CURRICULUM and SYLLABI

FOR

B. TECH DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

SEMESTERS VII & VIII

2023 SCHEME

(AUTONOMOUS)

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY
(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)
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MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

B. TECH DEGREE PROGRAMME

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for

SEMESTERS VII & VIII

Items	Board of Studies (BoS)	Academic Council (AC)
Date of Approval	27-02-2026	12-03-2026

Head of Department
Chairman, Board of Studies

Principal
Chairman, Academic Council

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Vision and Mission of the Institution

Vision:

To be an Institution moulding globally competent professionals as epitomes of Noble Values.

Mission:

To transform the Youth as technically competent, ethically sound and socially committed professionals, by providing a vibrant learning ambience for the welfare of humanity.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Vision and Mission of the Department

Vision:

To be a Centre of Excellence in Electronics and Communication Engineering Education and Research for the service of humanity.

Mission:

To provide quality Engineering Education and to carry out Research in the field of Electronics and Communication Engineering addressing the challenges faced by the society.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: The graduates of the Programme will have a successful career as Professionals in Industry or as Entrepreneurs, encompassing a broad spectrum of areas related to Electronics and Communication Engineering.

PEO2: They will be able to adapt to the changing needs of Industry and Academia through continuous learning and professional upgrading.

PEO3: They will exhibit social responsibility in their pursuit of technical excellence.

PROGRAMME OUTCOMES (POs)

Engineering Graduates will have the ability to:

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.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1: Design Electronic Circuits and Systems for Communication, Monitoring and Control Applications.

PSO2: Demonstrate the knowledge, in Electronics, Signal processing, Embedded Systems and Communication Engineering, required for providing technical solutions to real world problems

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

B.TECH. PROGRAMME IN ELECTRONICS AND COMMUNICATION ENGINEERING

For the students admitted from 2023-24

SCHEDULING OF COURSES

i) Knowledge Segments and Credits

Every course of B. Tech Programme is placed in one of the nine categories as listed in table below. No semester shall have more than six lecture-based courses and two laboratory courses, and/or drawing/seminar/project courses in the curriculum.

Sl. No.	Category	Category Code	Total credits
1	Humanities and Social Sciences including Management Courses	HSC	**9**
2	Basic Science Courses	BSC	**26**
3	Engineering Science Courses	ESC	**21**
4	Programme Core Courses	PCC	**72**
5	Programme Elective Courses	PEC	**18**
6	Institute Elective Courses	IEC	**6**
7	Project Work, Seminar, Comprehensive Viva Voce and Internship	PWS	**15**
8	Mandatory Student Activities (P/F)	MSA	**3**
	Total Mandatory Credits		**170**
	Value Added Courses (Optional) – Honours/Minor	VAC	15

ii) Semester-wise Credit Distribution

Semester	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***Total***
Credits for Courses	***19***	***22***	***23***	***21***	***22***	***22***	***24***	***14***	***167***
Credits for Activities	*3*								***3***
Total Credits									***170***
Value Added Courses (Optional) – Honours / Minor									***15***
Total Credits									***185***

SEMESTER I										
Slot	Category	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	BSC	23MAL10A	Linear Algebra and Calculus	3	1	0	0	5	4	4
B	BSC	23PYL10A	Engineering Physics	3	1	0	0	5	4	4
D	ESC	23ESB10D	Problem Solving and Programming in C	2	1	2	0	4.5	5	4
E	ESC	23ESL10J	Basics of Electrical Engineering A	2	0	0	0	3	4	2
		23ESL10L	Basics of Electronics Engineering	2	0	0	0	3		2
G	ESC	23ESL1NA	Environmental Science	2	0	0	0	3	2	1*
S	BSC	23PYP10A	Engineering Physics Lab	0	0	2	0	1	2	1
T	ESC	23ESP10B	Electrical and Electronics Workshop	0	0	2	0	1	2	1
TOTAL								25.5	23	19

**Not to be considered for Grade/GPA/CGPA. Pass or Fail Only*

SEMESTER II										
Slot	Cate gory	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	BSC	23MAL10B	Vector Calculus, Differential Equations and Transforms	3	1	0	0	5	4	4
B	BSC	23CYL10A	Engineering Chemistry	3	1	0	0	5	4	4
C	ESC	23ESB10A	Engineering Graphics	2	0	2	0	4	4	3
D	ESC	23ESB10G	Python Programming	2	0	2	0	4	4	3
E	PCC	23ECL10A	Network Theory	3	1	0	0	5	4	4
G	HSC	23HSJ1NB	Professional Communication	2	0	0	2	5	4	1*
S	BSC	23CYP10A	Engineering Chemistry Lab	0	0	2	0	1	2	1
T	ESC	23ESB10P	Manufacturing and Construction Practices B	1	0	2	0	2.5	3	2
TOTAL								31.5	29	22

**Not to be considered for Grade/GPA/CGPA. Pass or Fail Only*

SEMESTER III									
Slot	**Category**	**Course Code**	**Courses**	**Credit Structure**				**SS**	**Hours**	**Credit**
				L	**T**	**P**	**J**			
A	BSC	23MAL20A	Partial Differential Equation and Complex Analysis	3	1	0	0	5	4	4
B	PCC	23ECL20A	Analog Circuits	3	1	0	0	5	4	4
C	PCC	23ECL20B	Solid State Devices	3	1	0	0	5	4	4
D	PCC	23ECJ20C	Logic Circuit Design	2	1	0	1	4.5	4	4
E	ESC	23ESL00A	Design Engineering	2	0	0	0	3	2	2
G	HSC	23HSL2NA	Professional Ethics	2	0	0	0	3	2	1*
S	PCC	23ECP20A	Analog Circuits Lab	0	0	3	0	1.5	3	2
T	PCC	23ECP20B	Logic Circuit Design Lab	0	0	3	0	1.5	3	2
M	VAC	23ECL2MX	Minor Course	3	0	0	0	4.5	3	3
				2	1	0	0	3.5		
TOTAL								**28.5/ 33/32**	**26/ 29**	**23/ 26**

**Not to be considered for Grade/GPA/CGPA. Pass or Fail Only*

SEMESTER IV									
Slot	**Category**	**Course Code**	**Courses**	**Credit Structure**				**SS**	**Hours**	**Credit**
				L	**T**	**P**	**J**			
A	BSC	23MAL20C	Probability, Random Processes and Numerical Methods	3	1	0	0	5	4	4
B	PCC	23ECL20D	Linear Integrated Circuits	3	1	0	0	5	4	4
C	PCC	23ECL20E	Signals and Systems	3	1	0	0	5	4	4
D	PCC	23ECJ20F	Microcontroller based system design	3	0	2	1	6.5	6	5
E	HSC	23HSL2NB	Universal Human Values-II	2	1	0	0	3.5	3	1*
G	ESC	23ESL2NC	Industrial Safety Engineering	2	1	0	0	3.5	3	1*
S	PCC	23ECP20C	Linear Integrated Circuits Lab	0	0	3	0	1.5	3	2
M/H	VAC	23ECL2MX / 23ECL2HX	Minor / Honours Course	3	0	0	0	4.5	3	3
				2	1	0	0	3.5		
TOTAL								**30/ 34.5 / 33.5**	**27/ 30/ 33**	**21/ 24/ 27**

**Not to be considered for Grade/GPA/CGPA. Pass or Fail Only*

SEMESTER V										
Slot	Category	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	PCC	23ECL30A	Analog and Digital Communication	3	1	0	0	5	4	4
B	PCC	23ECL30B	Digital Signal Processing	3	1	0	0	5	4	4
C	PCC	23ECL30C	Electromagnetic Field Theory	3	1	0	0	5	4	4
D	PEC	23ECL31X	Program Elective I	3	0	0	0	4.5	3	3
E	HSC	23HSL00A	Management for Engineers	3	0	0	0	4.5	3	3
S	PCC	23ECP30A	Communication Lab	0	0	3	0	1.5	3	2
T	PCC	23ECP30B	Digital Signal Processing Lab	0	0	3	0	1.5	3	2
M/H	VAC		Minor/Honours Course	3	0	0	0	4.5	3	3
				2	1	0	0	3.5		
TOTAL								**27/ 31.5 /30.5**	**24/ 27/ 30**	**22/25/ 28**

SEMESTER VI										
Slot	Category	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	PCC	23ECL30D	Control Systems	3	1	0	0	5	4	4
B	PCC	23ECJ30E	VLSI Circuit Design	3	1	2	0	6	6	5
D	PEC	23ECL32X	Program Elective II	3	0	0	0	4.5	3	3
E	IEC	23IEL31X	Institute Elective I	3	0	0	0	4.5	3	3
F	HSC	23HSL30A	Business Economics and Accountancy	3	0	0	0	4.5	3	3
T	PWS	23ECS38A	Seminar	0	0	4	0	2	4	2
U	PWS	23ECJ38B	Mini Project	0	0	4	0	4	4	2
M/H	VAC		Minor/Honours Course	3	0	0	0	4.5	3	3
				2	1	0	0	3.5		
TOTAL								**30.5/ 35/ 34**	**27/ 30/ 33**	**22/25/ 28**

SEMESTER VII										
Slot	**Category**	**Course Code**	**Courses**	**Credit Structure**				**SS**	**Hours**	**Credit**
				L	**T**	**P**	**J**			
A	PCC	23ECL40A	Information Theory and Coding	3	1	0	0	5	4	4
B	PCC	23ECL40B	Wireless Communication	3	0	0	0	4.5	3	3
C	PCC	23ECL40C	Computer Networks	3	0	0	0	4.5	3	3
D	PEC	23ECL43X	Program Elective III	3	0	0	0	4.5	3	3
E	IEC	23IEL42X	Institute Elective II	3	0	0	0	4.5	3	3
T	PWS	23ECV48A	Comprehensive Course Viva Voce	0	0	2	0	1	2	1
U	PWS	23ECJ48A	Project	0	0	10	0	10	10	5
		23ECI48A	Internship*							
S	PCC	23ECP40A	Advanced Communication Lab	0	0	3	0	1.5	3	2
M/H	VAC		Minor/Honours Course	0	1	6	0	4.5	3	3
				3	0	0	0	4.5		
TOTAL								**35.5/ 40/40**	**31/34/37**	**24/ 27/ 30**

** Students can opt for Internship either in S7 or S8. However, in S7, the internship can be permitted only if there are no pending Programme/Course requirements in the semester, that need to be completed in College in the offline mode, such as laboratory sessions.*

SEMESTER VIII										
Slot	**Category**	**Course Code**	**Courses**	**Credit Structure**				**SS**	**Hours**	**Credit**
				L	**T**	**P**	**J**			
A	PEC	23ECL44X	Program Elective IV	3	0	0	0	4.5	3	3
B	PEC	23ECL45X	Program Elective V	3	0	0	0	4.5	3	3
C	PEC	23ECL46X	Program Elective VI	3	0	0	0	4.5	3	3
U	PWS	23ECJ48B	Project	0	0	10	0	10	10	5
		23ECI48A	Internship*							
H	VAC		Honours Course					3	6	3
TOTAL								**23.5 / 26.5**	**19/25**	**14/17**

PROGRAMME ELECTIVE-I									
Slot	Category	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
D	PEC	23ECL31A	Digital System Design	2	1	0	0	3.5	3	3
		23ECL31B	Power Electronics	3	0	0	0	4.5	3	3
		23ECL31C	Mechatronics	3	0	0	0	4.5	3	3
		23ECL31D	DSP architectures	3	0	0	0	4.5	3	3
		23ECL31E	Computer Architecture	2	1	0	0	3.5	3	3
		23ECL31F	Data Structures using C	3	0	0	0	4.5	3	3
		23ECL31G	Bio medical Engineering	3	0	0	0	4.5	3	3

PROGRAMME ELECTIVE-II									
Slot	Category	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
D	PEC	23ECL32A	Digital Image Processing	2	1	0	0	3.5	3	3
		23ECL32B	Data Analysis using Python	2	1	0	0	3.5	3	3
		23ECL32C	Embedded Systems	3	0	0	0	4.5	3	3
		23ECL32D	Introduction to MEMS	3	0	0	0	4.5	3	3
		23ECL32E	Satellite Communication	3	0	0	0	4.5	3	3
		23ECL32F	Antenna and Wave Propagation	2	1	0	0	3.5	3	3
		23ECL32G	Multi-rate Systems	2	1	0	0	3.5	3	3

PROGRAMME ELECTIVE-III									
Slot	Category	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
D	PEC	23ECL43A	Real Time Operating System	3	0	0	0	4.5	3	3
		23ECL43B	Microwave Engineering	3	0	0	0	4.5	3	3
		23ECL43C	Speech and Audio Processing	3	0	0	0	3.5	3	3
		23ECL43D	Machine Learning	2	1	0	0	3.5	3	3
		23ECL43E	Optical Fibre Communication	3	0	0	0	4.5	3	3
		23ECL43F	Quantum Computing	3	0	0	0	4.5	3	3
		23ECL43G	Wavelet Theory	2	1	0	0	3.5	3	3

PROGRAMME ELECTIVE-IV										
Slot	Category	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
D	PEC	23ECL44A	Organic Electronics	3	0	0	0	4.5	3	3
		23ECL44B	Pattern Recognition	3	0	0	0	4.5	3	3
		23ECL44C	RF MEMS	3	0	0	0	4.5	3	3
		23ECL44D	Secure Communication	3	0	0	0	3.5	3	3
		23ECL44E	Deep Learning	3	0	0	0	4.5	3	3
		23ECL44F	Robotics	3	0	0	0	3.5	3	3
		23ECL44G	Mixed Signal Circuit Design	2	1	0	0	3.5	3	3

PROGRAMME ELECTIVE-V										
Slot	Category	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
D	PEC	23ECL45A	Low Power VLSI	3	0	0	0	4.5	3	3
		23ECL45B	Cyber Security	3	0	0	0	4.5	3	3
		23ECL45C	Adaptive Signal Processing	2	1	0	0	3.5	3	3
		23ECL45D	Wireless Sensor Networks	3	0	0	0	4.5	3	3
		23ECL45E	RF Circuit Design	3	0	0	0	4.5	3	3
		23ECL45F	Advanced Coding Theory	2	1	0	0	3.5	3	3
		23ECL45G	Digital Video Processing	3	0	0	0	3.5	3	3

PROGRAMME ELECTIVE-VI										
Slot	Category	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
D	PEC	23ECL46A	Introduction to Queuing theory	2	1	0	0	4.5	3	3
		23ECL46B	Computer Vision	3	0	0	0	4.5	3	3
		23ECL46C	Next Generation Wireless Communication Systems	3	0	0	0	4.5	3	3
		23ECL46D	Microwave Devices and Circuits	3	0	0	0	4.5	3	3
		23ECL46E	Nano Electronics	3	0	0	0	4.5	3	3
		23ECL46F	Instrumentation	3	0	0	0	4.5	3	3
		23ECL46G	Analog CMOS Design	3	0	0	0	4.5	3	3

INSTITUTE ELECTIVE-I										
Slot	Category	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
E	IEC	23IEL31I	Optimization Techniques	2	1	0	0	3.5	3	3
		23IEL31J	Biosensors and Transducers	2	1	0	0	3.5	3	3
		23IEL31K	Essentials of Entrepreneurship	2	1	0	0	3.5	3	3
		23IEL31L	Internet of Things	2	1	0	0	3.5	3	3

INSTITUTE ELECTIVE-II										
Slot	Category	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
D	PEC	23IEL42I	Operations Research	2	1	0	0	3.5	3	3
		23IEL42J	Space Technology	3	0	0	0	4.5	3	3
		23IEL42K	Assistive Technology	3	0	0	0	4.5	3	3
		23IEL42L	Intellectual Property Rights	2	1	0	0	3.5	3	3

MINOR BASKETS

Semester	BASKET- I EMBEDDED SYSTEMS AND APPLICATIONS				BASKET-II ARTIFICIAL INTELLIGENCE FOR SIGNAL PROCESSING			
	Course Code	**Course**	**L-T-P-J**	**Credit**	**Course Code**	**Course**	**L-T-P-J**	**Credit**
S3	23ECL2 MA	Electronic Circuits	2-1-0-0	3	23ECL2 MC	Introduction to Multidimensional Data	2-1-0-0	3
S4	23ECL2 MB	Microcontrollers	2-1-0-0	3	23ECL2 MD	Machine Learning for data processing	2-1-0-0	3
S5	23ECL3 MA	Embedded System Design	3-0-0-0	3	23ECL3 MC	Deep Learning	2-1-0-0	3
S6	23ECL3 MB	Design for IoT	3-0-0-0	3	23ECL3 MD	Computational tools for AI	2-1-0-0	3
S7/ S8	23ECJ4 MA	Mini Project	0-0-6-0	3	23ECJ4 MC	Mini Project	0-0-6-0	3

MINOR BASKETS (cont…)

Semester	BASKET-III ROBOTICS				BASKET-IV BIOMEDICAL ENGINEERING			
	Course Code	Course	L-T-P-J	Credit	Course Code	Course	L-T-P-J	Credit
S3	23ECL2 ME	Fundamentals of Robotics	3-0-0-0	3	23ECL2 MG	Fundamentals of Biomedical E ngineering	3-0-0-0	3
S4	23ECL2 MF	Introduction to Industrial Automation	2-1-0-0	3	23ECL2 MH	Assistive Technologies	3-0-0-0	3
S5	23ECL3 ME	Vision System	3-0-0-0	3	23ECL3 MG	Medical Devices Engineering	3-0-0-0	3
S6	23ECL3 MF	Artificial Intelligence for Robotics	3-0-0-0	3	23ECL3 MH	Bio Signal and Image Processing	3-0-0-0	3
S7/ S8	23ECJ4 ME	Mini Project	0-0-6-0	3	23ECJ4 MG	Mini Project	0-0-6-0	3

HONOURS BASKETS

Semester	BASKET I VLSI AND EMBEDDED SYSTEMS				BASKET II COMMUNICATION				BASKET III SIGNAL PROCESSING			
	Course Code	Course	L-T-P-J	Credit	Course Code	Course	L-T-P-J	Credit	Course Code	Course	L-T-P-J	Credit
S4	23ECL 2HB	Nanoelectronics	3-0-0-0	3	23ECL 2HD	Random Process and Applications	2-1-0-0	3	23ECL 2HF	Wavelet Transform and Applications	2-1-0-0	3
S5	23ECL 3HA	FPGA based System Design	3-0-0-0	3	23ECL 3HC	Detection and Estimation Theory	3-0-0-0	3	23ECL 3HE	DSP System Design	3-0-0-0	3
S6	23ECL 3HB	Electronics Design and Automation	3-0-0-0	3	23ECL 3HD	Design and Analysis of Antennas	3-0-0-0	3	23ECL 3HF	Multirate Signal Processing	2-1-0-0	3
S7	23ECL 4HA	RF MEMS	3-0-0-0	3	23ECL 4HC	MIMO and Multiuser Communication Systems	3-0-0-0	3	23ECL 4HE	Computational tools for Signal Processing	2-1-0-0	3
S8	23ECJ 4HB	Mini Project	0-0-6-0	3	23ECJ 4HD	Mini Project	0-0-6-0	3	23ECJ 4HF	Mini Project	0-0-6-0	3

SEMESTER VII

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL40A	INFORMATION THEORY AND CODING	PCC	3	1	0	0	4	2023

i. PREREQUISITE :23ECL30A – Analog and Digital Communication

ii. COURSE OVERVIEW

This course aims to lay down the foundation of information theory introducing both source coding and channel coding. It also aims to expose students to algebraic and probabilistic error- control codes that are used for reliable transmission.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Compute information, entropy and mutual information related with different components in a communication system	Understand
CO 2	Apply Shannon's source coding theorem for data compression	Apply
CO 3	Apply the concept of channel capacity to characterize the limits of error-free transmission.	Apply
CO 4	Design linear block encoders and decoders for error detection and correction.	Analyze
CO 5	Apply algebraic codes with reduced structural complexity for error correction.	Apply
CO 6	Perform error detection and correction using convolutional and LDPC codes.	Apply

iv. SYLLABUS

Information, Entropy, Mutual Information – formulation & properties. Differential entropy. Discrete Memory-less source, Average codelength, Kraft's inequality, Huffman Code

Discrete Memoryless channels – capacity, channel coding theorem. Gaussian channels -. Shannon Hartley theorem

Block codes – Error detection and correction capability, Generator and parity matrix. Decoding. Hamming Codes

Cyclic codes - Polynomial and matrix description, Systematic and Non-systematic encoding and decoding. BCH codes

Convolutional - State diagram. Trellis diagram. Maximum likelihood decoding. Viterbi algorithm.

Capacity achieving Codes - LDPC Codes

v (a) TEXT BOOKS

1. Shu Lin & Daniel J. Costello. Jr., Error Control Coding: Fundamentals and Applications, 2nd Edition, 2001.
2. Simon Haykin, Digital Communication Systems, 4th edition, Wiley, 2000.
3. Bernard Sklar, Digital Communications: Fundamentals and Applications, 2nd edition, Pearson 2021

(b) REFERENCES

1. Joy A Thomas and Thomas M Cover, Elements of Information Theory, 2nd edition, Wiley- Interscience, 2005.
2. David JC McKay, Information Theory, Inference and Learning Algorithms, Cambridge University Press, 2005
3. R. G Gallager, Principles of digital communication, Cambridge University Press, 2008
4. Ron M Roth, Introduction to Coding Theory, Cambrdige University Press, 2006
5. RüdigerUrbanke and TJ Richardson, Modern Coding Theory, Cambdridge University, 2008

vi. COURSE PLAN

Module	Contents	Hours
I	Information Theory - Information, Entropy, Properties of Entropy, Joint and Conditional Entropy, Mutual Information, Properties of Mutual Information. Differential Entropy, Differential Entropy of Gaussian random variable. Discrete memoryless sources, Source code, Average length of source code, Bounds on average length, Uniquely decodable and prefix-free source codes. Shannon's source coding theorem, Kraft's inequality, Huffman Code	13
II	Discrete memoryless channels - Binary symmetric channels (BSC), Binary Erasure channels (BEC) - Capacity of simple discrete memoryless channels- Capacity of BSC and BEC - Shannon's channel coding theorem. Modeling of Additive White Gaussian channels. Continuous-input channels with average power constraint. Shannon Hartley theorem.Inferences from Shannon Hartley theorem – spectral efficiency versus SNR per bit, power-limited and bandwidth-limited regions, Shannon limit.	9

III	**Channel Coding** – Types of channel coding schemes. **Block codes**: Parameters, Error detecting and correcting capability. **Linear block codes** – Generator matrix and parity-check matrix. Encoder Circuit. Maximum likelihood decoding. Bounded distance decoding. Syndrome and Standard array decoding. Syndrome Circuit and Decoder Circuit Repetition code, Single parity-check code and Hamming Code	13
IV	**Cyclic codes** - Polynomial and matrix description. Interrelation between polynomial and matrix view point. Systematic and Non-systematic encoding. Decoding of cyclic codes. BCH Code	12
V	**Convolutional Codes-** State diagram. Trellis diagram. Maximum likelihood decoding. Viterbi algorithm. **Capacity achieving Codes -** Low-density parity check (LDPC) codes, Tanner graph representation. Message-passing decoding for transmission over binary erasure channel.	13
	Total Hours	**60**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL40B	WIRELESS COMMUNICATION	PCC	3	0	0	0	3	2023

i. PREREQUISITE Nil

ii. COURSE OVERVIEW

This course aims to introduce students to basic theory and principles of wireless communication systems in general, and cellular systems in particular.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply the principles of wireless communication systems to analyze cellular concepts and handoff strategies.	Apply
CO 2	Apply principles of radio wave propagation to predict path loss using large-scale propagation models.	Apply
CO 3	Analyse the impact of time-varying and fading channel characteristics on wireless system performance.	Apply
CO 4	Apply diversity techniques and MIMO system models to enhance receiver performance in wireless communication system.	Analyse
CO 5	Apply multicarrier modulation techniques to design communication systems that reduce PAPR.	Apply

iv. SYLLABUS

Introduction to Wireless Communication Systems: Cellular System Design Fundamentals and concepts. Wireless channel models.

Large Scale propagation models: Free space and 2-ray propagation path loss models, Empirical analysis of urban and indoor models.

Small scale propagation model-impulse response of a channel, Types of fading, Narrowband fading, Wideband fading.

Performance of digital modulation schemes over flat fading channels.
Diversity: Receive and Transmit diversity – selection combining, maximal ratio combining, Alamouti scheme.

Multi-carrier Modulation: OFDM. Cyclic Prefix, Peak-to-average power and reduction techniques. MIMO System Model – Zero Forcing and Minimum Mean Square Error receivers - Beam forming.

v (a) TEXT BOOKS

1. Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2005
2. Theodore S. Rappaport, Wireless communication: Principles and Practice, 2/e, Pearson Education, 1990.

3. Aditya Jagannatham, Principles of Modern Wireless Communication Systems, Mc Graw Hill, 2017.
4. Robert Collin, Antennas and Radio wave Propagation, McGraw Hill, 2016.

(b) REFERENCES

1. David Tse and Pramod Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005
2. Jochen Schiller, Mobile Communications, Pearson, 2008.
3. Andreas F Molish, Wireless Communications, 2nd Edition, Wiley India Publications, 2013.
4. W. C. Y. Lee, Mobile Cellular Telecommunication, McGraw Hill,2017.
5. Gordon L. Stuber, Principles of Mobile Communication, Springer,2017.
6. Rahim Thafazoli, Technologies for The Wireless Future, Volume 2, Wiley and Sons,2004.
7. Edward C Jordan and Keith G Balmain, Electromagnetic Wave and Radiating System, Pearson,2015.

vi. COURSE PLAN

Module	Contents	Hours
I	Overview of Wireless Communication, Cellular concept – Frequency reuse – Channel assignment strategies – Handoff strategies – Interference and system capacity – Power control for reducing interference-Trunking and grade of service – Improving coverage and capacity in cellular system-Cell splitting, sectoring, microcell zone concept.	9
II	Large scale propagation mechanism- Reflection, Diffraction and Scattering, Free space and 2 ray propagation model, Empirical path loss model for outdoor and Indoor propagation.	9
III	Small scale propagation model- impulse response model of a channel, Classification of fading, narrowband fading, wideband fading -delay spread and coherence bandwidth, doppler spread and coherence time, fading distributions, level crossing rate and average fade duration.	8
IV	Performance of digital modulation scheme over flat fading channels. Diversity- Types of Diversity: Antenna, Frequency, Time; Receive Diversity Combining Techniques-Analysis of Selection combining and Maximal ratio combining. Transmit Diversity Techniques: Alamouti scheme	9
V	Multi carrier modulation in frequency-selective channel, OFDM DFT/IDFT, Cyclic Prefix, PAPR and reduction techniques. MIMO System Model – Zero Forcing and Minimum Mean Square Error receivers - Beam forming	10
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL40C	COMPUTER NETWORKS	PCC	3	0	0	0	3	2023

i. PREREQUISITE :Nil

ii. COURSE OVERVIEW

This course aims to expose students to computer networks taking a top-down approach of viewing from the layer of user applications and zooming into link layer protocol

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe the TCP/IP model and components in computer networks	Understand
CO 2	Explain the concept of protocols in transport layer and network layer.	Understand
CO 3	Apply routing algorithm in the computer networks	Apply
CO 4	Explain link layer services, addressing, and the fundamentals of IEEE 802.11 WLAN and Ethernet.	Understand
CO5	Apply basic queuing concepts to evaluate network performance metrics and Go-Back-N ARQ operation.	Apply

iv. SYLLABUS

Components of computer network, Applications of computer network – the Internet, TCP/IP model, TDM versus statistical multiplexing, Datagram versus Virtual-circuit networks ,Application layer: Web application: HTTP, Message format, Email application: SMTP, Message format, MIME, POP3 and Web-based email.

Transport Layer: UDP, Protocols for reliable data transfer: TCP Connection, segment structure, Congestion Control.

Network Layer: Router architecture, -IPv4 and IPv6. Routing Algorithms- Link-State (Dijkstra"s) Algorithm, Distance vector algorithm. Routing in Internet.

Packet analysis using Wireshark, Introduction to Socket Programming.

Services of link layer, Error detection and correction. Multiple access protocols. Link layer addressing.

Wireless LAN and Introductory Queueing Concepts Littles theorem and examples. M/M/1 Queue. Delay analysis of Go-Back-N ARQ system

v (a) TEXT BOOKS

1. James F. Kurose, Keith W. Ross, Computer Networking: A Top-Down Approach Featuring the Internet, 9th edition(2025), Pearson
2. D. Bertsekas, RG Gallager, Data Networks, 2nd Edition Prentice Hal
3. A. Kumar, D. Manjunath, J. Kuri, Communication Networking – An Analytical Approach, Morgan Kauffman Series

(b) REFERENCES

1. N. Abramson, F. Kuo, Computer Communication Networks, Prentice Hall
2. A. S. Tanenbaum, D. J. Wetherall, Computer Networks, 6th Edition Pearson
3. Michael J. Donahoo, Kenneth L. Calvert, TCP/IP Sockets in C: Practical Guide for Programmers, 2nd edition (2009), Morgan Kaufmann.

vi. COURSE PLAN

Module	Contents	Hours
I	Components of computer networks: Applications of computer network – the Internet, TCP/IP model. Client and server hosts, connectionless and connection-oriented services. FDM, TDM versus statistical multiplexing, Datagram versus Virtual-circuit networks. Layered Architecture: Protocol layering, Internet protocol stack, Message encapsulation. Application Layer: Communication between processes, Web application**:** HTTP, Message format, Email application: SMTP, Message format, MIME, POP3 and Web-based email.	10
II	Transport Layer: UDP, Protocols for reliable data transfer: ARQ protocols, stop-and-wait protocol, Go-backN, Selective Repeat. TCP Connection, segment structure, RTT estimate, Flow control. Congestion Control general approaches. TCP congestion control	9
III	Network Layer: IPv4: datagram format, addressing, address assignment – manual and DHCP, ICMP. IPv6. Routing Algorithms: Link-State (Dijkstra"s) Algorithm, Distance vector algorithm. Routing in Internet – RIP, OSPF, BGP. Packet analysis using Wireshark: IPv4/IPv6 header inspection, ICMP message analysis, ARP and DHCP packet study, routing path observation using TTL, and visualization of protocol encapsulation across layers. Introduction to Socket Programming	10
IV	Link Layer: Services of link layer, Error detection and correction – checksum, CRC. Multiple access protocols – Channel partitioning, random access, taking-turns. CSMA, CSMA/CA, CSMA/CD. Link layer addressing: MAC address, ARP, DHCP. IEEE 802.3 Ethernet: Frame format, IEEE 802.11 wireless LAN architecture and MAC protocol.	8

V	Introductory Queuing Concepts: Introduction to queuing models in computer networks. Little's Theorem with applications and numerical examples. M/M/1 queue and basic performance measures. Go-Back-N ARQ protocol and qualitative delay analysis.	8
	Total Hours	**45**

vii. ASSESSMENTPATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECV48A	COMPREHENSIVE VIVA VOCE	PWS	0	0	2	0	1	2023

i. COURSE OVERVIEW

The objective of this course is to evaluate the students' basic understanding and application capability in the core domains of their respective engineering branch.

ii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO1	Apply fundamental concepts from core engineering courses to analyze and solve basic engineering problems relevant to the branch of study.	Apply
CO2	Demonstrate comprehensive technical understanding by articulating engineering concepts, reasoning, and solutions effectively during viva voce examination.	Understand

iii. SYLLABUS

Network Theory: Circuit analysis using mesh and nodal methods, major network theorems, Laplace-based transient analysis of RL/RC/RLC circuits, network functions and pole-zero interpretation, two-port network modelling.

Solid State Devices: Semiconductor fundamentals, PN junction behaviour, BJT operation and current components, MOSFET structure, threshold voltage and device characteristics.

Logic Circuit Design: Boolean algebra and logic minimization, design of combinational and sequential circuits, finite state machines, basic Verilog modelling concepts.

Analog Circuits: MOSFET amplifier configurations (CS, CG, CD), small-signal analysis, multistage and feedback amplifiers, oscillators and power supplies.

Linear Integrated Circuits: Op-amp fundamentals and applications, active filters and oscillators, ADC/DAC, PLL and voltage regulation concepts.

Signals and Systems: Signals and system classifications, signal operations, Convolution and system response, Laplace and Fourier transforms, transfer function and stability, sampling theorem, Z-transform and discrete time Fourier transform.

Analog and Digital Communication: AM, FM, and PM systems, digital base band

and passband modulation schemes, Digital base band transmission in AWGN channels, spread spectrum communication.

Electromagnetic Field Theory: Electric and magnetic field theory, Maxwell's equations, EM wave propagation, Poynting vector theorem, Transmission line theory, rectangular wave guide parameters.

Microcontroller based system design: 8051 and ARM architecture basics, instruction sets, interrupts and interfacing concepts.

Control Systems: Mathematical modelling, transfer function and block diagram reduction, stability analysis (Routh, Root Locus, Bode, Nyquist), controllers and state-space methods.

VLSI Circuit Design: CMOS inverter operation, logic design styles, dynamic logic, latches and memory basics, semiconductor fabrication overview.

iv (a) TEXT BOOKS

1. Valkenburg V., "Network Analysis", Pearson, 3/e, 2019.
2. Ben Streetman and Sanjay Banerjee, Solid State Electronic Devices, Pearson Education, 7th Edn., 2014.
3. Morris Mano, Digital Design, Prentice Hall of India,6 /e, 2013.
4. Sedra A. S. and K. C. Smith, Microelectronic Circuits, 6/e, Oxford University Press, 2013
5. Roy D. C. and S. B. Jain, Linear Integrated Circuits, 5/e, New Age International, 2018
6. Alan V. Oppenheim and Alan Willsky, Signals and Systems, PHI, 2/e, 2018
7. Simon Haykin, Digital Communication Systems, 4th edition, Wiley, 2000.
8. John D. Kraus, Electromagnetics, 5/e, TMH, 2010.
9. M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, The 8051 Microcontroller and Embedded Systems: Using Assembly and C, Pearson Education, Second edition, 2011.
10. Farid Golnaraghi, Benjamin C. Kuo, Automatic Control Systems,10th ed., McGraw-Hill Education, 2017.
11. Jan M.Rabaey, Digital Integrated Circuits- A Design Perspective, Prentice Hall, Second Edition, 2005.

(b) REFERENCES

1. Sudhakar A, Shyammohan S. P., "Circuits and Networks- Analysis and Synthesis", McGraw Hill, 5/e, 2015.
2. Sung Mo Kang, CMOS Digital Integrated Circuits: Analysis and Design, McGraw-Hill, Third Ed., 2016
3. Donald D Givone, Digital Principles and Design, Tata McGraw Hill, 2007.
4. Millman J. and C. Halkias, Integrated Electronics, 2/e, McGraw-Hill, 2010
5. Simon Haykin, Signals & Systems, John Wiley, 2/e, 2003
6. D Sklar, Digital Communications: Fundamentals and Applications,3/e, Pearson

7. Mathew N O Sadiku, Elements of Electromagnetics, Oxford University Press, 6/e, 2014.
8. Steve Furber, ARM System-on-Chip Architecture, Second Edition, PEARSON, 2016.
9. I.J. Nagarath, M. Gopal, Control Systems Engineering, 7th ed., New Age International Publishers, 2021.
10. N.H.E. Weste and D.M. Harris, CMOS VLSI design: A Circuits and Systems Perspective, 4th Edition, Pearson Education India, 2011.

v. COURSE PLAN

Module	Contents	Hours
I	Network Theory	3
	Solid State Devices	3
II	Logic Circuit Design	3
	Analog Circuits and Linear Integrated Circuits	3
III	Signals & Systems	3
	Analog and Digital Communication	3
IV	Electromagnetic Field Theory	3
	Microcontroller based system design	3
V	Control Systems	3
	VLSI Circuit Design	3
	Total Hours	**30**

vi. COURSE GUIDLINE

i) The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed in the curriculum. Mock tests, mock viva voce sessions, technical discussions may be conducted by the faculty in charge during the hours assigned for the course.

vii. ASSESSMENT PATTERN

Continuous Assessment : Final Assessment – 25 : 25

Continuous Assessment		
Attendance	:	5 marks
Multiple Choice Questions test and comprehensive viva (minimum 2 each)	:	20 marks
Total Continuous Assessment	**:**	**25 marks**
Final Assessment		
Viva Voce Examination	:	25 marks
Total Final Assessment	**:**	**25 marks**
TOTAL	**:**	**50 marks**

Total: 50 marks (Minimum required to pass: 25 Marks)

The mark will be treated as internal and should be uploaded along with internal marks of other courses.

The final viva voce examination shall be conducted by a panel of two evaluators. The panel shall consist of one senior faculty member from the Department and an expert from Industry/research institute/academia **or** two senior faculty members from the Department.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECJ48A	PROJECT	PWS	0	0	10	0	5	2023

i. COURSE OVERVIEW

The aim of this course is to apply engineering knowledge in solving practical problems, to foster innovation in design of products, processes or systems, and to develop creative thinking in finding viable solutions to engineering problems. The course is mainly intended to evoke the innovation and invention skills of a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation.

Desirable: The project outcome should be published in a peer-reviewed journal or presented at a conference, or a patent application should be filed.

It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

ii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply multidisciplinary knowledge to model and solve real world problems.	Apply
CO 2	Apply innovative and creative problem-solving to develop sustainable and socially relevant products, processes, or technologies.	Create
CO 3	Exhibit effective teamwork and leadership skills in diverse environments, with the ability to comprehend and carry out designated responsibilities.	Apply
CO 4	Execute tasks by planning effectively and utilizing available resources to meet deadlines, while adhering to ethical and professional standards.	Apply
CO 5	Effectively document, present, and communicate technical and scientific outcomes in professional written and verbal formats.	Apply

iii. ASSESSMENT PATTERN & RUBRICS

Continuous Assessment : Final Assessment – 70 : 30

Continuous Assessment		
Project Progress Evaluation by Guide	:	20 marks
Interim Evaluation -1 by Evaluation Committee	:	15 marks
Interim Evaluation -2 by Evaluation Committee	:	15 marks
Quality of the report evaluated by Evaluation Committee	:	20 marks
Total Continuous Assessment	**:**	**70 marks**
Final Assessment (Final Evaluation by Final Evaluation Committee)	**:**	**30 marks**
TOTAL	**:**	**100 marks**

Total: 100 marks (Minimum required to pass: 50 Marks)

Interim Evaluation:

The Evaluation committee comprises of HoD or a senior faculty member, Project coordinator and Project supervisor.

Final Evaluation:

The final evaluation committee comprises of Project coordinator, domain expert from the Department and expert from Industry/research/academic Institute / senior faculty from a sister department.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECI48A	INTERNSHIP	PWS	0	0	-	0	5	2023

i. COURSE OBJECTIVES

The internship is an integral component of the undergraduate programme aimed at providing students with immersive learning through practical exposure in industry, research organizations, or academic institutions.

BENEFITS OF INTERNSHIP

Benefits to Students

- Provides practical exposure to real-world industrial and organizational environments, enabling the application of theoretical knowledge gained in classrooms.
- Enhances professional competencies such as communication, teamwork, time management, interpersonal skills, and workplace ethics.
- Facilitates the development of technical and domain-specific skills, thereby strengthening overall professional readiness.
- Assists students in assessing their career interests and determining the suitability of a particular industry or profession.
- Improves employability by strengthening profiles for placements, higher education, and potential recruitment by the host organization.
- Encourages professional networking and relationship - building with industry experts and peers.
- Offers an opportunity to evaluate the organization and work culture before committing to full-time employment.

Benefits to the Institute

- Strengthens industry - academia collaboration.
- Facilitates smoother and more effective placement processes.
- Enhances institutional credibility and brand value.
- Supports student engagement and retention.
- Enables curriculum updates based on industry and student feedback.
- Improves the overall teaching - learning process through industry relevance.

Benefits to the Industry

- Provides access to a pool of motivated, job-ready students who can contribute immediately.
- Offers a cost-effective mechanism to evaluate and recruit potential employees.
- Enables the availability of a flexible workforce for temporary, project-based, or seasonal requirements.
- Brings fresh perspectives and innovative approaches to problem-solving.

- Enhances organizational visibility and employer branding within academic institutions.
- Strengthens corporate image by contributing to education and skill development.

TYPES OF INTERNSHIPS

- Industry Internship with/without Stipend
- Government / PSU Internship (BARC/Railway/ISRO etc.)
- Internship with prominent education/ Research Institutes
- Internship with Incubation centres /Start-ups

ii. COURSE OVERVIEW

Students may undertake an internship in an industry, research organization, or reputed academic institution with prior approval from the respective Head of the Department.

The internship is designed to promote meaningful skill development through structured, outcome-driven experiential learning. It shall focus on clearly defined technical competencies, such as domain-specific skills, software proficiency, exposure to industry-standard tools, and structured engineering problem-solving tasks. The learning objectives of the internship, along with the expectations of the host organization and the academic requirements of the institution, shall be clearly defined in consultation with the host organization and mutually agreed upon prior to the approval of the internship.

Each student shall be assigned a faculty guide/supervisor for monitoring and evaluation. The internship shall be relevant to the student's stream of study and can be carried out in Semester **VII** or Semester **VIII**, as specified by the Department, for a minimum duration of **three months.**

A student shall be permitted to undertake the internship only after the respective semester registration. During the internship period, any other courses or academic activities shall be pursued in online mode or as specified by the Department, to ensure timely fulfillment of all academic requirements.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply theoretical knowledge and engineering principles to practical problems encountered in professional practice.	Apply
CO 2	Demonstrate technical competence and understanding of tools, techniques, and processes relevant to the chosen field of specialization.	Apply
CO 3	Analyse social, environmental, economic, safety, and administrative factors influencing industrial operations and decision-making processes.	Analyze

CO 4	Communicate effectively through technical reports, presentations, and professional interactions in an industrial or research environment.	Apply
CO 5	Apply professional ethics, teamwork, and adaptability while performing assigned tasks in a multidisciplinary work setting.	Apply

iv. GUIDELINES FOR STUDENTS

- Duration of internship is three to six months (One semester).
- Students may undertake mini projects, case studies, or related technical tasks during the internship with the prior approval of the competent authority at the host organisation.
- Students shall strictly adhere to the rules, regulations, code of conduct, and working hours prescribed by the host organisation.
- Prior permission shall be obtained from the host organisation before using or reproducing any data, documents, drawings, photographs, or proprietary information for academic purposes.
- Students shall follow all ethical practices, confidentiality requirements, and Standard Operating Procedures (SOPs) of the host organisation.
- Students shall comply with all health, safety, and environmental guidelines prescribed by the host organisation during the internship period.
- Students shall maintain regular contact with the assigned faculty guide/supervisor and submit weekly progress updates on the work carried out.
- Each student shall maintain a diary/logbook recording daily activities, learning outcomes, and progress throughout the internship period.
- On completion of the internship, students shall submit the following documents to the Department:
  - ✓ Internship report detailing the work carried out and learning outcomes
  - ✓ Internship Completion Certificate issued by the host organisation
  - ✓ Feedback from the employer
  - ✓ Proof of stipend received, if applicable

v. ASSESSMENT PATTERN

The marks awarded for the Internship will be based on the following:

(i) Evaluation done by the industry,
(ii) Student's diary,
(iii) Internship report, and
(iv) Internship viva voce.

Continuous Assessment : Final Assessment – 50 : 50

Continuous Assessment		
Student's diary/ Daily Log	:	25 marks
Evaluation done by the industry	:	25 marks
Total Continuous Assessment	**:**	**50 marks**
Final Assessment		
Internship Report	:	25 marks
Internship Viva Voce	:	25 marks
Total Final Assessment	**:**	**50 marks**
TOTAL	**:**	**100 marks**

Total: 100 marks (Minimum required to pass: 50 Marks)

Student's Diary/ Daily Log

The purpose of maintaining a daily diary is to cultivate systematic documentation habits and to encourage students to record observations, impressions, information gathered and suggestions, if any, during the internship period. The diary shall contain a day-to-day record of activities, learning experiences, technical details, and relevant sketches or drawings related to the work carried out. The daily diary shall be signed regularly by the industry supervisor and shall be verified and ratified by the faculty guide during the interim review.

The interim review shall be conducted midway through the internship by the Internship Review Committee, comprising the internship coordinator, faculty supervisor, and a senior faculty member of the Department. The review may be conducted in online or offline mode, based on the feasibility of the student's physical presence on campus.

Internship Report

On completion of the internship, each student shall prepare and submit a comprehensive internship report to the faculty supervisor. The report shall present a systematic account of the activities undertaken, observations made and knowledge gained during the training period. Students may consult the industry supervisor during the preparation of the final report, subject to compliance with the confidentiality policies and norms of the host organisation. The completed report shall be duly certified and signed by the Industry Supervisor, Faculty guide and the Head of the Department.

The internship report shall be evaluated based on the following criteria:

- Originality and technical content
- Adequacy, clarity and relevance of the written presentation

- Organization, format, use of drawings, sketches, language and overall style
- Variety and relevance of learning experiences documented
- Demonstration of practical applications and linkage with theoretical concepts covered in the curriculum

Evaluation done by the industry

The performance of the student during the internship shall be evaluated by the industry supervisor or the person-in-charge using a prescribed evaluation format provided by the institution. The evaluation shall cover key parameters such as professional behaviour, technical competence, learning ability, initiative, quality of work, communication skills, teamwork, discipline, time management, and overall professional attitude.

The faculty guide shall share the evaluation format with the host organisation and coordinate the assessment process. The completed evaluation form shall be duly signed and sealed by the industry supervisor and submitted to the Department as part of the internship assessment records.

Internship Viva Voce

The viva voce examination shall be conducted by the Internship Review Committee. The committee shall assess the student's understanding of the internship work, technical competence, learning outcomes, and professional orientation.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECP40A	ADVANCED COMMUNICATION LAB	PCC	0	0	3	0	2	2023

i. PREREQUISITE : 23ECL30A - Analog and Digital Communication

ii. COURSE OVERVIEW

To enable students to simulate various communication systems and construction of networks using MATLAB, Software Defined Radio (SDR) and NS2.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Simulate digital modulation schemes, BER performance, pulse shaping, matched filtering, and OFDM transmission in noisy communication environments.	Apply
CO 2	Implement source coding and error control coding techniques.	Apply
CO 3	Model and simulate computer networks to analyze unicast routing performance in terms of delay, throughput, and packet behavior.	Apply

iv. SYLLABUS

Simulation of BFSK and M-ary ASK, BER Performance in AWGN channel, Pulse Shaping and Matched Filtering using Software Defined Radios, Variable length source coding using Huffman Coding and decoding, Hamming coding, Modeling and Simulation of Networks using NS2/OPNET, OFDM Signal Transmission and Reception using MATLAB/ Software Defined Radio.

v. REFERENCES

1. John G. Proakis, Digital Communications, 5/e, McGraw-Hill, 2016.
2. “Elements of Information Theory”, Joy A Thomas, Thomas M Cover, Wiley-Interscience, 2012.
3. Teerawat Issariyakul, Ekram Hossain, Introduction to Network Simulator NS2, Springer, 2012.

vi. COURSE PLAN

Expt	Contents	Hours
1.	Simulate BFSK and M-ary ASK using MATLAB.	6
2.	Carrier Phase Modulation and Quadrature Amplitude Modulation-BER Performance in AWGN channel.	6
3.	Pulse Shaping and Matched Filtering using SDR.	6
4.	Implement a program for generation and evaluation of variable length source coding using Huffman Coding and decoding using MATLAB.	6
5.	Implement Error Control Codes using MATLAB.	6
6.	Familiarisation of NS2/OPNET.	3
7.	Simulate a unicast network and analyze delay, throughput, and packet behavior using NS2 / OPNET.	6
8.	OFDM Signal Transmission and Reception using MATLAB/SDR.	6
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : Final Assessment – 60 : 40

Continuous Assessment		
Attendance	:	5 marks
Continuous Assessment in Lab (Lab work + Record + Viva - voce)	:	35 marks
Internal Lab test (Hardware lab : Written exam including design Software lab : Lab exam	:	20 marks
Total Continuous Assessment	**:**	**60 marks**
Final Assessment	**:**	**40 marks**
TOTAL	**:**	**100 marks**

FINAL ASSESSMENT

- Maximum Marks : 40
- Exam Duration : 3 hours

Final Assessment		
Preliminary Work	:	10 marks
Implementing the work / Conducting the experiment	:	10 marks
Viva	:	10 marks
Performance, result and inference (usage of equipment and troubleshooting)	:	10 marks
Total Final Assessment	**:**	**40 marks**

SEMESTER VIII

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECJ48A	PROJECT	PWS	0	0	10	0	5	2023

i. COURSE OVERVIEW

The aim of this course is to apply engineering knowledge in solving practical problems, to foster innovation in design of products, processes or systems, and to develop creative thinking in finding viable solutions to engineering problems. The course is mainly intended to evoke the innovation and invention skills of a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation.

Desirable: The project outcome should be published in a peer-reviewed journal or presented at a conference, or a patent application should be filed.

It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

ii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply multidisciplinary knowledge to model and solve real world problems.	Apply
CO 2	Apply innovative and creative problem-solving to develop sustainable and socially relevant products, processes, or technologies.	Create
CO 3	Exhibit effective teamwork and leadership skills in diverse environments, with the ability to comprehend and carry out designated responsibilities.	Apply
CO 4	Execute tasks by planning effectively and utilizing available resources to meet deadlines, while adhering to ethical and professional standards.	Apply
CO 5	Effectively document, present, and communicate technical and scientific outcomes in professional written and verbal formats.	Apply

iii. ASSESSMENT PATTERN & RUBRICS

Continuous Assessment : Final Assessment – 70 : 30

Continuous Assessment		
Project Progress Evaluation by Guide	:	20 marks
Interim Evaluation -1 by Evaluation Committee	:	15 marks
Interim Evaluation -2 by Evaluation Committee	:	15 marks
Quality of the report evaluated by Evaluation Committee	:	20 marks
Total Continuous Assessment	**:**	**70 marks**
Final Assessment (Final Evaluation by Final Evaluation Committee)	**:**	**30 marks**
TOTAL	**:**	**100 marks**

Total: 100 marks (Minimum required to pass: 50 Marks)

Interim Evaluation:

The Evaluation committee comprises of HoD or a senior faculty member, Project coordinator and Project supervisor.

Final Evaluation:

The final evaluation committee comprises of Project coordinator, domain expert from the Department and expert from Industry/research/academic Institute / senior faculty from a sister department.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECI48A	INTERNSHIP	PWS	0	0	-	0	5	2023

i. COURSE OBJECTIVES

The internship is an integral component of the undergraduate programme aimed at providing students with immersive learning through practical exposure in industry, research organizations, or academic institutions.

BENEFITS OF INTERNSHIP

Benefits to Students

- Provides practical exposure to real-world industrial and organizational environments, enabling the application of theoretical knowledge gained in classrooms.
- Enhances professional competencies such as communication, teamwork, time management, interpersonal skills, and workplace ethics.
- Facilitates the development of technical and domain-specific skills, thereby strengthening overall professional readiness.
- Assists students in assessing their career interests and determining the suitability of a particular industry or profession.
- Improves employability by strengthening profiles for placements, higher education, and potential recruitment by the host organization.
- Encourages professional networking and relationship - building with industry experts and peers.
- Offers an opportunity to evaluate the organization and work culture before committing to full-time employment.

Benefits to the Institute

- Strengthens industry - academia collaboration.
- Facilitates smoother and more effective placement processes.
- Enhances institutional credibility and brand value.
- Supports student engagement and retention.
- Enables curriculum updates based on industry and student feedback.
- Improves the overall teaching - learning process through industry relevance.

Benefits to the Industry

- Provides access to a pool of motivated, job-ready students who can contribute immediately.
- Offers a cost-effective mechanism to evaluate and recruit potential employees.
- Enables the availability of a flexible workforce for temporary, project-based, or seasonal requirements.
- Brings fresh perspectives and innovative approaches to problem-solving.

- Enhances organizational visibility and employer branding within academic institutions.
- Strengthens corporate image by contributing to education and skill development.

TYPES OF INTERNSHIPS

- Industry Internship with/without Stipend
- Government / PSU Internship (BARC/Railway/ISRO etc.)
- Internship with prominent education/ Research Institutes
- Internship with Incubation centres /Start-ups

ii. COURSE OVERVIEW

Students may undertake an internship in an industry, research organization, or reputed academic institution with prior approval from the respective Head of the Department.

The internship is designed to promote meaningful skill development through structured, outcome-driven experiential learning. It shall focus on clearly defined technical competencies, such as domain-specific skills, software proficiency, exposure to industry-standard tools, and structured engineering problem-solving tasks. The learning objectives of the internship, along with the expectations of the host organization and the academic requirements of the institution, shall be clearly defined in consultation with the host organization and mutually agreed upon prior to the approval of the internship.

Each student shall be assigned a faculty guide/supervisor for monitoring and evaluation. The internship shall be relevant to the student's stream of study and can be carried out in Semester **VII** or Semester **VIII**, as specified by the Department, for a minimum duration of **three months.**

A student shall be permitted to undertake the internship only after the respective semester registration. During the internship period, any other courses or academic activities shall be pursued in online mode or as specified by the Department, to ensure timely fulfillment of all academic requirements.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply theoretical knowledge and engineering principles to practical problems encountered in professional practice.	Apply
CO 2	Demonstrate technical competence and understanding of tools, techniques, and processes relevant to the chosen field of specialization.	Apply
CO 3	Analyse social, environmental, economic, safety, and administrative factors influencing industrial operations and decision-making processes.	Analyze

CO 4	Communicate effectively through technical reports, presentations, and professional interactions in an industrial or research environment.	Apply
CO 5	Apply professional ethics, teamwork, and adaptability while performing assigned tasks in a multidisciplinary work setting.	Apply

iv. GUIDELINES FOR STUDENTS

- Duration of internship is three to six months (One semester).
- Students may undertake mini projects, case studies, or related technical tasks during the internship with the prior approval of the competent authority at the host organisation.
- Students shall strictly adhere to the rules, regulations, code of conduct, and working hours prescribed by the host organisation.
- Prior permission shall be obtained from the host organisation before using or reproducing any data, documents, drawings, photographs, or proprietary information for academic purposes.
- Students shall follow all ethical practices, confidentiality requirements, and Standard Operating Procedures (SOPs) of the host organisation.
- Students shall comply with all health, safety, and environmental guidelines prescribed by the host organisation during the internship period.
- Students shall maintain regular contact with the assigned faculty guide/supervisor and submit weekly progress updates on the work carried out.
- Each student shall maintain a diary/logbook recording daily activities, learning outcomes, and progress throughout the internship period.
- On completion of the internship, students shall submit the following documents to the Department:
  - ✓ Internship report detailing the work carried out and learning outcomes
  - ✓ Internship Completion Certificate issued by the host organisation
  - ✓ Feedback from the employer
  - ✓ Proof of stipend received, if applicable

v. ASSESSMENT PATTERN

The marks awarded for the Internship will be based on the following:

(v) Evaluation done by the industry,
(vi) Student's diary,
(vii) Internship report, and
(viii) Internship viva voce.

Continuous Assessment : Final Assessment – 50 : 50

Continuous Assessment		
Student's diary/ Daily Log	:	25 marks
Evaluation done by the industry	:	25 marks
Total Continuous Assessment	**:**	**50 marks**
Final Assessment		
Internship Report	:	25 marks
Internship Viva Voce	:	25 marks
Total Final Assessment	**:**	**50 marks**
TOTAL	**:**	**100 marks**

Total: 100 marks (Minimum required to pass: 50 Marks)

Student's Diary/ Daily Log

The purpose of maintaining a daily diary is to cultivate systematic documentation habits and to encourage students to record observations, impressions, information gathered and suggestions, if any, during the internship period. The diary shall contain a day-to-day record of activities, learning experiences, technical details, and relevant sketches or drawings related to the work carried out. The daily diary shall be signed regularly by the industry supervisor and shall be verified and ratified by the faculty guide during the interim review.

The interim review shall be conducted midway through the internship by the Internship Review Committee, comprising the internship coordinator, faculty supervisor, and a senior faculty member of the Department. The review may be conducted in online or offline mode, based on the feasibility of the student's physical presence on campus.

Internship Report

On completion of the internship, each student shall prepare and submit a comprehensive internship report to the faculty supervisor. The report shall present a systematic account of the activities undertaken, observations made and knowledge gained during the training period. Students may consult the industry supervisor during the preparation of the final report, subject to compliance with the confidentiality policies and norms of the host organisation. The completed report shall be duly certified and signed by the Industry Supervisor, Faculty guide and the Head of the Department.

The internship report shall be evaluated based on the following criteria:

- Originality and technical content
- Adequacy, clarity and relevance of the written presentation

- Organization, format, use of drawings, sketches, language and overall style
- Variety and relevance of learning experiences documented
- Demonstration of practical applications and linkage with theoretical concepts covered in the curriculum

Evaluation done by the industry

The performance of the student during the internship shall be evaluated by the industry supervisor or the person-in-charge using a prescribed evaluation format provided by the institution. The evaluation shall cover key parameters such as professional behaviour, technical competence, learning ability, initiative, quality of work, communication skills, teamwork, discipline, time management, and overall professional attitude.

The faculty guide shall share the evaluation format with the host organisation and coordinate the assessment process. The completed evaluation form shall be duly signed and sealed by the industry supervisor and submitted to the Department as part of the internship assessment records.

Internship Viva Voce

The viva voce examination shall be conducted by the Internship Review Committee. The committee shall assess the student's understanding of the internship work, technical competence, learning outcomes, and professional orientation.

PROGRAMME ELECTIVE - III

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL43A	REAL TIME OPERATING SYSTEMS	PEC	3	0	0	0	3	2023

i. PREREQUISITE : Nil

ii. COURSE OVERVIEW

This course provides an in-depth understanding of real-time operating systems, which are designed to manage hardware resources and run tasks with strict timing constraints. It focuses on the concepts, design principles, and implementation techniques used in building reliable, predictable, and efficient real-time systems used in embedded, automotive, aerospace, and industrial applications. Students will learn how RTOS differs from general-purpose operating systems, explore task scheduling, inter-task communication, synchronization, memory management, and interrupt handling.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Summarize the functions and structure of general-purpose operating systems.	Understand
CO 2	Use different scheduling algorithms on processes and threads.	Apply
CO 3	Interpret a real time operating system along with its synchronization, communication and interrupt handling tools.	Understand
CO 4	Illustrate task constraints and analyze the different scheduling algorithms on tasks.	Apply
CO 5	Illustrate the applications of real time operating systems.	Understand

iv. SYLLABUS

Operating system: Types, Objectives and functions, Kernel, Process - States, Process Control Block, Operations on processes

Process Scheduling: FCFS, SJF, Priority, Round-Robin, Multilevel Queue and Multilevel Feedback Queue Scheduling. Thread: Structure. User and kernel level threads, multi-threading models, multiprocessor scheduling

Real Time Operating Systems: Structure and characteristics of Real Time Systems, Task: Task states, Task synchronization -Semaphores- types, Inter task communication mechanisms: message queues, pipes, event registers, signals, Exceptions and interrupt handling.

Task constraints, Task scheduling: Aperiodic task scheduling: EDD. EDF, LDF, EDF with precedence constraints. Periodic task scheduling: Rate monotonic and Deadline monotonic, Real time Kernel- Structure, State transition diagram, Kernel primitives.

Features of FreeRTOS and Linux Commercial real time operating systems: PSOS, VRTX, RT Linux. Case study of (Kernel design, threads and task scheduling) RTOS: MicroC/OS-II. RTOS control system used in real life applications - in adaptive cruise control.

v (a) TEXT BOOKS

1. Abraham Silberschatz-“Operating System Principles": Wiley India, 9th edition, 2013
2. William Stallings –„Operating systems- Internals and design principles", Prentice Hall, 7th edition, 2011
3. Qing Li – Real-Time Concepts for Embedded Systems, CMP Books, 2013
4. Giorgio C. Buttazzo -HARD REAL-TIME COMPUTING SYSTEMS Predictable Scheduling Algorithms and Applications", Kluwer Academic Publishers

(b) REFERENCES

1. Tanenbaum -”Modern Operating Systems", Pearson Edition, 5/e, 2024.
2. Jean J Labrosse, Micro C/OS-II, The Real Time Kernel", CMP Books, 2011
3. Rajib Mall,”Real-Time Systems: Theory and Practice”, 2009.
4. David E. Simon, “An Embedded Software Primer", Pearson 2012

vi. COURSE PLAN

Module	Contents	Hours
I	Operating system: Types, Objectives and functions, Kernel, Process - States, Process Control Block, Operations on processes.	9
II	Process Scheduling: FCFS, SJF, Priority, Round-Robin, Multilevel Queue and Multilevel Feedback Queue Scheduling. Thread: Structure. User and kernel level threads, multi-threading models, multiprocessor scheduling	9
III	Real Time Operating Systems: Structure and characteristics of Real Time Systems, Task: Task states, Task synchronization - Semaphores- types, Inter task communication mechanisms: message queues, pipes, event registers, signals, Exceptions and interrupt handling.	9
IV	Task constraints, Task scheduling: Aperiodic task scheduling: EDD. EDF, LDF, EDF with precedence constraints. Periodic task scheduling:Rate monotonic and Deadline monotonic, Real time Kernel- Structure, State transition diagram, Kernel primitives.	9
V	Features of FreeRTOS and Linux Commercial real time operating systems: PSOS, VRTX, RT Linux Features and	9

	application only. Case study of (Kernel design, threads and task scheduling) RTOS: MicroC/OS-II. RTOS control system used in real life applications - in adaptive cruise control.	
	Total Hours	**45**

Simulation assignment: Programming on any popular RTOS platforms such as FreeRTOS, VxWorks, or RTLinux may be included.

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL43B	MICROWAVE ENGINEERING	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23ECL30C - Electromagnetic Field Theory

ii. COURSE OVERVIEW

This course aims to impart knowledge on the basics of microwave transmission lines, microwave frequency range, its applications, and its importance in modern era. It also introduces various microwave sources, their principle of operation and study of various microwave hybrid circuits and microwave semiconductor devices.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Analyze the mode characteristics of rectangular waveguides and evaluate microstrip lines.	Apply
CO 2	Explain the operation of microwave solid-state devices and cavity resonators.	Understand
CO 3	Analyze the characteristics and performance parameters of O-type microwave tubes.	Apply
CO 4	Explain the operation, characteristics, and applications of M-type microwave tubes.	Understand
CO 5	Analyze the operation and performance of waveguide components and scattering parameters used in microwave systems.	Apply

iv. SYLLABUS

Introduction, Applications of Microwaves, Rectangular Waveguides: Power Transmission and Power Losses, Micro strip Lines.

Principle of Gunn diodes: Different modes, Principle of operation Gunn Diode Oscillators. Cavity Resonators: Rectangular and Cylindrical Cavities.

Classification of microwave tubes. O-type tubes: Two-cavity klystron and Single cavity klystron-Reflex Klystron Oscillators: Derivation of Power output, efficiency and admittance. Travelling Wave Tube: Slow wave structures, Helix TWT

M-Type Microwave Tubes, Magnetron oscillators: Cylindrical magnetron, Amplification process. Cross-field effects.

Scattering parameters, Waveguide Tees-Magic tees, Hybrid rings Formulation of S-matrix. Directional couplers: Two hole directional couplers, S-matrix. Circulators and

Isolators, Phase Shifter.

v (a) TEXT BOOKS

1. Samuel Y. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003.
2. Robert E. Collin, Foundation of Microwave Engineering, 2/e, Wiley India, 2012.
3. M. L. Sosodia, G. S. Raghuvanshi, Microwave Circuits and Passive Devices, 2/e, Wiley Eastern Ltd., New Age International Publishers Ltd., 2008.

(b) REFERENCES

1. Das, Microwave Engineering, 4/e, McGraw Hill Education India Education, 2020
2. David M. Pozar, Microwave Engineering, 4/e, Wiley India, 2012.
3. R. Chatterjee, Affiliated, Elements of Microwave Engineering, 2/e, East-West Press Pvt. Ltd., New Delhi, 2003.

vi. COURSE PLAN

Module	Contents	Hours
I	Microwave Transmission Lines: Introduction, Microwave Spectrum and Bands, Applications of Microwaves. Rectangular Waveguides: Power Transmission and Power Losses in Rectangular Waveguide. Micro strip Lines– Introduction, Characteristic impedance, Effective Dielectric Constant, Losses, Q factor.	9
II	Microwave solid-state devices: Introduction, classification, and applications. Transferred Electron Devices (TEDs): Gunn diode—RWH theory, characteristics, modes of operation, oscillation modes, and LSA mode. Cavity Resonators– Introduction, Rectangular and Cylindrical Cavities, Dominant Modes and Resonant Frequencies, Q factor and Coupling Coefficients.	9
III	O-Type Microwave Tubes: Limitations and losses of conventional tubes at microwave frequencies. Classification of microwave tubes. O-type tubes: Two-cavity klystron and Reflex klystron—principle of operation, mathematical theory of bunching, power output, efficiency. Helix Traveling Wave Tube (TWT): significance, slow wave structures, construction, amplification process, and gain considerations.	10
IV	M-Type Microwave Tubes: Introduction to M-type microwave tubes and cross-field effects. Magnetrons: types and construction. Cylindrical travelling wave magnetron—Hull cut-off and Hartree conditions. Modes of resonance and π-mode operation.	9

V	Microwave Hybrid circuits: Scattering parameters, Waveguide Tees- E-plane tee, H-plane tee, Magic tees, Hybrid rings. Formulation of S-matrix. Directional couplers: Two-hole directional couplers, S-matrix. Circulators, Isolators and Phase Shifter.	8
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL43C	SPEECH AND AUDIO PROCESSING	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23ECL20E – Signals and Systems,
23ECL30B – Digital Signal Processing

ii. COURSE OVERVIEW

This course introduces students to the mechanism of speech production and the basic concepts of methods for speech analysis and parametric representation of speech. The course imparts ideas related to perception of sound, psycho-acoustic analysis, spatial audio perception and rendering and introduces audio compression schemes to the students.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the fundamental principles of human speech production and the key aspects used in time-domain analysis of speech signals.	Understand
CO 2	Apply time domain and frequency domain techniques to analyse and extract features from speech signals.	Apply
CO 3	Describe the signal processing models of sound perception and the application of perception models in audio signal processing	Understand
CO 4	Explain the principles of audio compression and key digital audio coding techniques	Understand
CO 5	Describe the concept of Spatial Audio Perception and audio quality analysis techniques	Understand

iv. SYLLABUS

Speech Production and Time domain analysis: Overview of the human speech production mechanism, Concept of voiced and unvoiced sounds, Acoustic theory of speech production, Speech waveform characteristics, Short-time analysis, Time-domain features:

Frequency domain analysis, Spectrogram, Frequency domain features. Cepstral Analysis, MFCC. Speech enhancement, Speaker verification, Language Identification.

Signal Processing Models of Audio Perception: Human auditory system – Auditory Filter Banks, Psycho-acoustic analysis, MPEG psycho-acoustic model.

Audio compression methods: Sampling rate and bandwidth requirement for digital

audio, Redundancy removal and perceptual irrelevancy removal, Transform coding of digitalaudio, Pre-echo and pre-echo suppression, Lossless coding methods.

Spatial Audio Perception and rendering: The physical and psycho- acoustical basis of sound localization and space perception. Spatial audio perception, Audio quality analysis: Objective analysis methods, Subjective analysis methods.

v (a) TEXT BOOKS

1. W. Fischer, Digital Video and Audio Broadcasting Technology: A Practical Engineering Guide (Signals and Communication Technology), Springer, 2020
2. Lars-Ingemar Lundström, Understanding Digital Television: An Introduction to DVB Systems with Satellite, Cable, Broadband and Terrestrial TV, Focal Press, Elsevier, 2006.
3. K F Ibrahim, Newnes Guide to Televeision and Video Technology, Newnes, 2007.
4. Jiun-Haw Lee, David N. Liu, Shin-Tson Wu, Introduction to Flat Panel Displays, Wiley, 2008.

(b) REFERENCES

1. C. Poynton, "Digital Video and HD Algorithms and Interfaces", Morgan Kaufmann, 2012.
2. Wolfgang Hoeg, Thomas Lauterbach, Digital audio broadcasting: principles and applications of DAB, DAB+ and DMB, Wiley, 2009.
3. John Watkinson, Introduction to Digital Audio, Focal Press, 1994.
4. John Watkinson, Art of Digital Video, Focal Press, 2008.
5. John Watkinson, Introduction to Digital Video, Focal Press, 2001.

vi. COURSE PLAN

Module	Contents	Hours
I	**Speech Production and Time domain analysis:** Overview of the human speech production mechanism (lungs, glottis, articulators), Concept of voiced and unvoiced sounds, Acoustic theory of speech production – Source filter model, Speech waveform characteristics: pitch, formants, loudness, **Short-time analysis:** segmentation and framing, Time-domain features: Short-time energy (STE), Zero crossing rate (ZCR), Autocorrelation function (ACF)	9
II	**Frequency domain analysis -** Filter Banks, STFT, Spectrogram: narrow band and wide band spectrogram, Frequency domain features: Spectral centroid, spectral spread, spectral entropy, spectral flux, spectral roll-off. Cepstral Analysis, MFCC. **Speech enhancement:** fundamentals, basic types, Speaker verification (block diagram), Language Identification (block	9

	diagram)	
III	**Signal Processing Models of Audio Perception:** Human auditory system – structure and basic function (outer/middle/inner ear), Auditory Filter Banks, Psycho-acoustic analysis: Critical Band Structure, Absolute Threshold of Hearing, Simultaneous Masking, Temporal Masking, MPEG psycho-acoustic model.	9
IV	**Audio compression methods:** Sampling rate and bandwidth requirement for digital audio, Redundancy removal and perceptual irrelevancy removal, Transform coding of digital audio: MPEG2-AAC coding standard, MDCT and its properties, Pre-echo and pre-echo suppression, Lossless coding methods.	9
V	**Spatial Audio Perception and rendering:** The physical and psycho- acoustical basis of sound localization and space perception. Spatial audio perception - Interaural time and level differences, Binaural and surround sound, Audio quality analysis: Objective analysis methods- PEAQ, Subjective analysis methods - MOS score, MUSHRA score	9
	Total Hours	**45**

Simulation assignments using PRAAT / Audacity for time and frequency domain analysis of speech and audio analysis may be given.

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL43D	MACHINE LEARNING	PEC	2	1	0	0	3	2023

i. PREREQUISITE : 23MAL10A - Linear Algebra and Calculus

23MAL20C - Probability, Random Processes and Numerical Methods

ii. COURSE OVERVIEW

This course introduces the foundational principles of machine learning, regression and classification algorithms, linear models such as perceptrons and support vector machines, and explores techniques including clustering, decision trees, ensemble methods, and dimensionality reduction to solve data-driven problems. The course also emphasizes evaluating model performance and generalization to ensure effective and reliable machine learning solutions.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the foundations of machine learning, including supervised and unsupervised paradigms, feature representation, and basic probability concepts.	Understand
CO 2	Apply regression and classification algorithms for modelling data, analyzing errors, and interpreting decision boundaries.	Apply
CO 3	Implement linear models such as perceptron and support vector machines for various classification scenarios.	Apply
CO 4	Use clustering, decision trees, ensemble methods, and dimensionality reduction techniques to solve data-driven problems.	Apply
CO 5	Evaluate machine learning models to assess performance and generalization.	Apply

iv. SYLLABUS

Introduction to machine learning concepts; supervised and unsupervised learning; features and feature vectors; feature extraction; overfitting; curse of dimensionality. Includes a review of probability theory.

Regression and Classification: Linear and multivariate regression; bias–variance concepts. Classification fundamentals including Bayes decision theory, discriminant functions, decision surfaces.

Linear Models & SVM: Linear discriminant methods: perceptron learning algorithm,

and gradient descent. Support Vector Machines (SVM) for separable and non-separable classes.

Decision Trees, Clustering & Ensemble Methods: Unsupervised learning with clustering algorithms. Introduction to decision trees, random forests, and ensemble techniques.

Dimensionality Reduction & Model Evaluation: Principal Component Analysis (PCA) and Fisher's Discriminant Analysis. Performance evaluation using ROC curves, validation methods, bias–variance trade-off.

v (a) TEXT BOOKS

1. Bishop, C.M. "Pattern Recognition and Machine Learning" Springer, New York, 2006.
2. Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems", Third Edition, 2022.

(b) REFERENCES

1. Trevor Hastie, Robert Tibshirani & Jerome Friedman, "The Elements of Statistical Learning", 2nd edition, Springer, 2009

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction** to machine learning concepts; supervised and unsupervised learning; features and feature vectors; training, target, and test sets; feature extraction; overfitting; curse of dimensionality. Includes a review of probability theory, Gaussian distributions, and basic decision theory.	8
II	**Regression and Classification:** Linear and multivariate regression; regression error functions; applications; bias–variance concepts. Classification fundamentals including Bayes decision theory, discriminant functions, decision surfaces, and Bayesian classification for Gaussian distributions.	9
III	**Linear Models & SVM**: Linear discriminant methods: perceptron, perceptron learning algorithm, and gradient descent. Support Vector Machines (SVM) for separable and non-separable classes, including multiclass extensions.	10
IV	**Decision Trees, Clustering & Ensemble Methods** Unsupervised learning with clustering: types, criteria, proximity measures, and clustering algorithms. Introduction to decision trees, random forests, and ensemble techniques such as bagging and boosting.	9
V	**Dimensionality Reduction & Model Evaluation** Principal Component Analysis (PCA) and Fisher's Discriminant	9

	Analysis. Performance evaluation using ROC curves, validation methods, confusion matrix, precision, recall, accuracy, and bias–variance trade-off.	
	Total Hours	**45**

Note: Case Studies are to be done as simulation assignments on **at least two** of the following topics:

i) Spam detection
ii) MNIST feature extraction
iii) House price prediction (regression)
iv) Medicaldisease prediction (classification)
v) Email classification using Gaussian models
vi) Handwritten digit classification using SVM
vii) Sentiment analysis using linear classifiers
viii) Document clustering using k-means
ix) PCA for face recognition

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL43E	OPTICAL FIBRE COMMUNICATION	PEC	3	0	0	0	3	2023

i. PREREQUISITE : Nil

ii. COURSE OVERVIEW

This course aims to introduce the concepts of light transmission through optical fibers and introduce the working of optical components.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the working and classification of optical fibers in terms of propagation modes.	Understand
CO 2	Analyze the problems of transmission characteristics and losses in optical fiber.	Apply
CO 3	Explain the constructional features and the characteristics of optical sources and detectors.	Understand
CO 4	Describe the operations of optical amplifiers.	Understand
CO 5	Explain the concepts of WDM, FSO, LiFi and OTDR.	Understand

iv. SYLLABUS

Optical fiber Communications: The general system, Advantages of optical fiber communication, Optical fiber waveguides: Ray theory transmission, Modes in planar guide, Phase and group velocity. Fibres: Types and refractive index profiles, Step index fibers, Graded index fibers, Single mode fibers, Cutoff wavelength, Mode field diameter, effective refractive index. Fibre materials, photonic crystal fibre, index guiding PCF, photonic band- gap fibres, fibre cables.

Transmission characteristics of optical fiber: Attenuation, Material absorption losses, Linear scattering losses, Nonlinear scattering losses, Fiber bend loss, Dispersion, Chromatic dispersion, Intermodal dispersion: Multimode step index fiber.

Optical Fiber Connectors: Fiber alignment and joint loss, Fiber splices, Fiber connectors, Fiber couplers.

Optical sources: LEDs and LDs, structures, characteristics, modulators using LEDs and LDs. coupling with fibres, noise in Laser diodes, Amplified Spontaneous Emission noise, effects of Laser diode noise in fibre communications.

Optical detectors: Types and characteristics, structure and working of PIN and AP, noise in detectors, comparison of performance. Optical receivers, Ideal photo receiver and quantum limit of detection.

Optical Amplifiers: basic concept, applications, types, doped fibre amplifiers, EDFA, basic theory, structure and working, Semiconductor laser amplifier, Raman amplifiers, TDFA, amplifier configurations, performance comparison.

The WDM concept, WDM standards, WDM components, couplers, splitters, Add/ Drop multiplexers, gratings, tunable filters. Introduction to free space optics, LiFi technology and VLC. Optical Time Domain Reflectometer (OTDR) – fault detection length and refractive index measurements.

v (a) TEXT BOOKS

1. Gerd Keiser, Optical Fiber Communications, 5/e, McGraw Hill, 2013.
2. Mishra and Ugale, Fibre optic Communication, Wiley, 2013.

(b) REFERENCES

1. Chakrabarthi, Optical Fibre Communication, McGraw Hill, 2015.
2. Hebbar, Optical fibre communication, Elsevier, 2014
3. John M Senior- Optical communications, 3/e, Pearson, 2009.
4. Joseph C. Palais, Fibre Optic Communications, 5/e Pearson, 2013.
5. Keiser, Optical Communication Essentials (SIE), 1/e McGraw Hill Education New Delhi, 2008

vi. COURSE PLAN

Module	Contents	Hours
I	**Optical fiber Communications:** The general system, Advantages of optical fiber communication, Optical fiber waveguides: Ray theory transmission, Modes in planar guide, Phase and group velocity. **Fibres:** Types and refractive index profiles, Step index fibers, Graded index fibers, Single mode fibers, Cutoff wavelength, Mode field diameter, effective refractive index. Fibre materials, photonic crystal fibre, index guiding PCF, photonic band-gap fibres, fibre cables.	10
II	**Transmission characteristics of optical fiber:** Attenuation, Material absorption losses, Linear scattering losses, Nonlinear scattering losses, Fiber bend loss, Dispersion, Chromatic dispersion, Intermodal dispersion: Multimode step index fiber. **Optical Fiber Connectors**: Fiber alignment and joint loss, Fiber splices, Fiber connectors, Fiber couplers.	10

III	**Optical sources:** LEDs and LDs, structures, characteristics, modulators using LEDs and LDs. coupling with fibres, noise in Laser diodes, Amplified Spontaneous Emission noise, effects of Laser diode noise in fibre communications**.** **Optical detectors:** Types and characteristics, structure and working of PIN and AP, comparison of performance, noise in detectors. Optical receivers, Ideal photo receiver and quantum limit of detection.	10
IV	**Optical Amplifiers:** Basic concept, applications, types, doped fibre amplifiers, EDFA, basic theory, structure and working, Semiconductor laser amplifier, Raman amplifiers, TDFA, amplifier configurations, performance comparison.	8
V	The WDM concept, WDM standards, WDM components, couplers, splitters, Add/ Drop multiplexers, gratings, tunable filters. Introduction to free space optics, LiFi technology and VLC. Optical Time Domain Reflectometer (OTDR) – fault detection length and refractive index measurements.	7
	Total Hours	**45**

Simulation Assignment: Simulation may be given using any optical system design software.

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL43F	QUANTUM COMPUTING	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23MAL10A - Linear Algebra and Calculus

ii. COURSE OVERVIEW

Goal of this course is to have an understanding of the fundamentals of quantum computing, working of quantum computer and algorithms, quantum error corrections, designed for bigger quantum computers which are yet to be developed.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply the basic constructs in linear algebra needed to build the concepts of quantum computing	Apply
CO 2	Illustrate quantum measurement and quantum mechanics for computation	Understand
CO 3	Build quantum circuit models using quantum gates for implementing appropriate quantum algorithms.	Apply
CO 4	Implement quantum algorithms including QFT, Quantum Phase Estimation, and Deutsch's Algorithm to demonstrate problem-solving using quantum circuits.	Apply
CO5	Apply quantum communication concepts in secure information transfer.	Apply

iv. SYLLABUS

Preliminaries- Review of Linear Algebra, Overview of Quantum Information and Computation.

Basics of Quantum Mechanics – Overview of Quantum mechanics - Postulates of quantum mechanics, Superposition, Dirac Notation, Quantum Measurements, Basics of Quantum Information - Qubit, Bloch Sphere representation, Quantum operations, Density matrix.

Quantum Gates and Circuits – Single Qubit gates – two-qubit gates – Multiple Qubits gates, Universal gates, Quantum circuit model of computation, Realization of classical gates with quantum gates – Z Gate

Algorithms – Quantum algorithms summarized - Quantum computational complexity, Quantum Fourier Transform (QFT) – Quantum circuit for QFT, Quantum phase estimation, Modular exponentiation, Order finding and factorization – Deutsch's algorithm, Grovers Algorithm, Shor's Algorithm.

Quantum Communication - Entanglement – EPR paradox, Bells inequality, No cloning theorem, Quantum cryptography – Introduction to classical cryptography vs. quantum cryptography, Quantum key distribution, Quantum teleportation.

v (a) TEXT BOOKS

1. M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum Information,7/e, Cambridge University Press, 2010
2. G. Strang, Linear algebra and its applications, 4/e, Thomson, 2006
3. David McMahon, Quantum Computing Explained (IEEE Press), A John Wiley & Sons, Inc., Publication, 2007.
4. J. Gruska, Quantum Computing,12/e, McGraw Hill, 1999

(b) REFERENCES

1. P. Kaye, R. Laflamme, and M. Mosca, An Introduction to Quantum Computing, 11/e, Oxford, 2007
2. Eleanor G. Rieffel, Wolfgang H. Polak, Quantum Computing: A Gentle Introduction, 3/e, MIT Press, 2011
3. NosonYanofsky and MircoMannucci, Quantum Computing for Computer Scientists, 4/e, Cambridge University Press, 2008
4. Abhijith, J., Adedoyin, Adetokunbo, Ambrosiano, John (and 30 others), Quantum Algorithm Implementations for Beginners, 1/e, 2020
5. Preskil Lectures:

vi. COURSE PLAN

Module	Contents	Hours
I	Review of Linear Algebra - Vector Space, Hilbert Space, Bases, Matrices, Eigenvalues and Eigenvectors, Hermitian matrices, and Unitary matrices, The Pauli matrices, Linear operators, Inner products, Outer products (Tensor products) Overview of Quantum Computation and Quantum Information, Classical Computation Vs Quantum Computation.	9
II	Quantum Mechanics - Postulates of quantum mechanics, Superposition, Dirac Notation, Quantum Measurements, Qubit, Bloch Sphere representation, Quantum operations – State evolution, Unitary operations, Density matrix- Pure states, Mixed states.	9
III	Quantum Gates and Circuits: Single Qubit gates – Pauli X, Y and Z gates, Hadamard gates, Two qubit gates – SWAP gates, C-NOT Gates, Multi qubit gates - Fredkein Gate, Controlled Swap and Controlled U- operations, Toffoli gate, Universal gates, Realisation of classical gates with quantum gates – Z Gate, Quantum circuit model of computation.	9

IV	Algorithms: Quantum algorithms summarized - Quantum computational complexity, Quantum Fourier Transform (QFT) – Quantum circuit for QFT, Quantum phase estimation, Modular exponentiation, Order finding and factorization – Deutsch's algorithm, Grovers Algorithm, Shor's Algorithm.	9
V	Quantum Communication: Entanglement – EPR paradox, Bells inequality, No cloning theorem, Quantum cryptography – Introduction to classical cryptography vs. quantum cryptography, Quantum key distribution, Quantum teleportation.	9
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL43G	WAVELET THEORY	PEC	2	1	0	0	3	2023

i. PREREQUISITE : 23ECL20E – Signals and Systems
23ECL30B – Digital Signal Processing

ii. COURSE OVERVIEW

This course provides a comprehensive understanding of wavelet theory, beginning with the fundamentals of time-frequency analysis and progressing through continuous and discrete wavelet transforms, multiresolution analysis, and filter bank design. It emphasizes both theoretical concepts and practical applications, enabling students to apply wavelet techniques in signal and image processing, compression, and communication systems.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO1	Explain the need for time-frequency analysis and the limitations of Fourier methods.	Understand
CO2	Apply Continuous Wavelet Transform for time-frequency signal analysis.	Apply
CO3	Apply Discrete Wavelet Transform and filter banks for multiresolution signal representation.	Apply
CO4	Apply multiresolution analysis and wavelet bases for one and two-dimensional signal analysis.	Apply
CO5	Explain wavelet-based methods in practical applications in the area of signal processing and communication systems.	Understand

iv. SYLLABUS

Time-frequency analysis of stationary and non-stationary signals, Fourier and Short-Time Fourier Transforms and their limitations,

Continuous Wavelet Transform (CWT) – concept, time-frequency resolution and construction of wavelets,

Discrete Wavelet Transform (DWT) – implementation using multirate filter banks and tree structures,

Multiresolution analysis and design of orthogonal and bi-orthogonal wavelet bases, Different classes of wavelets such as Haar, Daubechies, Symlets, Coiflets and Bi-orthogonal wavelets, Two-dimensional and higher-dimensional wavelet transforms,

Wavelet-based signal and image compression techniques, Denoising and feature extraction methods, and applications of wavelets in audio analysis, image fusion and digital communication systems.

v (a) TEXT BOOKS

1. Bernard P. P. Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education, 2006.
2. K. P. Soman, K. I. Ramachandran, "Insight Into Wavelets - From Theory to Practice", Prentice Hall of India, 3rd Edition, Eastern Economy Edition, Prentice Hall of India Private Limited, 2010.
3. Mallat, Stephane, A Wavelet Tour of Signal Processing: The Sparse Way, 3rd Edition, Academic Press, 2008.
4. Raguveer M. Rao and Ajit S. Bopardikar, “Wavelet Transforms – Introduction and Applications”, Pearson Education, 2008

(b) REFERENCES

1. Strang, Gilbert, and Nguyen, Truong, Wavelets and Filter Banks, Wellesley-Cambridge Press, 1996.
2. Burrus, C. Sidney, Gopinath, Ramesh A., and Guo, Haitao, Introduction to Wavelets and Wavelet Transforms: A Primer, Prentice Hall, 1998.

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to Signals and Time-Frequency Analysis:** Stationary and non-stationary signals, Signal representation using basis and frames, Limitations of Fourier analysis for non-stationary signals, Fourier Transform (FT), Short-Time Fourier Transform (STFT), Time-frequency resolution trade-off, Uncertainty principle, Introduction to time-frequency analysis.	9
II	**Continuous Wavelet Transform (CWT):** Definition and mathematical formulation of Continuous Wavelet Transform (CWT), Admissibility condition and mother wavelet, Time and frequency resolution of CWT, Construction of continuous wavelets – Spline, Orthonormal and Bi-orthonormal wavelets, Inverse continuous wavelet transform, Redundancy and zoom property of CWT, Filtering in the continuous wavelet transform domain.	9
III	**Discrete Wavelet Transform and Filter Banks:** Discrete-time multirate systems, Orthogonal and bi-orthogonal two-channel filter banks, Perfect reconstruction condition, Design of two-channel filter banks, Tree-structured filter banks, Discrete Wavelet Transform (DWT), Computation	9

	and construction of DWT, Redundant DWT (Stationary Wavelet Transform), Non-linear approximation in the wavelet domain, Energy compaction property.	
IV	**Multiresolution Analysis and Wavelet Design:** Concept of multiresolution analysis (MRA), Scaling and wavelet functions, Parameterization of discrete wavelets, Bi-orthogonal wavelet bases, Wavelets from filters, Classes of wavelets – Haar, Daubechies, Symlets, Coiflets, Bi-orthogonal, Two-dimensional and higher-dimensional wavelet transforms, Wavelet packets, Time-frequency tiling, Construction of compactly supported wavelets.	9
V	**Applications of Wavelets:** Signal and image compression (JPEG2000 standard), Detection of signal changes and transient features, Analysis and classification of audio signals using CWT, Wavelet-based signal denoising and energy compaction, Adaptive wavelet techniques for signal acquisition, coding and lossy transmission, Digital communication and multicarrier modulation (OFDM), Image fusion, Feature detection.	9
	Total Hours	**45**

Simulation assignments using MATLAB or Python from any one of the following topics may be included.

1. Time-frequency analysis – STFT
2. Continuous Wavelet Transform
3. Discrete Wavelet Transform
4. Filter banks
5. Multiresolution analysis

vii. ASSESSMEN TPATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

PROGRAMME ELECTIVE - IV

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL44A	ORGANIC ELECTRONICS	PEC	3	0	0	0	3	2023

i. PREREQUISITE: 23PYL10A - Engineering Physics
23ECL20B - Solid State Devices

ii. COURSE OVERVIEW

The course aims to provide a foundational understanding of the principles underlying organic electronics. It equips students with knowledge of emerging alternative energy technologies and the operating mechanisms of organic/polymer solar cells, photovoltaic devices, and organic LEDs.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the fundamental electronic structure, transport mechanisms, and properties of conducting polymers and organic semiconductors.	Understand
CO 2	Describe the architecture, operation, and characteristics of OLEDs, OFETs, and flexible electronic devices.	Understand
CO 3	Explain the working principles, device architectures, charge transport mechanisms, and fabrication processes of plastic (organic) solar cells.	Understand
CO 4	Describe the electrode materials and device architectures for improving efficiency and shelf life of organic electronic devices.	Understand
CO 5	Explain thin-film coating and deposition techniques used in the fabrication of organic electronic devices.	Understand

iv. SYLLABUS

Fundamentals of Organic Semiconductors: conducting polymers, conduction mechanism in doped polymeric semiconductors, physics of organic semiconductors

Organic Electronic Devices and Architectures, organic light emitting diodes (OLED) and polymer light emitting diodes (PLED), Flexible electronics, organic transistors, FETs, molecular rectifiers.

Plastic Solar Cells, Multilayer and heterojunction structures, cell architecture. Charge transport and exciton formation, Photogeneration process, Processing of organic solar cells. Dye Sensitization

Electrode Materials, Conductivity and transparency factors. Indium Tin Oxide (ITO) as

anode material, novel inorganic anode materials, doping the device, annealing, architecture.

Techniques in Organic electronic Device materials. Thin film coating techniques for device fabrication, R.F and microwave plasma assisted film coating.

v (a) TEXT BOOKS

1. Stephen R. Forrest, “Organic Electronics: Foundations to applications”, OUP Oxford, 2020
2. Hagen Klauk, “Organic Electronics: Materials, Manufacturing, and Applications”, Wiley-VCH, 2006
3. Sam-Shajing Sun & Larry R. Dalton, “Introduction to Organic Electronic and Optoelectronic Materials and Devices”, 2nd Edition, CRC Press, 2016

(b) REFERENCES

1. Bernier, “Advanced Synthetic Metals”, Elsevier, 1999
2. R. Farchioni & G. Grosso (Eds.), “Organic Electronic Materials: Conjugated Polymers and Low Molecular Weight Organic Solids”, Springer, 2007
3. Gregory Crawford, “Flexible Flat Panel Displays”, Wiley, 2005
4. Arieh Aviram, Mark A. Ratner, Molecular rectifiers, Chemical Physics Letters, Volume 29, Issue 2, 1974, Pages 277-283, ISSN 0009-2614, https://doi.org/10.1016/0009-2614(74)85031-1

vi. COURSE PLAN

Module	Contents	Hours
I	**Fundamentals of Organic Semiconductors**: Conducting polymers: structure and properties, π and σ bonding, Polymers fundamentals-conducting polymers. Organic semiconductors, charge transport in conjugated polymers. Conduction mechanism in doped polymeric semiconductors. Physics of organic semiconductors (Luminescence, injection and transports properties), Methods of developing organic semiconductors.	9
II	**Organic Electronic Devices and Architectures**: Basic device architecture in organic devices. Historical review. Organic light emitting diodes (OLED) and Polymer light emitting diodes (PLED). Multilayer architecture. Single layer architecture. Bulk hetero-junctions. Flexible electronics: new display media. Flexible displays device architecture. Fabrication and characterization. Organic transistors. FETs: Principle and device architecture. Molecular Rectifiers.	9
III	**Plastic Solar Cells:** Basic principles. Multilayer and heterojunction structures, cell architecture. Charge transport and exciton formation– effects of exciton diffusion, dissociation and luminescence. Photogeneration process in organic heterojunction photovoltaic cells. Processing of organic solar cells. Dye Sensitization – dye sensitized solar cell.	9

IV	**Electrode Materials:** Essential characteristics of electrode materials for organic electronic devices – work function. Conductivity and transparency factors. Indium Tin Oxide (ITO) as anode material. Effect of ITO oxidative properties on efficiency and shelf life of organic electronic devices, novel inorganic anode materials and their limitations. Buffer organic layer protection to the active layer. Doping the device and annealing the device for increased efficiency and shelf life– architecture.	9
V	**Techniques in Organic electronic Device materials**. Thin film coating techniques for device fabrication. Spin coating, dip coating, doctor blading screen printing, inkjet printing, vapor deposition. R.F and microwave plasma assisted film coating.	9
	Total Hours	**45**

Note: Case study to be conducted on any one of the following topics:

i. Conducting-polymer-based biosensors for wearable and disposable devices
ii. OLED displays in modern smartphones and wearables
iii. Bulk heterojunction organic solar cells
iv. Inkjet-printed active layers for flexible organic photovoltaic (OPV) devices
v. Graphene-based transparent electrodes for flexible OLEDs
vi. Annealing effects on inkjet-printed organic solar cells
vii. Organic thin-film transistors (OTFTs) for flexible electronics
viii. The Aviram–Ratner Molecular Rectifier: Concept and Significance in Organic Electronics

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL44B	PATTERN RECOGNITION	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23MAL10A - Linear Algebra and Calculus,
23MAL20C - Probability, Random Process and Numerical Methods

ii. COURSE OVERVIEW

This course provides a comprehensive understanding of pattern recognition principles and system design, covering both statistical and non-parametric approaches. It introduces advanced techniques such as linear classifiers, SVMs, HMMs, decision trees, and neuro-fuzzy methods for effective pattern classification. Emphasis is placed on practical applications like face recognition and real-life data analysis using soft computing and fuzzy-based techniques.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the basics of statistical pattern recognition	Understand
CO 2	Apply statistical methods in linear classification	Apply
CO 3	Apply linear algebra and statistical methods in parameter and non-parameter estimation	Apply
CO 4	Apply Hidden Markov Models and decision tree methods for pattern recognition applications.	Apply
CO 5	Apply pattern recognition and neuro-fuzzy techniques for real-life classification and density estimation problems.	Apply

iv. SYLLABUS

Basics of pattern recognition system, various applications, classification of pattern recognition systems, design of Pattern recognition system. Statistical pattern recognition.

Linear Classifiers, normal density, discriminant functions, decision surfaces, the Ho-Kashyap procedure, SVM kernel optimization.

Parameter estimation methods: Maximum-Likelihood estimation, Bayesian parameter estimation, mixture models, Expectation-maximization method. Non-Parameter methods: Non-parametric techniques for density estimation.

Hidden Markov Models (HMMs). Non-metric methods for pattern classification: Non-

numeric data or nominal data. Decision trees: Classification and Regression Trees (CART). Application(s): Face recognition, classification algorithms.

Recent advances in Pattern Recognition, Soft computing and Neuro-fuzzy techniques, and real-life examples, Histograms rules, Density Estimation, Nearest Neighbor Rule, Fuzzy classification.

v (a) TEXT BOOKS

1. Bishop, C. M. “Pattern Recognition and Machine Learning” Springer, New York, 2006
2. Duda, R.O., Hart, P.E., and Stork, D.G. “Pattern Classification”. Wiley, New York, 2001.

(b) REFERENCES

1. Hastie, T., Tibshirani, R. and Friedman, J. “The Elements of Statistical Learning”. Springer. 2001.
2. K. Fukunaga, Introduction to Statistical Pattern Recognition, 2nd Ed. Academic Press, New York, 1990.
3. S. Theodoridis and K. Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009.
4. Morton Nadier and Eric Smith P., “Pattern Recognition Engineering”, John Wiley & Sons, New York, 1993.

vi. COURSE PLAN

Module	Contents	Hours
I	Basics of pattern recognition system, various applications, types of pattern recognition systems, design of Pattern recognition system. Statistical pattern recognition: review of probability theory, Baye’s decision theory, optimal solutions for minimum error and minimum risk criteria.	9
II	Linear Classifiers, linearly separable classes, normal density, discriminant functions, decision surfaces, linear discriminant functions – two category, multi-category, minimum squared error procedures, the Ho-Kashyap procedure, SVM kernel optimization.	9
III	Parameter estimation methods: Maximum-Likelihood estimation, mixture models - mixtures of Gaussians, Expectation-maximization method. Non-parametric techniques for density estimation - Parzen-window method, K-nearest neighbour density estimation, nearest neighbour rule.	10
IV	Hidden Markov Models (HMMs). Discrete HMMs. Continuous HMMs. Non-metric methods for pattern classification: Non-numeric data or nominal data. Decision trees: Classification and Regression Trees (CART). Application(s): Face recognition - pre-processing, face detection algorithms – eigen faces.	9

V	Recent advances in Pattern Recognition, Structural PR, FCM, Soft computing and Neuro-fuzzy techniques, and real-life examples, Histogram rules, Density Estimation, Fuzzy classification.	8
	Total Hours	**45**

vii. ASSESSMENTPATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL44C	RF MEMS	PEC	3	0	0	0	3	2023

i. PREREQUISITE : Nil

ii. COURSE OVERVIEW

This course introduces students to the rapidly emerging, area of MEMS with special emphasis on its applications in RF and wireless engineering.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe the various fabrication techniques, sensing and actuation mechanisms used in RF MEMS design.	Understand
CO 2	Apply the principles of RF MEMS switches to evaluate switching performance parameters and design circuit models for series and shunt switches	Apply
CO 3	Explain the principle of operation and types of micromachined passive elements.	Understand
CO 4	Describe the principle of operation and types of micromachined filters, phase shifters and antennas.	Understand
CO 5	Discuss the importance, types and reliability issues in RF MEMS packaging.	Understand

iv. SYLLABUS

Introduction to MEMS and RF MEMS, Microfabrication techniques for MEMS - surface micromachining, Bulk micromachining, LIGA, Electromechanical Transducers, Microsensing for MEMS, Materials for MEMS.

Evaluation of switching performance parameters, Switches for RF and Microwave applications – PIN diode RF switches, RF MEMS switches, Integration and biasing issues for RF switches, Capacitive shunt and series switches - Physical description and circuit model, MEMS switch design considerations.

Micromachined inductors: Meander inductor, spiral inductor and solenoid inductors, Effect of inductor layout, folded inductors, variable inductors and polymer-based inductors. MEMS Capacitors: Gap-tuning and area tuning capacitors, dielectric tunable capacitors.

Principle of operation of micromachined filters, Surface acoustic wave filters, Micromachined filters for millimetre wave frequencies. Principle of operation of micromachined phase shifters, MEMS phase shifters, Ferroelectric phase shifters.

Micromachining techniques to improve antenna performance, Micromachining as a fabrication process for small antennas, Micromachined reconfigurable antennas. Role of MEMS packages, types of MEMS packages, Reliability issues of RF MEMS packages.

v(a) TEXT BOOKS

1. Vijay Varadan, K. J. Vinoy, K. A. Jose, "RF MEMS and Their Applications", Wiley, 2003.
2. Hector J. De Los Santos, "RF MEMS Circuit Design for Wireless Applications", Artech House, 2002.

(b) REFERENCES

1. Gabriel M. Rebeiz, "RF MEMS: Theory, Design, and Technology", Wiley, 2003
2. Eun Sok Kim "Fundamentals of Micro electro mechanical Systems (MEMS)" McGraw Hill, 2021
3. Shiban K. Koul, Sukomal Dey, "Radio Frequency Micromachined Switches, Switching Networks, and Phase Shifters", CRC Press, 2018.

vi. COURSE PLAN

Module	Contents	Hours
I	**MEMS and RF MEMS:** Introduction to MEMS and RF MEMS, Microfabrication techniques for MEMS - surface micromachining, Bulk micromachining, LIGA, Electromechanical transducers, microsensing for MEMS, Materials for MEMS.	9
II	**RF MEMS switches:** Evaluation of switching performance parameters, Switches for RF and Microwave applications – PIN diode RF switches, RF MEMS switches, Integration and biasing issues for RF switches, Capacitive shunt and series switches - physical description and circuit model, MEMS switch design considerations.	10
III	**Micromachined passive elements:** Micromachined inductors: Meander inductor, spiral inductor and solenoid inductors, Effect of inductor layout, folded inductors, variable inductors and polymer-based inductors MEMS Capacitors: Gap-tuning and area tuning capacitors, dielectric tunable capacitors.	10
IV	**Micromachined filters and Phase sifters:** Principle of operation of micromachined filters, Surface acoustic wave filters, Micromachined filters for millimetre wave frequencies. Principle of operation of micromachined phase shifters, MEMS phase shifters, Ferroelectric phase shifters.	8
V	**Micromachined antennas:** Micromachining techniques to	8

	improve antenna performance, fabrication process for small antennas, Micromachined reconfigurable antennas. **Integration and packaging of RF MEMS devices:** Role of MEMS packages, types of MEMS packages, reliability issues of RF MEMS packages.	
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL44D	SECURE COMMUNICATION	PEC	3	0	0	0	3	2023

i. PREREQUISITE : NIL

ii. COURSE OVERVIEW

This course provides an overview of current technologies used to ensure the secure transmission of information across networks.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain network security services, mechanisms, and the types of attacks.	Understand
CO 2	Model the symmetric encryption process and techniques.	Apply
CO 3	Apply the concepts of group, ring, field, modular arithmetic, Euclidean algorithm, finite fields, and polynomial arithmetic in the field of secure communication.	Apply
CO 4	Describe the principles of Data Encryption Standard and Advanced Encryption Standard	Understand
CO 5	Apply the concepts of RSA algorithm, key distribution, and management for public key cryptosystems	Apply
CO 6	Explain the requirements for authentication and the types of functions used to produce an authenticator.	Understand

iv. SYLLABUS

OSI Security Architecture, Security Attacks, Security Services, Security Mechanisms. Model for network security.

Classic Symmetric Key Encryption Techniques - Substitution techniques and Transposition techniques.

Algebraic Structures, Modular arithmetic, Euclidean and Extended Euclidean algorithm, Finite Fields of the form GF(p), Polynomial arithmetic

Block Cipher Principles – Stream Ciphers and Block Ciphers, Feistel Cipher, Data Encryption Standard, AES Standard.

Principles of public key cryptosystems: Fermat’s theorem, Euler’s Totient

Function, Euler's theorem, RSA algorithm, Key management.

Authentication requirements, Authentication functions- Message Encryption, Public Key Encryption, Message Authentication Code, Hash function

v (a) TEXT BOOKS

1. William Stallings, Cryptography and Network security: principles and practice", 4th Edition, Prentice Hall of India, New Delhi, 2006
2. Behrouz A. Forouzan, Cryptography and Network security Tata McGraw-Hill, 2008

(b) REFERENCES

1. David S. Dummit & Richard M Foote, Abstract Algebra, 2nd Edition, Wiley India Pvt. Ltd., 2008.
2. Douglas A. Stinson, Cryptography, Theory and Practice, 2/e, Chapman & Hall, CRC Press Company, Washington, 2005.
3. Lawrence C. Washington, Elliptic Curves: Theory and Cryptography, Chapman &Hall, CRC Press Company, Washington, 2008.N.
4. Koeblitz: A course in Number theory and Cryptography, 2008
5. Thomas Koshy: Elementary Number Theory with Applications, 2/e, Academic Press, 2007
6. Tyagi and Yadav, Cryptography and network security, Dhanpatrai, 2012

vi. COURSE PLAN

Module	Contents	Hours
I	OSI security architecture, Security attacks – Passive attacks, Active attacks, Security services- Authentication, Access Control, Data Confidentiality, Data integrity, Nonrepudiation, Availability service. Model for network security. Cryptography, Cryptoanalysis, Symmetric Cipher model, Substitution techniques- Caeser Cipher, Play-Fair Cipher, Hill Cipher, One time pad. Transposition Techniques.	9
II	Finite Fields: Algebraic Structures - Groups, Rings and Fields. Overview of Integer Arithmetic, Modular arithmetic, Euclidian and Extended Euclidean algorithm, Finite Fields of the form GF(p), Polynomial arithmetic.	8
III	**Block Ciphers** - Principles, Stream Ciphers and Block Ciphers, Feistel Cipher, Feistel Decryption algorithm, The Data encryption standard (DES), DES Decryption - Avalanche effect, AES Cipher, substitute bytes transformation, Shift row transformation, Mix Column transformation	10

IV	Public key cryptosystems - Public key cryptosystems, Application for Public key cryptosystem requirements, Fermat's theorem, Euler's Totient Function, Euler's theorem, RSA algorithm, Key management, Distribution of public keys, Publicly available directory, Public key authority, public key certificates, Distribution of secret keys using public key cryptography	9
V	Authentication requirements, Authentication functions- Message Encryption, Public Key Encryption, Message Authentication Code, Hash function	9
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL44E	DEEP LEARNING	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23MAL20C- PROBABILITY, RANDOM PROCESSES AND NUMERICAL METHODS

ii. COURSE OVERVIEW

This course introduces the foundational concepts and methodologies of deep learning, including neural networks, backpropagation, and model training techniques. It covers key architectures such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Generative Adversarial Networks (GANs). Students will gain an understanding of optimization methods, regularization strategies, and practical challenges in building and deploying deep learning models. The course also helps students to use deep learning architectures for real-world applications in computer vision, natural language processing, and generative modelling.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the fundamental principles of deep learning in various applications	Understand
CO 2	Apply optimization techniques involved in training deep neural networks.	Apply
CO 3	Apply Convolutional Neural Networks (CNNs) for solving different problems.	Apply
CO 4	Apply recurrent neural networks (RNNs) and their variants in sequence modelling.	Apply
CO 5	Explain the concepts of attention mechanisms, transformers, and generative models	Understand

iv. SYLLABUS

Foundations of Deep Learning: Single layer perceptron, Feed-Forward Neural Networks, Multi-Layer Perceptron (MLP), Activation functions, Risk minimization, Loss function (MSE, Cross-entropy), Training MLPs with backpropagation, Practical issues in neural network training.

Training and Optimization: Vanishing and exploding gradient problems, Optimization techniques. Regularization Techniques, Weight initialization.

Convolutional Neural Networks (CNNs) and Vision Applications: The Convolution Operation, Pooling, Structure of CNN, CNN architectures, Transfer learning & fine-

tuning, Need for data augmentation, Data augmentation techniques for images, Image classification & object detection applications.

Recurrent Neural Networks: Sequence-to-Sequence Modelling, Recurrent Neural Networks, Analyzing Variable Length Inputs – Tackling seq2seq Problem – Beam Search and Global Normalization – Recurrent Neural Networks (RNN), Modern RNNs.

Encoder-Decoder models: Attention Mechanism, Self-Attention and Positional Encoding, Generative Pre-trained Transformers, Generative Adversarial Networks, Autoencoder: Architecture, Denoising and Sparsity.

v (a) TEXT BOOKS

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press, 2017.
2. Nikhil Buduma, Nicholas Locasio, “Fundamentals of Deep Learning”, O-Reilly, 2017.
3. Aston Zhang, Zachary C. Lipton, Mu Li, Alexander J. Smola, “Dive into Deep Learning”, Amazon Senior Scientists – Open source and Free Book, March 2022.
4. Michel Neilson, “Neural Networks and Deep Learning”, Open source Online Book, 2019.

(b) REFERENCES

1. Kevin P. Murphy "Machine Learning: A Probabilistic Perspective", The MIT Press, 2012.
2. Ethem Alpaydin,"Introduction to Machine Learning”, MIT Press, Prentice Hall of India, Third Edition 2014.
3. Giancarlo Zaccone, Md. Rezaul Karim, Ahmed Menshawy "Deep Learning with TensorFlow: Explore neural networks with Python", Packt Publishers, 2017.
4. Antonio Gulli, Sujit Pal "Deep Learning with Keras", Packt Publishers, 2017.
5. Francois Chollet "Deep Learning with Python", Manning Publications, 2017.

vi. COURSE PLAN

Module	Contents	Hours
I	**Foundations of Deep Learning:** Single layer perceptron and its limitations, Training Feed-Forward Neural Networks - Gradient Descent, Multi-Layer Perceptron (MLP) - simple problems, Representation Power of MLPs, Activation functions - Sigmoid, Tanh, ReLU, Softmax, Risk minimization, Loss function (MSE, Cross-entropy), Training MLPs with backpropagation, Practical issues in neural network training - The Problem of Overfitting.	9
II	**Training and Optimization:** Training deep models, Vanishing and exploding gradient problems, Optimization techniques - Gradient Descent (GD), GD with momentum, Nesterov accelerated GD, Stochastic GD, AdaGrad,	9

	RMSProp, Adam. Regularization Techniques - L1 and L2 regularization, Early stopping, Dropout, Weight initialization.	
III	**Convolutional Neural Networks (CNNs) and Vision Applications:** The Convolution Operation - 2D convolution, kernel/filters, strides, padding, Motivation, Pooling - Max pooling, average pooling, Structure of CNN, CNN architectures - LeNet, AlexNet. Transfer learning & fine-tuning, Need for data augmentation, Data augmentation techniques for images, Image classification & object detection applications.	9
IV	**Sequential models:** Sequence-to-Sequence Modelling – Embedding - Recurrent Neural Networks - Bidirectional RNNs, Analyzing Variable Length Inputs – Tackling seq2seq Problem – Beam Search and Global Normalization – Recurrent Neural Networks (RNN)– Hidden States – Perplexity – Character-level Language Models –Modern RNNs: Gated Recurrent Units (GRU), Long Short-Term Memory (LSTM).	9
V	**Encoder-Decoder models:** Attention Mechanism - Attention Cues, Attention Pooling, Scoring Functions, Self-Attention and Positional Encoding–Bidirectional Encoder Representations from Transformers (BERT) – Generative Pre-trained Transformers, Generative Adversarial Networks – Generator, Discriminator, Training, GAN variants; Autoencoder: Architecture, Denoising and Sparsity.	9
	Total Hours	**45**

Simulation assignments: Any 2 can be simulated using Matlab/ Tensorflow/ PyTorch.

1. Implement & Train a Deep Feedforward Network using any available dataset.
2. Hyperparameter Search and Overfitting Analysis.
3. Implement Convolution & Pooling Layers.
4. Build & Train a Small CNN for Image Classification.
5. Transfer Learning: Fine-tune a Pretrained Model (AlexNet, LeNet, etc).
6. Implement an RNN for Sequence Prediction.
7. LSTM for Time-Series Forecasting or Text Generation.
8. Object Detection
9. Semantic Segmentation / 3D-CNN Demonstration.
10. Speech Recognition with RNN/CNN Hybrid.

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL44F	ROBOTICS	PEC	3	0	0	0	3	2023

i. PREREQUISITE : Nil

ii. COURSE OVERVIEW

The goal of this course is to introduce the emerging field of robotics by imparting fundamental knowledge on robot design, multidisciplinary engineering aspects, and applications.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain fundamental aspects of embedded systems and robotics	Understand
CO 2	Choose appropriate sensors and actuators based on the robotic applications.	Understand
CO 3	Solve forward and inverse kinematics and dynamics of robotic systems.	Apply
CO 4	Develop basic robot programs using VAL Programming language.	Apply
CO 5	Explain recent advancements and applications of intelligent and collaborative robotic systems.	Apply

iv. SYLLABUS

Introduction to Robotics: Definition and Origin of Robotics.- Robot Anatomy. Robot Specifications. Robot Characteristics - Classification of Robots - Robot Structure – Common Kinematic Arrangements. Degree of Freedom.

Embedded Systems: Hardware and Interfacing.

Introduction to Sensors and Actuation Systems for Robots: Actuators – Sensors

Introduction to Robot Kinematics: Kinematic Modelling - Velocity Kinematics – Forward and Inverse Kinematics.

Introduction to Dynamic Modelling: Forward and Inverse Dynamics.

Introduction to Robot Programming: Structure, Commands, Simple Programs

Recent Developments in Robotics. Mobile Robots: Mobile Robot Kinematics, Navigation. Humanoid Robotics -. Collaborative Robots - Artificial Intelligence in

Robotics: Industrial Applications of Robots in Material Handling and Assembly.

v (a) TEXT BOOKS

1 S.K. Saha, Introduction to Robotics, Tata McGraw Hill, 2nd Edition, 2014

2 Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, John Wiley & Sons, 2nd Edition, 2011

3 Spong and Vidyasagar, Robot Dynamics and Control, John Wiley & Sons, 2nd Edition, 2004

4 Mikell P. Groover, et al., Industrial Robotics – Technology, Programming and Applications, McGraw Hill, 2nd Edition, 2012.

(b) REFERENCES

1. John. J.Craig, Introduction to Robotics: Mechanics and Control, PHI.
2. Ashitava Ghosal, Robotics, Fundamental concepts and analysis, OXFORD University Press, 2006.
3. Fu, K.S, Gonzalez, R.C Lee, C.S.G., Robotics, Control, Sensing, Vision and Intelligence, McGraw-Hill, 1987.
4. Asada, H., and J. J. Slotine. Robot Analysis and Control. New York, NY: Wiley, 1986.
5. Robert J. Schilling, Fundamentals of Robotics: Analysis & Control, Pearson Education, 2000.
6. Klafter, R.D., Chmielewski, T.A, Negin, M, Robotic Engineering An Integrated Approach, PHI, 2007.
7. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill, New Delhi, 1994.

vi. COURSE PLAN

Module	Contents	Hours
I	Introduction to Robotics: Definition and Origin of Robotics. Robot Anatomy. Robot Specifications. Robot Characteristics – Accuracy, Precision, and Repeatability. Classification of Robots. Robot Structure - Types of Joints and End Effectors, Common Kinematic Arrangements. Degree of Freedom. Robot Coordinates. Reference Frames. Embedded Systems: Microcontroller Architecture and Integration with Sensors, Actuators and Components. Areas of Application for Robots.	9
II	Introduction to Sensors and Actuation Systems for Robots: Sensors: Types and Applications of Sensors in Robotics: Position, Displacement and Velocity Sensors. Tactile Sensors for Contact and Proximity Assessment. Strain Gauge based Force Sensor, Parameters for selection of sensors. Actuators: Types of Robotic Drive Systems and Actuators:	9

	Hydraulic, Pneumatic and Electric drives. Parameters for selection of actuators. Areas of Application for: Stepper Motor, Servo Motor and Brushless DC Motor. Speed Control using PWM and Direction Control using H- Bridge.	
III	Introduction to Robot Kinematics: Position and Orientation of Objects, Rotation, Euler Angles, Rigid Motion Representation using Homogenous Transformation Matrix. Kinematic Modelling: Translation and Rotation Representation, Forward and Inverse Kinematics. Forward Kinematics-Link Coordinates, Denavit-Hartenberg Representation, Inverse Kinematics – General Properties of Solutions, Kinematic Decoupling, Importance of Singularities.	9
IV	Introduction to Dynamic Modelling: Forward and Inverse Dynamics- Equations of Motion using Euler-Lagrange formulation, Newton Euler Formulation, Jacobian. Introduction to Robot Programming – Programming Methods, Robot Language Classification, Robot Language Structure, Elements and its Functions. Motion, End-Effector and Sensor Commands in VAL Programming Language. Simple Programs.	9
V	Mobile Robots: Mobile Robot Kinematics, Navigation. Humanoid Robotics: Biped Locomotion, Imitation Learning. Collaborative Robots: Collaborative Robot, Collaborative Operation, Applications. Artificial Intelligence in Robotics: Applications in Unmanned Systems, Defense, Medical, Industries, etc. Industrial Applications of Robots in Material Handling and Assembly. Robotics and Automation for Industry 4.0., Robot Safety. Social Robotics. Case Study on Applications of Modern Robots	9
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL44G	MIXED SIGNAL CIRCUIT DESIGN	PEC	2	1	0	0	3	2023

i. PREREQUISITE : 23ECL20A - ANALOG CIRCUITS
23ECJ20C - LOGIC CIRCUIT DESIGN

ii. COURSE OVERVIEW

This course covers the principles and design of mixed-signal CMOS integrated circuits including sampling circuits, switched-capacitor techniques, phase-locked loops (PLL), and data converters, with emphasis on circuit analysis, architectures, and performance evaluation in VLSI systems.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe the basic sampling techniques and the operation of sample-and-hold circuits.	Understand
CO 2	Explain the operation and design principles of comparators and PLL.	Understand
CO 3	Design switched-capacitor circuits to realize analog building blocks.	Apply
CO 4	Illustrate the operation of A/D and D/A converters	Understand

iv. SYLLABUS

Sampling Circuits: Basic sampling techniques, performance metrics, sampling switches and sample-and-hold architectures including open-loop, closed-loop, switched-capacitor and current-mode implementations.

Phase Locked Loops: CMOS comparators, analog multipliers, basic PLL topology, loop dynamics, charge-pump PLLs, non-ideal effects, delay-locked loops and applications.

Switched Capacitor Circuits: Switched-capacitor building blocks, amplifiers, integrators, filters, oscillators and common-mode feedback circuits.

D/A Converters: Ideal characteristics, performance metrics, voltage, current and charge-scaling DAC architectures including resistor ladder and current steering structures.

A/D Converters: Quantization principles, pipelined ADC architectures, successive approximation and interleaved converters.

v (a) TEXT BOOKS

1. Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, McGraw-Hill, 2/e, 2002
2. Razavi, “Principles of data conversion system design”, Wiley IEEE Press, 1st Edition, 1995.
3. R. Gregorian, G. C. Temes, “Analog MOS Integrated Circuits for Signal Processing”, John Wiley and Sons, 1986.
4. Meyer Gray , Hurst, Lewis, “Analysis and Design of Analog Integrated Circuits”, 5th Edition ,Wiley 2009.

(b) REFERENCES

1. R. Jacob Baker, “CMOS circuit design, layout and simulation” by Revised third edition, IEEE press, 2010
2. R. Jacob Baker “CMOS mixed-signal circuit design” second edition, Wiley India, 2009.
3. Phillip E. Allen, Douglas R. Holbery, CMOS Analog Circuit Design, Oxford, 2004
4. Razavi B., Fundamentals of Microelectronics, Wiley student Edition2014
5. Baker, Li, Boyce, CMOS: Circuits Design, Layout and Simulation, PHI, 2000.

vi. COURSE PLAN

Module	Contents	Hours
I	**Sampling Circuits:** Basic sampling circuits for analog signal sampling, performance metrics of sampling circuits, different types of sampling switches. Sample-and-Hold Architectures- Open-loop & closed-loop architectures, open loop architecture with miller capacitance, multiplexed-input architectures, recycling architecture, switched capacitor architecture, current-mode architecture	9
II	**Phase Locked Loops:** Characterization of a comparator, basic CMOS comparator design, adaptive biasing, analog multiplier design. Simple PLL-phase detector, basic PLL topology, dynamics of basic PLL. Charge-Pump PLLs, non-ideal effects in PLL, Delay-Locked Loops, Applications	9
III	**Switched Capacitor Circuits:** Basic building blocks, general considerations, switched-capacitor amplifiers, switched-capacitor integrator, first order filters. Peak detectors, full wave rectifier, voltage-controlled oscillator, sinusoidal oscillator. Switched-capacitor common-mode feedback.	9
IV	**Digital to Analog Converters:** Input and output characteristics of an ideal D/A converter, performance metrics of D/A converter, D/A converter in terms of	9

	voltage, current and charge division or multiplication Switching functions. Resistor-Ladder architectures, Current steering architectures.	
V	**Analog to Digital Converters:** Input and output characteristics of an A/D converter, quantization error. Pipelined A/D converters – types, pipelined converter circuits, generalized k-bit per stage pipelined converters, successive approximation architectures, interleaved architectures	9
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

PROGRAMME ELECTIVE - V

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL45A	LOW POWER VLSI	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23ECL20B - Solid State Devices
23ECJ30E - VLSI Design

ii. COURSE OVERVIEW

This course offers a comprehensive insight into low-power VLSI design, addressing deep-submicron transistor design challenges and sources of power dissipation in CMOS circuits. It further focuses on low-power design techniques, adiabatic and reversible logic approaches, and efficient circuit design styles for power-efficient VLSI systems.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain MOSFET device physics, submicron design challenges, and the sources of power dissipation in CMOS circuits.	Understand
CO 2	Apply various clocked and non-clocked design styles for logic implementation.	Apply
CO 3	Apply adiabatic and reversible logic for circuit implementation.	Apply
CO 4	Describe the circuit techniques for leakage and power reduction in VLSI systems.	Understand
CO5	Illustrate adder and multiplier architectures for high-performance VLSI systems.	Understand

iv. SYLLABUS

Need for low power design, MIS Structure, deep submicron transistor design issues. Sources of power dissipation in CMOS.

Non-clocked and clocked circuit design styles, realization of functions.

Principle of adiabatic switching, conventional charging versus adiabatic charging, adiabatic amplification and buffers, adiabatic logic gates, realization of functions using adiabatic logic. Pulsed power supplies. Reversible logic gates.

Leakage and power reduction using dual threshold CMOS, multiple supply voltage scaling, transistor stacks, sleep transistors, variable threshold CMOS, dynamic Vdd scaling. Power gating and clock gating. Transistor sizing for power reduction.

Standard adder cells, carry select, carry save adders. Braun multiplier, Baugh - Wooley multiplier, Booth multiplier, Wallace Tree multiplier.

v (a) TEXT BOOKS

1. Kaushik Roy, Sharat C Prasad, “Low power CMOS VLSI circuit design”, Wiley India, 2009.
2. Kiat Seng Yeo, Kaushik Roy, “Low voltage, low power VLSI subsystems”, McGraw-Hill, 2005.
3. Gray Yeap, “Practical low power digital VLSI design”, Springer, 1998.

(b) REFERENCES

1. Christian Piguet, “Low power CMOS circuits”, Taylor & Francis, 2006.
2. Abdellatif Bellaouar, Mohamed I Elmasry, “Low power digital VLSI design”, Kluwer Academic, 1995.

vi. COURSE PLAN

Module	Contents	Hours
I	**Device physics and submicron design issues:** Need for low power circuit design. MIS Structure. Deep submicron transistor design issues. **Sources of power dissipation:** Static power dissipation, switching power dissipation, and short circuit power dissipation (derivations required). Dependency of short circuit current on input waveform and output load. Glitching Power dissipation.	9
II	**Circuit design styles:** Non-clocked circuit design style - NMOS with resistive load, fully complementary logic, pseudo NMOS logic, differential cascade voltage switch logic (DCVS). Clocked design styles - Differential Current Switch Logic (DCSL). Realization of functions using non-clocked and clocked design styles.	9
III	**Adiabatic switching:** Principle, **c**onventional charging versus adiabatic charging, adiabatic amplification, and adiabatic buffers. Adiabatic logic gates, Realization of functions using adiabatic logic. Pulsed power supplies. **Reversible logic:** Basic concept. Reversible logic gates – Feynman and Fredkin.	9
IV	**Circuit techniques for leakage and power reduction:** Dual threshold CMOS (DTCMOS), multiple supply voltage scaling, static supply scaling. Leakage reduction using transistor stacks, sleep transistors, variable threshold CMOS (VTCMOS). Dynamic Vdd scaling (DVS). Power gating and clock gating. Transistor sizing for Power Reduction.	9

V	**Low-voltage low-power adders and multipliers:** Standard adder cells, carry select adders, carry save adders. Braun multiplier, Baugh - Wooley multiplier, Booth multiplier, Wallace Tree multiplier.	9
	Total Hours	**45**

Simulation assignment: At least one assignment shall be simulation-based using standard EDA tools involving the design of circuits with analysis of power dissipation and delay.

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL45B	CYBER SECURITY	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23ECL40C - Computer Networks

ii. COURSE OVERVIEW

The goal of this course is to familiarize various types of vulnerability scanning, network defense tools, cryptography, cyber-attacks, cyber-crimes, cyber laws and to study the defensive techniques against these attacks.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the components of the cyber world, cyber attacks and their classification.	Understand
CO 2	Describe the various vulnerabilities and network vulnerability scanning.	Understand
CO 3	Analyze the basic encryption and decryption techniques	Apply
CO 4	Describe the cyber laws used to prevent cyber crimes.	Understand
CO 5	Explain about the processes involved in cybercrime investigation	Understand

iv. SYLLABUS

Introduction to Cybersecurity: History of Internet, Future of Cybersecurity and Mobility-Gartner Hype Cycle, Cyber Attacks and their Classification, Types of hackers, Password Cracking, Keyloggers and Spyware, Virus and Worms, Trojan and backdoors, DOS and DDOS attack, SQL injection, Buffer Overflow

Introduction to Vulnerability Scanning: Open Port / Service Identification, Banner / Version Check, Traffic Probe, Vulnerability Probe, Vulnerability Examples, OpenVAS, Metasploit

Network Vulnerability Scanning: Netcat, Socat, understanding Port and Services tools - Datapipe, Fpipe, WinRelay, Network Reconnaissance – Nmap, THC-Amap and System tools

Network Defense tools: Packet Filter Vs Firewall, How a Firewall Protects a Network, Packet Characteristic to Filter, Stateless Vs Stateful Firewalls, Network Address Translation (NAT) and Port Forwarding, the basic of Virtual Private Networks, Linux Firewall, Windows Firewall

Cryptography: Basic Encryption & Decryption-Feistel Networks, RSA Algorithm, DES Algorithm, Hash function, Digital signature

Introduction to Cyber Crime and law: Types of Cybercrime, Hacking, Attack vectors,

Cyberspace and Criminal Behavior, Traditional Problems Associated with Computer Crime, Introduction to Incident Response, Computer Language, Network Language, Indian IT ACT 2000, Offences dealt with IPC-RBI Act-IPR in India

Introduction to Cyber Crime Investigation: Data Frauds, Analysis of Crimes-Human Behaviour- Stylometry-Incident Handling, Investigation Methods-Criminal Profiling- Cyber Trails, Digital Forensics, Challenges-Branches of Digital Forensics, Digital Forensic Investigation Methods-Reporting-Management of Evidence

v (a) TEXT BOOKS

1. Anti-Hacker Tool Kit, Mike Shema, 4/e, Mc Graw Hill, 2014.
2. Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Nina Godbole and Sunit Belpure, Wiley, 2011.

(b) REFERENCES

1. Forouzan, Data Communication and Networking (Global Edition), 5/e, McGraw Hill Education India, 2013.
2. Forouzan, TCP/IP Protocol Suite, 4/e, McGraw Hill Education India, 2010.
3. Achyut S. Godbole Data Communication and Networking, 2/e, McGraw –Hill Education New Delhi, 2011.

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to Cybersecurity** Basics, Security Principles, History of Internet, Future of Cybersecurity and Mobility-Gartner Hype Cycle, Cyber Attacks and their Classification, Types of hackers, Password Cracking, Keyloggers and Spyware, Virus and Worms, Trojan and backdoors, DOS and DDOS attack, SQL injection, Buffer Overflow **Introduction to Vulnerability Scanning** Overview of vulnerability scanning, Open Port / Service Identification, Banner / Version Check, Traffic Probe, Vulnerability Probe, Vulnerability Examples, OpenVAS, Metasploit.	10
II	**Network Vulnerability Scanning** Networks Vulnerability Scanning - Netcat, Socat, understanding Port and Services tools - Datapipe, Fpipe, WinRelay, Network Reconnaissance – Nmap, THC-Amap and System tools. **Network Defense tools** Firewalls and Packet Filters: Firewall Basics, Packet Filter Vs Firewall, How a Firewall Protects a Network, Packet Characteristic to Filter, Stateless Vs Stateful Firewalls, Network Address Translation (NAT) and Port Forwarding, the basic of Virtual Private Networks, Linux Firewall, Windows Firewall	10
III	**Cryptography: Basic Encryption & Decryption** Transposition & substitution ciphers – Caesar substitution – Polyalphabetic substitutions – Crypt analysis – Symmetric key	9

	algorithms – Feistel Networks – Confusion – Diffusion – DES Algorithm – Strength of DES – Comparison & important features of modern symmetric key algorithms – Public key cryptosystems – The RSA Algorithm – Diffie Hellman key exchange – comparison of RSA & DES – Message Authentication & Hash functions – Digital signature	
IV	**Introduction to Cyber Crime and law** Cyber Crimes, Types of Cybercrime, Hacking, Attack vectors, Cyberspace and Criminal Behavior, Clarification of Terms, Traditional Problems Associated with Computer Crime, Introduction to Incident Response, Computer Language, Network Language, Indian IT ACT 2000, Offences dealt with IPC-RBI Act-IPR in India	8
V	**Introduction to Cyber Crime Investigation** Types-Data Frauds, Analysis of Crimes-Human Behaviour-Stylometry-Incident Handling, Investigation Methods-Criminal Profiling- Cyber Trails, Digital Forensics-History- Challenges-Branches of Digital Forensics, Digital Forensic Investigation Methods-Reporting-Management of Evidence	8
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL45C	ADAPTIVE SIGNAL PROCESSING	PEC	2	1	0	0	3	2023

i. PREREQUISITE : 23ECL30B - Digital Signal Processing

ii. COURSE OVERVIEW

This course introduces the principles and characteristics of adaptive systems and their role in real-time signal processing. It covers key algorithms such as LMS, RLS, and Kalman filters for adaptive filtering, prediction, and system identification. Practical applications include communication channel equalization, geophysical exploration, and digital filter design using adaptive techniques.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the basic concepts of statistical signal processing.	Understand
CO 2	Design filters for optimizing the cost function indicating error in estimation of parameters.	Apply
CO 3	Evaluate the performance of various methods for designing adaptive filters.	Apply
CO 4	Analyze convergence and stability issues associated with adaptive filter design.	Apply
CO 5	Design filtering solutions for applications considering present day challenges	Apply

iv. SYLLABUS

Adaptive systems- applications – properties, adaptive linear combiner input signal and weight vectors - introduction to filtering- linear optimum filtering-orthogonality - Wiener – Hopf equation performance surface

Searching performance surface-stability and rate of convergence: Learning curve gradient search comparison - Gradient estimation, misadjustments

LMS algorithm, sequential regression algorithm - random-search algorithms - lattice structure - adaptive filters with orthogonal signals, RLS algorithm.

Kalman filters. Applications-adaptive modelling and system identification: Kalman filter as the unifying basis for RLS filters.

Inverse adaptive modelling: adaptive equalization of telephone channels-adapting poles and zeros for IIR digital filter synthesis

v (a) TEXT BOOKS

1. Bernard Widrow and Samuel D. Stearns, —Adaptive Signal Processing, Person Education, 1985
2. Mons H Hays -Statistical Digital Signal Processing and Modeling -Wiley Publications, 2006

(b) REFERENCES

1. Simon Haykin, —Adaptive Filter Theory, Pearson Education, 2003.
2. John R. Treichler, C. Richard Johnson, Michael G. Larimore, —Theory and Design of Adaptive Filters, Prentice-Hall of India, 2002
3. John G. Proakis, Dimitris G. Manolokis, “Digital Signal Processing”, Prentice Hall of India, New Delhi, 2005
4. S. Thomas Alexander, “Adaptive Signal Processing - Theory and Application”, Springer Verlag, 1986 (Original version).
5. D. G. Manolokis, V. K. Ingle and S. M. Kogar, “Statistical and Adaptive Signal Processing”, Mc Graw Hill International Edition, 2000.

vi. COURSE PLAN

Module	Contents	Hours
I	Adaptive systems- Definitions and characteristics - applications – properties, adaptive linear combiner input signal and weight vectors - performance function-gradient and minimum mean square error - introduction to filtering-smoothing and prediction - linear optimum filtering-orthogonality - Wiener – Hopf equation performance surface	10
II	Searching performance surface-stability and rate of convergence: Learning curve gradient search - Newton's method - method of steepest descent - comparison - Gradient estimation - performance penalty - variance - excess MSE and time constants, misadjustments	9
III	LMS algorithm, convergence of weight vector: properties - sequential regression algorithm - adaptive recursive filters - random-search algorithms - lattice structure - adaptive filters with orthogonal signals. Recursive least squares (RLS) algorithm for adaptive filtering of stationary process- Matrix inversion – Comparison with LMS	9
IV	Kalman filters-recursive minimum mean square estimation for scalar random variable. Applications-adaptive modelling and system identification: Multipath communication channel, geophysical exploration, Kalman filter as the unifying basis for RLS filters	9

V	Inverse adaptive modelling: Equalization, and deconvolution adaptive equalization of telephone channels-adapting poles and zeros for IIR digital filter synthesis	8
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL45D	WIRELESS SENSOR NETWORKS	PEC	3	0	0	0	3	2023

i. REREQUISITE : Nil

ii. COURSE OVERVIEW

This course aims to gain knowledge on fundamentals of Wireless Sensor Networks, the MAC layer, Routing Protocols, operating systems of WSN and 6LoWPAN technology.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe the principles, architectures, communication standards, and design issues of Wireless Sensor Networks.	Understand
CO 2	Explain various MAC and Routing Protocols	Understand
CO 3	Explain the architecture of 6LOWPAN and functioning of various layers	Understand
CO 4	Construct communication architectures using protocol paradigms and common IoT/WSN protocols.	Apply
CO 5	Develop WSN applications using TinyOS, Contiki OS, and event-driven programming techniques.	Apply

iv. SYLLABUS

Principles of Wireless Sensor Networks -Introduction to wireless sensor networks- Node architecture and Network architecture, design principles - Short range radio communication standards.

MAC protocols- Schedule-based protocols- Routing protocols.

6LoWPAN Architecture- protocol stack, Adaptation Layer, Link layers- Fragmentation and Reassembly- Header Compression- Mobility.

Design Issues, Protocol Paradigms- Common Protocols- MQ telemetry transport for sensor networks (MQTT-S), ZigBee compact application protocol (CAP),Service discovery, Simple network management protocol (SNMP), Industry- Specific protocols.

Programming in Wireless Sensor Networks- Tiny Operating System, Contiki OS, Event-Driven Programming, Techniques for Protocol Programming.

v (a) TEXT BOOKS

1. Holger Karl , Andreas willig, “Protocol and Architecture for Wireless Sensor Networks”, John Wiley Publication, 2006.
2. Anna Forster, “Introduction to Wireless Sensor Networks”, Wiley, 2017.
3. Zach Shelby Sensinode and Carsten Bormann, “ 6LoWPAN: The Wireless Embedded Internet” John Wiley and Sons, Ltd, Publication, 2009.
4. Philip Levis, “TinyOS Programming”, 2006 –www.tinyos.net.
5. The Contiki Operating System.http://www.sics.se/contiki

(b) REFERENCES

1. Jun Zheng and Abbas Jamalipour, “Wireless Sensor Networks: A Networking Perspective” Wiley-IEEE Press, 2009
2. Jean-Philippe Vasseur and Adam Dunkels, “Interconnecting Smart Objects with IP”, Elsevier, 2010
3. S. Sitharama Iyengar, Nandan Parameshwaran, Vir V. Phoha, Chuka D. Okoye and Narayanaswamy Balakrishnan,” Fundamentals of Sensor Network Programming: Applications and Technology”, Wiley-IEEE Press, 2011

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction :** Principles of Wireless Sensor Networks - 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.	9
II	**MAC and Routing Protocols:** 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.	9
III	**6LoWPAN** : 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.	9
IV	**Applications:** Design Issues, Protocol Paradigms -End-to-end, Real-time streaming and sessions, Publish/subscribe, Web	9

	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.	
V	**Tools**: Programming in Wireless Sensor Networks, Tiny Operating System, Contiki OS, Event-Driven Programming, Techniques for Protocol Programming.	9
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL45E	RF CIRCUIT DESIGN	PEC	3	0	0	0	3	2023

i. PREREQUISITE : Nil

ii. COURSE OVERVIEW

The course aims to provide students with a fundamental understanding of RF design concepts and characteristics of RF components, along with their modeling aspects. It intends to develop the ability to design biasing networks and RF amplifiers for practical applications, and to familiarize students with the working principles of RF oscillators and mixer circuits used in high-frequency systems.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe the fundamentals of RF design and filter configurations.	Understand
CO 2	Explain the operation and modeling of active RF components.	Understand
CO 3	Design biasing networks and amplifiers for RF applications	Apply
CO 4	Illustrate the working principle of RF oscillators and mixer circuits.	Understand

iv. SYLLABUS

Importance of radio frequency design, RF behavior of passive components. Scattering parameters of n-port networks. Basic resonator and filter configurations, special filter realizations, and filter implementation.

RF diodes. Construction, functionality, and frequency response of RF FET – MESFET, HEMT. Active RF component modelling.

Amplifier biasing networks for BJTs and FETs. RF amplifiers - Characteristics, power Relations, stability considerations. Broadband, high-power, and multistage amplifiers. Low noise amplifiers.

Feedback oscillator, Negative Resistance Oscillator- emitter/source feedback circuit, and cross-coupled oscillator. Dielectric resonator oscillator, YIG-tuned oscillator, Varactor diode oscillators.

Mixers - basic concept, frequency domain considerations. Single-ended mixer, Single and double-balanced mixer. Integrated active mixers - Single and double-balanced (Gilbert cell) active mixer. Image reject mixer.

v (a) TEXT BOOKS

1. Reinhold Ludwig, Gene Bogdanov, “RF Circuit Design: Theory & Applications”, second edition, Pearson Education India, 2009.
2. C. Bowick, Cheryl Ajluni, John Blyler, “RF circuit design,” 2nd Edition, Newnes, 2008.
3. Richard Chi Hsi Li, “RF circuit design”, second edition, Wiley, 2012.

(b) REFERENCES

1. Pozar, David M., “Microwave and RF design of wireless systems”, John Wiley & Sons, 2000.
2. Davis, W. Alan, and Krishna Kumar Agarwal, “Radio frequency circuit design”, John Wiley, 2001.
3. Carr, Joseph J., “Secrets of RF circuit design”. McGraw-Hill Education, 2001.
4. Rohde, Ulrich L., and David P. Newkirk., “RF/microwave circuit design for wireless applications”, John Wiley & Sons, 2000.

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction:** Importance of radio frequency design, RF behavior of passive components. Review of scattering parameters of n-port networks. **RF filter design:** Basic resonator and filter configurations – LPF, HPF, bandpass and bandstop filters, special filter realizations, filter implementation.	9
II	**Active RF Components:** RF Diodes – Schottky, PIN, Varactor, and IMPATT diodes. RF Field Effect Transistors – Construction, functionality, and frequency response of MESFET and High Electron Mobility Transistors (HEMT). **Active RF component modeling:** Diode Models, Transistor Models - Ebers Moll model.	9
III	**Amplifier biasing networks**: Passive and active biasing for bipolar transistors. Unipolar and bipolar passive biasing network for FET. **RF amplifier design:** Characteristics of Amplifiers, Amplifier Power Relations, Stability Considerations. Broadband, High Power, and multistage amplifiers. Low Noise Amplifiers	9
IV	**Oscillators:** Feedback oscillator, Negative Resistance Oscillator-emitter/source feedback circuit, and cross-coupled oscillator. Dielectric resonator oscillator, YIG-tuned oscillator, Varactor diode oscillators.	9
V	**Mixer circuits**: Basic concept, frequency domain considerations. Single-ended mixer, single, and double-balanced mixer.	9

	Integrated active mixers – Single, and double-balanced (Gilbert cell) active mixer. Image reject mixer.	
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL45F	ADVANCED CODING THEORY	PEC	2	1	0	0	3	2023

i. PREREQUISITE : 23ECL40A - Information Theory and Coding

ii. COURSE OVERVIEW

This course introduces advanced concepts of coding theory used in modern communication systems. It covers advanced algebraic decoding techniques, cyclic and burst error correcting codes, BCH and Reed–Solomon codes, convolutional codes, and modern capacity-approaching codes such as LDPC and Turbo codes.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply advanced algebraic decoding techniques for block codes using error locator and evaluator polynomial methods.	Apply
CO 2	Apply decoding strategies for cyclic and burst error correcting codes to detect and correct transmission errors.	Apply
CO 3	Apply encoding and decoding procedures of BCH and Reed–Solomon codes for reliable digital communication.	Apply
CO 4	Apply convolutional coding techniques using trellis representation and Viterbi decoding algorithms.	Apply
CO 5	Apply iterative decoding principles for modern coding schemes such as LDPC and Turbo codes.	Apply

iv. SYLLABUS

Review of extension fields and cyclotomic cosets. Algebraic structure of cyclic and BCH codes. Syndrome-based decoding methods. Error locator and evaluator polynomials. Euclidean algorithm, Chien search algorithm, and Forney’s algorithm. Performance analysis of linear codes including weight distribution, coding gain, and union bound on error probability.

Advanced cyclic code structures including idempotent generators, dual codes, and self-dual codes. Extended and punctured cyclic codes. Burst error correcting codes such as Fire codes and interleaved cyclic codes. Burst error detection techniques. Meggitt decoding, majority logic decoding, and introduction to soft-decision decoding.

Construction of primitive and non-primitive BCH codes. Single and double error correcting BCH codes. Generator and parity check matrices. Error location polynomial and iterative decoding algorithms. Reed–Solomon code construction, encoding, and decoding. Berlekamp algorithm for Reed–Solomon decoding.

Encoding of convolutional codes and structural properties. Distance properties and trellis representation. Maximum likelihood decoding and sequential decoding. Majority logic decoding. Viterbi decoding algorithm and its applications. Use of convolutional codes in Automatic Repeat Request (ARQ) systems.

Low-Density Parity Check (LDPC) codes and sparse graph representation. Tanner graphs and decoding for binary erasure channels. Log-likelihood ratio algebra and belief propagation decoding. Product codes and iterative decoding. Concatenated convolutional codes including serial and parallel concatenation. Turbo codes, UMTS Turbo code, and turbo decoding principles.

v (a) TEXT BOOKS

1. Shu Lin and Daniel J. Costello Jr., Error Control Coding: Fundamentals and Applications, 2nd Edition, Pearson/Prentice Hall, 2004.
2. Man Young Rhee, Error Correcting Coding Theory, McGraw-Hill, 1989.
3. Salvatore Gravano, Introduction to Error Control Codes, Oxford University Press, 1st Edition, 2001.
4. Todd K. Moon, Error Correction Coding: Mathematical Methods and Algorithms, Wiley, 2005.
5. John G. Proakis and Masoud Salehi, Essentials of Error Control Coding*, 1st Edition*, McGraw-Hill/Wiley, 2008.
6. W. Cary Huffman and Vera Pless, Fundamentals of Error-Correcting Codes, 1st Edition, Cambridge University Press, 2003.

(b) REFERENCES

1. Sarah J. Johnson, *Iterative Error Correction:* Turbo, Low-Density Parity-Check and Repeat-Accumulate Codes, 1st Edition, Cambridge University Press, 2010.
2. William Ryan and Shu Lin, Channel Codes: Classical and Modern, 1st Edition, Cambridge University Press, 2009.

vi. COURSE PLAN

Module	Contents	Hours
I	Review of extension fields and field representations, minimal polynomials and cyclotomic cosets, algebraic structure of cyclic and BCH codes, syndrome-based algebraic decoding, error locator and evaluator polynomials, Euclidean algorithm for error location, Chien search algorithm, Forney's algorithm for error magnitude computation, weight distribution of linear codes, coding gain and performance bounds, union bound on error probability	**10**

II	Idempotent generators and spectral properties, dual codes and self-dual codes, extended and punctured cyclic codes, Fire codes, interleaved cyclic codes, burst error detection and correction techniques, Meggitt decoder, majority logic decoding for cyclic codes, soft-decision decoding concepts	**8**
III	BCH codes: generation of primitive and non-primitive BCH codes using binary arithmetic, single and double error correcting BCH codes, parity check matrix, decoding of BCH codes using iterative algorithm for error location polynomial, Reed–Solomon code generation and decoding, Berlekamp algorithm	**10**
IV	Encoding of convolutional codes, structural and distance properties, maximum likelihood decoding, sequential decoding, majority logic decoding of convolutional codes, applications of Viterbi and sequential decoding, applications of convolutional codes in ARQ systems	**8**
V	LDPC codes based on sparse graphs, decoding for binary erasure channel, log-likelihood ratio algebra, belief propagation decoding, product codes and iterative decoding, concatenated convolutional codes, UMTS Turbo code, serial and parallel concatenation, turbo decoding	**9**
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL45G	DIGITAL VIDEO PROCESSING	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23ECL20E – Signals and Systems
23ECL30B – Digital Signal Processing

ii. COURSE OVERVIEW

This course focuses on the analysis, compression, and enhancement of digital video signals using advanced signal processing techniques. The course covers video representation, motion estimation, and modern coding standards like MPEG and H.264/HEVC. Students learn to design and implement video processing algorithms for applications in streaming, broadcasting, and computer vision.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Represent digital video signals using appropriate sampling, colour models, and mathematical formulations.	Understand
CO 2	Apply motion estimation and motion compensation techniques for digital video signals.	Apply
CO 3	Apply various video compression techniques using transform, predictive, and entropy coding methods.	Apply
CO 4	Explain the different types of video coding standards.	Understand
CO 5	Explain video processing applications for real-world domains such as streaming, broadcasting, and surveillance.	Understand

iv. SYLLABUS

Fundamentals of video signals, including analog and digital video concepts, major video formats and standards (NTSC, PAL, HDTV), and sampling principles across spatial and temporal domains, colour models - RGB, YUV, and YCbCr.

Motion estimation and compensation techniques – motion analysis in image sequences, block matching, optical flow, global motion models, and motion-compensated prediction.

Video compression techniques- redundancy reduction, intra-frame and inter-frame coding, transform and entropy coding, and hybrid predictive models

Video coding standards - MPEG-1/2/4, H.261–H.265 (HEVC), AV1 and VVC (H.266).

Video processing applications – video restoration, enhancement, segmentation, object tracking, streaming, transmission, and quality assessment metrics (PSNR, SSIM, VMAF), with applications in surveillance, broadcasting, and computer vision.

v (a) TEXT BOOKS

1. Yao Wang, Joern Ostermann, and Ya-Qin Zhang, Video Processing and Communications, Prentice Hall, 2001.
2. M. Tekalp, Digital Video Processing. Signal Processing Series, Prentice Hall, 2015 (2nd edition).
3. Alan C. Bovik (Ed.), The Essential Guide to Video Processing, Academic Press, 2nd Edition, 2009.
4. Yao Wang, Joern Ostermann, and Ya-Qin Zhang, Video Processing and Communications, Prentice Hall, 2002.

(b) REFERENCES

1. R. C. Gonzalez and R. E. Woods, Digital Image Processing, 4th Edition, Pearson, 2018.
2. Iain E. Richardson, H.264 and MPEG-4 Video Compression, Wiley, 2003.
3. Alan C. Bovik (Ed.), Handbook of Image and Video Processing, Academic Press, 2020.

vi. COURSE PLAN

Module	Contents	Hours
I	Fundamentals of Video Signals– Image formation, Image filtering, Analog and digital video fundamentals, Video formats and standards (NTSC, PAL, HDTV, etc.), Sampling of video signals: spatial and temporal aspects, Colour models: RGB, YUV, YCbCr models, Human visual system and perceptual aspects	9
II	Motion Estimation and Compensation - Motion in image sequences, Block matching algorithms, Optical flow estimation, Global motion models and affine transformations, Motion-compensated prediction and frame interpolation	9
III	Video Compression Techniques - Need for video compression and redundancy reduction, Intra-frame vs. inter-frame coding, Transform coding (DCT, Wavelets), Entropy coding (Huffman, Arithmetic, CABAC), Overview of predictive and hybrid video coding	10
IV	**Video Coding Standards -** Architecture and tools of MPEG-1, MPEG-2 and MPEG-4, H.261, H.263, H.264/AVC, and H.265/HEVC standards, Scalable and multiview video coding, AV1, VVC (H.266)	10
V	**Video Processing Applications -** Video restoration and enhancement, Video segmentation and object tracking, Video	8

	streaming and transmission over networks, Quality assessment metrics (PSNR, SSIM, VMAF), Applications in surveillance, broadcasting, and computer vision	
	Total Hours	**45**

Simulation assignments using MATLAB or Python may be included from any one of the topics below.

1. Reading and playing different video standards
2. Motion estimation
3. Video compression techniques
4. Segmentation
5. Enhancement

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

PROGRAMME ELECTIVE - VI

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL46A	INTRODUCTION TO QUEUING THEORY	PEC	2	1	0	0	3	2023

i. PREREQUISITE : 23MAL20C - Probability, Random Processes and Numerical Methods

ii. COURSE OVERVIEW

This course introduces the basic principles of queueing theory for analyzing waiting line systems. It covers classical Markovian and non-Markovian queueing models, key performance measures, and special queueing systems, with applications in communication, computer, manufacturing, and service systems.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the concepts of queueing system characteristics.	Understand
CO 2	Analyze Markovian queueing models and compute key performance measures.	Apply
CO 3	Analyze non-Markovian queueing model using embedded Markov chain techniques.	Apply
CO 4	Evaluate special queueing systems such as priority queues, finite capacity queues, and queues with vacations.	Apply
CO 5	Describe the application of queueing theory concepts in computer networking and communication systems	Understand

iv. SYLLABUS

Fundamentals of Queueing

Introduction to queueing systems, structure of a queue, performance measures, Little's Law, Poisson process, and exponential distribution.

Markovian Birth–Death and M/M/1 Queue

Markovian queueing systems, M/M/1 model, steady-state analysis, and performance measures.

Multi-Server and Special Models

M/M/c and M/M/∞ queues, comparison of single and multi-server systems, and introduction to queueing networks.

Finite Capacity and Priority Queues

M/M/1/K, M/M/c/K models, preemptive and non-preemptive priority queues, and

applications.

General Queueing Models and Vacation Queues

Limitations of Markovian models, M/G/1 queues and queues with server vacations.

v (a) TEXT BOOKS

1. J.F. Shortle, J.M. Thompson, D. Gross and C.M. Harris, Fundamentals of Queueing Theory, 5th Edition, Wiley, 2018.
2. J. Medhi, Stochastic Models in Queueing Theory, 2nd Edition, Academic Press, 2003
3. U.N. Bhat, An Introduction to Queueing Theory, Springer, 2015
4. D. Gross and C. Harris, Introduction to Queueing Theory, 3rd Edition, Wiley, 1998 (WSE Edition, 2004)

(b) REFERENCES

1. S.K. Bose, An Introduction to Queueing Systems, Springer, 2002.
2. R.B. Cooper, Introduction to Queueing Theory, 2nd Edition, North Holland, 1981
3. L. Kleinrock, Queueing Systems, Vol. I: Theory, Wiley, 1975.

vi. COURSE PLAN

Module	Contents	Hours
I	**Fundamentals of Queueing** Introduction to queueing systems and their importance in communication, computer, manufacturing, and service systems. Structure of a queue: study of arrival process (deterministic, Poisson, batch), service process (deterministic, exponential, general), and queue discipline (FCFS, LCFS, priority, round-robin). Performance measures: average number of customers in the system (L), average number in the queue (Lq), average waiting time in the system (W), average waiting time in the queue (Wq), server utilization, and system throughput. Little's Law, applications and limitations.	9
II	**Markov's Birth–Death Process and M/M/1 Queue** Analysis of Markovian queueing systems with Poisson arrivals and exponential service times. M/M/1 queue: steady-state probabilities and performance measures. Computation of key performance measures: L, Lq, W, Wq, server utilization and system throughput.	9
III	**Multi-Server and Special Models** Application of multi-server queueing models to real systems.	9

	M/M/c queue: performance analysis and computation of system measures. M/M/∞ queue: modeling of infinite server systems and practical applications. Comparison of single-server and multi-server queueing systems based on waiting time, utilization and throughput. Introduction to basic queueing networks and their applications in communication and computer systems.	
IV	**Finite Capacity and Priority Queueing Systems** M/M/1/K queue (finite buffer system): blocking probability and throughput analysis. M/M/c/K queue: basic model and performance concepts. Priority queues: preemptive and non-preemptive priority disciplines and their performance impact. Applications of finite capacity and priority queueing systems in real-world scenarios.	9
V	**General Queueing Models and Vacation Queues** Limitations of Markovian assumptions in practical systems. M/G/1 queue: general service time distribution, Pollaczek–Khinchine (P–K) formula, and performance measures. Queues with vacations: concept of server vacations, types (single, multiple, limited) and their impact on system performance measures.	9
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL46B	COMPUTER VISION	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23ECL30B – Digital Signal Processing

ii. COURSE OVERVIEW

This course provides a comprehensive study of digital image processing, covering filtering, morphological operations, object labelling, and shape descriptors for image analysis. It introduces feature detection, edge and corner detection, segmentation, texture analysis, motion estimation, and 3D shape recovery techniques. Advanced topics include object and face recognition using statistical and machine learning methods, with applications in real-time systems such as in-vehicle vision.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply image processing and morphological techniques for image enhancement, segmentation, and object analysis.	Apply
CO 2	Analyze features using shape descriptors, transformations, and advanced recognition and detection techniques.	Apply
CO 3	Explain scale-space analysis, and segmentation techniques for texture analysis and object detection.	Understand
CO 4	Describe shape-from-X and motion analysis techniques for 3D shape and motion estimation.	Understand
CO 5	Explain object and face recognition techniques for scene analysis and real-time applications.	Understand

iv. SYLLABUS

Review of image processing techniques - Digital filters, Mathematical morphology, opening and closing operations, connectedness, object labelling and counting,

Boundary descriptors – Chain codes. Properties of Binary Regions, Transformation: Orthogonal, Euclidean, Affine, Projective.

Feature Detection and Image Synthesis, Edge, line and corner detection, segmentation - Normalized cuts, Graph cuts, energy-based methods. Texture Segmentation; Object detection

Shape from X, Photometric stereo, Texture Occluding contour detection. Motion Analysis, Optical Flow, Structure from motion,

Object recognition, Baye’s rule and ML methods. Eigen faces,Face detection, Face

recognition, Application, Examples of real time applications: In-vehicle vision system.

v (a) TEXT BOOKS

1. E. R .Davies, Computer and Machine Vision – Theory Algorithm and Practicalities, Academic Press, 2012.
2. Richard Szeliski, Computer Vision: Algorithms and Applications, ISBN 978-1-84882-935-0, Springer 2011.
3. David Forsyth and Jean Ponce, Computer Vision: A Modern Approach, Pearson India, 2002.
4. R. J. Schalkoff, Digital Image Processing and Computer Vision, John Wiley, 2004.

(b) REFERENCES

1. Simon J D Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press, 2012.
2. Daniel Lelis Baggio, Khvedchenia Ievgen, Shervin Emam, David Millan Escriva, Naureen Mahmoo, Jason Saragi, Roy Shilkrot, Mastering OpenCV with Practical Computer Vision Projects, Packt Publishing Limited, 2012.
3. D. L. Baggio et al., —Mastering OpenCV with Practical Computer Vision Projects, Packt Publishing, 2012.
4. Jan Erik Solem, —Programming Computer Vision with Python: Tools and algorithms for analyzing images‖, O'Reilly Media, 2012.

vi. COURSE PLAN

Module	Contents	Hours
I	Review of image processing techniques – Digital filters, linear filters. Homomorphic filtering, Mathematical morphology, Binary shape analysis, Erosion, Dilation, Opening and Closing, Hit-or-Miss Transform. Neighbours, Connectedness, object labelling and counting,	8
II	Boundary descriptors – Chain codes. Properties of Binary Regions, Geometric Features, Statistical Shape Properties. Transformation: Orthogonal, Euclidean, Affine, Projective. Feature Detection - Edge detection - active contours, Canny, LOG, DOG; Line detectors - Hough Transform, Corner detection - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH.	10
III	Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT. Segmentation - Split and merge, Mean shift and mode finding, Normalized cuts, Graph cuts, MRFs, energy-based methods-Cranny's Algorithm, Texture Segmentation; Object detection	9

IV	Shape from X – Shape from shading, Photometric stereo, Texture Occluding contour detection. Motion Analysis-Regularization theory, Optical Flow: brightness constancy equation, aperture problem, Horn-Shunck method, Lucas-Kanade method. Structure from motion	9
V	Object recognition – Shape correspondence and shape matching PCA, SVM, LDA, Baye's rule and ML methods. Eigen faces, Face detection, Face recognition, Application: Scene analysis. Examples of real time applications: In-vehicle vision system.	9
	Total Hours	**45**

Simulation assignments using MATLAB or OpenCV may be included from any one of the topics below.

1. Image processing algorithms
2. Image morphology
3. Feature detection
4. Motion estimation
5. Segmentation

vii. ASSESSMENTPATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL46C	NEXT GENERATION WIRELESS COMMUNICATION SYSTEMS	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23ECL30A - Analog and Digital Communication

ii. COURSE OVERVIEW

This course aims to impart knowledge on the basics of modern communication systems and the breakthrough wireless technologies.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply multicarrier modulation and multiple access techniques to compare the performance of broadband wireless communication systems.	Apply
CO 2	Apply millimeter wave propagation principles, advanced multiple access techniques, and IRS-assisted communication concepts to analyze next-generation (5G/6G) wireless systems.	Apply
CO 3	Explain the IoT architecture and various connectivity technologies used in IoT Systems	Understand
CO 4	Explain various communication standards for connected autonomous vehicles.	Understand
CO 5	Explain the significance and architecture of software defined radio and cognitive radio.	Understand

iv. SYLLABUS

Need for multicarrier communication systems. Multiple access techniques in multicarrier systems: Orthogonal Frequency Division Multiple Access (OFDMA) and Single Carrier Frequency Division Multiple Access (SC-FDMA)

5G New Radio (NR) architecture. Advanced Multiple Access and Spatial Techniques, Advanced Modulation and Signaling, Millimeter Wave Communication- Propagation characteristics, Channel behavior at 60 GHz, Reconfigurable and Intelligent Wireless

Environments, Beamforming concepts. Beyond 5G and 6G Networks

Introduction of IoT, physical and logical design of IoT, Wireless Sensor networks, Cloud computing. Introduction to IoT, IoT Networking Components. IoT Connectivity Technologies, IoT Communication Technologies, Data Protocols, IoT Case Studies and Future Trends

Introduction to Intelligent Vehicular Communication – Evolution, Vehicular Networks and ITS, Vehicular Communication Standards/ Technologies – DSRC, IEEE 802.11p WAVE, IEEE 1609, IEEE 802.15.7 - Visible Light Communication (VLC), 4G/5G-Device to Device (D2D), 6G Cellular Networks and Connected Autonomous Vehicles.

Software radio concepts, Transmitter and Receiver specifications of SDR, Architecture of SDR, Introduction of cognitive radio, significance of cognitive radio and spectrum subleasing, spectrum sharing in cognitive radio, implementation of cognitive radio.

v (a) TEXT BOOKS

1. Aditya K. Jagannatham, “Principles of Modern Wireless Communication Systems”, Tata McGraw Hill, 2016.
2. T.L. Singal, “Wireless Communications”, Tata McGraw Hill Education Private Limited, Second Edition, 2011.
3. K. C. Huang, Z. Wang, “Millimeter Wave Communication systems”, John Wiley & Sons.
4. Sudip Misra, Anandarup Mukherjee & Arijit Roy. “Introduction to IoT”. Cambridge University Press. 2021.
5. George J. Dimitrakopoulos. “Current Technologies in Vehicular Communication”, Springer International Publishing, 2017.
6. He, J., Yang, K. and Chen, H.H, “6G Cellular Networks and Connected Autonomous Vehicles”, IEEE Network, vol. 35, no. 4, pp. 255 -261, 2020.
7. Walter Tuttlebee, “SDR Enabling Technologies”, John Wiley. 2002
8. Huseyin Arslan, “Cognitive Radio, SDR and Adaptive Wireless System”, Springer, 2007.

(b) REFERENCES

1. Dipankar Raychaudhuri, Mario Gerla, “Emerging Wireless Technologies and the Future Mobile Internet”, Cambridge University Press, 2011.
2. Arshdeep Bahga, A., & Vijay Madisetti V. “Internet of Things: A hands-on approach”. Vpt., 2014.
3. Paul, A., Chilamkurti, N., Daniel, A. and Rho, S. “Intelligent vehicular networks and communications: fundamentals, architectures and solutions”, Elsevier, 2016.
4. Peter B. Kenington, “RF and baseband techniques for software defined radio”, Artech House Mobile Communication, 2005.
5. Qingqing Wu , Xinrong Guan, Meng Hua “Intelligent Reflecting Surface For B5G/6G Wireless Networks”, Springer International Publishing AG,2023.

6. Liu, Y., Liu, L., Ding, Z., and Shen, X. S., “Next Generation Multiple Access (NGMA) for 6G”, *Wiley-IEEE Press*, 1st ed., pp. 1-450, 2024.

vi. COURSE PLAN

Module	Contents	Hours
I	Need for multicarrier communication systems. Multiple access techniques in multicarrier systems: Orthogonal Frequency Division Multiple Access (OFDMA) and Single Carrier Frequency Division Multiple Access (SC-FDMA) — operating principles, resource allocation, uplink and downlink transmission, and comparative performance analysis.	9
II	Evolution from OFDM-based systems to 5G New Radio (NR) architecture. Advanced Multiple Access and Spatial Techniques-NOMA, SDMA, RSMA. Advanced Modulation and Signaling-OTFS. Millimeter Wave Communication- Propagation characteristics, Channel behavior at 60 GHz, Deployment challenges in indoor and outdoor environments. Reconfigurable and Intelligent Wireless Environments-Structure, Working principle, Beamforming concepts, Performance enhancement in wireless systems. Beyond 5G and 6G Networks-use cases and technologies	10
III	Introduction of IoT, characteristics, physical and logical design of IoT, IoT Enabling Technologies – Wireless Sensor networks, Cloud computing. Introduction to IoT, Evolution of IoT, IoT Networking Components. IoT Connectivity Technologies – Zigbee, Wireless HART, RFID, NFC, LoRa, WiFi, Bluetooth. IoT Communication Technologies – Infrastructure Protocols – IPv6, 6LoWPAN, Data Protocols – MQTT, MQTT-SN, CoAP. IoT Case Studies and Future Trends – Agricultural IoT, Vehicular IoT, Healthcare IoT.	8
IV	Introduction to Intelligent Vehicular Communication – Evolution, Vehicular Networks and ITS, Vehicular Communication Standards/ Technologies – DSRC, IEEE 802.11p WAVE, IEEE 1609, IEEE 802.15.7 - Visible Light Communication (VLC), 4G/5G-Device to Device (D2D), 6G Cellular Networks and Connected Autonomous Vehicles, Operational Scenario – Collision Avoidance.	8
V	Software radio concepts, Operating frequency bands, Transmitter and Receiver specifications of SDR, Architecture of SDR, Introduction of cognitive radio, significance of cognitive radio and spectrum subleasing, spectrum sharing in cognitive radio, implementation of cognitive radio	10
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL46D	MICROWAVE DEVICES AND CIRCUITS	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23ECL30C- Electromagnetic Field Theory
23ECL20A- Analog Circuits

ii. COURSE OVERVIEW

This course aims to understand the concepts of active and passive microwave semiconductor devices, components, microwave sources and amplifiers used in microwave communication systems and the analysis of microwave networks and microwave integrated circuits.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the operation and characteristics of microwave diodes and transistors used for generation and amplification.	Understand
CO 2	Design of Bipolar transistors, MESFET, Microwave amplifiers and oscillator.	Apply
CO 3	Apply microwave network parameters and signal flow graphs to analyze circuits and perform impedance matching using stub tuning and quarter-wave transformers.	Apply
CO 4	Design Microwave filters using image parameter and insertion loss method transformation and implement them using filter transformation techniques.	Apply
CO 5	Explain different MICs, Distributed and lumped elements of integrated circuits, Diode control devices.	Understand

iv. SYLLABUS

Introduction, Characteristic, features of microwaves, Power output and efficiency of IMPATT and TRAPATT diodes. Structure and Operation of Bipolar transistors, FET and MESFET.

Microwave amplifiers gain and stability, Design of single stage transistor amplifier, Oscillator- Design of One port negative resistance oscillators.

Microwave Network Analysis, Equivalent voltages and currents, Impedance and Admittance matrices, Scattering matrix, The transmission matrix Signal flow graphs. Impedance matching and tuning– Matching with lumped elements, Single stub tuning, Double stub tuning. Quarter wave transformer, Theory of small reflections.

Microwave filters, Filter design by image parameter method, Filter design by insertion loss method. Filter transformation and implementation.

Introduction to MICs, Distributed and lumped elements of integrated circuits, Diode control devices, Diode phase shifter, Circulators and isolators.

v (a) TEXT BOOKS

1. David M. Pozar, Microwave Engineering,4/e, Wiley India,2012.
2. Robert E.Collin, Foundation of Microwave Engineering,2/e,Wiley India, 2012.
3. Samuel Y. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003.

(b) REFERENCES

1. Bharathi Bhat and Shiban K. Koul: Stripline-like Transmission Lines for MIC, New Age International (P) Ltd, 2007.
2. I. Kneppo, J. Fabian, et al., Microwave Integrated Circuits, BSP, India, 2006.
3. Leo Maloratsky, Passive RF and Microwave Integrated Circuits, Elsevier, 2006.

vi. COURSE PLAN

Module	Contents	Hours
I	Microwave generation and amplification. Structure,Operation, Power output and efficiency of IMPATT and TRAPATT diodes. Bipolar transistors – biasing, FET – biasing, MESFET – Structure, Operation.	9
II	Microwave amplifiers and oscillators – Amplifiers: Gain and stability, single-stage transistor amplifier design. Oscillator design – One-port negative resistance oscillators.	9
III	Microwave Network Analysis – Equivalent voltages and currents, Impedance and Admittance matrices, Scattering matrix, The transmission matrix Signal flow graphs. Impedance matching and tuning– Matching with lumped elements, Single stub tuning, Double stub tuning. Quarter wave transformer, Theory of small reflections	9
IV	Microwave filters, periodic structures, and analysis of periodic structures. Filter design by image parameter method – Constant-k, m-derived, and composite filters. Filter design by insertion loss method. Filter transformation and implementation.	9
V	Introduction to MICs: Technology of hybrid MICs and monolithic MICs. Comparison of both MICs. Planar transmission lines such as stripline, microstrip line, and slotline. Distributed and lumped elements of integrated circuits—	9

	capacitors, inductors, resistors, terminations, attenuators, resonators, and discontinuities. Diode control devices—switches, attenuators, and limiters. Diode phase shifter. Circulators and isolators.	
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL46E	NANOELECTRONICS	PEC	3	0	0	0	3	2023

i . PREREQUISITE : 23PYL10A - Engineering Physics,
23ECL20B- Solid State Devices

ii. COURSE OVERVIEW

The goal of this course is to introduce the students to the fundamental concepts of nanoelectronics devices and materials.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the fundamental concepts associated with low-dimensional semiconductors.	Understand
CO 2	Describe the characteristics of different quantum well structures.	Understand
CO 3	Describe the carrier transport mechanisms in different nanostructures.	Understand
CO 4	Discuss the structure and operation of various nanoelectronic devices.	Understand
CO 5	Explain the fabrication methods and characterization tools for nanomaterials.	Understand

iv. SYLLABUS

Introduction to nanotechnology - Limitations of conventional microelectronics, Characteristic lengths in mesoscopic systems, Quantum mechanical coherence. Low dimensional structures - Quantum wells, wires and dots, DOS and dimensionality.

Heterojunctions and Quantum wells - Basic properties of quantum wells, Modulation doped quantum wells, Multiple quantum wells, concept of superlattices, Kronig - Penney model of superlattice.

Transport of charge under electric field: Parallel transport - Electron scattering mechanisms, MODFETS, Hot electron transistors. Perpendicular Transport - Resonant tunnelling transport and Resonant Tunneling devices.

Quantum Transport - Coulomb blockade effect, Structure and operation of Single Electron Transistor. Transport of charge under magnetic field - Effect of magnetic field on a crystal, Aharonov-Bohm effect, Shubnikov-de Hass effect.

Optoelectronic nanostructure devices - Heterostructure semiconductor laser, Quantum well laser, quantum dot LED, quantum dot laser. Introduction to fabrication methods:

Deposition techniques, Ion Implantation, Sol Gel, Fabrication of quantum dots. Introduction to characterization tools: Principle of operation of various microscopes.

v (a) TEXT BOOKS

1. J.M. Martinez-Duart, R.J. Martin Palma, F. Agulle Rueda, Nanotechnology for Microelectronics and optoelectronics, Elsevier, 2006.
2. W.R. Fahrner, Nanotechnology and Nanoelectronics, Springer, 2005
3. Chattopadhyay, Banerjee, Introduction to Nanoscience and Technology, PHI, 2012.

(b) REFERENCES

1. George W. Hanson, Fundamentals of Nanoelectronics, Pearson Education, 2009.
2. Murty, Shankar, Text book of Nanoscience and Nanotechnology, Universities Press, 2012.
3. Supriyo Dutta, Quantum Transport - Atom to transistor, Cambridge, 2013.
4. Angsuman Sarkar, Chandan Kumar Sarkar, Arpan Deyasi, Debashis De, Arezki Benfdila, “Nanoelectronics: Physics, Materials and Devices”, Elsevier, 1st Ed., 2023.
6. Vinod Kumar Khanna, “Introductory Nanoelectronics: Physical Theory and Device Analysis”, CRC Press, Boca Raton, FL, USA, 2020.

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to nanotechnology -** Limitations of conventional microelectronics, Characteristic lengths in mesoscopic systems, Quantum mechanical coherence. **Low dimensional structures** - Quantum wells, wires and dots, DOS and dimensionality - Density of states of 1D and 2D nanostructures.	9
II	**Heterojunctions and Quantum wells -** Basic properties of square quantum wells of finite depth, parabolic and triangular quantum wells, Modulation doped quantum wells, Multiple quantum wells concept of superlattices, Kronig - Penney model of superlattice, Zone folding	9
III	**Transport of charge under electric field: Parallel transport -** Electron scattering mechanisms, Structure and operation of MODFETS, Hot electrons, Hot electron transistors. **Perpendicular Transport** - Resonant tunnelling transport, Working principle of Resonant Tunneling Diode, Resonant Tunneling Transistors Carbon Nanotubes (CNT) transistors, Properties of Graphene.	9
IV	**Quantum Transport -** Coulomb blockade effect, Structure and operation of Single Electron Transistor. **Transport of charge under magnetic field** - Effect of	9

	magnetic field on a crystal, Aharonov-Bohm effect, Shubnikov-de Hass effect. **Optoelectronic nanostructure devices** - Heterostructure semiconductor laser, Quantum well laser, quantum dot LED, quantum dot laser.	
V	**Introduction to fabrication methods:** Physical vapour deposition, Laser ablation, Chemical vapour deposition, Molecular Beam Epitaxy, Ion Implantation, Sol Gel, Fabrication of quantum dots. **Introduction to characterization tools:** Principle of operation of Scanning Tunnelling Microscope, Atomic Force Microscope, Scanning Electron microscope, Transmission Electron Microscope	9
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL46F	INSTRUMENTATION	PEC	3	0	0	0	3	2023

i. PREREQUISITE : NIL

ii. COURSE OVERVIEW

This course aims to introduce the basic concepts of electronic measuring instruments for measuring physical variables using transducers and to familiarize the concepts of the control systems PLC, DCS and SCADA.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Interpret the basic concepts of measuring instruments, it's classification, and measurement of resistance, Capacitance, inductance and frequency.	Understand
CO 2	Explain the principle, construction and working of transducers for measuring physical variables.	Understand
CO 3	Explain the principle, construction and working of various electronic measuring instruments	Understand
CO 4	Explain the hardware architecture for PLC, DCS and SCADA.	Understand
CO 5	Apply PLC programming for basic applications	Apply

iv. SYLLABUS

Generalized Configurations and Functional elements of Instrumentation systems. Need for Measurement Systems, Classification of Types of Measuring instruments. Measurement of R, L, C and frequency.

Sensors and Transducers: - Need, Classification and selection criteria. Transducer: Principles of operation, construction, applications of Resistive Transducers, Inductive Transducers, and Capacitive Transducers: Active Transducers: Thermocouple, Piezo-electric transducer, Hall Effect transducer, Flow meter.

Electronic Measuring Instruments Digital storage oscilloscope, Working principle and applications of waveform analyser, digital frequency meter, harmonic distortion meter, harmonic analyser, spectrum analyser.

Grounding and Shielding PLC, DCS and SCADA PLC Basics: General PLC Programming Procedures, Distributed Control System; hardware components of DCS; DCS software. Introduction to SCADA: overview, Architecture – Monolithic, Distributed and Networked, SCADA Protocols.

PLC Programming Basic PLC Programming : Programming ON/OFF Inputs, Creating Ladder diagrams, Register Basics, PLC Timers and Counters, PLC Arithmetic functions, Number comparison functions, Data handling Functions: master control relay function and applications; jump with non-return and return; data table, register and other move functions

v (a) TEXT BOOKS

1. Ernest Doebelin, Dhanesh N. Manik, „Doebelin's Measurement Systems", McGraw Hill, 7th Edition, 2019
2. Kalsi HS, "Electronic Instrumentation," Tata McGraw Hill, 4th Edition
3. J. R. Hackworth and F. D. Hackworth Jr., Programmable Logic Controllers: Programming Methods and Applications, Pearson Education, 2004

(b) REFERENCES

1. Sawhney, A. K. (2020). A Course in Electrical and Electronic Measurements and Instrumentation (19th ed.). Dhanpat Rai & Co.
2. Webb, J. W., & Reis, R. A. (2016). Programmable Logic Controllers: Principles and Applications (5th ed.). PHI Learning.

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to measuring instruments:** Generalized Configurations and Functional elements of Instrumentation systems. Need for Measurement Systems, Classification of Types of Measuring instruments. Static and Dynamic characteristics of measuring instruments. Measurement of Resistance - Wheatstone's Bridge, Kelvin's Double Bridge (Simple Problems). Measurement of Inductance - Maxwell's Inductance Bridge, Measurement of Capacitance - Schering's Bridge Measurement of Frequency- Wien Bridge (Simple Problems) Q-meter.	8
II	**Transducers:** Sensors and Transducers: - Need, Classification and selection criteria. Resistive Transducers: Potentiometers, strain gauges, (metallic and semi-conductor type), Thermistors. Inductive Transducers: LVDT (Linear variable differential transformer). Capacitive Transducers: Variable Distance Type, Variable Area Type, Variable Dielectric Constant Type, Active Transducers: Thermocouple, Piezo-electric transducer, Hall Effect transducer.	9
III	**Electronic Instruments:** Static and Dynamic characteristics of	8

	measuring instruments. Working Principle and Applications of Digital Storage Oscilloscope, waveform analyser, digital frequency meter, harmonic distortion meter, harmonic analyser and spectrum Analyser, Introduction to Virtual Instrumentation. (Case study)	
IV	**Programmable Logic Controller:** Introduction to PLCs, General PLC Programming Procedures, Devices to which PLC Inputs and Outputs are connected. **Distributed Control System:** Meaning and necessity of distributed control, hardware components of DCS, DCS software. **SCADA Systems:** Introduction to SCADA, SCADA overview, SCADA Architecture – Monolithic, Distributed and Networked, SCADA Protocols- IEC 60870- 5-101, DNP-3, Profibus, Modbus.	10
V	**PLC Programming:** Programming ON/OFF Inputs, Creating Ladder diagrams, Register Basics, PLC Timers and Counters, PLC Arithmetic functions, Number comparison functions. **Data handling Functions:** Skip function and applications; master control relay function and applications, jump with non-return and return, data table, register and other move functions	10
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL46G	ANALOG CMOS DESIGN	PEC	3	0	0	0	3	2023

i. PREREQUISITE : 23ECL20A – Analog Circuits,
23ECL20B – Solid State Devices

ii. COURSE OVERVIEW

This course aims to impart the basic knowledge of CMOS analog circuits design and enable the students to design integrated circuits.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Design differential amplifiers and various types of current mirrors.	Apply
CO 2	Apply the design and frequency response concepts of single-stage, differential, and CMOS operational amplifiers.	Apply
CO 3	Apply the concepts of noise in single-stage and differential amplifiers.	Apply
CO 4	Explain the concepts of Phase Locked Loops (PLL) in basic applications.	Understand

iv. SYLLABUS

Differential Amplifiers - Single-ended and differential operation, Basic differential pair, Common-mode response, Differential pair with MOS load, differential pair with active load. Current Mirror - Simple, Cascode and Basic concepts of active current mirror.

CMOS operational Amplifiers - Design of CMOS Op Amps, Compensation of Op Amps, Design of two-stage Op Amps, power-supply rejection ratio of two-stage Op Amps.

Frequency Response of Amplifiers - Miller Effect, Poles and Zeros, Frequency response analysis of Common Source, Source Follower, Common Gate and Differential Pair.

Noise in Amplifiers - Noise in Single Stage amplifier (CS, CG, Source Follower, Cascode Stage), Noise in Differential Pair, Noise bandwidth.

Phase Locked Loops (PLL) – Basic PLL topology, Type I and Type II (charge pump) PLL, non-ideal effects in PLL, applications of PLL (frequency multiplication, frequency synthesizer, skew reduction),jitter reduction.

v (a) TEXT BOOKS

1. Behzad Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill, 2/e, 2002.
2. Phillip E. Allen, Douglas R. Holberg, CMOS Analog Circuit Design, Oxford Univ Press 3/e, 2012.

(b) REFERENCES

1. Razavi Behzad, Fundamentals of Microelectronics, Wiley 2/e, 2013.
2. Baker, Li, Boyce, CMOS: Circuits Design, Layout and Simulation, IEEE; 3/e, 2010.

vi. COURSE PLAN

Module	Contents	Hours
I	**Differential Amplifiers and Current Mirrors** – Single-ended and differential operation, Basic differential pair, Common-mode response, Differential pair with MOS load, differential pair with active load. Current Mirror – Simple, Cascode and basic concepts of active current mirror.	10
II	**CMOS Operational Amplifiers -** Design of CMOS Op Amps, Compensation of Op Amps, Design of two-stage Op Amps, power-supply rejection ratio of two-stage Op Amps.	9
III	**Frequency Response of Amplifiers** – Miller Effect, Poles and Zeros, Frequency response analysis of Common Source, Source Follower, Common Gate and Differential Pair.	9
IV	**Noise in Amplifiers** – Noise in single-stage amplifier - Common Source , Common Gate , Source Followers , Cascode Stage, Noise in differential pair, Noise bandwidth.	8
V	**Phase Locked Loops (PLL)** – Basic PLL topology, Type I and Type II (charge pump) PLL, non-ideal effects in PLL, applications of PLL such as frequency multiplication, frequency synthesizer and skew reduction, jitter reduction.	9
	Total Hours	**45**

Simulation Assignment:

Simulation assignments using Cadence EDA tool may be included from any one of the topics below.

1. Simulation of Common Source Amplifier.
2. Simulation of Common Gate Amplifier.
3. Simulation of Common Drain Amplifier.
4. Simulation of Differential Amplifier.
5. Simulation of two stage Operational Amplifier.

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½ hours
- Topics : 2½ modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

MINOR

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECJ4MX	MINIPROJECT	VAC (Minor)	0	0	6	0	3	2023

i. COURSE OVERVIEW

The course encourages students to apply the concepts, methods, and tools learned to solve real-world or socially relevant problems. The course also emphasizes innovation, and critical thinking, encouraging students to explore new ideas and technologies. The mini project topic selected will be assigned to a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. It helps students develop skills in teamwork, project planning, technical documentation, and communication.

ii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Identify real life engineering problems that are socially relevant, technically feasible and economically viable.	Apply
CO 2	Design proper scientific methodology to successfully complete the project	Apply
CO 3	Develop solutions to socially relevant practical problems by applying suitable scientific tools	Apply
CO 4	Evaluate the performance of the developed solution using suitable data analysis, validation techniques, and engineering judgement.	Evaluate
CO 5	Prepare a technical report and present the project outcomes effectively using appropriate engineering and communication tools	Apply
CO 6	Build the culture of working effectively in a team, upholding professional and ethical responsibilities	Apply

iii. COURSE OUTCOMES

In this course, each group consisting of a maximum of four members is expected to identify a topic of interest in consultation with Faculty-in-charge of mini project, review the literature and gather information pertaining to the chosen topic, state the objectives and develop a methodology to achieve the objectives. Execute experimental procedure, design/fabrication or develop codes/programs or conduct case studies to achieve the objectives. Demonstrate the novelty of the project through the results and outcomes. The progress of the mini project is evaluated based on a minimum of two

reviews. The review committee may be constituted by the Head of the Department. A project report is submitted by each student at the end of the semester.

iv. ASSESSMENT SCHEME

The final evaluation will be conducted as an internal evaluation based on the level of objectives achieved, the report and a viva-voce examination, conducted by a 3-member committee appointed by Head of the Department offering minor. The committee members shall be HoD or a senior faculty member, Mini project coordinator and project supervisor. The Committee will evaluate the level of completion and demonstration of functionality/specifications, presentation, oral examination, working knowledge and involvement. The progress of the mini project is evaluated through a minimum of TWO reviews. At the time of the 1st review, students are expected to propose a methodology to achieve the objectives after completing a thorough literature study of the existing systems under their chosen area. In the 2nd review students are expected to highlight the implementation details of the proposed solution.

iv. ASSESSMENT PATTERN

Continuous Assessment : Final Assessment – 70 : 30

Continuous Assessment		
Project Progress Evaluation by Guide	:	20 marks
Interim Evaluation -1 by Evaluation Committee	:	15 marks
Interim Evaluation -2 by Evaluation Committee	:	15 marks
Quality of the report evaluated by Evaluation Committee	:	20 marks
Total Continuous Assessment	**:**	**70 marks**
Final Assessment (Final Evaluation by Final Evaluation Committee)	**:**	**30 marks**
TOTAL	**:**	**100 marks**

Total: 100 marks (Minimum required to pass: 50 Marks)

HONOURS

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL4HA	RF MEMS	VAC (Honours)	3	0	0	0	3	2023

i. PREREQUISITE : Nil

ii.COURSE OVERVIEW

This course introduces students to the rapidly emerging, area of MEMS with special emphasis on its applications in RF and wireless engineering.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe the various fabrication techniques, sensing and actuation mechanisms used in RF MEMS design.	Understand
CO 2	Apply the principles of RF MEMS switches to evaluate switching performance parameters and design circuit models for series and shunt switches	Apply
CO 3	Explain the principle of operation and types of micromachined passive elements.	Understand
CO 4	Describe the principle of operation and types of micromachined filters, phase shifters and antennas.	Understand
CO 5	Discuss the importance, types and reliability issues in RF MEMS packaging.	Understand

iv. SYLLABUS

Introduction to MEMS and RF MEMS, Microfabrication techniques for MEMS - surface micromachining, Bulk micromachining, LIGA, Electromechanical Transducers, Microsensing for MEMS, Materials for MEMS.

Evaluation of switching performance parameters, Switches for RF and Microwave applications – PIN diode RF switches, RF MEMS switches, Integration and biasing issues for RF switches, Capacitive shunt and series switches - Physical description and circuit model, MEMS switch design considerations.

Micromachined inductors: Meander inductor, spiral inductor and solenoid inductors, Effect of inductor layout, folded inductors, variable inductors and polymer-based inductors. MEMS Capacitors: Gap-tuning and area tuning capacitors, dielectric tunable capacitors.

Principle of operation of micromachined filters, Surface acoustic wave filters, Micromachined filters for millimetre wave frequencies. Principle of operation of

micromachined phase shifters, MEMS phase shifters, Ferroelectric phase shifters.

Micromachining techniques to improve antenna performance, Micromachining as a fabrication process for small antennas, Micromachined reconfigurable antennas. Role of MEMS packages, types of MEMS packages, Reliability issues of RF MEMS packages.

v(a) TEXT BOOKS

1. Vijay Varadan, K. J. Vinoy, K. A. Jose, “RF MEMS and Their Applications”, Wiley, 2003.
2. Hector J. De Los Santos, “RF MEMS Circuit Design for Wireless Applications”, Artech House, 2002.

(b) REFERENCES

1. Gabriel M. Rebeiz, ″RF MEMS: Theory, Design, and Technology″, Wiley, 2003
2. Eun Sok Kim “Fundamentals of Micro electro mechanical Systems (MEMS)” McGraw Hill, 2021
3. Shiban K. Koul, Sukomal Dey, “Radio Frequency Micromachined Switches, Switching Networks, and Phase Shifters”, CRC Press, 2018.

vi. COURSE PLAN

Module	Contents	Hours
I	**MEMS and RF MEMS:** Introduction to MEMS and RF MEMS, Microfabrication techniques for MEMS - surface micromachining, Bulk micromachining, LIGA, Electromechanical transducers, microsensing for MEMS, Materials for MEMS.	9
II	**RF MEMS switches:** Evaluation of switching performance parameters, Switches for RF and Microwave applications – PIN diode RF switches, RF MEMS switches, Integration and biasing issues for RF switches, Capacitive shunt and series switches - physical description and circuit model, MEMS switch design considerations.	10
III	**Micromachined passive elements:** Micromachined inductors: Meander inductor, spiral inductor and solenoid inductors, Effect of inductor layout, folded inductors, variable inductors and polymer-based inductors MEMS Capacitors: Gap-tuning and area tuning capacitors, dielectric tunable capacitors.	10
IV	**Micromachined filters and Phase sifters:** Principle of operation of micromachined filters, Surface acoustic wave filters, Micromachined filters for millimetre wave frequencies.	8

	Principle of operation of micromachined phase shifters, MEMS phase shifters, Ferroelectric phase shifters	
V	**Micromachined antennas:** Micromachining techniques to improve antenna performance, fabrication process for small antennas, Micromachined reconfigurable antennas. **Integration and packaging of RF MEMS devices:** Role of MEMS packages, types of MEMS packages, reliability issues of RF MEMS packages	8
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL4HC	MIMO AND MULTIUSER COMMUNICATION SYSTEMS	VAC (Honour)	3	0	0	0	3	2023

i. PREREQUISITE : 23ECL30A – Analog and Digital Communication

ii. COURSE OVERVIEW

This course introduces Multiple Input Multiple Output (MIMO) communication techniques and multiuser communication strategies used in modern wireless systems. It covers MIMO channel modeling, spatial diversity, spatial multiplexing, multiuser detection, resource allocation, and applications in advanced cellular systems such as 4G and 5G networks.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Apply MIMO channel models and capacity concepts in wireless communication systems.	Apply
CO 2	Apply spatial diversity and spatial multiplexing techniques in MIMO systems.	Apply
CO 3	Apply signal detection and precoding techniques in MIMO communication systems.	Apply
CO 4	Apply multiuser detection and resource allocation techniques in wireless networks.	Apply
CO 5	Apply MIMO and multiuser communication concepts in modern cellular systems such as LTE and 5G.	Apply

iv. SYLLABUS

Fundamentals of MIMO communication including channel models, channel state information, and capacity analysis.

Spatial diversity techniques, Space-time block codes and space-time trellis codes

Spatial multiplexing and detection techniques including V-BLAST, Zero Forcing, MMSE, and maximum likelihood detection.

Multiuser communication concepts such as multiuser detection, interference management, and resource allocation.

Implementation of MIMO in modern wireless systems including LTE, 5G, massive MIMO, beamforming, and related applications.

v (a) TEXT BOOKS

1. Ezio Biglieri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj and H. Vincent Poor, *MIMO Wireless Communications*, Cambridge University Press, 2007.
2. Arogyaswami Paulraj, Rohit Nabar and Dhananjay Gore, *Introduction to Space-Time Wireless Communications*, Cambridge University Press, 2003.

(b) REFERENCES

1. David Tse and Pramod Viswanath, *Fundamentals of Wireless Communication*, Cambridge University Press, 2005.
2. Andrea Goldsmith, *Wireless Communications*, Cambridge University Press, 2005.
3. Erik G. Larsson and Ove Edfors, *Fundamentals of Massive MIMO*, Cambridge University Press, 2016.

vi. COURSE PLAN

Module	Contents	Hours
I	Introduction to MIMO systems. Advantages of MIMO in wireless communication. MIMO channel models and propagation characteristics. Narrowband and wideband MIMO channel models. Channel state information. Capacity of MIMO systems. Ergodic and outage capacity. Impact of fading and correlation.	**9**
II	Transmit and receive diversity techniques. Space-Time Block Codes (STBC). Alamouti scheme. Orthogonal space-time block codes. Space-Time Trellis Codes. Diversity gain and coding gain. Performance analysis of diversity techniques in fading channels.	**9**
III	Spatial multiplexing concepts. Vertical Bell Laboratories Layered Space-Time (V-BLAST) architecture. Linear detection techniques – Zero Forcing (ZF) and Minimum Mean Square Error (MMSE) detectors. Successive interference cancellation. Maximum likelihood detection. Precoding and beamforming techniques.	**9**
IV	Introduction to multiuser communication. Multiple access techniques. Uplink and downlink transmission models. Multiuser detection techniques. Linear and nonlinear detection methods. Power control and interference management. Resource allocation and scheduling algorithms.	**9**

V	MIMO in LTE and 5G systems. Massive MIMO concepts. Beamforming in 5G communication. Multiuser MIMO (MU-MIMO). Channel estimation techniques. Hybrid beamforming. Applications of MIMO in broadband wireless and IoT communication systems.	**9**
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL4HE	COMPUTATIONAL TOOLS FOR SIGNAL PROCESSING	VAC (Honour)	3	0	0	0	3	2023

i. PREREQUISITE : 23ECL30B - Digital Signal Processing
23ECP30B - Digital Signal Processing Lab

ii. COURSE OVERVIEW

This course aims to provide a clear understanding of the TMS320C6748 DSP architecture, memory organization, and on-chip peripherals, to develop proficiency in using Code Composer Studio and associated tools for programming, building, and debugging DSP applications, to introduce real-time DSP concepts, including fixed-point representation and implementation of FIR and IIR filters, to enable hands-on development of real-time audio processing applications using the C6748 DSP and to build practical skills in image processing and system-level DSP application development through a real-time microproject.

iii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the architecture, memory map, and peripherals of the TMS320C6748 and the associated DSP development tools.	Understand
CO 2	Develop C programs on the TMS320C6748 using Code Composer Studio.	Apply
CO 3	Implement fixed-point DSP algorithms, including FIR and IIR filters, using MATLAB/Python and DSP hardware.	Apply
CO 4	Design real-time audio and image processing applications on the TMS320C6748 processor.	Apply
CO 5	Develop image processing applications on the DSP as part of a real-time microproject.	Apply

iv. SYLLABUS

Introduction to Digital Signal Processing using the TMS320C6748 DSP processor, focusing on both theoretical concepts and hands-on implementation. C6748 architecture, memory map, peripherals, and the complete DSP development flow using Code Composer Studio, including project configuration, compilation, linking, loading, and debugging of C programs.

Real-time DSP principles, fixed-point number representation, and the impact of

quantization on FIR and IIR filter implementations, supported by analysis using MATLAB/Python.

Real-time audio processing, exploring audio fundamentals, codec interfacing, McASP, DMA, and implementation of common audio effects on the DSP.

Image processing on DSPs, addressing image formats, memory management, optimization, and debugging for large data sets, culminating in a hands-on microproject that enables end-to-end development and validation of real-time DSP applications.

Applications:real-time processing capabilities in video processing, industrial control and motor control, biomedical signal processing, communication systems, and embedded data acquisition. Signal-processing requirements in these areas

v (a) TEXT BOOKS

1. Digital Signal Processing and Applications with the C674x DSP - RulphChassaing& Donald Reay, 2/e, 2008
2. Digital Signal Processors, Architecture, Programming and Applications – B. Venkataramani and M. Bhaskar, 2002, TMH.
3. DSP Processor Fundamentals, Architectures & Features – Lapsley et al. 2000, S. Chand & Co.

(b) REFERENCES

1. TMS320C6748 DSP Technical Reference Manual, https://www.ti.com/lit/ug/spruh79c/spruh79c.pdf

vi. COURSE PLAN

Module	Contents	Hours
I	**TMS320C6748:** TMS320C6748 architecture, key features, memory map, and on-chip peripherals, programming tools used for the processor,Code Composer Studio (CCS), C6000 compiler, linker, emulator, and Chip Support Library, configure CCS, create and manage projects, and set up target configurations for the C6748. writing, building, loading, and debugging C programs, understanding linker command files, and working with memory and registers.	10
II	**Real-Time DSP:** Develop and debug applications for the TMS320C6748 using Code Composer Studio, Fixed-point representation of signals and introduction of the fixed-point toolbox in MATLAB/Python. Learning the impact of number representations in signal processing applications, including IIR and FIR filter design in C, implementation of signal processing algorithms by applying quantization techniques, and analysis using MATLAB/Python and a DSP processor.	10

III	**Audio processing using DSP processor:**digital audio fundamentals, audio formats, and real-time constraints, audio capabilities of the C6748 such as McASP, DMA, and codec interfacing, audio data flow on the processor Core audio processing techniques such as gain control, mixing, FIR and IIR filtering, and basic effects (echo or delay) are implemented in C on the DSP. Debugging and verification of audio signals using CCS tools	9
IV	**Image processing using DSP processor:** Digital image fundamentals such as image formats, grayscale and color representations, C6748 architecture features relevant to image processing. configure CCS projects for image-based applications and handle image data stored in memory or external interfaces. optimization concepts, memory management, and debugging techniques for large data arrays.	9
V	**Application domains of the TMS320C6748 DSP:** architecture and peripherals in real-world embedded systems, real-time processing capabilities in video processing, industrial control and motor control, biomedical signal processing, communication systems, and embedded data acquisition. Signal-processing requirements in these areas.	7
	Total Hours	**45**

SIMULATION ASSIGNMENT (At least one may be given using Code Composer Studio)

1. Real-time implementation of a signal processing system using DSP processor - reinforces end-to-end development, enabling learners to build and debug applications on the TMS320C6748 using CCS independently.
2. Implementing a real-time audio filter or simple audio effects processor, enabling participants to design, implement, and test audio signal processing applications on the TMS320C6748.
3. Implementing a basic image filtering or feature extraction application, enabling learners to develop and test image processing solutions on the TMS320C6748 DSP

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1½hours
- Topics : 2½modules

END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECJ4HX	MINIPROJECT	VAC (Honour)	0	0	6	0	3	2023

i. COURSE OVERVIEW

The main objective of this course is to apply fundamental concepts learned in the respective Honour streams of Engineering through practical implementation. The course provides students with exposure to the development of application-oriented software, hardware solutions, or software simulations in their chosen field. Working in small teams under faculty supervision, students identify a relevant problem, perform literature review, plan and execute the project, and present the outcomes through a working model or prototype. The mini project enhances problem-solving ability, teamwork, project planning, and technical communication skills, and serves as a foundation for future research or major project work

ii. COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Identify engineering problems that are socially relevant, technically feasible, and economically viable.	Apply
CO 2	Make use of relevant literature and existing engineering principles to explore and analyze potential solutions.	Apply
CO 3	Develop a suitable design or methodology using modern tools while adhering to professional ethics.	Apply
CO 4	Evaluate the performance or feasibility of the proposed solution using theoretical or experimental validation.	Evaluate
CO 5	Apply effective communication techniques to prepare technical reports, presentations, and demonstrations.	Apply
CO 6	Plan and execute project activities and coordinate effectively within a team to meet objectives and deadlines.	Apply

iii. COURSE PLAN / GUIDELINES

In this course, each group consisting of a maximum of 4 members is expected to design and develop a moderately complex software/hardware system relevant to their domain with practical applications. The basic concept of product design may be taken into consideration. Students should identify a topic of interest in consultation with the Project guide assigned and Project coordinator in charge of the course. They should review the literature from latest journals, relevant conferences and gather information pertaining to the chosen topic. Later the group should state the objectives and develop

a methodology to achieve the objectives and then carry out the design/fabrication or develop codes/programs to achieve the objectives. Finally the team should demonstrate the novelty of the project through the working results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department/Project Coordinator in charge. A project report is required at the end of the semester which will be evaluated and approved by the department. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due considerations. A zeroth review may be conducted to finalize the topic and plan in the beginning. Two continuous reviews will assess progress and implementation.

iv. ASSESSMENT SCHEME

The Mini Project shall be evaluated through a comprehensive assessment framework designed to monitor continuous progress, technical competence, and quality of documentation. The evaluation carries a total of 100 marks, with a minimum pass requirement of 50 marks, and is conducted through multiple stages involving the project guide and an evaluation committee. Continuous assessment includes project progress evaluation by the guide, two interim evaluations by the Evaluation Committee to assess problem formulation, design, and implementation progress, and a final evaluation to judge the level of completion, functionality, demonstration, technical understanding, and viva-voce performance. In addition, the quality of the project report is assessed for technical depth, clarity, organization, and adherence to prescribed standards. The Evaluation Committee comprises the Head of the Department or a senior faculty member, the Mini Project Coordinator, and the Project Supervisor, ensuring a fair and holistic evaluation of the mini project.

v. ASSESSMENT PATTERN

Continuous Assessment : Final Assessment – 70 : 30

Continuous Assessment		
Project Progress Evaluation by Guide	:	20 marks
Interim Evaluation -1 by Evaluation Committee	:	15 marks
Interim Evaluation -2 by Evaluation Committee	:	15 marks
Quality of the report evaluated by Evaluation Committee	:	20 marks
Total Continuous Assessment	**:**	**70 marks**
Final Assessment (Final Evaluation by Final Evaluation Committee)	**:**	**30 marks**
TOTAL	**:**	**100 marks**

Total: 100 marks (Minimum required to pass: 50 Marks)