparing with other alternative coins.
CO3:	Devise solution using the Ethereum model.
CO4:	Understand and use Hyperledger and its development framework.
CO5:	Track alternative Blockchains and emerging trends in Blockchain.

TEXT BOOKS:

1.	Imran Bashir, "Mastering Blockchain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained", Second Edition, Packt Publishing, 2018.

REFERENCES:

1.	Arshdeep Bahga, Vijay Madisetti, "Blockchain Applications: A Hands On Approach", VPT, 2017..
2.	Andreas Antonopoulos, Satoshi Nakamoto, "Mastering Bitcoin", O'Reilly, 2014.
3.	Roger Wattenhofer, "The Science of the Blockchain" CreateSpace Independent Publishing, 2016.
4.	A. Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder, "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction", Princeton University Press, 2016.
5.	Alex Leverington, "Ethereum Programming" Packt Publishing, 2017.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	-	-	1	1	-	2	-	-	-	2	3	-	1
CO2	3	2	1	-	3	-	-	-	-	-	-	2	3	-	1
CO3	3	3	2	3	2	2	2	3	-	-	1	2	3	2	1
CO4	2	2	3	1	1	3	3	2	1	2	1	3	2	3	2
CO5	2	1	2	-	2	2	3	2	-	2	1	3	2	-	3
CO	2.6	2	1.6	0.8	1.8	1.6	1.6	1.8	0.2	0.8	0.6	2.4	2.6	1	1.6

1 - low, 2 - medium, 3 - high, '-' - no correlation

BoS Chairman

24CEC507	3D PRINTING AND DESIGN	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To discuss on basics of 3D printing
- To explain the principles of 3D printing technique
- To explain and illustrate inkjet technology
- To explain and illustrate laser technology
- To discuss the applications of 3D printing

UNIT I	INTRODUCTION	6

Introduction; Design considerations – Material, Size, Resolution, Process; Modelling and viewing - 3D; Scanning; Model preparation – Digital; Slicing; Software; File formats

UNIT II	PRINCIPLE	6

Processes – Extrusion, Wire, Granular, Lamination, Photopolymerisation; Materials - Paper, Plastics, Metals, Ceramics, Glass, Wood, Fiber, Sand, Biological Tissues, Hydrogels, Graphene; Material Selection - Processes, applications, limitations;

UNIT III	INKJET TECHNOLOGY	6

Printer - Working Principle, Positioning System, Print head, Print bed, Frames, Motion control; Print head Considerations – Continuous Inkjet, Thermal Inkjet, Piezoelectric Drop-On-Demand; Material Formulation for jetting; Liquid based fabrication – Continous jet, Mulitjet; Powder based fabrication – Colourjet.

UNIT IV	LASER TECHNOLOGY	6

Light Sources – Types, Characteristics; Optics – Deflection, Modulation; Material feeding and flow – Liquid, powder; Printing machines – Types, Working Principle, Build Platform, Print bed Movement, Support structures, Process parameters affecting print quality (conceptual) – Safety considerations in laser-based additive manufacturing.

UNIT V	INDUSTRIAL APPLICATIONS	6

Product Models, manufacturing – Printed electronics, Biopolymers, Packaging, Healthcare, Food, Medical, Biotechnology, Displays; Customization and rapid prototyping using additive manufacturing – Industrial benefits and limitations of 3D printing, Future trends in additive manufacturing technologies.

TOTAL: 30 PERIODS

PRACTICAL EXERCISES: **TOTAL: 30 PERIODS**

1. Study the interface and basic tools in the CAD software

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2. Study the interface and basic tools in the CAD software. 2. Study 3D printer(s)including print heads, build envelope, materials used and related support removal system(s).
3. Review of geometry terms of a 3D mesh.
4. Commands for moving from 2D to 3D
5. Advanced CAD commands to navigate models in 3D space
6. Design any four everyday objects Refer to web sites like Thingiverse, Shapeways and GitFab to design four everyday objects that utilize the advantages of 3D printing Choose four models from a sharing site like Thingiverse, Shapeways or Gitfab. Improve upon a file and make it your own. Some ideas include ● Redesign it with a specific user in mind ● Redesign it for a slightly different purpose ● Improve the look of the product
7. Use the CAM software to prepare files for 3D printing.
8. Manipulate machine movement and material layering
9. Repair a 3D mesh using a) Freeware utilities: Autodesk MeshMixer (http://goo.gl/x5nhYc), MeshLab (http://goo.gl/fgztLl) or Netfabb Basic or Cloud Service (http://goo.gl/Q1P47a) b) Freeware tool tutorials: Netfabb Basic or Cloud Service (http://goo.gl/Q1P47a), Netfabb and MeshLab (http://goo.gl/WPOVec) c) Professional tools: Magics or Netfabb
COURSE OUTCOMES:
At the end of the course, the students will be able to:

CO1:	Outline and examine the basic concepts of 3D printing technology
CO2:	Outline 3D printing workflow
CO3:	Explain and categorise the concepts and working principles of 3D printing using inkjet technique
CO4:	Explain and categorise the working principles of 3D printing using laser technique
CO5:	Explain various method for designing and modeling for industrial applications

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TEXT BOOKS:	
1.	Christopher Barnatt, 3D Printing: The Next Industrial Revolution, CreateSpace Independent Publishing Platform, 2013.
2.	Ian M. Hutchings, Graham D. Martin, Inkjet Technology for Digital Fabrication, John Wiley & Sons, 2013.
REFERENCES:	
1.	Chua, C.K., Leong K.F. and Lim C.S., Rapid prototyping: Principles and applications, second edition, World Scientific Publishers, 2010
2.	Ibrahim Zeid, Mastering CAD CAM Tata McGraw-Hill Publishing Co., 2007
3.	Joan Horvath, Mastering 3D Printing, APress, 2014

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	1	1	2	2	3	1	-	-	2	-	2	2	3	2	1
CO2	3	2	3	3	3	2	-	-	3	-	2	2	3	2	3
CO3	2	2	2	2	2	2	-	-	2	-	2	2	3	2	2
CO4	2	2	2	2	3	2	-	-	2	-	2	2	3	3	2
CO5	1	3	3	3	3	3	-	-	3	-	3	3	3	3	1
CO	1.8	2	2.4	2.4	2.8	2	-	-	2.4	-	2.2	2.2	3	2.4	1.8

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC508	**CRYPTOGRAPHY AND NETWORK SECURITY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand basic cryptography concepts and number theory needed for security.
- To learn and apply symmetric encryption techniques like DES and AES.
- To understand public-key algorithms, RSA, Diffie–Hellman, and key management.
- To study authentication, hash functions, MACs, and digital signatures.

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- To understand network security tools such as firewalls, IDS, SSL/TLS, and email/web security.

UNIT I	INTRODUCTION	9

Security trends - Legal, Ethical and Professional Aspects of Security, Need for Security at Multiple levels, Security Policies - Model of network security – Security attacks, services and mechanisms – OSI security architecture – Classical encryption techniques: substitution techniques, transposition techniques, steganography- Foundations of modern cryptography: perfect security – information theory – product cryptosystem – cryptanalysis.

UNIT II	SYMMETRIC KEY CRYPTOGRAPHY	9

MATHEMATICS OF SYMMETRIC KEY CRYPTOGRAPHY: Algebraic structures - Modular arithmetic- Euclid‟s algorithm- Congruence and matrices - Groups, Rings, Fields- Finite fields- SYMMETRIC KEY CIPHERS: SDES – Block cipher Principles of DES – Strength of DES – Differential and linear cryptanalysis - Block cipher design principles – Block cipher mode of operation – Evaluation criteria for AES – Advanced Encryption Standard - RC4 – Key distribution.

UNIT III	PUBLIC KEY CRYPTOGRAPHY	9

MATHEMATICS OF ASYMMETRIC KEY CRYPTOGRAPHY: Primes – Primality Testing – Factorization – Euler’s totient function, Fermat’s and Euler’s Theorem - Chinese Remainder Theorem – Exponentiation and logarithm - ASYMMETRIC KEY CIPHERS: RSA cryptosystem – Key distribution – Key management – Diffie Hellman key exchange - ElGamal cryptosystem – Elliptic curve arithmetic- Elliptic curve cryptography

UNIT IV	MESSAGE AUTHENTICATION AND INTEGRITY	9

Authentication requirement – Authentication function – MAC – Hash function – Security of hash function and MAC – SHA –Digital signature and authentication protocols – DSS- Entity Authentication: Biometrics, Passwords, Challenge Response protocols- Authentication applications - Kerberos, X.509

UNIT V	SECURITY PRACTICE AND SYSTEM SECURITY	9

Electronic Mail security – PGP, S/MIME – IP security – Web Security - SYSTEM SECURITY: Intruders – Malicious software – viruses – Firewalls - Basic concepts of intrusion detection and prevention systems – Secure system administration practices – Security challenges in modern networked systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the students will be able to:

CO1:	Understand the fundamentals of networks security, security architecture, threats and vulnerabilities
CO2:	Apply the different cryptographic operations of symmetric cryptographic algorithms
CO3:	Apply the different cryptographic operations of public key cryptography

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CO4:	Apply the various Authentication schemes to simulate different applications.
CO5:	Understand various Security practices and System security standards
TEXT BOOKS:	
1.	William Stallings, Cryptography and Network Security: Principles and Practice, PHI 3rd Edition, 2006
REFERENCES:	
1.	C K Shyamala, N Harini and Dr. T R Padmanabhan: Cryptography and Network Security, Wiley India Pvt.Ltd
2.	BehrouzA.Foruzan, Cryptography and Network Security, Tata McGraw Hill 2007
3.	Charlie Kaufman, Radia Perlman, and Mike Speciner, Network Security: PRIVATE Communication in a PUBLIC World, Prentice Hall, ISBN 0-13-046019-2

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	-	1	-	-	-	1	-	1	-	2	3	-	2
CO2	3	2	1	1	2	-	-	-	-	1	-	1	3	1	2
CO3	3	2	-	1	2	1	-	1	-	1	-	2	3	1	2
CO4	2	3	-	2	1	2	-	2	1	2	-	2	2	2	2
CO5	2	2	1	2	3	2	2	2	1	2	1	2	2	3	3
CO	2.6	2.2	0.2	1.4	1.6	1	0.4	1.2	0.4	1.4	0.2	1.8	2.6	1.4	2.2

1 - low, 2 - medium, 3 - high, '-' - no correlation

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VERTICAL 6: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

24CEC601	KNOWLEDGE ENGINEERING	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To explain the fundamental concepts and principles of Knowledge Engineering.
- To apply suitable methodologies and modeling approaches for designing and developing intelligent agents.
- To develop ontologies using appropriate ontology-building tools and techniques.
- To demonstrate reasoning mechanisms using ontologies and rule-based systems.
- To analyze learning strategies and illustrate various rule-learning techniques.

UNIT I	REASONING UNDER UNCERTAINTY	6

Introduction – Abductive reasoning – Probabilistic reasoning: Enumerative Probabilities – Subjective Bayesian view – Belief Functions – Baconian Probability – Fuzzy Probability – Uncertainty methods - Evidence-based reasoning – Intelligent Agent – Mixed-Initiative Reasoning – Knowledge Engineering - Markov Decision Processes (MDP) for Uncertain Reasoning.

UNIT II	METHODOLOGY AND MODELING	6

Conventional Design and Development – Development tools and Reusable Ontologies – Agent Design and Development using Learning Technology – Problem Solving through Analysis and Synthesis – Inquiry-driven Analysis and Synthesis – Evidence-based Assessment – Believability Assessment – Drill-Down Analysis, Assumption-based Reasoning, and What-If Scenarios.

UNIT III	ONTOLOGIES – DESIGN AND DEVELOPMENT	6

Concepts and Instances – Generalization Hierarchies – Object Features – Defining Features – Representation – Transitivity – Inheritance – Concepts as Feature Values – Ontology Matching. Design and Development Methodologies – Steps in Ontology Development – Domain Understanding and Concept Elicitation – Modelling-based Ontology Specification.

UNIT IV	REASONIING WITH ONTOLOGIES AND RULES	6

Production System Architecture – Complex Ontology-based Concepts – Reduction and Synthesis rules and the Inference Engine – Evidence-based hypothesis analysis – Rule and Ontology Matching – Partially Learned Knowledge – Reasoning with Partially Learned Knowledge - Case-Based Reasoning with Ontologies.

UNIT V	LEARNING AND RULE LEARNING	6

Machine Learning – Concepts – Generalization and Specialization Rules – Types – Formal definition of Generalization. Modelling, Learning and Problem Solving – Rule learning and Refinement – Overview – Rule Generation and Analysis – Hypothesis Learning.	
TOTAL: 30 PERIODS	
TOTAL: 30 PERIODS	
PRACTICAL EXERCISES:	
1. Perform operations with Evidence Based Reasoning.	
2.Perform Evidence based Analysis.	
3.Perform operations on Probability Based Reasoning.	
4.Perform Believability Analysis.	
5.Implement Rule Learning and refinement.	
6.Perform analysis based on learned patterns.	
7. Construction of Ontology for a given domain.	
TOTAL: 60 PERIODS	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Describe the fundamentals of Knowledge Engineering.
CO2:	Apply methodologies and modeling for agent design.
CO3:	Construct ontologies using standard tools and techniques.
CO4:	Perform reasoning with ontologies and rules.
CO5:	Examine learning strategies and rule-learning methods.
TEXT BOOKS:	
1.	Gheorghe Tecuci, Dorin Marcu, Mihai Boicu, David A. Schum, Knowledge Engineering Building Cognitive Assistants for Evidence-based Reasoning, Cambridge University Press, First Edition, 2016. (Unit 1 – Chapter 1 / Unit 2 – Chapter 3,4 / Unit 3 – Chapter 5, 6 / Unit 4 - 7 , Unit 5 – Chapter 8, 9)
REFERENCES:	

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1.	Ronald J. Brachman, Hector J. Levesque: Knowledge Representation and Reasoning, Morgan Kaufmann, 2004.
2.	Ela Kumar, Knowledge Engineering, I K International Publisher House, 2018.
3.	John F. Sowa: Knowledge Representation: Logical, Philosophical, and Computational Foundations, Brooks/Cole, Thomson Learning, 2000.
4.	King, Knowledge Management and Organizational Learning, Springer, 2009.
5.	Jay Liebowitz, Knowledge Management Learning from Knowledge Engineering, 1st Edition,2001.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	1	1	1	1	1	-	-	1	2	1	2	1	1	1
CO2	3	2	3	2	2	-	-	-	2	1	2	1	3	3	1
CO3	2	2	3	2	2	-	-	-	3	2	2	2	3	2	3
CO4	2	2	3	1	1	-	-	-	2	2	2	2	2	1	1
CO5	2	2	2	1	1	-	-	-	2	1	1	1	2	1	1
CO	**2.4**	**1.8**	**2.4**	**1.4**	**1.4**	**0.2**	**0**	**0**	**2**	**1.6**	**1.6**	**1.6**	**2.2**	**1.6**	**1.4**

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC602	**SOFT COMPUTING**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- To explain the concepts of fuzzy sets, fuzzy logic, and heuristics based on human experience.
- To apply mathematical techniques for optimization in neural network learning.
- To analyze and implement various evolutionary algorithms.
- To develop neural networks that can learn from examples and generalize rules for inference systems.
- To evaluate case studies demonstrating intelligent behavior in soft computing applications.

UNIT I	**INTRODUCTION TO SOFT COMPUTING AND FUZZY LOGIC**	**6**
Introduction - Fuzzy Logic - Fuzzy Sets, Fuzzy Membership Functions, Operations on Fuzzy Sets, Fuzzy Relations, Operations on Fuzzy Relations, Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems.		
UNIT II	**NEURAL NETWORKS**	**6**
Supervised Learning Neural Networks – Perceptrons - Backpropagation -Multilayer Perceptrons – Unsupervised Learning Neural Networks – Kohonen Self-Organizing Networks.		
UNIT III	**GENETIC ALGORITHMS**	**6**
Chromosome Encoding Schemes -Population initialization and selection methods - Evaluation function - Genetic operators- Cross over – Mutation - Fitness Function – Maximizing function.		
UNIT IV	**NEURO FUZZY MODELING**	**6**
ANFIS architecture – hybrid learning – ANFIS as universal approximator – Coactive Neuro fuzzy modeling – Framework – Neuron functions for adaptive networks – Neuro fuzzy spectrum - Analysis of Adaptive Learning Capability - Comparison of Neuro-Fuzzy and Pure Neural Models		
UNIT V	**APPLICATIONS**	**6**
Modeling a two input sine function - Printed Character Recognition – Fuzzy filtered neural networks – Plasma Spectrum Analysis – Hand written neural recognition - Soft Computing for Color Recipe Prediction - Intelligent Control Systems using Soft Computing.		
TOTAL: 30 PERIODS		
PRACTICAL EXERCISES:		**30 PERIODS**
1. Implementation of fuzzy control/ inference system		
2. Programming exercise on classification with a discrete perceptron		
3. Implementation of XOR with backpropagation algorithm		
4. Implementation of self organizing maps for a specific application		
5. Programming exercises on maximizing a function using Genetic algorithm		
6. Implementation of two input sine function		
7. Implementation of three input non linear function		
TOTAL: 60 PERIODS		
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Describe the fundamentals of fuzzy logic operators and inference mechanisms.	
CO2:	Explain neural network architectures for AI applications such as classification and clustering.	
CO3:	Analyze the functionality of Genetic Algorithms in optimization problems.	

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CO4:	Apply hybrid techniques involving neural networks and fuzzy logic.
CO5:	Implement soft computing techniques in real-world applications.
TEXT BOOKS:	
1.	SAJANG, J.-S. R., SUN, C.-T., & MIZUTANI, E. (1997). Neuro-fuzzy and soft computing: A computational approach to learning and machine intelligence. Upper Saddle River, NJ, Prentice Hall,1997
2.	Himanshu Singh, Yunis Ahmad Lone, Deep Neuro-Fuzzy Systems with Python
3.	With Case Studies and Applications from the Industry, Apress, 2020
REFERENCES:	
1.	Roj Kaushik and Sunita Tiwari, Soft Computing-Fundamentals Techniques and Applications, 1st Edition, McGraw Hill, 2018.
2.	S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI, 2003.
3.	Samir Roy, Udit Chakraborthy, Introduction to Soft Computing, Neuro Fuzzy and Genetic Algorithms, Pearson Education, 2013.
4.	S.N. Sivanandam, S.N. Deepa, Principles of Soft Computing, Third Edition, Wiley India Pvt Ltd, 2019.
5.	R.Eberhart, P.Simpson and R.Dobbins, "Computational Intelligence - PC Tools", AP Professional, Boston, 1996

CO's-PO's & PSO's MAPPING:

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	3	3	3	-	-	-	3	1	3	2	3	1	2
CO2	2	3	3	2	3	-	-	-	3	2	3	2	2	1	3
CO3	1	3	2	2	1	-	-	-	3	1	1	2	1	3	2
CO4	1	2	1	3	2	-	-	-	3	3	1	1	2	1	1
CO5	2	3	1	2	1	-	-	-	3	3	3	2	1	2	3
CO	**1.8**	**2.6**	**2**	**2.4**	**2**	**-**	**-**	**-**	**3**	**2**	**2.2**	**1.8**	**1.8**	**1.6**	**2.2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24CEC603	NEURAL NETWORKS AND DEEP LEARNING	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To explain the principles and architectures of deep neural networks.
- To examine associative memory and unsupervised learning networks.
- To apply convolutional neural network (CNN) architectures for solving practical tasks.
- To analyze the computational processes in deep learning and design networks for training and deployment.
- To implement autoencoders and generative models for appropriate applications.

UNIT I	INTRODUCTION	6

Neural Networks-Application Scope of Neural Networks-Artificial Neural Network: An Introduction-Evolution of Neural Networks-Basic Models of Artificial Neural Network- Important Terminologies of ANNs-Supervised Learning Network.

UNIT II	ASSOCIATIVE MEMORY AND UNSUPERVISED LEARNING NETWORKS	6

Training Algorithms for Pattern Association-Autoassociative Memory Network-Heteroassociative Memory Network-Bidirectional Associative Memory (BAM)-Hopfield Networks-Iterative Autoassociative Memory Networks-Temporal Associative Memory Network-Fixed Weight Competitive Nets-Kohonen Self-Organizing Feature Maps-Learning Vector Quantization-Counter propagation Networks-Adaptive Resonance Theory Network.

UNIT III	THIRD-GENERATION NEURAL NETWORKS	6

Spiking Neural Networks-Convolutional Neural Networks-Deep Learning Neural Networks-Extreme Learning Machine Model-Convolutional Neural Networks: The Convolution Operation – Motivation – Pooling – Variants of the basic Convolution Function – Structured Outputs – Data Types – Efficient Convolution Algorithms – Neuroscientific Basis – Applications: Computer Vision, Image Generation, Image Compression - Attention Mechanisms in Deep Neural Networks.

UNIT IV	DEEP FEED FORWARD NETWORKS	6

History of Deep Learning- A Probabilistic Theory of Deep Learning- Gradient Learning – Chain Rule and Backpropagation - Regularization: Dataset Augmentation – Noise Robustness -Early Stopping, Bagging and Dropout - batch normalization- VC Dimension and Neural Nets.

UNIT V	RECURRENT NEURAL NETWORKS	6

Recurrent Neural Networks: Introduction – Recursive Neural Networks – Bidirectional RNNs – Deep Recurrent Networks – Applications: Image Generation, Image Compression, Natural Language Processing. Complete Auto encoder, Regularized Autoencoder, Stochastic Encoders and Decoders, Contractive Encoders.

	TOTAL: 30 PERIODS
PRACTICAL EXERCISES:	**30 PERIODS**
1. Implement simple vector addition in TensorFlow.	
2. Implement a regression model in Keras.	
3. Implement a perceptron in TensorFlow/Keras Environment.	
4. Implement a Feed-Forward Network in TensorFlow/Keras.	
5. Implement an Image Classifier using CNN in TensorFlow/Keras.	
6. Improve the Deep learning model by fine tuning hyper parameters.	
7. Implement a Transfer Learning concept in Image Classification.	
8. Using a pre trained model on Keras for Transfer Learning	
9. Perform Sentiment Analysis using RNN	
10. Implement an LSTM based Autoencoder in TensorFlow/Keras.	
11. Image generation using GAN	
	TOTAL: 60 PERIODS
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Implement convolutional neural networks (CNN) for solving image processing problems.
CO2:	Describe the structure and function of associative memory and unsupervised learning networks.
CO3:	Apply different CNN architectures and variants to relevant tasks.
CO4:	Examine the computations involved in deep learning and construct networks for training and inference.
CO5:	Utilize autoencoders and generative models for practical applications.
TEXT BOOKS:	
4.	Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press, 2016.
5.	Francois Chollet, “Deep Learning with Python”, Second Edition, Manning Publications, 2021.
REFERENCES:	
6.	Aurélien Géron, “Hands-On Machine Learning with Scikit-Learn and TensorFlow”, Oreilly, 2018.
7.	Josh Patterson, Adam Gibson, “Deep Learning: A Practitioner’s Approach”, O’Reilly Media, 2017.
8.	Charu C. Aggarwal, “Neural Networks and Deep Learning: A Textbook”, Springer International Publishing, 1st Edition, 2018. 116

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9.	Learn Keras for Deep Neural Networks, Jojo Moolayil, Apress,2018
10.	Deep Learning Projects Using TensorFlow 2, Vinita Silaparasetty, Apress, 2020
11.	Deep Learning with Python, FRANÇOIS CHOLLET, MANNING SHELTER ISLAND,2017.
12.	S Rajasekaran, G A Vijayalakshmi Pai, "Neural Networks, FuzzyLogic and Genetic Algorithm, Synthesis and Applications", PHI Learning, 2017.
13.	Pro Deep Learning with TensorFlow, Santanu Pattanayak, Apress,2017
14.	James A Freeman, David M S Kapura, "Neural Networks Algorithms, Applications, and Programming Techniques", Addison Wesley, 2003.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	3	2	3	1	-	-	2	1	-	-	2	2	1
CO2	3	1	2	1	-	-	-	-	-	1	2	2	-	1	-
CO3	3	3	3	3	3	1	-	-	2	1	-	-	2	2	1
CO4	3	3	3	3	3	-	-	-	2	-	2	3	2	2	2
CO5	1	1	3	2	3	-	-	-	2	-	-	-	1	1	-
CO	**2.6**	**2**	**2.8**	**2.2**	**2.4**	**0.4**	**0**	**0**	**1.6**	**0.6**	**0.8**	**1**	**1.4**	**1.6**	**0.8**

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC604	**TEXT AND SPEECH ANALYSIS**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- To describe the basic concepts and processes in natural language processing.
- To implement classification algorithms for analyzing text documents.
- To construct question-answering and dialogue systems.
- To design and implement a speech recognition system.
- To design and implement a speech synthesizer.

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UNIT I	**NATURAL LANGUAGE BASICS**	**6**
Foundations of natural language processing – Language Syntax and Structure- Text Preprocessing and Wrangling – Text tokenization – Stemming – Lemmatization – Removing stop-words – Feature Engineering for Text representation – Bag of Words model- Bag of N-Grams model – TF-IDF model.		
UNIT II	**TEXT CLASSIFICATION**	**6**
Vector Semantics and Embeddings -Word Embeddings - Word2Vec model – Glove model – Fast Text model – Overview of Deep Learning models – RNN – Transformers – Overview of Text summarization and Topic Models.		
UNIT III	**QUESTION ANSWERING AND DIALOGUE SYSTEMS**	**6**
Information retrieval – IR-based question answering – knowledge-based question answering – language models for QA – classic QA models – chatbots – Design of dialogue systems -– evaluating dialogue systems		
UNIT IV	**TEXT-TO-SPEECH SYNTHESIS**	**6**
Overview. Text normalization. Letter-to-sound. Prosody, Evaluation. Signal processing - Concatenative and parametric approaches, Wave Net and other deep learning-based TTS systems - Case Study: Text-to-Speech Systems for Indian Languages.		
UNIT V	**AUTOMATIC SPEECH RECOGNITION**	**6**
Speech recognition: Acoustic modelling – Feature Extraction - HMM, HMM-DNN systems - Case Study: Voice Assistants		
		TOTAL: 30 PERIODS
		TOTAL: 30 PERIODS

PRACTICAL EXERCISES:

1. Create Regular expressions in Python for detecting word patterns and tokenizing text
2. Getting started with Python and NLTK - Searching Text, Counting Vocabulary, Frequency Distribution, Collocations, Bigrams
3. Accessing Text Corpora using NLTK in Python
4. Write a function that finds the 50 most frequently occurring words of a text that are not stop words.
5. Implement the Word2Vec model
6. Use a transformer for implementing classification
7. Design a chatbot with a simple dialog system

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8. Convert text to speech and find accuracy	
9. Design a speech recognition system and find the error rate	
TOTAL: 60 PERIODS	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Analyze and compare existing and emerging deep learning architectures for processing text and speech.
CO2:	Apply deep learning methods to perform NLP tasks, including language modeling and machine translation.
CO3:	Examine techniques for coreference resolution and maintaining coherence in text processing.
CO4:	Design and develop question-answering systems, chatbots, and dialogue systems.
CO5:	Develop deep learning models for speech recognition and text-to-speech systems.
TEXT BOOKS:	
1.	Daniel Jurafsky and James H. Martin, "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition", Third Edition, 2022.
REFERENCES:	
1.	Dipanjan Sarkar, "Text Analytics with Python: A Practical Real-World approach to Gaining Actionable insights from your data", APress,2018.
2.	Tanveer Siddiqui, Tiwary U S, "Natural Language Processing and Information Retrieval", Oxford University Press, 2008.
3.	Lawrence Rabiner, Biing-Hwang Juang, B. Yegnanarayana, "Fundamentals of Speech Recognition" 1st Edition, Pearson, 2009.
4.	Steven Bird, Ewan Klein, and Edward Loper, "Natural language processing with Python", O'REILLY.

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CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	3	1	3	-	-	-	1	2	1	2	1	1	1
CO2	3	1	2	1	3	-	-	-	2	2	1	3	3	2	1
CO3	2	2	1	3	1	-	-	-	3	3	1	2	3	3	1
CO4	2	1	1	1	2	-	-	-	2	1	2	2	3	1	1
CO5	1	3	2	2	1	-	-	-	3	2	1	1	2	3	1
CO	**2.2**	**1.8**	**1.8**	**1.6**	**2**	**-**	**-**	**-**	**2.2**	**2**	**1.2**	**2**	**2.4**	**2**	**1**

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC605	**OPTIMIZATION TECHNIQUES**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- Formulate linear programming problems and apply suitable methods to solve them.
- Analyze and solve integer programming, transportation, and assignment problems.
- Apply CPM and PERT techniques to compute solutions for network scheduling problems.
- Optimize objective functions while satisfying constraints.
- Model and solve problems using Markovian queuing theory.

UNIT I	**LINEAR MODELS**	**6**
Introduction of Operations Research - mathematical formulation of LPP- Graphical Methods to solve LPP- Simplex Method- Two-Phase method.		
UNIT II	**INTEGER PROGRAMMING AND TRANSPORTATION PROBLEMS**	**6**
Integer programming: Branch and bound method- Transportation and Assignment problems - Traveling salesman problem.		
UNIT III	**PROJECT SCHEDULING**	**6**

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Project network -Diagram representation – Floats - Critical path method (CPM) – PERT- Cost considerations in PERT and CPM.		
UNIT IV	**CLASSICAL OPTIMIZATION THEORY**	**6**
Unconstrained problems – necessary and sufficient conditions - Newton-Raphson method, Constrained problems – equality constraints – inequality constraints - Kuhn-Tucker conditions - Gradient Descent and Steepest Descent Methods**.**		
UNIT V	**QUEUING MODELS**	**6**
Introduction, Queuing Theory, Operating characteristics of a Queuing system, Constituents of a Queuing system, Service facility, Queue discipline, Single channel models, multiple service channels.		
		TOTAL: 30 PERIODS
		TOTAL: 30 PERIODS

PRACTICAL EXERCISES:

1. Solving simplex maximization problems using R programming.
2. Solving simplex minimization problems using R programming.
3. Solving mixed constraints problems – Big M & Two phase method using TORA.
4. Solving transportation problems using R.
5. Solving assignment problems using R.
6. Solving optimization problems using LINGO.
7. Studying Primal-Dual relationships in LP using TORA.
8. Solving LP problems using dual simplex method using TORA.
9. Sensitivity & post optimality analysis using LINGO.
10. Solving shortest route problems using optimization software
11. Solving Project Management problems using optimization software
12. Testing random numbers and random variates for their uniformity.
13. Testing random numbers and random variates for their independence
14. Solve single server queuing model using simulation software package.
15. Solve multi server queuing model using simulation software package.

TOTAL: 60 PERIODS

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COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Formulate and solve linear programming problems (LPP).
CO2:	Analyze and evaluate integer programming, transportation, and assignment problems.
CO3:	Apply CPM and PERT techniques to solve network scheduling problems.
CO4:	Optimize objective functions subject to given constraints.
CO5:	Model and solve problems using Markovian queuing systems.
TEXT BOOKS:	
1.	Hamdy A Taha, Operations Research: An Introduction, Pearson, 10th Edition, 2017.
REFERENCES:	
1.	ND Vohra, Quantitative Techniques in Management, Tata McGraw Hill, 4th Edition, 2011.
2.	J. K. Sharma, Operations Research Theory and Applications, Macmillan, 5th Edition, 2012.
3.	Hiller F.S, Liberman G.J, Introduction to Operations Research, 10th Edition McGraw Hill, 2017.
4.	Jit. S. Chandran, Mahendran P. Kawatra, KiHoKim, Essentials of Linear Programming, Vikas Publishing House Pvt.Ltd. New Delhi, 1994.
5.	Ravindran A., Philip D.T., and Solberg J.J., Operations Research, John Wiley, 2nd Edition, 2007.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	2	1	1	-	-	-	2	1	1	2	3	3	3
CO2	3	1	2	2	3	-	-	-	3	2	3	1	2	1	1
CO3	2	3	3	2	2	-	-	-	3	3	1	3	1	3	1
CO4	2	2	1	1	3	-	-	-	2	1	3	1	2	1	2
CO5	2	1	1	3	2	-	-	-	3	3	1	3	3	2	1
CO	**2.4**	**2**	**1.8**	**1.8**	**2.2**	**-**	**-**	**-**	**2.6**	**2**	**1.8**	**2**	**2.2**	**2**	**1.6**

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24CEC606	GAME THEORY	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To explain the concept of a game, solution concepts, and the basic tools of game theory, along with their main applications, including electronic trading markets.
- To formalize strategic thinking and rational choice using game theory tools, and analyze their use in modeling applications.
- To examine the connections between game theory, computer science, and economics, highlighting computational considerations.
- To discuss contemporary topics at the intersection of game theory, computer science, and economics.
- To apply game theory concepts in searching, auctioning, and trading scenarios.

UNIT I	INTRODUCTION	6

Introduction — Making rational choices: basics of Games — strategy — preferences — payoffs — Mathematical basics — Game theory — Rational Choice — Basic solution concepts-non-cooperative versus cooperative games — Basic computational issues — finding equilibria and learning in games- Typical application areas for game theory (e.g. Google's sponsored search, eBay auctions, electricity trading markets).

UNIT II	GAMES WITH PERFECT INFORMATION	6

Games with Perfect Information — Strategic games — prisoner's dilemma, matching pennies - Nash equilibria —mixed strategy equilibrium — zero-sum games

UNIT III	GAMES WITH IMPERFECT INFORMATION	6

Games with Imperfect Information — Bayesian Games — Motivational Examples — General Definitions — Information aspects — Illustrations — Extensive Games with Imperfect — Information — Strategies — Nash Equilibrium —Repeated Games — The Prisoner's Dilemma — Bargaining - Signaling Games

UNIT IV	NON-COOPERATIVE GAME THEORY	6

Non-cooperative Game Theory — Self-interested agents — Games in normal form — Analyzing games: from optimality to equilibrium — Computing Solution Concepts of Normal — Form Games — Computing Nash equilibria of two-player, zero-sum games —Computing Nash equilibria of two-player, general- sum games — Identifying dominated strategies

UNIT V	MECHANISM DESIGN	6

Aggregating Preferences — Social Choice — Formal Model — Voting — Existence of social functions — Ranking systems — Protocols for Strategic Agents: Mechanism Design — Mechanism design with unrestricted preferences	
30 PERIODS	
PRACTICAL EXERCISES:	**30 PERIODS**
1. Prisoner's dilemma	
2. Pure Strategy Nash Equilibrium	
3. Extensive Form – Graphs and Trees, Game Trees	
4. Strategic Form – Elimination of dominant strategy	
5. Minimax theorem, minimax strategies	
6. Perfect information games: trees, players assigned to nodes, payoffs, backward Induction, subgame perfect equilibrium,	
7. Imperfect-information games - Mixed Strategy Nash Equilibrium - Finding mixed-strategy Nash equilibria for zero sum games, mixed versus behavioral strategies.	
8. Repeated Games	
9. Bayesian Nash equilibrium	
TOTAL: 60 PERIODS	
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Explain the notion of strategic games, equilibria, and the characteristics of their main applications.
CO2:	Analyze the use of Nash Equilibrium in solving various problems.
CO3:	Identify key strategic aspects in real-world situations and relate them to appropriate game-theoretic concepts.
CO4:	Recognize applications that require concepts from Bayesian Games.
CO5:	Model and implement a typical virtual business scenario using game theory.
TEXT BOOKS:	
1.	M. J. Osborne, An Introduction to Game Theory. Oxford University Press, 2012.
2.	M. Machler, E. Solan, S. Zamir, Game Theory, Cambridge University Press, 2013.
3.	N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani, Algorithmic Game Theory. Cambridge University Press, 2007.
4.	A.Dixit and S. Skeath, Games of Strategy, Second Edition. W W Norton & Co Inc, 2004.
5.	YoavShoham, Kevin Leyton-Brown, Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Cambridge University Press 2008.

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6.	Zhu Han, DusitNiyato, WalidSaad, TamerBasar and Are Hjorungnes, "Game Theory in Wireless and Communication Networks", Cambridge University Press, 2012.
7.	Y.Narahari, "Game Theory and Mechanism Design", IISC Press, World Scientific.
8.	William Spaniel, "Game Theory 101: The Complete Textbook", CreateSpace Independent Publishing, 2011.

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	2	3	3	-	-	-	-	-	-	-	1	1	3
CO2	3	3	3	2	3	-	-	-	-	-	-	-	1	1	1
CO3	1	1	3	3	3	-	-	-	-	-	-	-	1	1	2
CO4	2	1	1	1	1	-	-	-	-	-	-	-	1	1	2
CO5	2	2	3	2	1	-	-	-	-	-	-	-	1	1	2
CO	**2.2**	**2**	**2.4**	**2.2**	**2.2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

24CEC607	**COGNITIVE SCIENCE**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- To provide a conceptual foundation for theoretical models of cognition.
- To explain the relationship between cognitive processes and computational intelligence.
- To introduce probabilistic programming as a framework for modeling cognitive functions.
- To examine computational inference models that represent cognitive reasoning.
- To explore computational learning models that describe how cognitive systems acquire knowledge.

UNIT I	**PHILOSOPHY, PSYCHOLOGY AND NEUROSCIENCE**	**6**

Philosophy: Mental-physical Relation – From Materialism to Mental Science – Logic and the Sciences of the Mind – Psychology: Place of Psychology within Cognitive Science – Science of Information Processing – Cognitive Neuroscience – Perception – Decision – Learning and Memory – Language Understanding and Processing.		
UNIT II	**COMPUTATIONAL INTELLIGENCE**	**6**
Machines and Cognition – Artificial Intelligence – Architectures of Cognition – Knowledge Based Systems – Logical Representation and Reasoning – Logical Decision Making –Learning – Language – Vision.		
UNIT III	**PROBABILISTIC PROGRAMMING LANGUAGE**	**6**
Web PPL Language – Syntax – Using Java script Libraries – Manipulating probability types and distributions – Finding Inference – Exploring random computation – Coroutines: Functions that receive continuations – Enumeration		
UNIT IV	**INFERENCE MODELS OF COGNITION**	**6**
Generative Models – Conditioning – Causal and statistical dependence – Conditional dependence – Data Analysis – Algorithms for Inference - Case Study: Spectrum Allocation for Telecommunication.		
UNIT V	**LEARNING MODELS OF COGNITION**	**6**
Learning as Conditional Inference – Learning with a Language of Thought – Hierarchical Models– Learning (Deep) Continuous Functions – Mixture Models.		
		TOTAL: 30 PERIODS
PRACTICAL EXERCISES: 30 PERIODS		
1. Demonstration of Mathematical functions using WebPPL.		
2. Implementation of reasoning algorithms.		
3. Developing an Application system using generative model.		
4. Developing an Application using conditional inference learning model.		
5. Application development using hierarchical model.		
6. Application development using Mixture model.		
		TOTAL: 60 PERIODS
COURSE OUTCOMES:		
At the end of the course, the students will be able to:		
CO1:	Describe the core theoretical foundations that explain cognitive processes.	

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CO2:	Analyze how cognitive elements correspond to computational representations.
CO3:	Use Web PPL to implement the required mathematical functions.
CO4:	Develop applications based on cognitive inference models.
CO5:	Develop applications based on cognitive learning models.
TEXT BOOKS:	
1.	Vijay V Raghavan, Venkat N. Gudivada, Venu Govindaraju, C.R. Rao, Cognitive Computing: Theory and Applications: (Handbook of Statistics 35), Elsevier publications, 2016
2.	Judith Hurwitz, Marcia Kaufman, Adrian Bowles, Cognitive Computing and Big Data Analytics, Wiley Publications, 2015
3.	Robert A. Wilson, Frank C. Keil, "The MIT Encyclopedia of the Cognitive Sciences",The MIT Press, 1999.
4.	Jose Luis Bermúdez, Cognitive Science -An Introduction to the Science of the Mind, Cambridge University Press 2020
REFERENCES:	
1.	Noah D. Goodman, Andreas Stuhlmuller, "The Design and Implementation of Probabilistic Programming Languages", Electronic version of book, https://dippl.org/.
2.	Noah D. Goodman, Joshua B. Tenenbaum, The Prob Mods Contributors, "Probabilistic Models of Cognition", Second Edition, 2016, https://probmods.org/.

CO's-PO's & PSO's MAPPING:

Course Outcomes	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	3	2	2	-	-	-	1	1	2	2	1	2	2
CO2	2	2	1	1	2	-	-	-	3	2	3	1	2	3	2
CO3	1	3	1	3	3	-	-	-	1	3	1	3	3	1	2
CO4	2	1	1	2	3	-	-	-	1	2	3	1	3	3	1
CO5	2	3	2	2	-	-	-	1	2	2	2	2	2	1	2
CO	**1.8**	**1.8**	**1.8**	**2**	**2.4**	**-**	**-**	**-**	**1.4**	**2**	**2.2**	**1.8**	**2.2**	**2.2**	**1.6**

1 - low, 2 - medium, 3 - high, '-' - no correlation

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24CEC608	ETHICS AND AI	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To examine the concepts of morality and ethics in AI.
- To review the ethical initiatives developed within artificial intelligence.
- To outline the key AI standards and regulatory considerations.
- To examine the social and ethical issues related to robot ethics.
- To explore the challenges and opportunities connected to AI and ethics.

UNIT I	INTRODUCTION	6

Definition of morality and ethics in AI-Impact on society-Impact on human psychology-Impact on the legal system-Impact on the environment and the planet-Impact on trust - Human–AI Interaction and Ethical Design Principles

UNIT II	ETHICAL INITIATIVES IN AI	6

International ethical initiatives-Ethical harms and concerns-Case study: healthcare robots, Autonomous Vehicles, Warfare and weaponization.

UNIT III	AI STANDARDS AND REGULATION	6

Model Process for Addressing Ethical Concerns During System Design - Transparency of Autonomous Systems-Data Privacy Process- Algorithmic Bias Considerations - Ontological Standard for Ethically Driven Robotics and Automation Systems

UNIT IV	ROBOETHICS: SOCIAL AND ETHICAL IMPLICATION OF ROBOTICS	6

Robot-Robo ethics- Ethics and Morality- Moral Theories-Ethics in Science and Technology - Ethical Issues in an ICT Society- Harmonization of Principles- Ethics and Professional Responsibility- Roboethics Taxonomy.

UNIT V	AI AND ETHICS- CHALLENGES AND OPPORTUNITIES	6

Challenges - Opportunities- ethical issues in artificial intelligence- Societal Issues Concerning the Application of Artificial Intelligence in Medicine- decision-making role in industries-National and International Strategies on AI.- Future ethical challenges in AI.

TOTAL: 30 PERIODS

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	TOTAL: 30 PERIODS
PRACTICAL EXERCISES:	
1. Recent case study of ethical initiatives in healthcare, autonomous vehicles and defense	
2. Exploratory data analysis on a 2-variable linear regression model	
3. Experiment the regression model without a bias and with bias	
4. Classification of a dataset from UCI repository using a perceptron with and without bias	
5. Case study on ontology where ethics is at stake	
6. Identification on optimization in AI affecting ethics	
	TOTAL: 60 PERIODS
COURSE OUTCOMES:	
At the end of the course, the students will be able to:	
CO1:	Explain the principles of morality and ethics in AI.
CO2:	Analyze real-time application ethics, associated issues, and emerging challenges.
CO3:	Examine ethical harms and evaluate major ethical initiatives in AI.
CO4:	Describe AI standards and regulations, including AI agents and the safe design of autonomous and semi-autonomous systems.
CO5:	Discuss robo ethics, AI-related societal concerns, and the professional responsibilities involved at national and international levels.
TEXT BOOKS:	
1.	Y. Eleanor Bird, Jasmin Fox-Skelly, Nicola Jenner, Ruth Larbey, Emma Weitkamp and Alan Winfield,"The ethics of artificial intelligence: Issues and initiatives", EPRS | European Parliamentary Research Service Scientific Foresight Unit (STOA) PE 634.452 – March 2020
2.	Patrick Lin, Keith Abney, George A Bekey," Robot Ethics: The Ethical and Social Implications of Robotics", The MIT Press- January 2014.
REFERENCES:	
1.	Towards a Code of Ethics for Artificial Intelligence (Artificial Intelligence: Foundations, Theory, and Algorithms) by Paula Boddington, November 2017
2.	2. Mark Coeckelbergh," AI Ethics", The MIT Press Essential Knowledge series, April 2020
3.	Web link: https://sci-hub.mksa.top/10.1007/978-3-540-30301-5_65

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4.	Web link: https://www.scu.edu/ethics/all-about-ethics/artificial-intelligence-and-ethics-sixteen-challenges-and-opportunities/
5.	Web link: https://www.weforum.org/agenda/2016/10/top-10-ethical-issues-in-artificial-intelligence/
6.	Web link: https://sci-hub.mksa.top/10.1159/000492428

CO's-PO's & PSO's MAPPING

Course Outcomes	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	3	3	1	-	-	-	1	2	1	1	3	1	1
CO2	2	1	1	2	1	-	-	-	1	2	1	1	3	3	1
CO3	2	3	1	1	3	-	-	-	2	1	1	2	3	2	2
CO4	3	1	3	3	2	-	-	-	2	2	3	1	2	1	3
CO5	3	1	1	3	3	-	-	-	2	3	3	3	1	3	3
CO	**2.6**	**1.6**	**1.8**	**2.4**	**2**	**-**	**-**	**-**	**1.6**	**2**	**1.8**	**1.6**	**2.4**	**2**	**2**

1 - low, 2 - medium, 3 - high, '-' - no correlation

Anna University Nominee **Academic Expert 1** **Academic Expert 2**

Industry Person **Alumni Member**

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