CURRICULUM and SYLLABI

FOR

B. TECH DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

SEMESTERS V & VI

2023 SCHEME
(AUTONOMOUS)

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY
(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)
MAR IVANIOS VIDYANAGAR, NALANCHIRA, THIRUVANANTHAPURAM – 695015, KERALA.
Phone: 0471 2545866
Fax: 0471 2545869
Web: www.mbcet.ac.in
email: hodec@mbcet.ac.in

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

B. TECH DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

CURRICULUM and SYLLABI

for

SEMESTERS V & VI

Items	Board of Studies (BoS)	Academic Council (AC)
Date of Approval	04-04-2024	19-06-24
	29-04-2025	28-05-2025

Head of Department
Chairman, Board of Studies

Principal
Chairman, Academic Council

MAR BASELIOS COLLEGE OF ENGINEERING & TECHNOLOGY (AUTONOMOUS) ★ MAR IVANIOS VIDYANAGAR THIRUVANANTHAPURAM PIN: 695015

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 Course 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	23MAL20 C	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/ 35/3 4**	**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	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	2	1	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	RFMEMS	3	0	0	0	4.5	3	3
		23ECL44D	Secure Communication	2	1	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	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	2	1	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	3	0	0	0	4.5	3	3
		23ECL46B	Computer Vision	3	0	0	0	4.5	3	3
		23ECL46C	Modern 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	23ECL2ME	Fundamentals of Robotics	3-0-0-0	3	23ECL2MG	Fundamentals of Biomedical Engineering	3-0-0-0	3
S4	23ECL2MF	Introduction to Industrial Automation	2-1-0-0	3	23ECL2MH	Assistive Technologies	3-0-0-0	3
S5	23ECL3ME	Vision System	3-0-0-0	3	23ECL3MG	Medical Devices Engineering	3-0-0-0	3
S6	23ECL3MF	Artificial Intelligence for Robotics	3-0-0-0	3	23ECL3MH	Bio Signal and Image Processing	3-0-0-0	3
S7/ S8	23ECJ4ME	Mini Project	0-0-6-0	3	23ECJ4MG	Mini Project	0-0-6-0	3

HONOURS BASKETS

Semester	GROUP I VLSI AND EMBEDDED SYSTEMS				GROUP II COMMUNICATION				GROUP 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	Nanoelect ronics	3-0-0-0	3	23ECL 2HD	Random Process and Applicati ons	2-1-0-0	3	23ECL 2HF	Wavelet Transfor m and Applicati ons	2-1-0-0	3
S5	23ECL 3HA	FPGA based System Design	3-0-0-0	3	23ECL 3HC	Detection and Estimatio n Theory	3-0-0-0	3	23ECL 3HE	DSP System Design	3-0-0-0	3
S6	23ECL 3HB	Electronic s Design and Automati on	3-0-0-0	3	23ECL 3HD	Design and Analysis of Antennas	3-0-0-0	3	23ECL 3HF	Multirate Signal Processin g	2-1-0-0	3
S7	23ECL 4HA	RF MEMS	3-0-0-0	3	23ECL 4HC	MIMO and Multiuser Communi cation Systems	3-0-0-0	3	23ECL 4HE	Computat ional tools for Signal Processin g	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 V

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL30A	ANALOG AND DIGITAL COMMUNICATION	PCC	3	1	0	0	4	2023

i. PREREQUISITE: 23ECL20E - Signals and Systems
23MAL20C- Probability, Random Process and Numerical Methods

ii. COURSE OVERVIEW

Goal of this course is to provide an insight into the concepts of analog and digital communication system.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Compute various parameters of analog modulation systems	Apply
CO 2	Apply waveform coding techniques in digital transmission	Apply
CO 3	Apply signal modelling techniques in the design of digital receivers	Apply
CO 4	Apply digital modulation techniques in signal transmission	Apply
CO 5	Explain techniques in spread spectrum communication	Understand

iv. SYLLABUS

Analog communication systems – Modulation schemes- Amplitude modulation, Frequency modulation and Phase modulation, AM & FM transmitters and receivers.

Digital base band communication – sampling, PAM, PCM, DPCM, DM

ISI, Duobinary coding, Digital base band transmission in AWGN channels – GS procedure, Matched and correlation receivers

Digital passband Modulation – ASK, PSK, FSK. M-ary schemes – MPSK, MFSK, MASK and QAM

Spread Spectrum Communication

v (a) TEXT BOOKS

1. Simon Haykin, Digital Communication Systems, 4th edition, Wiley, 2000.
2. D Sklar, Digital Communications: Fundamentals and Applications,3/e, Pearson

3.	R. C. Dixen, "Spread Spectrum Systems with commercial application", John Wiley, 3rd Ed.

(b) REFERENCES

1.	John G Proakis, Digital Communication,4/e, Wiley
2.	R. Gallager, Principles of Digital Communication, Oxford University Press

vi. COURSE PLAN

Module	Contents	Hours
I	Fundamentals of analog communication systems. Need for modulation. **Amplitude modulation** – Mathematical representation and spectrum- DSB-SC, SSB modulation and Vestigial Sideband modulation. Transmitter and receiver. **Frequency and phase modulation**– Mathematical representation and spectrum. Relationship between FM & PM. FM transmitter and receiver.	12
II	**Digital baseband communication** - Sampling: sampling of bandpass signals, Pulse Amplitude Modulation (PAM), Quantization, Pulse Code Modulation (PCM), Differential PCM, Delta modulator-Power and bandwidth efficiency, Line coding schemes	13
III	Pulse shaping- Inter Symbol Interference (ISI) - Nyquist criterion for zero ISI. Eye pattern. Correlative level coding - Duobinary coding, precoding, modified duobinary coding, generalized partial response filtering. Representation of a signal in signal space, Gram Schmidt orthogonalization, Cauchy-Schwarz inequality- Digital baseband transmission in AWGN channel - Matched filter receiver, Correlation receiver.	13
IV	**Digital passband communication** - Modulation techniques: Amplitude shift keying, Binary phase shift keying-– method of generation and detection, Probability of error, binary frequency shift keying – Probability of error.	12
V	M-ary digital modulation schemes - MPSK, MFSK, MASK and QAM method of generation and detection – Probability of error – Power-Bandwidth tradeoff. Introduction to Spread spectrum communication- direct sequence and frequency hoping spread spectrum	10
	Total Hours	**60**

vii. ASSESSMENTPATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5marks
Assignments	:	15marks
Assessment through Tests	:	20marks
Total Continuous Assessment	:	**40marks**
End Semester Examination	:	**60marks**
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
23ECL30B	DIGITAL SIGNAL PROCESSING	PCC	3	1	0	0	4	2023

i. PREREQUISITE 23ECL20E – Signals and Systems

ii. COURSE OVERVIEW

This course aims to provide an understanding of the principles, algorithms and applications of DSP, analysis of discrete signals in time and frequency domain, design of digital filters, and analysis of finite word length effects in DSP systems.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Analyze discrete time signals and systems in time and frequency domains.	Apply
CO2	Design digital FIR filters for specific applications using various techniques and their implementation.	Apply
CO3	Design analog and digital IIR filters for specific applications using various techniques and their implementation.	Apply
CO4	Explain the basic design aspects of DSP systems using TMS320C6713 processor.	Understand
CO5	Analyze multirate digital signal processing systems.	Apply

iv. SYLLABUS

Discrete Fourier Transform and its Properties, Linear filtering of long duration sequences – overlap add and save algorithms, Frequency analysis of signals using the DFT, Computation of DFT,

FFT Algorithms, IDFT computation using Radix-2 FFT Algorithms, Efficient computation of DFT of two real sequences and a 2N-Point real sequence,

Design of FIR Filters, Design of linear phase FIR Filters using window methods and frequency sampling method, FIR Filter Structures.

Design of IIR Digital Filters from Analog Filters, IIR Filter Design, Frequency Transformations, IIR Filter Structures,

Introduction to TMS320C67xx digital signal processor, Multi-rate Digital Signal Processing, Finite word length effects in DSP systems, IIR digital filters, FFT algorithms.

v (a) TEXT BOOKS

1. Proakis J. G. and Manolakis D. G., Digital Signal Processing, 4/e, Pearson

	Education, 2007
2.	Alan V Oppenheim, Ronald W. Schafer, Discrete-Time Signal Processing, 3rd Edition, Pearson, 2010
3.	Mitra S. K., Digital Signal Processing: A Computer Based Approach, 4/e, McGraw Hill (India), 2014
(b) REFERENCES	
1.	Ifeachor E.C. and Jervis B. W., Digital Signal Processing: A Practical Approach, 2/e, Pearson Education, 2009
2.	Vinay.K.Ingle, John.G.Proakis, Digital Signal Processing: Bookware Companion Series, Thomson, 2004
3.	Salivahanan S, Digital Signal Processing,4e, McGraw Hill Education New Delhi, 2019.

vi. COURSE PLAN

Module	Contents	Hours
I	Basic Elements of a DSP system, Typical DSP applications – an overview, Finite- length discrete transforms, Orthogonal transforms – The Discrete Fourier Transform: DFT as a linear transformation (Matrix relations), Relationship of the DFT to other transforms, IDFT, Properties of DFT and examples. Circular convolution, Linear Filtering methods based on the DFT, linear convolution using circular convolution, Filtering of long data sequences, overlap save and overlap add methods, Frequency Analysis of Signals using the DFT (concept only required)	**13**
II	Efficient Computation of DFT: Fast Fourier Transform Algorithms- Radix-2 Decimation in Time and Decimation in Frequency FFT Algorithms, IDFT computation using Radix-2 FFT Algorithms, Application of FFT Algorithms, Efficient computation of DFT of Two Real Sequences and a 2N-Point Real Sequence	**10**
III	Design of FIR Filters - Symmetric and Anti-symmetric FIR Filters, Design of linear phase FIR filters using Window methods, (rectangular, Hamming and Hanning) and frequency sampling method, Comparison of design methods for Linear Phase FIR Filters. Structures for the realization of Discrete Time Systems - Block diagram and signal flow graph representations of filters, FIR Filter Structures: Linear structures, Direct Form, Cascade Form.	**12**
IV	Design of IIR Digital Filters from Analog Filters (Butterworth), IIR Filter Design by Impulse Invariance, and Bilinear Transformation, Frequency Transformations in the Analog and Digital Domain.	**12**

	Structures for the realization of IIF filters - Direct Form, Transposed Form, Cascade Form, and Parallel Form, Computational Complexity of Digital filter structures.	
V	Multi-rate Digital Signal Processing: Decimation and Interpolation (Time domain and Frequency Domain Interpretation only), anti- aliasing and anti-imaging filters. Computer architecture for signal processing: Harvard Architecture, Introduction to TMS320C67xx digital signal processor, Functional Block Diagram. Finite word length effects in DSP systems: Introduction (analysis not required), fixed-point and floating-point DSP arithmetic, ADC quantization noise, Finite word length effects in IIR and FIR digital filters: coefficient quantization errors. Finite word length effects in FFT algorithms: Round off errors	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: 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
23ECL30C	ELECTROMAGNETIC FIELD THEORY	PCC	3	1	0	0	4	2023

i. PREREQUISITE	23MAL10B – Vector Calculus 23PYL10A – Engineering Physics

ii. COURSE OVERVIEW

This course aims to impart knowledge on the basic concepts of electric and magnetic fields, the concepts of reflection and refraction for normal and oblique incidence, different modes of propagation, and different media for the transmission of EM waves.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Apply the concepts of vector algebra in electromagnetic field theory.	Apply
CO2	Apply Maxwell's equations to solve problems in electromagnetic wave propagation.	Apply
CO3	Analyse electromagnetic wave propagation and wave polarization in different media.	Apply
CO4	Analyse the parameters of transmission lines using Smith chart.	Apply
CO5	Analyse the different modes of propagation in Waveguides.	Apply

iv. SYLLABUS

Introduction to Electromagnetic Theory, Review of vector calculus, Expression of curl divergence and Laplacian in cartesian, cylindrical and spherical coordinate system. Electric field theory – review of different laws, determination of E and V using Laplace equation. Derivation of capacitance and energy stored in Electric field.

Magnetic field theory - Amperes current law, Derivation of inductance and energy stored in Magnetic field. Displacement current density, continuity equation. Relation between scalar potential and vector potential. Maxwell's equation from fundamental laws. Boundary condition of electric field and magnetic field.

Solution of wave equation. Propagation of plane EM wave in perfect dielectric, lossy medium, good conductor, media attenuation, phase velocity, group velocity, skin depth. Reflection and refraction of plane electromagnetic waves at boundaries for normal & oblique incidence – parallel and perpendicular polarization, Snell's law of refraction, Brewster angle.

Power density of EM wave, Poynting vector theorem. Uniform lossless transmission line – line parameters. Transmission line equations, Voltage and Current distribution of a line terminated with load. Reflection coefficient and VSWR. Derivation of input impedance of transmission line.

Transmission line as circuit elements (L and C). Development of Smith chart - calculation of line impedance and VSWR using smith chart. The hollow rectangular wave guide –modes of propagation of wave - dominant mode, group velocity and phase velocity.

v (a) TEXT BOOKS

1.	John D. Kraus, Electromagnetics, 5/e, TMH, 2010.
2.	Mathew N O Sadiku, Elements of Electromagnetics, Oxford University Press, 6/e, 2014.
3.	William, H. Hayt, and John A. Buck, Engineering Electromagnetics, 8/e McGraw-Hill, 2014

(b) REFERENCES

1.	Edminister, Schaum's Outline of Electromagnetics, 4/e, McGraw-Hill, 2014.
2.	Jordan and Balmain, Electromagnetic waves and Radiating Systems, PHI, 2/e,2013
3.	Martin A Plonus, Applied Electromagnetics, McGraw Hill, 2/e,1978.
4.	Nannapaneni Narayana Rao, Elements of Engineering Electromagnetics, Pearson, 6/e, 2006
5.	Umran S. Inan and Aziz S. Inan, Engineering Electromagnetics, Pearson, 2010.

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to Electromagnetic Theory** – Review of vector calculus- curl, divergence gradient. Rectangular, cylindrical and spherical coordinate systems. Expression of curl divergence and Laplacian in cartesian, cylindrical and spherical coordinate system. **Electric field theory** – Review of Coulomb's law, Gauss' law. Poisson and Laplace equations, Determination of E and V using Laplace equation. Derivation of capacitance of two wire transmission line and coaxial cable, Energy stored in Electric field.	13
II	**Magnetic field theory** – Ampere's current law, Derivation of inductance of two wire transmission line and coaxial cable. Energy stored in Magnetic field. Displacement current density, continuity equation. Magnetic vector potential. Relation between scalar potential and vector potential. **Maxwell's equation** – Maxwell's equations from fundamental laws. Boundary condition of electric field and magnetic field from Maxwell's equations. Solution of wave equation.	11
III	**Propagation of plane EM wave** – propagation in perfect dielectric, lossy medium, good conductor, media-attenuation,	12

	phase velocity, group velocity, skin depth. **Reflection and refraction** – reflection and refraction of plane electromagnetic waves at boundaries for normal & oblique incidence – parallel and perpendicular polarization, Snell's law of refraction, Brewster angle.	
IV	**Power density of EM wave** – Poynting vector theorem. **Transmission line** – Uniform lossless transmission line - line parameters. Transmission line equations Voltage and Current distribution of a line terminated with load. Reflection coefficient and VSWR. Derivation of input impedance of transmission line. Transmission line as circuit elements (L and C).	12
V	**Smith chart** - Development of Smith chart, calculation of line impedance, VSWR, input impedance, admittance, location of minimum and maximum voltages. **Waveguides** - The hollow rectangular waveguide – modes of propagation of wave dominant mode, group velocity and phase velocity	12
	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: 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
23HSL00A	MANAGEMENT FOR ENGINEERS	HSC	3	0	0	0	3	2023

i. PREREQUISITE	Nil

ii. COURSE OVERVIEW

The objective of the course is to introduce the basic concepts and functions of management, highlight its role in organizational performance, and explore decision-making approaches that help managers achieve excellence.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the characteristics of management in the contemporary context.	Understand
CO2	Summarize the functions of management.	Understand
CO3	Apply the concepts of decision-making models and productivity measurement to enhance organizational effectiveness.	Apply
CO4	Apply the project management techniques to determine project schedules and completion probabilities.	Apply
CO5	Explain the functional areas of management and the concept of entrepreneurship	Understand

iv. SYLLABUS:

Introduction to management theory - Characteristics of Management, Introduction to management theory, System approaches to Management, Levels of Manager and Skill required.

Management and organization - Functions of Management, Planning types, Principles of organisation, Organisation Structures. Staffing, Leading and Controlling.

Productivity and decision making - Concept of productivity and its measurement. Decision making process, Decision trees;

Project management- Network construction, CPM and PERT

Networks, Scheduling computations, PERT time estimates, Probability of completion of project.

Functional areas of management- Operations management, Human resources management, Marketing management, Financial management, Entrepreneurship, Business plans, Corporate social responsibility.

v (a) TEXT BOOKS

1.	H. Koontz, and H. Weihrich, Essentials of Management: An International Perspective. 10th ed., McGraw-Hill, 2015.
2.	P. Kotler, K. L. Keller, A. Koshy, and M. Jha, Marketing Management: A South Asian Perspective. 15th ed., Pearson, 2016.
3.	R. D. Hisrich, and M. P. Peters, Entrepreneurship: Strategy, Developing, and Managing a New Enterprise, 11th ed., McGraw-Hill Education, 2020.
4.	M. Y. Khan, and P. K. Jain, Financial Management, Tata-McGraw Hill, 2020.

(b) REFERENCES

1.	R. B. Chase, Ravi Shankar and F. R. Jacobs, Operations and Supply Chain Management, 15th ed. McGraw Hill Education (India), 2018.
2.	P C Tripathi and P N Reddy, Principles of management, TMH, 5th edition, 2012.
3.	K. Ashwathappa, Human Resources and Personnel Management, TMH, 7th edition, 2011.
4.	D. J. Sumanth, Productivity Engineering and Management, McGraw-Hill Education, 2019.

vi. COURSE PLAN

Module	Contents	Hours
I	Management Definition, Characteristics of Management, Importance of Management, Management - Art or Science perspective, Evolution of Management - Introduction to Management Theories-Taylor's Scientific Management, Gilbreth's Motion Study, McGregor's Theory X and Theory Y, System Approach and Contingency Approach to Management, Henry Mintzberg's Managerial Roles, Levels of Management – Top, Middle, and Operational, Skills Required for Managers – Technical, Human, and Conceptual skills.	**8**
II	Functions of Management - Planning, Organizing, Staffing, Leading, Controlling. Planning- Planning types- strategic, tactical and operational plans, Mission, Goals, Strategy, Programmes, Procedures, Steps in Planning.	**8**

	Organising- Principles of Organisation, Delegation, Span of Control, Organisation Structures. Staffing- Selection process and employee training, Employee retention- Maslow's Hierarchy of Needs. Directing and Leadership -Traits of a leader, Leader vs Manager, Managerial grid model for leadership styles. Controlling-Types of control: Preventive, Concurrent, and Feedback.	
III	Concept of productivity and its measurement; Competitiveness- Cost Advantage and Differential advantage, Quality, Speed, Innovation. Decision making process; Steps, types - Programmed and Non- Programmed decisions. Decision making under uncertainty-Maximum Criterion, Minimax Criterion, Maximin Criterion, Laplace Criterion, Hurwicz Alpha Criterion, Decision making under risk – Expected Monetary Value, Expected Opportunity Loss, Decision trees.	**10**
IV	Project Management, Network construction, Arrow diagram, CPM and PERT to find critical paths, Critical Path Method - Determining Start and Finish Times: Earliest Start Time (ES), Earliest Finish Time (EF), Latest Start Time (LS), Latest Finish Time (LF), Float. Project Evaluation Review Technique PERT, PERT Time Estimates – Optimistic, Pessimistic, and Most Likely Time Calculations, Probability of completion of project.	**10**
V	Introduction to functional areas of management, Operations management, Human resources management, Marketing management, Financial management, Entrepreneurship- Characteristics and mindset of successful entrepreneurs Types of entrepreneurship- Small Business Entrepreneurship, Scalable Start up Entrepreneurship, Social Entrepreneurship, Corporate social responsibility.	**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
23ECP30A	COMMUNICATION LAB	PCC	0	0	3	0	2	2023

i. PREREQUISITE Analog and Digital Communication, Digital Signal Processing

ii. COURSE OVERVIEW

Objective of the course is to simulate the system performance parameter of a digital communication system and to emulate a communication system with software-designed-radio.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Implement simple prototype circuits for analog and digital modulation techniques.	**Apply**
CO 2	Simulate the error performance of various digital modulation schemes.	**Apply**
CO 3	Develop hands-on skills to emulate a communication system with software-defined-radio.	**Apply**

iv. SYLLABUS

FM generation and demodulation using PLL, Generation and Detection of PCM/BPSK/ 16-QPSK/Delta modulated signals. Performance of Waveform Coding Using PCM, Pulse Shaping and Matched Filtering, Eye Diagram, Error Performance of BPSK, Error Performance of QPSK. Familiarization with Software Defined Radio, FM Transmission and Reception

v. REFERENCES

1. Carl Laufer, The Hobbyist’s Guide to the RTL-SDR: Really Cheap Software Defined Radio,4/e, Createspace Independent Publishing Platform,2015.
2. Neel Pandeya, Implementation of a Simple FM Receiver in GNU Radio, https://kb.ettus.com/
3. WH Tranter, KS Shanmugan, TS Rappaport, KL Kosbar, Principles of Communication Systems Simulation with Wireless Applications, Prentice Hall, 2004.
4. Digital Communication using GNU Radio, https://onlinecourses.nptel.ac.in/noc24_ee51/preview

vi. COURSE PLAN	
Expt	**Contents**
Part A: Hardware Experiments	
1	AM GENERATION AND DEMODULATION USING AD633
2	FM GENERATION AND DEMODULATION USING PLL
Part B: MATLAB Experiments	
1	FAMILIARIZATION OF COMMUNICATION TOOLBOX
2	PERFORMANCE OF WAVEFORM CODING USING PCM 1. Generate an arbitrary waveform with a DC offset so that it takes only positive amplitude value. 2. Sample and quantize the signal using an uniform quantizer with number of representation levels L. Vary L. Represent each value using decimal to binary encoder. 3. Compute the signal-to-noise ratio in dB. 4. Plot the SNR versus number of bits per symbol. Observe that the SNR increases linearly.
3	PULSE SHAPING AND MATCHED FILTERING 1. Generate a string of message bits. 2. Use root raised cosine pulse p(t) as the shaping pulse and generate the corresponding baseband signal with a fixed bit duration T_b. You may use roll-off factor as $\alpha = 0.4$. 3. Simulate transmission of baseband signal via an AWGN channel. 4. Apply matched filter with frequency response $P_r(f) = P^*(f)$ to the received signal. 5. Sample the signal at mT_b and compare it against the message sequence.
4	ERROR PERFORMANCE OF BPSK 1. Generate a string of message bits. 2. Encode using BPSK with energy per bit E_b and represent it using points in a signal-space. 3. Simulate transmission of the BPSK modulated signal via an AWGN channel with noise variance $N_0/2$. 4. Perform optimal detection (using ML or MAP detection), and estimate the probability of error as a function of E_b/N_0
5	ERROR PERFORMANCE OF QPSK 1. Generate a string of message bits. 2. Encode using QPSK with energy per symbol Es and represent it using points in a signal-space. 3. Simulate transmission of the QPSK modulated signal via an AWGN channel with variance $N_0/2$ in both I-channel and Q-channel. 4. Perform optimal detection (using ML or MAP detection) and estimate the

	probability of bit error as a function of E_b/N_0
	Part C: GNU RADIO Related Ex
1	FAMILIARIZATION WITH SOFTWARE DEFINED RADIO (HARDWARE AND CONTROL SOFTWARE) 1. Generate sinusoidal signal and plot the frequency spectrum 2. Add two sinusoidal signals and obtain frequency spectrum 3. Multiplication of two sinusoidal signals and obtain frequency spectrum 4. Add three sinusoidal signals and pass it through different filters: LPF, HPF, BPF, BSF
2	FM RECEPTION 1. Receive digitized FM signal (for the clearest channel in the lab) using the SDR board. 2. Set up an LPF and FM receiver using GNU Radio. 3. Use appropriate sink in GNU Radio to display the spectrum of signal. 4. Resample the voice to make it suitable for playing on a computer speaker.

Vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 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**
End Semester Examination	:	**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**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECP30B	DIGITAL SIGNAL PROCESSING LAB	PCC	0	0	3	0	3	2023

i. PREREQUISITE	23ESB10D - Programming in C 23ECL20E - Signals and Systems
ii. COURSE OVERVIEW	

To enable the students to explore the concepts of design, simulation and implementation of various systems using MATLAB and DSP kit.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Generate digital signals using simulation tool.	Understand
CO2	Analyse the properties of DFT using simulation tool.	Apply
CO3	Design real time filters using DSP hardware.	Analyse
CO4	Analyse LTI systems using convolution.	Apply
CO5	Analyse signals using FFT and IFFT.	Analyse
CO6	Analyse speech signals using IIR low pass filter	Analyse
CO7	Design LTI systems with block convolution and FFT.	Analyse

iv. SYLLABUS

Simulation of basic signals

Verification of the Properties of DFT

Spectrum Analysis using FFT

Overlap Save and Overlap Add Block Convolutions

- Verification of convolution property of DFT

Familiarization of DSP Hardware

- Glowing LED
- Tone Generation

FFT and IFFT using DSP Kit

Linear Convolution using DSP Kit

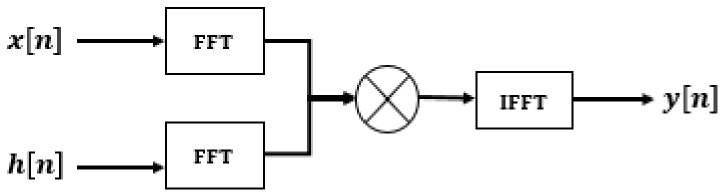
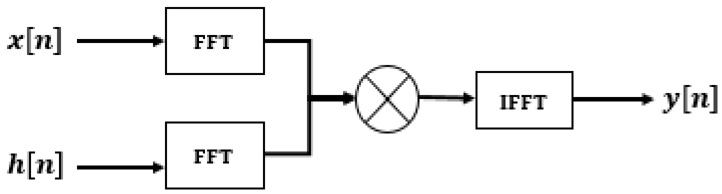
Real Time filtering of signals

- IIR low pass and high pass filters

v. REFERENCES	
1.	Vinay K. Ingle, John G. Proakis, Digital Signal Processing Using MATLAB.
2.	Allen B. Downey, Think DSP: Digital Signal Processing using Python.
3.	Rulph Chassaing, DSP Applications Using C and the TMS320C6x DSK (Topics in Digital Signal Processing)

vi. COURSE PLAN

Expt	Contents
1	Simulation of basic signals like impulse, step, ramp, exponential, and sinusoidal signals using MATLAB.
2	Verification of the Properties of DFT a) Generate and appreciate a DFT matrix. i. Write a function that returns the N point DFT matrix A_N for a given N. ii. Plot its real and imaginary parts of A_N as images using *imshow* in MATLAB for N = 16, N = 64 and N = 1024 iii. Compute the DFTs of 16 point, 64 point and 1024 point random sequences using the above matrices. iv. Observe the time of computations for N = 2γ for 2≤ γ ≤18. v. Use some iterations to plot the times of computation against γ. Plot and understand this curve. Plot the times of computation for the FFT function over this curve and appreciate the computational saving with FFT. b) Circular Convolution. i. Write a MATLAB function *circcon.m* that returns the circular convolution of an N1 point sequence and an N2 point sequence given at the input. ii. Function can be based on conversion from linear convolution into circular convolution with N = max(N1, N2). c) Parseval's Theorem i. For the random sequences $x_1[n]\ and\ x_2[n]$ $$\sum_{n=0}^{N-1} x_1[n]x_2^*[n] = \frac{1}{N}\sum_{k=0}^{N-1} X_1[k]X_2^*[k]$$ ii. Generate two random complex sequences. iii. Prove the theorem for these signals.
3	Spectrum Analysis using FFT a) Generate an arbitrary complex signal. For eg: AM or FM signal b) Simulate the spectrum of the signal and verify sampling theorem
4	Overlap Save Block Convolution a) Realize the system below for arbitrary signals x[n] and h[n].

	 b) Segment the signal values into blocks of length N. Pad the last block with zeros, if necessary. c) Implement the overlap save block convolution method
5	Overlap Add Block Convolution a) Realize the system below for arbitrary signals x[n] and h[n].  b) Segment the signal values into blocks of length N. Pad the last block with zeros, if necessary. c) Implement the overlap save block convolution method
6	Familiarization of DSP Hardware a) Familiarization of the code composer studio (CCS) for the programming of DSP hardware. b) Familiarization of the analog and digital input and output ports of the DSP board. c) Generation and cross compilation and execution of the C code to connect the input digital switches to the output LEDs. d) Generation and cross compilation and execution of the C code to connect the input analog port to the output. Connect a microphone, speak into it, and observe the output electrical signal on a DSO and store it.
7	FFT and IFFT using DSP Kit FFT using DSP Kit a) Write a C function for N - point FFT. b) Apply the FFT on the input signal with the appropriate window size and observe the result. IFFT using DSP Kit a) Use the FFT function in the previous experiment to compute the IFFT of the input signal. b) Apply IFFT on the stored FFT values from the previous experiments and observe the reconstruction.
8	Linear Convolution using DSP kit a) Write a C function for the linear convolution of two arrays. b) The arrays may be kept in different files and downloaded to the DSP hardware.

	c) Store the result as a file and observe the output.
9	Real time filtering – IIR low pass and high pass filters a) Use MATLAB to implement the IIR filter response with impulse response h[n]. b) Observe the low pass and high pass responses in the simulator. c) Download the filter on to the DSP target board and test with 1mV sinusoid from a signal generator connected to the analog port. d) Test the operation of the filters.

iv. 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**

PROGRAMME ELECTIVE -I

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL31A	DIGITAL SYSTEM DESIGN	PEC	2	1	0	0	3	2023

i. PREREQUISITE 23ECJ20C- Logic Circuit Design

ii. COURSE OVERVIEW

This course introduces methods for designing and synthesizing digital systems. It provides a comprehensive understanding of behavioral and structural design techniques, logic synthesis, and post-synthesis validation.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain structural and behavioral design techniques for digital systems.	Understand
CO2	Apply design principles to implement combinational and sequential circuits.	Apply
CO3	Explain the working of data path controllers and processor architecture.	Understand
CO4	Apply synthesis techniques using PLDs for digital system implementation.	Apply
CO5	Explain timing verification and fault simulation techniques.	Understand

iv. SYLLABUS

Review of Combinational and Sequential logic design – Structural models of combinational logic – Propagation delay – Behavioral Modeling – Boolean equation based behavioral models of combinational logic – Cyclic behavioral model of flip-flop and latches – A comparison of styles for behavioral modeling – Design documentation with functions and tasks

Review of logic design, behavioral and structural modeling, flip-flops, functions and tasks, Logic synthesis, gated clocks, resets, design traps, partitioning, Controller/datapath design, RISC processor, ALU, UART, PLDs, CPLDs, FPGAs, pipelined designs, clock domain issues, Post-synthesis timing, BIST, fault simulation

v (a) TEXT BOOKS

1.	Michael D. Ciletti, "Advanced Digital Design with the VERILOG HDL, 2nd Edition, Pearson Education, 2010.
2.	M. Morris Mano & Michael D. Ciletti, Digital Design: With an Introduction to Verilog HDL, VHDL, and SystemVerilog, Pearson, 6th Edition, 2017
3.	Charles H. Roth Jr., Larry L. Kinney, Fundamentals of Logic Design, Cengage Learning, 7th Edition, 2013
(b) REFERENCES	
1.	Pong P. Chu, FPGA Prototyping by VHDL/Verilog Examples, Wiley, Latest Edition
2.	Brian Holdsworth and Clive Woods, Digital Logic Design, Elsevier, 4th Edition
3.	Ronald J. Tocci, Neal S. Widmer, Digital Systems: Principles and Applications, Pearson, 11th Edition

vi. COURSE PLAN

Module	Contents	Hours
I	Review of Combinational and Sequential logic design – Structural models of combinational logic – Propagation delay – Behavioral Modeling – Boolean equation based behavioral models of combinational logic – Cyclic behavioral model of flip-flop and latches – A comparison of styles for behavioral modeling – Design documentation with functions and tasks	9
II	Synthesis of Combinational and Sequential logic – Introduction to synthesis – Synthesis of combinational logic – Synthesis of sequential logic with latches – Synthesis of three-state devices and bus interfaces – Synthesis of sequential logic with flip-flops – Registered logic – State encoding – Synthesis of gated clocks and clock enables – Anticipating the results of synthesis – Resets – Synthesis of loops – Design traps to avoid – Divide and Conquer: partitioning a design.	9
III	Design and Synthesis of Datapath Controllers – Partitioned sequential machines – Design example: Binary counter – Design and synthesis of a RISC stored-program machine – Processor, ALU, Controller, Instruction Set, Controller Design and Program Execution – UART – Operation, Transmitter, Receiver.	9
IV	Programmable logic devices – Storage devices – Programmable Logic Array (PLA) – Programmable Array Logic (PAL) – Programmability of PLDs – Complex PLDs – Introduction to Altera and Xilinx FPGAs – Algorithms – Nested loop programs and data flow graphs – Functional units for	9

	addition, subtraction, multiplication and division – Multiplication of signed binary numbers and fractions.	
V	Postsynthesis Design Validation – Postsynthesis Timing Verification – Elimination of ASIC Timing Violations – False Paths – Dynamically Sensitized Paths – System Tasks for Timing Verification – Fault Simulation and Testing	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
23ECL31B	POWER ELECTRONICS	PEC	3	0	0	0	3	2023

i. PREREQUISITE 23ESL10L- Basic Electronics Engineering

ii. COURSE OVERVIEW

Goal of this course is to provide an insight into the basic concepts of various power electronic circuits and their applications.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Describe the characteristics of various power semiconductor switches.	Understand
CO2	Explain the principle of drive circuits and snubber circuits for power semiconductor switches.	Understand
CO3	Explain the working of diode bridge rectifiers and controlled rectifiers.	Understand
CO4	Illustrate the working of DC – DC Switch-Mode Converters and DC – AC Switch-Mode Inverter.	Apply
CO5	Explain the principle of power electronics for various applications.	Understand

iv. SYLLABUS

Power diodes, Power BJT, Power MOSFET and IGBT - static and dynamic characteristics, SCR and GTO

BJT and MOSFET drive circuits, Snubber circuits, Three phase diode bridge rectifiers, Single phase and three phase-controlled rectifiers.

Buck, Boost and Buck-boost DC-DC converters Waveforms and expression of DC-DC converters for output voltage, voltage and current ripple under continuous conduction mode. (No derivation required) Isolated converters: Flyback, Forward, Push Pull, Half bridge and Full bridge converters – Waveforms and governing equations (No derivation required)

Inverter topologies, Driven Inverters: Push-Pull, Half bridge and Full bridge configurations, Three phase inverter, Pulse width modulation

DC Motor Drives, Induction Motor Drives, Residential and Industrial applications.

v (a) TEXT BOOKS

1. Umanand L, Power Electronics: Essentials & Applications, Wiley India, 2015

2.	Ned Mohan, Tore M Undeland, William P Robbins., Power Electronics: Converters, Applications, and Design, 3/e, Wiley India Pvt. Ltd, 2015
(b) REFERENCES	
1.	Muhammad H. Rashid., Power Electronics: Circuits, Devices, and Applications, 4/e, Pearson Education India, 2014.
2.	Daniel W. Hart, Power Electronics, McGraw Hill, 2011.

vi. COURSE PLAN

Module	Contents	Hours
I	Power diodes and Bipolar power transistors structure, static and dynamic characteristics Power MOSFET and IGBT – structure, static and dynamic characteristics SCR and GTO construction and characteristics	9
II	BJT and MOSFET driver circuits (atleast two circuits each) Snubber circuits–ON and OFF snubbers. Three phase diode bridge rectifiers – basic principles only Single phase and three phase Controlled rectifiers (with R, RL & RLE loads) – basic principles only. (Simulate the basic circuits)	9
III	Buck, Boost and Buck-Boost DC-DC converters waveforms and expression of DC-DC converters for output voltage, voltage and current ripple under continuous conduction mode. (No derivation required) Isolated converters: Fly-back, Forward, Push-Pull, Half bridge and Full bridge converters – Waveforms and governing equations. DC-AC Switch Mode Inverters	10
IV	Inverter topologies: Push-Pull, Half bridge and Full bridge configurations. Three phase inverter Sinusoidal and Space vector modulation PWM in three phase inverters	9
V	DC Motor Drives – Adjustable-speed DC drive Induction Motor Drives – Variable frequency PWM-VSI drives Residential and Industrial applications.	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
23ECL31C	MECHATRONICS	PEC	3	0	0	0	3	2023

i. PREREQUISITE Nil

ii. COURSE OVERVIEW

This course introduces students to the rapidly emerging, multi-disciplinary, and exciting field of Mechatronics

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the working principles of various sensors and actuators in Mechatronics systems.	Understand
CO2	Simulate models of mechatronics systems.	Apply
CO3	Explain the implementation of PLC in mechatronics applications.	Understand
CO4	Explain the standard fabrication techniques and principle of operation of MEMS devices.	Understand
CO5	Design the mechatronics systems for real time application.	Apply

iv. SYLLABUS

Introduction to Mechatronics: Structure of Mechatronics system. Comparison between traditional and mechatronics approach. Sensors - Characteristics - Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Encoders: incremental and absolute. Resolvers and synchros. Piezoelectric sensors. Acoustic Emission sensors. vibration sensors. Force and tactile sensors. Range finders: ultrasonic and light base range finders.

Actuators: Hydraulic and Pneumatic actuators - Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols. Electrical drives: DC, AC, brushless, servo and stepper motors. Harmonic drive. Magnetostrictive actuators and piezoelectric actuators.

System modelling - Mathematical models and basic building blocks of general mechanical, electrical, fluid and thermal systems. Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Programmable Logic Controllers (PLC) – Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers. Development of simple ladder programs for specific purposes.

Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition, Lithography, Micromachining methods for MEMS -Surface and Bulk, Deep Reactive Ion Etching (DRIE) and LIGA processes. Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope.

Mechatronics in Robotics- choice of Sensors and Actuators. Robotic vision system – Image acquisition: Vidicon, charge coupled device (CCD) and charge injection device (CID) cameras. Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding. Case studies of Mechatronics systems: Automatic camera, bar code reader, simple weighing machine, pick and place robot, automatic car park barrier system, automobile engine management system

v (a) TEXT BOOKS

1.	Bolton W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, New Delhi, 2007
2.	Ramachandran K. P., G. K. Vijayaraghavan, M. S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley India Pvt. Ltd., New Delhi, 2008.
3.	Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, Person Education, Inc., New Delhi, 2006.
4.	Devdas Shetty, Richard A. Kolk, “Mechatronics System Design”, Thomson Learning Publishing Company, Vikas publishing house, Second edition, 2001.

(b) REFERENCES

1.	David G. Aldatore, Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill Inc., USA, 2003.
2.	Gordon M. Mair, Industrial Robotics, Prentice Hall International, UK, 1998.
3.	HMT, Mechatronics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
4.	Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, John Wiley & Sons Ltd., England, 2006.
5.	Bishop, Robert H. The Mechatronics Handbook-2 Volume Set. CRC press, 2002.

vi. COURSE PLAN

Module	Contents	Hours
I	Introduction to Mechatronics: Structure of Mechatronics system. Comparison between traditional and mechatronics approach. Sensors - Characteristics -Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Encoders:	9

	incremental and absolute. Resolvers and synchros. Piezoelectric sensors. Acoustic Emission sensors. vibration sensors. Force and tactile sensors. Range finders: ultrasonic and light base range finders	
II	Actuators: Hydraulic and Pneumatic actuators - Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols. Electrical drives: DC, AC, brushless, servo and stepper motors. Harmonic drive. Magneto strictive actuators and piezoelectric actuators.	9
III	System modelling - Mathematical models and basic building blocks of general mechanical, electrical, fluid and thermal systems. Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Programmable Logic Controllers (PLC) –Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers. Development of simple ladder programs for specific purposes	9
IV	Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition, Lithography, Micromachining methods for MEMS - Surface and Bulk, Deep Reactive Ion Etching (DRIE) and LIGA processes. Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope.	9
V	Mechatronics in Robotics- choice of Sensors and Actuators. Robotic vision system – Image acquisition: Vidicon, charge coupled device (CCD) and charge injection device (CID) cameras. Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding. Case studies of Mechatronics systems: Automatic camera, bar code reader, simple weighing machine, pick and place robot, automatic car park barrier system, automobile engine management system.	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
23ECL31D	DSP ARCHITECTURES	PEC	3	0	0	0	3	2023

i. PREREQUISITE 23ECJ20F-Microcontroller-Based System Design

ii. COURSE OVERVIEW

This course aims to introduce the architecture and features of DSP processors, familiarize students with programming concepts and development tools for DSPs, study design considerations for high-performance DSP architectures, and explore advanced DSP processors and their real-time applications.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the fundamental requirements of DSP systems and differentiate between general-purpose and DSP-specific architectures.	Understand
CO2	Describe the architectural features of typical DSP processors and explain their suitability for real-time applications.	Understand
CO3	Develop DSP algorithms using assembly-level or low-level programming and interface peripherals with DSP processors.	Apply
CO4	Compare advanced DSP architectures like TMS320C6x and Blackfin for performance optimization.	Understand
CO5	Demonstrate awareness of recent advancements such as multicore DSPs, low-power design, and DSP integration in modern applications.	Understand

iv. SYLLABUS

Introduction to DSP Systems and Processors: Introduction to DSP systems and their applications., Requirements of DSP systems, Comparison.

Numerical representations, Harvard and modified Harvard architectures, Pipelining and parallelism in DSP

Fundamentals of DSP Processor Architectures: Features of DSP processors: Multiply-accumulate unit (MAC), special addressing modes, instruction pipelining.

Architectural details of: Texas Instruments TMS320C54xx/ C55xx, Analog Devices ADSP-21xx.

Memory architecture, buses, interrupts and DMA, addressing modes and instruction

set overview.
Programming and Interfacing of DSP Processors: Assembly programming basics, Looping, branching, and conditional execution, Real-time implementation of DSP algorithms (e.g., FIR/IIR filters, FFT).

Interfacing peripherals: ADC, DAC, serial ports, DSP development tools and simulators (e.g., Code Composer Studio).

Advanced DSP Architectures: Introduction to VLIW (Very Long Instruction Word) architecture, Detailed study of Texas Instruments TMS320C6x series (C6000 family), Software pipelining and optimization techniques.

Brief overview of Analog Devices Blackfin Processor architecture, DSP system-on-chip (SoC) design concepts.

Emerging Trends and Applications: Multicore DSPs and heterogeneous processors, Introduction to Digital Signal Controllers, Overview of AI/ML accelerators integrated with DSP cores.

Case studies: DSP in audio, video, biomedical, and communication systems.

v (a) TEXT BOOKS

1.	Avtar Singh and S. Srinivasan, Digital Signal Processing: Implementations Using DSP Microprocessors with Examples from TMS320C54xx, Cengage Learning.
2.	B. Venkataramani and M. Bhaskar, Digital Signal Processors – Architecture, Programming and Applications, Tata McGraw-Hill.
3.	Rulph Chassaing, Digital Signal Processing and Applications with the C6713 and C6416 DSK, Wiley-Interscience.
4.	Texas Instruments, TMS320C6000 CPU and Instruction Set Reference Guide.

(b) REFERENCES

1.	Woon-Seng Gan and Sen M. Kuo, Embedded Signal Processing with the Micro Signal Architecture, Wiley.
2.	Analog Devices, Blackfin Processor Programming Reference Manual.
3.	K. K. Parhi, VLSI Digital Signal Processing Systems: Design and Implementation, Wiley.

vi. COURSE PLAN

Module	Contents	Hours
I	Introduction to DSP Systems and Processors: Introduction to DSP systems and their applications., Requirements of DSP systems, Comparison between general-purpose processors and DSP processors. Numerical representations: Fixed-point and floating-point arithmetic, Harvard and modified Harvard architectures, Pipelining and parallelism in DSP.	9

II	Fundamentals of DSP Processor Architectures: Features of DSP processors: Multiply-accumulate unit (MAC), special addressing modes, instruction pipelining. Architectural details of: Texas Instruments TMS320C54xx/ C55xx, Analog Devices ADSP-21xx Memory architecture, buses, interrupts and DMA, addressing modes and instruction set overview.	9
III	Programming and Interfacing of DSP Processors: Assembly programming basics, Looping, branching, and conditional execution, Real-time implementation of DSP algorithms (e.g., FIR/IIR filters, FFT). Interfacing peripherals: ADC, DAC, serial ports, DSP development tools and simulators (e.g., Code Composer Studio).	9
IV	Advanced DSP Architectures: Introduction to VLIW (Very Long Instruction Word) architecture, Detailed study of Texas Instruments TMS320C6x series (C6000 family), Functional units, data paths, cross paths, Software pipelining and optimization techniques. Brief overview of Analog Devices Blackfin Processor architecture, DSP system-on-chip (SoC) design concepts.	9
V	Emerging Trends and Applications: Multicore DSPs and heterogeneous processors, Introduction to Digital Signal Controllers, Low-power DSP design considerations, Overview of AI/ML accelerators integrated with DSP cores. Case studies: DSP in audio, video, biomedical, and 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: 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
23ECL31E	COMPUTER ARCHITECTURES	PEC	2	1	0	0	3	2023

i. PREREQUISITE : NIL

ii. COURSE OVERVIEW

Upon completion of this course, students will be able to: understand the role of functional units and architectural features; examine the data representation and execution procedure of an ALU; identify factors that degrade pipeline performance and countermeasures. The course covers basic computer structure, processing units, pipelining, memory systems, and I/O systems over 5 units. Students will learn about functional units, bus structures, instructions, addressing modes, arithmetic operations, pipelining, caches, virtual memory, and interfacing with I/O devices.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Realize the role of functional units and the various architectural features of a computer system	Understand
CO 2	Examine data representation and execution procedures of an ALU	Understand
CO 3	Identify the factors that degrade the pipeline performance and its counter measures.	Apply
CO 4	Evaluate and analyze the performance of memory	Apply
CO 5	Apply the different ways of communication with I/O devices and interfaces	Apply
CO 6	Explain the architecture of VEGA THEJAS32 Microcontroller.	Understand

iv. SYLLABUS

Functional units – bus structures – Memory operations – Instructions and sequencing – Instruction set architecture.

Number representations and operations – Instruction Execution – Bus organization

MIPS Implementations – Data path – Pipelining and Hazards - Exceptions

Semiconductor Memories – Cache Memories – Improving Cache Performance – Virtual Memory – Multithreading – Multi-Core processors

I/O Interfaces – Programmed I/O, Memory Mapped I/O, DMA. Multiprocessors – Characteristics-Communication and Synchronization, Multi core processors

VEGA THEJAS32 Microcontroller : RISC-V Instruction Set Architecture, Registers, Operating Modes, Programmers' Model for Base Integer ISA, Exceptions

v (a) TEXT BOOKS

1.	M. Moris Mano (2006), Computer System Architecture, 3rd edition, Pearson/ PHI, India
2.	William Stallings (2010), Computer Organization and Architecture-designing for performance, 8th edition, Prentice Hall, New Jersey.
3.	Carl Hamacher, Zvonks Vranseic, SafeaZaky (2002), Computer Organization, 5th edition, McGraw Hill, New Delhi, India
4.	Andrew S Tanenbaum (2006), Structured Computer Organization, 5th edition, Pearson Education Inc
5.	RISC_V ISA Manual, "Volume 1, Unprivileged Spec v. 20191213 "

(b) REFERENCES

1.	John P Hayes (1998), Computer Architecture and Organization, 3rd edition, Tata McGraw Hill
2.	Er. Rajiv Chopra (2013), Computer Architecture and Organization (A Practical Approach), S.Chand

vi. COURSE PLAN

Module	Contents	Hours
I	**Basic Structure of Computers** : Functional units, Operational Concepts, Bus structures, Performance, Memory Locations and Addresses, Memory Operations – Instructions and Instruction Sequencing, Instruction Set Architecture, Addressing Modes, I/O Operations	8
II	**Basic Processing Unit**: Fixed point arithmetic, Addition and subtraction of signed numbers, multiplication of positive number, signed operand multiplication and fast multiplication, restoring and non-restoring division algorithm. Execution of a complete instruction – Multiple bus organization, hardwired control, micro programmed control	9
III	**Pipelining:** A basic MIPS implementation, Building a data path, Control Implementation Scheme, Pipelining – Pipelined data path and control, Handling data hazards & control hazards, Exceptions.	9
IV	**Memory System:** Semiconductor RAM, ROM – Speed and Cost, Cache Memory, Improving Cache performance, Mapping techniques, Improving Cache performance. Virtual memory – Overlay, Memory management, Address translation, Paging, Secondary Storage, RAID	9

	Input/Output Organization – Introduction, Synchronous vs. asynchronous I/O, Programmed I/O, Interrupt driven I/O, Direct Memory Access.	
V	**Multiprocessors** - Characteristics, Interconnection structure, Inter Processor Arbitration, Inter processor communication and synchronization. **VEGA THEJAS32 Microcontroller**: RISC-V Instruction Set Architecture, Registers – General Purpose Registers, Control and Status Registers, Operating Modes, Programmers' Model for Base Integer ISA, Base Instruction Formats, Exceptions, Traps, and Interrupts.	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
23ECL31F	DATA STRUCTURES USING C	PEC	3	0	0	0	3	2023

i. PREREQUISITE 23ESB10D- Problem Solving and Programming in C

ii. COURSE OVERVIEW

This course introduces the fundamental concepts of data structures using the C programming language. It covers the design, implementation, and analysis of data structures such as arrays, linked lists, stacks, queues, trees, and graphs. The course emphasizes the application of these structures in solving real-world electronics and embedded systems problems. Through a combination of lectures and microprojects, students will develop a strong foundation in algorithmic thinking, programming, and data abstraction techniques relevant to electronics applications.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Construct simple programs using arrays, strings and structures using the C programming language.	Apply
CO2	Explain the concept of pointers and dynamic memory allocation in C to implement flexible data structures such as linked lists for control flow operations.	Understand
CO3	Discuss the concept of hierarchical data structures such as stacks, queues and trees.	Understand
CO4	Explain the concepts of linear and binary search algorithms, basic sorting techniques and the working of hash tables, including the role of hash functions and methods for handling collisions.	Understand
CO5	Describe basic graph terminology and types of graphs such as directed graphs and bi-connected components, and explain various methods for representing graphs.	Understand

iv. SYLLABUS

Role of data structures in embedded systems & electronics - Embedded vs general-purpose programming, Introduction to Data Structures and Algorithms, Time and Space Complexity, Big O Notation. Arrays, Strings & Structures - 1D, 2D arrays, String manipulation in C, Types of structures. Pointers & Dynamic Memory – Pointers and arrays, arrays of pointers, malloc, free, memory leaks, Stack vs heap in microcontrollers.

Linked Lists – Basic terminologies, linked lists versus arrays, Singly, doubly, circular lists. Stacks & Queues – array representation of Stacks, Operations on a Stack, array representation of Queues, types of queues. Trees – Types of trees, binary search trees. Searching and Sorting – Linear and binary search, introduction to sorting, types of sorting: Bubble sort, Insertion sort, Selection sort. Hash Tables – Hash tables and hash functions, Collision.

Graphs – Graph Terminology, Directed Graphs, Bi-connected Components, Representation of Graphs

v (a) TEXT BOOKS

1.	Reema Thareja, Data Structures Using C, 2nd Edition, 2014, Oxford University Press
2.	Yashavant Kanetkar, Data Structures Through C, 1st Edition, 2003, BPB Publications
3.	Richard F. Gilberg and Behrouz A. Forouzan, Data Structures: A Pseudocode Approach with C, 2nd Edition, 2004, Cengage Learning
4.	Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, 2nd Edition, 1988, Prentice Hall

(b) REFERENCES

1.	Barnett, R.H., Cox, S., and O'Cull, L., Embedded C Programming and the Atmel AVR, 2nd Edition, 2006, Cengage Learning
2.	Robert Sedgewick, Algorithms in C, Parts 1-4: Fundamentals, Data Structures, Sorting, Searching, 3rd Edition, 1997, Addison-Wesley Professional
3.	Ellis Horowitz, Sartaj Sahni, and Susan Anderson-Freed, Fundamentals of Data Structures in C, 2nd Edition, 2008, Universities Press

vi. COURSE PLAN

Module	Contents	Hours
I	**Role of data structures in embedded systems & electronics** - Embedded vs general-purpose programming, Introduction to Data Structures and Algorithms, Time and Space Complexity, Big O Notation **Arrays, Strings & Structures** - 1D, 2D arrays, String manipulation in C, Types of structures	12
II	**Pointers & Dynamic Memory** – Pointers and arrays, arrays of pointers, malloc, free, memory leaks, Stack vs heap in microcontrollers **Linked Lists** – Basic terminologies, linked lists versus arrays, Singly, doubly, circular lists	12
III	**Stacks & Queues** – array representation of Stacks, Operations on a Stack, array representation of Queues, types of queues **Trees** – Types of trees, binary search trees.	7
IV	**Searching and Sorting –** Linear and binary search, introduction to sorting, types of sorting: Bubble sort, Insertion sort, Selection sort **Hash Tables** – Hash tables and hash functions, Collision	7

V	**Graphs** – Graph Terminology, Directed Graphs, Bi-connected Components, Representation of Graphs	7
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignment	:	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL31G	**BIOMEDICAL ENGINEERIN G**	**PEC**	**3**	**0**	**0**	**0**	**3**	**2023**

i. PREREQUISITE Nil

ii. COURSE OVERVIEW

This course will introduce aspects of Biomedical Engineering as applied to biological systems described using engineering principles and the use of modern diagnostic and therapeutic equipment.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the functioning of Cardio Vascular and Nervous system and generation of bioelectric potentials.	Understand
CO2	Describe the techniques used for diagnosis and therapy of the Cardio Vascular system.	Understand
CO3	Explain the techniques used for diagnosis and therapy of the neuromuscular and respiratory systems.	Understand
CO4	Explain the principle and working of different types of biomedical equipment/device.	Understand
CO5	Explain the principle and working of medical imaging techniques.	Understand

iv. SYLLABUS

Introduction to bio-medical engineering, overview of Cardio Vascular and Nervous system. Bio-electric potential: Resting and action potential, propagation of action potentials. Electrodes, Bio potential Amplifiers, Patient Safety.

Electro conduction system of the heart, ECG machine, Einthoven triangle, analysis of ECG signals. Measurement of blood pressure and blood flow.

Neuron, action potential of brain, brain waves, EEG recording, analysis of EEG. Electrical activity of muscles- EMG. Signal Acquisition and analysis. Applications. Physiology of respiratory system (overview), Respiratory parameters, spirometer, body plethysmograph, gas exchange and distribution.

Instruments for clinical laboratory, Therapeutic Equipment, Biomedical Telemetry system.

Medical Imaging systems (Basic Principle only): X-ray imaging, Computed Tomography, Ultrasonic imaging systems and Magnetic Resonance Imaging.

v (a) TEXT BOOKS

1.	R. S. Khandpur, Handbook of Biomedical Instrumentation, McGraw Hill, 3rd ed., 2024.
2.	Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, PHI, 2nd ed., 1980

(b) REFERENCES

1.	John G Webster, "Medical Instrumentation application and design", John Wiley, 5th ed., 2020
2.	J. J. Carr, "Introduction to Biomedical Equipment Technology", Pearson Education, 4th ed., 2000
3.	Richard Aston, "Principle of Biomedical Instrumentation and Measurement". Merrill Publishing Company,1 ed., 1990.
4.	Barbara Christe, Introduction to Biomedical Instrumentation, Cambridge University Press, 2nd ed., 2017.

vi. COURSE PLAN

Module	Contents	Hours
I	Introduction to Bio-medical Engineering, Heart and Cardio Vascular system, Human Nervous System. **Bio-electric potentials**: Resting and action potential, propagation of action potentials. **Electrode theory:** Nernst relation, Electrode skin interface, Biopotential electrodes: Microelectrodes, skin surface electrodes, needle electrodes. **Bio potential amplifiers:** instrumentation amplifier, carrier amplifier, isolation amplifier, chopper amplifier. **Patient Safety:** Electric shock hazards, leakage current.	9
II	Electro conduction system of the heart. ECG machine - block diagram, ECG lead configurations, Einthoven triangle, analysis of ECG signals. **Measurement of blood pressure:** Auscultatory method, oscillometric and ultrasonic non-invasive pressure measurements. **Measurement of blood flow:** Electromagnetic blood flowmeters and ultrasonic blood flow meters.	9
III	**Electrical activity of brain:** Neuron, action potential of brain, brain waves, types of electrodes, placement of electrodes, evoked potential, EEG recording, analysis of EEG. **Electrical activity of muscles:** EMG, Signal Acquisition and analysis. Applications of EMG. Electrical stimulation of the muscle and nerve. **Respiratory system:** Physiology, Respiratory parameters,	9

	spirometer, body plethysmograph, gas exchange and distribution.	
IV	**Instruments for clinical laboratory:** Pulse Oximeter, pH meter, blood cell counter, spectrophotometer. **Therapeutic Equipment:** Pacemaker, cardiac defibrillator, heart–lung machine, dialyzer, ventilator. **Biomedical Telemetry system:** Components of biotelemetry system, application of telemetry in medicine, single channel telemetry system for ECG.	**9**
V	Medical Imaging systems (Basic Principle only) **X-ray imaging:** X-ray machine, applications of X- rays in medicine. **Computed Tomography:** Principle, image reconstruction, scanning system and applications. **Ultrasonic imaging systems:** Basic pulse echo system, propagation of ultrasonic through tissues and reflections, display types, applications. **Magnetic Resonance Imaging:** Basic NMR components, Biological effects and advantages of NMR imaging, applications.	**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

S5 MINOR

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3MA	**EMBEDDED SYSTEM DESIGN**	**MINOR**	**3**	**0**	**0**	**0**	**3**	**2023**

i. PREREQUISITE	23ECJ20C Logic Circuit Design 23ECJ20F Microcontroller Based System Design

ii. COURSE OVERVIEW

Goal of this course is to introduce embedded systems, various protocols used for communication between peripheral devices and processors, Embedded programming, the ARM processor organization and programming.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the basic concepts of embedded systems and different phases in the embedded system design process/EDLC.	Understand
CO2	Explain serial and parallel communication protocols and peripheral interfacing in embedded systems.	Understand
CO3	Explain the ARM processor architecture, pipeline organization, and the execution of ARM and Thumb instruction sets.	Understand
CO4	Summarize the different development tools and architectural features used in ARM-based embedded system applications.	Understand
CO5	Develop ARM assembly programs to implement solutions for various embedded system tasks.	Apply

iv. SYLLABUS

Introduction to Embedded Systems: The Embedded System Design Process, Embedded product development cycle (EDLC).

Interfacing and Communication Protocols: Serial Communication Standards and Devices, Serial Bus Protocols, Parallel communication standards, Peripheral interfacing: Timers, ADC/DAC, GPIO (basics).

ARM Microcontrollers & Architecture: ARM7 & ARM9 architecture, block diagrams & peripherals, ARM organization: 3-stage & 5-stage pipeline, instruction execution, ARM coprocessor interface.

ARM Assembly Language Programming: data processing, data transfer, control flow, Thumb instruction set: CPSR, programmer's model, branching, data transfer.

Architectural Support for System Development: ARM memory interface, AMBA bus architecture, Application examples: Audio Player, Engine Control Unit, Video Accelerator, Development tools: Keil IDE, debugging, flashing tools.

v (a) TEXT BOOKS	
1.	K.V. Shibu, Introduction to Embedded Systems, 2e, McGraw Hill Education India, 2016.
2.	Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Morgan Kaufman Publishers - Elsevier 3e, 2008.
3.	Steve Furber, ARM system-on-chip architecture, Addison Wesley, Second Edition, 2000.
4.	Raj Kamal, Embedded Systems Architecture, Programming and Design, TMH, Third Edition, 2017
(b) REFERENCES	
1.	David E. Simon, An Embedded Software Primer, First Indian Reprint, Pearson Education Asia, 2000.
2.	Steve Heath, Embedded Systems Design, Newnes – Elsevier 2/ed, 2002.
3.	Andrew N. Sloss, Dominic Symes, Chris Wright, ARM System Developer's Guide Designing Optimizing System Software, Morgan Kaufmann Publishers, 2004.
4.	Frank Vahid and Tony Givargis, Embedded Systems Design – A Unified Hardware/Software Introduction, John Wiley, 2002

5.	Tammy Noergaard, Embedded Systems Architecture, A Comprehensive Guide for Engineers and Programmers, Newnes – Elsevier 2/ed, 2013.
6.	Iyer - Embedded Real time Systems, 1/e, McGraw Hill Education New Delhi, 2003.
7.	Lyla B. Das, Embedded Systems: An Integrated Approach, 1/e, 2012.
8.	Shujen Chen, Muhammad Ali Mazidi, Eshragh Ghaemi, STM32 Arm Programming for Embedded Systems, 2018.

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to Embedded Systems** Introduction to embedded systems - Current trends and challenges - Applications of embedded systems, Characteristics, and quality attributes of an embedded system **The Embedded System Design Process:** Requirements, Specification, Architecture Design, Designing Hardware and Software Components and System Integration. **Embedded product development cycle (EDLC):** Different phases of EDLC and EDLC models.	8
II	**Interfacing and Communication Protocols** Serial Communication Devices and Standards: UART, HDLC, SPI, Serial Bus Protocols: I2C, CAN, USB, Parallel Communication Standards: ISA, PCI, PCI-X, Peripheral Interfacing: Timers, ADC/DAC, GPIO (Basics)	7
III	**ARM Microcontrollers and Architecture:** ARM Architecture Overview, Block Diagrams and On-chip Peripherals: ARM 7 and ARM 9, ARM Organization and Implementation: 3 stage pipeline ARM organization, 5-stage pipeline ARM organization, ARM instruction execution, ARM implementation, The ARM coprocessor interface.	10

IV	**ARM Assembly Language Programming**: Data processing instructions, Data transfer instructions, Control flow instructions, writing simple assembly language programs. **The Thumb Instruction Set**: The Thumb bit in the CPSR, The Thumb programmer's model, Thumb branch instructions, Thumb software interrupt instruction, Thumb data processing instructions, Thumb single register data transfer instructions, Thumb multiple register data transfer instructions.	10
V	**Architectural Support for System Development**: The ARM memory interface, The Advanced Microcontroller Bus Architecture (AMBA). **Embedded System Design examples**: Audio Player, Engine Control Unit, Video Accelerator, **Development Tools**: Keil IDE, Debugging, Flashing Tools	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3MC	DEEP LEARNING	MINOR	2	1	0	0	3	2023

i. PREREQUISITE	Basic knowledge of probability theory, machine learning, and linear algebra
ii. COURSE OVERVIEW	

Deep Learning is the recently emerged branch of machine learning, particularly designed to solve a wide range of problems in Computer Vision and Natural Language Processing. In this course, the building blocks used in deep learning are introduced. Specifically, neural networks, deep neural networks, convolutional neural networks and recurrent neural networks. Learning and optimization strategies such as Gradient Descent, Nesterov Accelerated Gradient Descent, Adam, AdaGrad and RMSProp are also discussed in this course. This course will helps the students to attain sound knowledge of deep architectures used for solving various Vision and NLP tasks. In future, learners can master modern techniques in deep learning such as attention mechanisms, generative models and reinforcement learning.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Illustrate the basic concepts of neural networks and their practical issues	Apply
CO2	Outline the standard regularization and optimization techniques for deep neural network	Understand
CO3	Implement the foundation layers of Convolutional Neural Network	Apply
CO4	Implement a sequence model using recurrent neural networks	Apply
CO5	Use different neural network/deep learning models for practical applications.	Apply

vi. Syllabus

Introduction to neural networks - Multi Layer Perceptrons (MLPs), Activation functions. Risk minimization, Loss function, Training MLPs with backpropagation, Practical issues in neural network training - Problem of Overfitting, Vanishing and exploding gradient problems, Difficulties in convergence, Local and spurious Optima, Computational Challenges. Applications of neural networks

Deep learning - Deep feed forward network, Training deep models, Optimization techniques. Regularization Techniques - L1 and L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Parameter initialization.
Convolutional Neural Networks – Convolution operation, Motivation, Pooling, Convolution, Variants of convolution functions, Structured outputs, Data types, Efficient convolution algorithms. Practical use cases for CNNs.

Recurrent neural networks – Computational graphs, RNN design, encoder – decoder sequence to sequence architectures, deep recurrent networks, recursive neural networks, modern RNNs LSTM and GRU, Practical use cases for RNNs.

Recent Trends in Deep Learning Architectures - Residual Network, Skip Connection Network, Fully Connected CNN. Generative Modeling with DL. Attention networks, Transformers, and Vision transformers for Computer Vision applications

v (a) TEXT BOOKS

1.	Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016.
2.	Neural Networks and Deep Learning, Aggarwal, Charu C., c Springer International Publishing AG, part of Springer Nature 2018
3.	Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms (1st. ed.). Nikhil Buduma and Nicholas Locascio. 2017. O'Reilly Media, Inc.

(b) REFERENCES

1.	Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004.
2.	Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
3.	Michael Nielsen, Neural Networks and Deep Learning, 2018.

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to neural networks -** Multi Layer Perceptrons (MLPs), Representation Power of MLPs, Activation functions - Sigmoid, Tanh, ReLU, Softmax. Risk minimization, Loss function, Training MLPs with backpropagation, Practical issues in neural network training - The Problem of Overfitting, Vanishing and exploding gradient problems, Difficulties in convergence, Local and spurious Optima, Computational Challenges. Applications of neural networks.	8
II	**Deep learning** - Deep feed forward network, Training deep models, Optimization techniques - Gradient Descent (GD), GD with momentum, Nesterov accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam. Regularization Techniques - L1	9

	and L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Parameter initialization.	
III	**Convolutional Neural Networks** – Convolution operation, Motivation, Pooling, Convolution and Pooling as an infinitely strong prior, Variants of convolution functions, Structured outputs, Data types, Efficient convolution algorithms. Practical use cases for CNNs Case study - Building CNN model AlexNet with handwritten digit dataset MNIST.	10
IV	**Recurrent neural networks** – Computational graphs, RNN design, encoder – decoder sequence to sequence architectures, deep recurrent networks, recursive neural networks, modern RNNs LSTM and GRU, Practical use cases for RNNs. Case study - Natural Language Processing.	9
V	**Recent Trends in Deep Learning Architectures** - Residual Network, Skip Connection Network, Fully Connected CNN. Generative Modeling with DL - Variational Autoencoder, Generative Adversarial Network. Attention networks, Transformers, and Vision transformers for Computer Vision applications.	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3ME	VISION SYSTEM	MINOR	3	0	0	0	3	2023

i. PREREQUISITE Nil

ii. COURSE OVERVIEW

This course introduces students to the field of Vision Systems, encompassing traditional image processing and modern computer vision techniques including image formation, image handling, feature extraction, geometric transformations, and machine learning methods for vision.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain fundamental principles of vision systems	Understand
CO2	Analyze image processing and transformation techniques	Apply
CO3	Explain feature detection and descriptor algorithms	Understand
CO4	Implement classification and segmentation methods	Understand
CO5	Integrate computer vision tools for real-world tasks	Apply

iv. SYLLABUS

Introduction to vision systems, imaging models, transformation, photometric concepts, Image processing filters, feature descriptors, Python tools, Homographies, camera models, AR, 3D vision, clustering, classification, Segmentation techniques, OpenCV tools and applications

v (a) TEXT BOOKS

1. Richard Szeliski, Computer Vision: Algorithms and Applications, 2nd Edition, Springer, 2022.
2. Jan Erik Solem, Programming Computer Vision with Python, O'Reilly Media, 2012.

(b) REFERENCES

1. Forsyth, D. A., & Ponce, J., Computer Vision: A Modern Approach, 2nd Edition, Pearson Education, 2011.
2. E. R. Davies, Computer Vision: Principles, Algorithms, Applications and Systems, 5th Edition, Academic Press, 2017.

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to vision systems.** Applications of computer vision. Biological versus machine vision. Geometric primitives and transformations. Photometric image formation. The digital camera – sampling, aliasing, color representation, and compression techniques. Image Processing: Point operators, Linear filtering, More neighbourhood operators	8
II	**Image Processing and Image Descriptors** Image processing techniques including point operators, linear filtering, and neighborhood operations. Frequency domain analysis using Fourier transforms. Introduction to local image descriptors – Harris corner detector, SIFT and matching geotagged images.	9
III	**Image Mappings and Camera Models-** Multiple view geometry – epipolar geometry, computing with cameras and 3D structure, multiple view reconstruction and stereo images. **Clustering techniques** K-means clustering, hierarchical clustering, and spectral clustering.	9
IV	**Image classification and Segmentation** Image content classification using K-nearest neighbours, Bayes classifier, support vector machines and optical character recognition. Image segmentation techniques including graph cuts, clustering-based segmentation, and variational methods.	9
V	**Python Libraries and OpenCV Applications** Basic image handling and processing using Python libraries: PIL (Python Imaging Library), Matplotlib, NumPy, and SciPy. Introduction to OpenCV – the OpenCV Python interface, basic operations, video processing, object tracking and practical examples.	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3MG	**MEDICAL DEVICES ENGINEERING**	**MINOR**	**3**	**0**	**0**	**0**	**3**	**2023**

i. PREREQUISITE Nil

ii. COURSE OVERVIEW

The Medical Devices Engineering course provides students with a comprehensive understanding of the design, development, and manufacturing processes involved in creating medical devices. The objective is to equip students with the skills necessary to contribute to the development of cutting-edge medical technologies that improve patient care and meet the highest standards of safety, reliability, and efficacy.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Classify medical devices and understand their lifecycle, from conception to market release.	Understand
CO2	Apply principles of engineering to explain the working of medical devices.	Apply
CO3	Select materials for medical devices based on their properties.	Understand
CO4	Explain the regulatory processes, quality management systems, and risk management practices to ensure compliance and safety in medical device development.	Understand
CO5	Discuss emerging technologies into the design and innovation of future medical devices along with the ethical issues.	Understand

iv. SYLLABUS

Classification of medical devices, device lifecycle, and the role of engineers in healthcare.

Mechanical, electrical, and software engineering fundamentals; Design for reliability, safety, and performance in medical devices.

Materials selection, biocompatibility and material testing; Standards for material safety and performance in medical devices.

FDA and ISO standards, medical device approval processes, risk management,

clinical trials, and quality management systems, Quality Assurance, Inspection and fees. Emerging technologies such as AI, robotics, wearables, and 3D printing.

v (a) TEXT BOOKS

1.	Introduction to Biomedical Engineering, John Enderle and Joseph Bronzino, Academic Press, 2011.
2.	Materials for Biomedical Engineering: Applications in Medical Devices and Therapy, Hatem H. S. Gad, Elsevier, 2016.
3.	FDA Regulatory Affairs: A Guide for Prescription Drugs, Medical Devices, and Biologics, Douglas J. Pisano and David J. Bearer, Informa Healthcare, 2004.
4.	Quality Assurance for the Pharmaceutical Industry, Graham Bunn, Wiley-Blackwell, 2008.

(b) REFERENCES

1.	Advanced Medical Device Design: A Comprehensive Guide to Prototyping and Manufacturing, Joe McDonnell, Springer, 2015.
2.	Medical Device Design: Innovation from Concept to Market, Peter J. Ogrodnik, John Wiley & Sons, 2009.
3.	Biomaterials for Implants and Medical Devices, Jean-Pierre Boutrand and Patrick K. B. Li, Elsevier, 2020.

vi. COURSE PLAN

Module	Contents	Hours
I	Introduction to Medical Devices Engineering Overview of medical devices and their classifications. The medical device lifecycle: design, development, manufacturing, and License. The role of medical device engineers in healthcare.	8
II	Engineering Principles for Medical Devices Biomedical Engineering fundamentals: biomechanics, physiology, and biomaterials. Mechanical, electrical, and software engineering principles for medical devices. Design for reliability, safety, and performance in medical devices.	9
III	Materials for Medical Devices Materials selection for medical devices: metals, polymers, ceramics, and composites. Biocompatibility and material testing. Design considerations for implantable and non-implantable devices. Standards for material safety and performance in medical devices.	9
IV	Regulatory Compliance and Quality Assurance Regulatory bodies (FDA, EMA, ISO). Medical device classification, approval, and compliance processes. Quality management systems (QMS) and the role of ISO 13485.Risk management and	9

	clinical trials in medical devices (ISO 14971). Quality Assurance, Inspection and fees.	
V	Advanced Topics in Medical Devices Emerging technologies in medical devices: AI, robotics, 3D printing. Wearable and implantable devices: design considerations and future trends. Case studies of successful medical device innovations (e.g., pacemakers, artificial heart valve). Ethical issues in medical device engineering.	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

S5 HONOURS

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3HA	FPGA BASED SYSTEM DESIGN	HONOURS	3	0	0	0	3	2023

i. PREREQUISITE 23ECJ20C - Logic Circuit Design

ii. COURSE OVERVIEW

This course is designed to equip students with a thorough understanding of circuit design using programmable logic, emphasizing digital system development through Verilog HDL for modeling, simulation, and practical implementation on commercial FPGA boards

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the architecture and design approaches of ASIC and FPGA	Understand
CO 2	Design combinational circuits using programmable logic devices	Apply
CO 3	Apply the concepts of Verilog HDL to model digital systems	Apply
CO 4	Apply the steps of the design flow to implement digital circuits on an FPGA board	Apply

iv. SYLLABUS

ASIC and FPGAs: Moore's Law, Types of ASICs, Generic structure of FPGA. ASIC and FPGA Design flow. FPGA-based system design: Goals, Design challenges, Design abstractions, Top-down and Bottom-Up design methodologies.

FPGA Fabrics: FPGA Architecture, coarse-grained vs. fine-grained, SRAM-based FPGAs, Permanently Programmed FPGAs, FPGA logic cells, Interconnects, I/O Pad. Programmable Logic Devices: SPLD, PLA, PAL, PROM, CPLD.

Hardware description language: Logic Design process, Modeling with Verilog HDL Tasks, and functions. Modeling of digital circuits, FSM, Memory. Test benches.

Physical Design Flow: Design translation, Mapping, Placement and Routing. Synthesis of the case statement, if statement, and arithmetic component.

Commercial FPGA Vendors: Architecture of Xilinx and Altera, Device families.

Design and implementation of a digital system using FPGA board.

v (a) TEXT BOOKS

1.	Wayne Wolf, FPGA-Based System Design, Pearson Education Inc., 2004
2.	Ian Grout, Digital Systems Design with FPGAs and CPLDs, Elsevier Ltd., 2008
3.	Samir Palnikar, Verilog HDL: A Guide to Digital Design and Synthesis, 2nd edition, Prentice Hall, 2003
4.	Charles H. Roth, Jr., Lizy Kurian John, Byeong Kil Lee, Digital Systems Design Using Verilog, 1st edition, Cengage Learning, 2016

(b) REFERENCES

1.	S.Trimberger, Edr., Field Programmable Gate Array Technology, Kluwer Academic Publications, 1st edition, 1994
2.	P.K.Chan & S. Mourad, Digital Design Using Field Programmable Gate Array, Prentice Hall (Pte), 1994
3.	S.Brown, R.Francis, J.Rose, Z.Vransic, Field Programmable Gate Array, Kluwer Publications, 2007

vi. COURSE PLAN

Module	Contents	Hours
I	**ASIC and FPGAs:** Moore's Law, Full custom ASICs, Standard cell-based ASICs, Gate array-based ASICs. Generic structure of FPGA. ASIC and FPGA Design flow. **FPGA-based system design:** Goals, Design challenges, Design abstractions, Top-down and Bottom-Up design methodologies.	8
II	**FPGA Fabrics:** FPGA Architecture, coarse-grained vs. fine-grained, SRAM-based FPGAs, Permanently Programmed FPGAs, FPGA logic cells, Interconnects, I/O Pad.	8
III	**Programmable Logic Devices:** Simple Programmable logic Device, Programmable Logic Array, Programmable Array Logic, Programmable Read Only Memory, Complex Programmable Logic Device.	10
IV	**Hardware description language:** Logic Design process, Modeling with Verilog HDL, Tasks and functions. Modelling of digital circuits, State machine design, RAM, ROM. Test benches.	10
V	**Physical Design flow:** Design translation, Mapping, Placement and Routing. Synthesis of case statement, if statement, and arithmetic component. **Commercial FPGA Vendors:** Architecture of Xilinx and Altera, Device families. Design and implementation of a digital system using an FPGA board.	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	:	**101 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3HC	DETECTION AND ESTIMATION THEORY	HONOURS	3	0	0	0	3	2025

i. PREREQUISITE	23MAL10A - Linear Algebra and Calculus, 23MAL20C- Probability, Random Process, and Numerical Methods, 23ECL20E - Signals and Systems
ii. COURSE OVERVIEW	

Goal of this course is to provide an insight into the fundamentals of detection and estimation theory in engineering applications

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 statistical detection and estimation principles used in various engineering problems	Understand
CO 2	Explain the estimation principles used in various engineering problems	Understand
CO 3	Apply various types of statistical decision rules in engineering applications.	Apply
CO 4	Apply different types of estimation methods in engineering applications.	Apply

iv. SYLLABUS

Fundamentals of detection and estimation theory and its applications, classical and Bayesian approach in detection and estimation theory, different types of statistical decision rules, different types of estimation algorithms and its applications.

v (a) TEXT BOOKS

1.	S.M. Kay, Fundamentals of Statistical Signal Processing, Vol I: Estimation Theory, 3/e, Pearson, 2010.
2.	S.M. Kay, Fundamentals of Statistical Signal Processing Vol II: Detection Theory, 3/e, Pearson, 2010

(b) REFERENCES

1.	H. L. Van Trees, Detection, Estimation, and Modulation Theory, Vol. I, John Wiley & Sons, 1968
2.	Monson H. Hayes, Statistical Digital Signal Processing and Modelling, John Wiley & Sons, 2002.

vi. COURSE PLAN

Module	Contents	Hours
I	Fundamentals of detection theory, the mathematical detection problem. Fundamentals of estimation theory, the mathematical estimation problem. Review of Gaussian distribution. Application examples.	9
II	Hypothesis testing, classical approach, Neyman-Pearson theorem, likelihood ratio test, receiver operating characteristics, Bayesian approach, minimum probability of error, Bayes risk, multiple hypothesis testing.	9
III	Detection of deterministic signals, matched filters, detection of random signals, estimator-correlator, linear model, application examples.	9
IV	Minimum variance unbiased estimation, basics of Cramer-Rao Lower Bound, linear models, best linear unbiased estimation, application examples.	9
V	Maximum likelihood estimation, least squares, Bayesian philosophy, minimum mean square error estimation, application examples.	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3HE	DSP SYSTEM DESIGN	HONOURS	3	0	0	0	3	2023

i. PREREQUISITE Nil

ii. COURSE OVERVIEW

1. To provide basic concepts in number representations
2. To study about issues in pipelining and DSP Processors

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain DSP architectures and number systems used in digital signal processing	Understand
CO2	Apply Distributed Arithmetic and CORDIC algorithm in RISC processor.	Apply
CO3	Describe MIPS pipeline and resolve hazards using instruction-level parallelism and dynamic scheduling.	Understand
CO4	Explain branch prediction techniques and memory hierarchy for improving DSP system performance	Understand
CO5	Describe basic DSP architectures and FPGA design flow	Understand

iv. SYLLABUS

Introduction to Programmable DSP, Number systems, Distributed arithmetic and CORDIC algorithm, Basic Pipelining, Basic performance issue in pipelining, Simple implementation of MIPS, Instruction Level Parallelism, Dynamic Scheduling, Dynamic Hardware Prediction, Memory hierarchy, DSP architectures, algorithms for FIR, IIR, and FFT, and the design and implementation of DSP systems on FPGA

v (a) TEXT BOOKS

1. Digital Signal Processing with Field Programmable Gate Arrays, Uwe Meyer-Baese, Springer; 3rd edition
2. Sen M Kuo, Woon- Seng S Gan, Digital Signal Processors.

(b) REFERENCES

1. Digital Signal Processing with Field Programmable Gate Arrays, Uwe Meyer-Baese, Springer; 3rd edition
2. Digital Signal Processing and Application with C6713 and C6416 DSK, Rulph Chassaing, Worcester Polytechnic Institute, A Wiley Interscience Publication
3. J L Hennessy, D A Patterson, Computer Architecture A Quantitative Approach: 3rd Edition Elsevier India.

4.	DSP Processor and Fundamentals: Architecture and Features. Phil Lapsley, JBier, AmitSohan, Edward A Lee; Wiley IEEE Press
5.	Sen M Kuo, Woon- Seng S Gan, Digital Signal Processors.

vi. COURSE PLAN

Module	Contents	Hours
I	Introduction to Programmable DSP - Block Diagram. MAC (Multiply and Accumulate), Numeric Representations and Arithmetic: Classification of number system, Conventional fixed point number system, Carry free adders, Multiplier Adder Graph, Floating point number format, Unconventional fixed point number system: Signed digit numbers, LNS and RNS. Chinese Remainder Theorem (CRT), Conversion of RNS to integer and Binary to RNS, Index Multiplier: Primitive mod root, Addition and Multiplication in index domain.	9
II	Distributed Arithmetic (DA): Design, Signed DA system, CORDIC Algorithm: Rotation mode and Vectoring mode. Basic Pipelining and Simple RISC Processors: RISC Architecture, instructions and its format, Implementation of RISC instruction set, Pipelining, Pipeline Registers, Basic performance issue in pipelining, Pipeline Hazards (based on MIPS), Reducing Pipeline Branch Penalties, Performance of pipeline with stalls.	9
III	Simple implementation of MIPS, Basic pipeline for MIPS, Instruction Level Parallelism: Concepts, Dependences, RAW, WAW, and WAR hazards, Dynamic Scheduling - Reducing data hazards, Tomasulo's Algorithm.	9
IV	Dynamic Hardware Prediction - Reducing branch hazards. 1-bit, 2-bit, correlating branch and tournament predictor, Limitations of ILP, Branch Target Buffer, Return address predictor, Memory hierarchy - Cache design, Cache performance review, Memory mapping techniques. Block identification and replacement.	9
V	Analysis of basic DSP Architectures on programmable hard wares. Algorithms for FIR, IIR, Lattice filter structures, architectures for real and complex fast Fourier transforms, 1D/2D Convolutions, Winograd minimal filtering algorithm. FPGA: Architecture, different sub-systems, design flow for DSP system design, mapping of DSP algorithms onto FPGA.	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

SEMESTER VI

Cour se Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL30D	CONTROL SYSTEMS	PCC	3	1	0	0	4	2023

i. PREREQUISITE 23ECL20E - Signals and Systems

ii. COURSE OVERVIEW

This course aims to develop the skills for mathematical modelling of various control systems. The time and frequency domain responses of control systems are analyzed. This course also presents the stability analysis using time domain and frequency domain approaches. Also, the course aims to get an overview of the basic concepts of controllers and compensators and make use of state space methods to determine the performance of a linear system.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Model electrical and mechanical systems and represent physical systems using signal flow graph, block diagram and transfer function.	Apply
CO2	Analyze the time and frequency domain responses of control systems.	Apply
CO3	Determine the stability of a system using time and frequency domain methods.	Apply
CO4	Explain the need of controllers and compensators.	Understand
CO5	Apply state-space methods for modelling, analysis and determine system controllability and observability.	Apply

iv. SYLLABUS

Basic Components of a Control System, Open-Loop Control Systems and Closed-Loop Control Systems, Mathematical modelling of Electrical Systems and Mechanical systems, Transfer Function from Block Diagrams and Signal Flow Graphs, Time domain analysis, Steady state error and static error coefficients, Frequency domain analysis.

Stability analysis using Routh Hurwitz Criterion, Root Locus Technique and Frequency domain methods: Nyquist Plot, Bode Plot. Controllers and Compensators: PID controller, lag, lead and lag-lead compensators. State-space Analysis of Linear Systems.

v (a) TEXT BOOKS	
1.	Farid Golnaraghi, Benjamin C. Kuo, Automatic Control Systems,10th ed., McGraw-Hill Education, 2017.
2.	I.J. Nagarath, M. Gopal, Control Systems Engineering, 7th ed., New Age International Publishers, 2021.
3.	Ogata K., Discrete-Time Control Systems, 2nd ed., Pearson Education,1995.
(b) REFERENCES	
1.	Norman S. Nise, Control System Engineering, 7th ed., Wiley India, 2019.
2.	M. Gopal, Digital Control and State Variable Methods, 4th ed., McGraw Hill Education India, 2012.
3.	Ogata K.,Modern Control Engineering, 5th ed., Prentice Hall of India, 2010.
4.	Richard C Dorf and Robert H. Bishop, Modern Control Systems,14th ed, Pearson Education, 2017.

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction:** Basic Components of a Control System, Open-Loop Control Systems and Closed-Loop Control Systems, Examples of control system, real world applications. **Mathematical modelling:** Electrical Systems and Mechanical systems. Force Voltage Analogy. **Transfer Function from Block Diagrams and Signal Flow Graphs:** Block Diagram representation and reduction methods. Signal Flow Graph reduction using Mason's gain formula.	12
II	**Time domain analysis:** Standard Test signals, Transient and steady state responses: Time response of first and second order systems to unit step, ramp and impulse inputs, Time domain specifications. Steady state error and static error coefficients. Introduction to software tools (MATLAB/SIMULINK) to analyze the control system. **Frequency domain analysis**: Frequency domain specifications. - correlation between time domain and frequency domain responses.	12
III	**Stability:** Concept of BIBO stability, absolute stability, relative stability, Routh Hurwitz Criterion, Stability analysis. **Root Locus Technique:** Introduction, concepts and its construction, Application to system stability studies. Illustration of the effect of addition of a zero and a pole on system response.	12
IV	**Frequency domain methods:** Nyquist Plot: Nyquist stability criterion, Construction, Stability	

	analysis. Bode Plot: Construction, Gain Margin and Phase Margin, Stability analysis. **Controllers and Compensators:** P, PD, PI & PID controllers. Need of compensators, lag, lead and lag - lead compensators.	**11**
V	**State Space Analysis of Linear Systems:** State variables, State equations, Matrix representation of State equations, Phase variable and canonical forms of state representation. State variable representation of electrical and mechanical systems. State Space representation from Transfer Function. Transfer function from State Space Representation, Solutions of the State equations, Eigen values & Eigen vectors, State transition matrix, Concept of Controllability and Observability and techniques to test – Kalman's Test.	**13**
	Total Hours	**60**

Simulation Assignment

The following simulations can be done in MATLAB / SIMULINK

1. Plot the pole-zero configuration in s-plane for the given transfer function.
2. Determine the transfer function for given closed loop system in block diagram representation.
3. Plot unit step response of given transfer function and find delay time, rise time, peak time and peak overshoot.
4. Determine the time response of the given system subjected to any arbitrary input.
5. Plot root locus of given transfer function, locate closed loop poles for different values of k.
6. Plot bode plot of given transfer function and determine the stability by measuring gain and phase margins.
7. Determine the steady state errors of a given transfer function.
8. Plot Nyquist plot for given transfer function and determine the relative stability.
9. Create the state space model of a linear continuous system.
10. Determine the state space representation of the given transfer function.

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
23ECJ30E	VLSI CIRCUIT DESIGN	PCC	3	1	2	0	5	2023

i. REREQUISITE	23ECL20B-Solid State Devices 23ECJ20C- Logic Circuit Design

ii. COURSE OVERVIEW

This course aims to build a comprehensive foundation in VLSI design, enabling students to understand MOS device fundamentals, design and implement digital circuits with optimal performance, and understand the operation of memory and sequential elements under critical timing constraints. In addition, students will gain practical experience in CMOS fabrication and layout design and proficiency in using industry-standard tools to develop and evaluate CMOS-based systems.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the fundamental concepts, characteristics, and performance parameters of CMOS devices.	Understand
CO2	Design digital circuits and interpret the delay and timing constraints.	Apply
CO3	Describe the operation of arithmetic building blocks and memory elements.	Understand
CO4	Explain the CMOS fabrication techniques and layout design rules.	Understand
CO5	Apply industry-standard tools to design CMOS-based circuits.	Apply

iv. SYLLABUS

Review of MOS Transistor theory, Moore’s law.
Static CMOS inverter: Voltage Transfer Characteristics, Switching Threshold, Beta Ratio Effect, Noise Margins, Sources of Power Dissipation.
Logic Designing Styles: Realizing logic functions with static CMOS logic, Pass transistor logic, and transmission gate logic. Logical Effort, Electrical effort, and parasitic delay.
Dynamic CMOS logic, Cascading issue in dynamic logic, Domino logic, NP CMOS.
Static and Dynamic Latches and Registers, Timing analysis- Setup and hold time, delay constraints, Clock Skew and Jitter.
Adder and Multiplier circuits, Memory architecture, Random Access Memory (RAM)
N-well and Twin-Tub fabrication process. Layout and Stick Diagram.

v(a) TEXT BOOKS	
1.	Jan M.Rabaey, Digital Integrated Circuits- A Design Perspective, Prentice Hall, Second Edition, 2005.
2.	N.H.E. Weste and D.M. Harris, CMOS VLSI design: A Circuits and Systems Perspective, 4^{th} Edition, Pearson Education India, 2011.
3.	Sung –Mo Kang & Yusuf Leblebici, CMOS Digital Integrated Circuits- Analysis & Design, McGraw-Hill, Third Ed., 2003
4.	S.M. SZE, VLSI Technology, 2/e, Indian Edition, McGraw-Hill,2003
5.	Wayne Wolf, Modern VLSI design, Third Edition, Pearson Education,2002
(b) REFERENCES	
1.	Neil H.E. Weste, Kamran Eshraghian, Principles of CMOS VLSI Design- A Systems Perspective, Second Edition. Pearson Publication, 2005
2.	Razavi - Design of Analog CMOS Integrated Circuits,1e, McGraw Hill Education India Education, New Delhi, 2003.
3.	Yuan Taur & Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press, 2008

vi. COURSE PLAN

Module	Contents	Hours
I	Review of MOS Transistor theory, Moore's law. Static CMOS Inverter: Voltage Transfer Characteristics, Derivation of switching Threshold, Beta ratio effect, Noise Margins, Sources of Power Dissipation.	12
II	Realization of logic functions with static CMOS logic, Pass transistor logic, and transmission gate logic. Delay in logic Gates: Logical Effort, Electrical effort, and parasitic delay. Dynamic CMOS logic, Cascading issue in dynamic logic, Domino logic, NP CMOS.	12
III	Latches and Registers: Multiplexer-based latches, Master-Slave edge triggered register, Dynamic transmission gate edge triggered register. Timing analysis- Setup and hold time, delay constraints, Clock Skew and Jitter.	12
IV	Adder and Multiplier circuits: Static adder, carry bypass adder, Array Multiplier Memory Architecture, Random Access Memory – 6T SRAM and 3T and 1T DRAM cells.	12
V	CMOS Fabrication sequence: N-well and Twin-Tub process. Layout and Design rules: Stick Diagram, Design rules-micron rules and Lambda rules, Layout of CMOS Inverter, two input NAND and NOR gates.	12
	Total Hours	**60**

VLSI CIRCUIT DESIGN LAB		No. of hours
1.	Familiarization with the simulation tool	3
2.	Design of CMOS Inverter	
	a. DC characteristics of CMOS inverter	3
	b. Analysis of CMOS inverter for different aspect/beta ratios	3
	c. Analysis of the chain of CMOS inverters	3
3.	Design of Combinatioal Circuits	
	a. Design of logic gates	3
	b. Design of 2 x1 multiplexer	3
4.	Design of Sequential Circuits	
	a. Design of D Flipflop	3
	b. Design of Master-Slave Flip Flop	3
5.	Layout Implementation	
	a. Layout of CMOS Inverter	3
	b. Layout of a 2-input NAND/NOR Gate.	3
	Total Hours	**30**

vii. ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 60: 40

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Lab Work	:	10 marks
Lab Exam	:	10 marks
Total Continuous Assessment	:	**60 marks**
End Semester Examination	:	**40 marks**
TOTAL	:	**100 marks**

CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 40
- Exam Duration: 2 hours

Cour se Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23HSL30A	Business Economics and Accountancy	HSC	3	0	0	0	3	2023

i. PREREQUISITE

ii. COURSE OVERVIEW

To familiarize the prospective engineers with elementary Principles of Business Economics and Accountancy to analyse various business structures by using Economics principles and Accounting tools at an elementary level.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the problem of scarcity of resources and consumer behaviour	Understand
CO2	Examine the production efficiency and profitability with the help of quantitative and qualitative methods	Analyse
CO3	Interpret the macro-economic policies, trends and issues of the economy	Understand
CO4	Analyse business viability with the help of business models and financial planning.	Analyse
CO5	Develop an accurate and compliant balance sheet by classifying and recording financial transactions systematically	Apply

iv. SYLLABUS

Introductory Micro-Economics

Scarcity and choice - Basic economic problems- PPC – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.

Microeconomic Foundations: Production, Cost, Market Structures & Pricing Strategies

Production function – law of variable proportion – economies of scale – internal and external economies – Cobb-Douglas production function - Cost concepts - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point. Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopolyNon-price competition – Product pricing strategies

Introductory Macro-Economics
Circular flow of income-two sector and multi-sector models- National Income Concepts-Measurement Methods-Problems-Inflation, deflation - Fiscal Policy (Government spending & taxation) - Monetary Policy (Interest rates & money supply) - Wage Rigidity & Unemployment - Demand-Pull vs. Cost-Push Inflation

Business Models and Financial Planning
Innovation and creativity in entrepreneurship - Business idea generation and feasibility analysis - Business planning (Lean Canvas, SWOT, PESTEL analysis) - Types of business structures (sole proprietorship, partnership, corporation) - Legal aspects and regulatory requirements - Sources of funding: Bootstrapping and personal savings, Venture capital and angel investors, Bank loans and government grants (Startup India, MSME financing), Crowdfunding and alternative finance - Financial planning and forecasting - Challenges in entrepreneurial finance (liquidity, risk management) - Exit strategies (IPO, mergers, acquisitions)

Introduction to Accounting
Book-Keeping and Accountancy- Elements of Double Entry- Book –Keeping-rules for journalizing-Ledger Accounts-Cash book- Banking transactions- Trial Balance-Method of Balancing accounts-the journal proper.
Final accounts: Preparation of trading and profit and loss Account- Balance sheet preparation and interpretation - Introduction to accounting packages. Modern methods in book keeping accounting.

v (a) TEXT BOOKS

1.	Gregory N Mankiw, Principles of Micro Economics, Cengage Publications 2023
2.	Gregory N Mankiw, Principles of Macro Economics, Cengage Publications 2023
3.	Steven Rogers, Entrepreneurial Finance, McGraw-Hill, Fourth Edition, 2020
4.	Agrawal R and Sriniwasan R, Accounting Made Easy, Tata McGraw-Hill 2010

(b) REFERENCES

1.	Dominick Salvatore, Theory and Problems of Micro Economic Theory. Tata Mac Graw- Hill, New Delhi.2017
2.	Dwivedi D.N., Macroeconomics: Theory And Policy, Tata McGraw Hill, New Delhi 2018
3.	Dornbusch, Fischer and Startz, Macroeconomics, McGraw Hill, 12th edition, 2018.
4.	Janet Kiholm Smith and Richard L Smith, Entrepreneurial Finance: Venture Capital, Deal Structure & Valuation, Stanford Business Books US, 2019
5.	M.Kasi Reddy and S.Saraswathi, Managerial Economics and Financial Accounting. Prentice Hall of India. New Delhi. 2008

vi. COURSE PLAN		
Module	**Contents**	**Hours**
I	Scarcity and choice - Basic economic problems - PPC – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.	**9**
II	Production function – law of variable proportion – economies of scale – internal and external economies – Cobb-Douglas production function - Cost concepts - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point. Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly - Non-price competition – Product pricing strategies	**8**
III	Circular flow of income - two sector and multi-sector models - National Income Concepts - Measurement Methods – Problems - Inflation, deflation - Fiscal Policy (Government spending & taxation) - Monetary Policy (Interest rates & money supply) - Wage Rigidity & Unemployment - Demand-Pull vs. Cost-Push Inflation	**9**
IV	Innovation and creativity in entrepreneurship - Business idea generation and feasibility analysis - Business planning (Lean Canvas, SWOT, PESTEL analysis) - Types of business structures (sole proprietorship, partnership, corporation) - Legal aspects and regulatory requirements - Sources of funding: Bootstrapping and personal savings, Venture capital and angel investors, Bank loans and government grants (Startup India, MSME financing), Crowdfunding and alternative finance - Financial planning and forecasting - Challenges in entrepreneurial finance (liquidity, risk management) - Exit strategies (IPO, mergers, acquisitions)	**9**
V	Book-Keeping and Accountancy - Elements of Double Entry - Book –Keeping - rules for journalizing - Ledger accounts - Cash book- Banking transactions - Trial Balance - Method of Balancing accounts - the journal proper. Final accounts: Preparation of trading and profit and loss Account - Balance sheet preparation and interpretation - Introduction to accounting packages. Modern methods in book keeping accounting.	**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
23ECS38A	SEMINAR	PWS	0	0	4	0	2	2023

i. PREREQUISITE	Nil
ii. COURSE OVERVIEW	

The course involves exploring academic literature to select a relevant document in the student's area of interest and, under a seminar guide's supervision, develop skills in presenting and preparing technical reports. The course aims to enhance students ability to engage critically with scholarly work and communicate technical information effectively.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Outline topic based on recent advancements and emerging trends	Understand
CO2	Identify academic documents from the literature which are related to her/his areas of interest.	Apply
CO3	Plan, study, and deliver a presentation on a selected topic.	Apply
CO4	Develop a technical report on the topic identified.	Apply

iv. GENERAL GUIDELINES

- An Internal Evaluation Committee (IEC) shall be constituted by the department, comprising the program's HOD/Senior Faculty as Chairperson, along with the seminar coordinator and the student's seminar guide as members. All IEC members must be present during each student's seminar presentation.
- Formation of IEC and guide allotment shall be completed within a week after the End Semester Examination (or last working day) of the previous semester.
- Guide shall provide required input to their students regarding the selection of topic/ paper.
- A topic/paper relevant to the discipline shall be selected by the student during the semester break.
- The seminar topic should be current and broad-based, rather than narrowly focused on specific research. Ideally, it should be closely related to the student's final year project area. Team members may select or be assigned seminar topics that cover different aspects of their common project theme.
- Topic/Paper shall be finalized in the first week of the semester and shall be submitted to the IEC.
- The IEC shall approve the selected topic/paper by the second week of the semester.
- Accurate references from genuine peer reviewed published material to be given in the report and to be verified.

v. EVALUATION PATTERN

Total Marks	CIE Marks
100	100

CONTINUOUS INTERNAL EVALUATION PATTERN

Seminar Guide (20 Marks)

Background Knowledge – 10 marks
(based on the student's understanding on the selected topic).
Relevance of Topic – 10 marks
(based on the suitability and significance of the s elected paper/topic).

Seminar Coordinator (15 Marks)

Seminar Diary – 10 marks
(weekly progress tracked and approved by the guide).
Attendance – 5 marks.

Evaluation of Presentation by IEC (45 Marks)

Clarity of Presentation – 10 marks.
Interaction – 10 marks (ability to answer questions).
Overall Participation – 10 marks
(engagement during others' presentations).
Quality of the content – 15 marks.

Marks awarded by IEC for report (20 Marks)

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECJ38B	MINI PROJECT	PWS	0	0	4	0	2	2023

i. PREREQUISITE	Nil
ii. COURSE OVERVIEW	

The objective of this course is to enable students to apply the fundamental principles of Electronics and Communication Engineering for the effective development of an application or research-oriented project. It guides learners through the essential phases of the problem identification, literature review, determination of methodology and its implementation for design and development of appropriate solution.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Identify problems that are socially relevant, technically feasible and economically viable.	Apply
CO2	Make use of relevant literature to explore existing solutions and established processes.	Apply
CO3	Identify appropriate design approaches, using modern tools with a strong commitment to professional ethics.	Apply
CO4	Deduce innovative interpretation of the study outcomes, using engineering and management principles to generate novel insights or improvements.	Evaluate
CO5	Apply appropriate communication techniques to prepare presentations and reports that convey project outcomes effectively.	Apply
CO6	Develop the ability to manage tasks independently and engage collaboratively in team environments to achieve shared goals.	Apply

iv. GENERAL GUIDELINES

Student groups consisting of three to four members are required to select a topic of interest in consultation with their Project Supervisor. They should conduct a thorough literature review and identify a problem to address the gaps identified, related to the chosen topic. Clear objectives must be defined, and a suitable methodology should be developed to achieve them. The project should incorporate innovative design concepts, while considering important factors such as performance, scalability, reliability, aesthetics, ergonomics, user experience, and security.

The progress of the mini project is evaluated based on three reviews. The first review is to check the feasibility in implementation of the project. The second review is to evaluate the progress of the work. The third review is to evaluate the completed work. The review committee will be constituted by the Head of the Department, comprising of HoD or a senior faculty member, Mini Project coordinator and project supervisor. The evaluation shall be made based on the progress/outcome of the project, reports and a viva-voce, conducted internally by the review committee. A project report is required at the end of the semester. The project has to be demonstrated for its full design specifications.

v. ASSESSMENT PATTERN

Total Marks	CIE Marks	ESE Marks
100	60	40

CONTINUOUS ASSESSMENT PATTERN

First Review and Second Review: 60 marks

Attendance : 5 marks

Marks awarded by Project Supervisor : 10 marks

Marks awarded by Review Committee : 45 marks

Final Review: 40 marks

Project Report : 10 marks

Marks awarded by Review Committee : 30 marks

PROGRAMME ELECTIVE - II

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL32A	DIGITAL IMAGE PROCESSING	PEC	2	1	0	0	3	2023

i. PREREQUISITE: **23ECL30B – Digital Signal Processing**

ii. COURSE OVERVIEW

This course aims to develop the skills for methods of various transformations and analysis of image enhancement, image reconstruction, image compression, image segmentation and image representation.

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 digital image processing at different levels of operations.	Understand
CO 2	Apply the concepts to analyze a 2D discrete signal in time and frequency domain.	Apply
CO 3	Apply the concepts to enhance digital images using various filtering techniques.	Apply
CO 4	Explain the concepts to restore digital images using various filtering techniques.	Understand
CO 5	Explain various image segmentation techniques.	Understand

iv. SYLLABUS

Digital Image Fundamentals: Image representation, Basic relationship between pixels, Elements of DIP system, Elements of visual perception- Simple image formation model. Vidicon and Digital Camera working principles, Brightness, Contrast, Hue, Saturation, Mach band effect. Colour image fundamentals- RGB, CMY, HIS models, 2D sampling, quantization.

Review of matrix theory: Row and column ordering- Toeplitz, Circulant and block matrix, 2D Image transforms: DFT, its properties, Walsh transform, Hadamard transform, Haar transform, DCT, KL transform and Singular Value Decomposition. Image Compression: Need for compression, Basics of lossless compression– Bit plane coding, Run length encoding and Predictive coding, Basics of lossy compression – Uniform and Non-uniform quantization techniques used in image compression, Concept of transform coding, JPEG Image compression standard.

Image Enhancement: Spatial domain methods: Point processing- Intensity transformations, Histogram processing, Image subtraction, Image averaging. Spatial filtering- Smoothing filters, Sharpening filters. Frequency domain methods: Low pass filtering, High pass filtering, Homomorphic filter.

Image Restoration: Degradation model, Unconstraint restoration- Lagrange multiplier and Constraint restoration, Inverse filtering- Removal of blur caused by uniform linear motion, Weiner filtering, Geometric transformations-Spatial transformations.

Image segmentation: Classification of Image segmentation techniques, Region approach, Clustering techniques. Segmentation based on thresholding, Edge based segmentation. Classification of edges, Edge detection, Hough transform, Active contour.

v (a) TEXT BOOKS

1.	Gonzalez Rafel C, Digital Image Processing, Pearson Education, 4th Edition, 2018.
2.	S Jayaraman, S Esakkirajan, T Veerakumar, Digital image processing, Tata McGrawHill, 2nd Edition, 2020.

(b) REFERENCES

1.	Jain Anil K, Fundamentals of digital image processing, 1st Edition, 2015.
2.	Kenneth R Castleman, Digital image processing, Pearson Education, 2nd Edition, 2003.
3.	Pratt William K, Digital Image Processing, John Wiley, 4th Edition, 2007.

vi. COURSE PLAN

Module	Contents	Hours
I	**Digital image fundamentals:** Image representation, Basic relationship between pixels, Elements of DIP system, Elements of visual perception, Simple image formation model. Vidicon and Digital Camera working principles, Brightness, Contrast, Hue, Saturation, Mach band effect. **Colour image fundamentals:** RGB, CMY, HIS models, 2D sampling, Quantization.	9
II	**Review of matrix theory:** Row and column ordering- Toeplitz, Circulant and Block matrix. **2D Image transforms:** DFT, its properties, Walsh transform, Hadamard transform, Haar transform, DCT, KL transform and Singular Value Decomposition. **Image compression:** Need for compression, Basics of lossless compression– Bit plane coding, Run length encoding and Predictive coding, Basics of lossy compression – Uniform and Non-uniform quantization techniques used in image compression, Concept of transform coding, JPEG Image compression standard.	9
III	**Image enhancement:** Spatial domain methods: Point processing-Intensity transformations, Histogram processing, Image subtraction, Image averaging. **Spatial filtering:** Smoothing filters, Sharpening filters. **Frequency domain methods:** Low pass filtering, High pass filtering,	9

	Homomorphic filter.	
IV	**Image restoration:** Degradation model, Unconstraint restoration-Lagrange multiplier and constraint restoration. **Inverse filtering:** Removal of blur caused by uniform linear motion, Weiner filtering. **Geometric transformations:** Spatial transformations.	9
V	**Image segmentation:** Classification of Image segmentation techniques, Region approach, Clustering techniques. Segmentation based on thresholding, Edge based segmentation. Classification of edges, Edge detection, Hough transform, Active contour.	9
	Total Hours	**45**

*** Hands-on session will 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: 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
23ECL32B	DATA ANALYSIS USING PYTHON	PEC	2	1	0	0	3	2023

i. PREREQUISITE 23ESB10G- Python Programming

ii. COURSE OVERVIEW

Goal of this course is to set the foundation for students to develop new-age skills pertaining to analysis of large-scale data using modern tools.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Interpret the data by reading the data from spreadsheets and databases.	Apply
CO2	Use pandas library to process data frames.	Apply
CO3	Compute the principal components and perform cluster analysis on data frames.	Apply
CO4	Apply Bayesian analysis on data frames.	Apply
CO5	Apply machine learning in data analysis problems.	Apply
CO6	Explain methods in high performance computing for data analysis.	Understand

iv. SYLLABUS

Numpy and Scipy Python modules, reading and processing spreadsheets and csv files with Python, data visualization with Matplotlib, three dimensional visualization using Mayavi module, reading data from sql and mongodb databases with Python, Reading and writing pandas dataframes, Reading and writing .txt, .csv, .pdf, .html and json files with pandas, Use of pivot tables.

Pickling of data frames in Python, Dimensionality reduction with PCA , Hierarchical and K-means clustering, Bayesian analysis, Use of pymc3 module to compute the posterior probability. MAP Estimation, Kernel density estimation, Supervised and unsupervised learning, scikit-learn, Deep learning with convolutional neural networks, Use of Keras and Tensorflow. Machine learning with pytorch, Reading and writing images with openCV. Case study of character recognition with MNIST dataset.High performance computing for machine learning.

v (a) TEXT BOOKS

1. Fabio Nelli, Python Data Analytics: With Pandas, NumPy, and Matplotlib,2/e, Apress, 2018

2.	Wes McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython, 2/e, O'Reilly, 2017
(b) REFERENCES	
1.	CyrilleRossant, IPython Interactive Computing and Visualization Cookbook, 2/e, PACKT Open Source Publishing, 2018
2.	Francois Chollet, Deep Learning with Python, 1/e, Manning, 2017
3.	Peters Morgan, Data Analysis from Scratch with Python, AI Sciences, 2018

vi. COURSE PLAN

Module	Contents	Hours
I	**Python packages for data science**: Numpy and Scipy Python modules for data analysis. Reading and processing spreadsheets and csv files with Python using xlrd, xlwt and openpyxl. Data visualization with Matplotlib. Two dimensional charts and plots. Scatter plots with matplotlib. Three dimensional visualization using Mayavi module. Reading data from sql and mongodb databases with Python.	8
II	**Big Data Arrays with Pandas**: Familiarization of the python pandas. Reading and writing pandas data frames. Reading rows and columns from pandas data frame. **Cleaning and Preparing the Data**: Handling NaN values. Reading and writing .txt, .csv, .pdf, .html and json files with pandas. Merging, concatenating and grouping of data frames. Use of pivot tables. Pickling of data frames in Python.	9
III	**PCA and Cluster Analysis:** Singular value decomposition of a matrix/array. Eigen values and eigen vectors. Principal component analysis of a data frame. Scree plot. Dimensionality reduction with PCA. Loadings for principal components. Case study with Python. Cluster analysis. Hierarchical and K-means clustering. Interpretation of dendrograms.	9
IV	**Statistical Data Analysis**: Hypothesis testing. Bayesian analysis. Meaning of prior, posterior and likelihood functions. Use of pymc3 module to compute the posterior probability. MAP Estimation. Credible interval, conjugate distributions. Contingency table and chi square test. Kernel density estimation.	9
V	**Machine Learning:** Supervised and unsupervised learning. Use of scikit-learn. Regression using scikit-learn. Deep learning with convolutional neural networks. Structure of CNN. Use of Keras Tensorflow. Machine learning with pytorch. Reading and writing images with openCV. Case study of character recognition with MNIST dataset. High performance computing for machine learning. Use of numba,	10

	jit and numexpr for faster Python code. Use of Ipython-parallel.	
	Total Hours	**45**

The following Simulation Assignments can be given:

1. Download the iris data set and read into a pandas data frame. Extract the header and replace with a new header. Extract columns and rows. Extract pivot tables. Filter the data based on the labels. Store a pivot table as a pickle and retrieve it.
2. For the same data set, perform principal component analysis. Observe the scree plot. Identify the principal components. Obtain a low dimensional data, with only the principal components and compute the mean square error between the original data and the approximated one. Compute the loadings for the principal components.
3. For the same data, perform hierarchical and K-means clustering with Python codes. Obtain dendrograms in each case and appreciate the clusters.
4. Download the MNIST letter data set. Construct a CNN network with appropriate layers using Keras and Tensorflow. Train the CNN with the MNIST data set. Appreciate the selection and use of training, test and cross-validation data sets. Save the model and weights and use the model to identify letter images. You may use openCV for reading images.
5. Write a Python script to generate alphanumeric images (26 upper case, 26 lowercase and 10 numbers each 12 point in size) of say 16x16 dimension out of windows .ttf files. Create 62 folders each containing a data set of every alphanumeric character. Create a new CNN with Keras and Tensorflow. Create a cross validation data set by taking 10 images out of every 62 folder. Use 80% of the total data for training and 20% for testing the CNN. Use an HPCC like system to train the model and save the model and weight. Test this model to recognize letter images. You may use openCV for reading images.
6. Repeat assignment 4 using pytorch instead of Keras.
7. Repeat assignment 5 using pytorch instead of Keras.

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
23ECL32C	EMBEDDED SYSTEMS	PEC	3	0	0	0	3	2023

i. PREREQUISITE

23ECJ20C- Logic Circuit Design

23ECJ20F- Microcontroller based system design

ii. COURSE OVERVIEW

This course is designed to introduce embedded systems, various protocols used for communication between peripheral devices and processors, the ARM processor organization and programming.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the basic concepts of embedded systems and different phases in the embedded system design process/EDLC.	Understand
CO2	Summarize the operation and characteristics of serial and parallel communication standards and devices	Understand
CO3	Apply the ARM Thumb instruction set to develop embedded programs.	Apply
CO4	Apply Embedded C to interface with GPIO, UART, ADC, and handle interrupts in ARM microcontrollers.	Apply
CO5	Explain ARM system design, power management, real-time applications, and sensor integration in embedded systems.	Understand

iv. SYLLABUS

Introduction to Embedded Systems, The Embedded System Design Process - Embedded product development cycle (EDLC).

Embedded System Interfacing and peripherals - Serial Communication Standards and Devices- Serial Bus Protocols - Parallel communication standards.

ARM Thumb Instruction Set - CPSR Thumb bit, programmer's model, Branching, interrupts, data processing, Single & multiple register data transfer. **Embedded C Programming in ARM**-

Register-level programming, GPIO, UART, ADC interfacing, Interrupt handling in C. **ARM System Design & Real-Time Applications**- Power management & optimization, Real-time systems: constraints, task handling, Tools, debugging, sensor & actuator integration.

v (a) TEXT BOOKS	
1.	K.V. Shibu, Introduction to Embedded Systems, 2/e, McGraw Hill Education India, 2016.
2.	Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, Morgan Kaufman Publishers - Elsevier 3ed, 2008
3.	Steve Furber, ARM system-on-chip architecture, Addison Wesley, Second Edition, 2000.
4.	Raj Kamal, Embedded Systems Architecture, Programming and Design, TMH, 2003.
(b) REFERENCES	
1.	David E. Simon, An Embedded Software Primer, Pearson Education Asia, First Indian Reprint 2000.
2.	Steve Heath, Embedded Systems Design, Newnes – Elsevier 2ed, 2002.
3.	Andrew N. Sloss, Dominic Symes, Chris Wright, ARM System Developer's Guide Designing Optimizing System Software, Morgan Kaufmann Publishers 2004
4.	Frank Vahid and Tony Givargis, Embedded Systems Design – A Unified Hardware / Software Introduction, John Wiley, 2002.
5.	Tammy Noergaard, Embedded Systems Architecture, A Comprehensive Guide for Engineers and Programmers, Newnes – Elsevier 2ed, 2013.
6.	Iyer - Embedded Real time Systems, 1/e, McGraw Hill Education New Delhi, 2003
7.	Lyla B. Das, Embedded Systems: An Integrated Approach, 1/e, 2012.
8.	SarmadNaimi, Muhammad Ali Mazidi, SepehrNaimi, The STM32F103 Arm Microcontroller and Embedded Systems: Using Assembly and C, MicroDigitalEd.,2020
9.	Shujen Chen, Muhammad Ali Mazidi, EshraghGhaemi,STM32 Arm Programming for Embedded Systems, 2018

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to Embedded Systems** Introduction to embedded systems - Current trends and challenges - Applications of embedded systems, Characteristics and quality attributes of an embedded system **The Embedded System Design Process** -Requirements, Specification, Architecture Design, Designing Hardware and Software Components, System Integration, An embedded system design example. **Embedded product development cycle** (EDLC) -Different	8

	phases of EDLC, EDLC models	
II	**Embedded system interfacing and peripherals** Communication devices**:** Serial Communication Standards and Devices - UART, HDLC and SPI **Serial Bus Protocols** -I2C Bus, CAN Bus and USB Bus. Parallel communication standards -ISA, PCI and PCI-X Bus.	7
III	**ARM Thumb Instruction Set** The Thumb bit in the CPSR, The Thumb programmer's model, Thumb branch instructions, Thumb software interrupt instruction, Thumb data processing instructions, Thumb single register data transfer instructions, Thumb multiple register data transfer instructions.	10
IV	**Embedded C programming in ARM** : Introduction, Register level programming , GPIO and peripheral interfacing : Programming GPIO, UART, ADC. Interrupt handling in C.	10
V	**ARM System Design and Real-time Application Development** Power Management & Optimization: Power-saving techniques (DVFS, low-power modes), Performance trade-offs and optimization, Real-time Systems with ARM: Real-time requirements and constraints, Implementing real-time tasks and interrupt handling, Development Tools & Debugging, Embedded Application Development: integrating sensors, actuators, and real-world interfaces	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
23ECL32D	INTRODUCTION TO MEMS	PEC	3	0	0	0	3	2023

i. PREREQUISITE NIL

ii. COURSE OVERVIEW

The course aims to develop students' understanding of MEMS device principles while exploring key mechanical concepts and structural aspects that impact their operation. It further introduces students to scaling effects, material selection, fabrication processes, packaging strategies, and diverse application domains within MEMS technology.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Describe the operating principles of microsensors and actuators used in MEMS.	Understand
CO2	Explain the fundamental mechanical concepts and structural elements relevant to MEMS devices.	Understand
CO3	Interpret scaling laws to describe their impact in miniaturized systems.	Understand
CO4	Identify commonly used MEMS materials and summarize key micromanufacturing processes.	Understand
CO5	Explain packaging techniques, bonding methods, and emerging application domains in MEMS.	Understand

iv. SYLLABUS

Actuation and Sensing techniques – Thermal, Electrostatic, Piezoelectric, Magnetic. Micro sensors and micro actuators. Stress, Strain, Modulus of Elasticity, yield strength, ultimate strength, General stress-strain relations, compliance matrix.

Types of Beams, longitudinal strain under pure bending, Cantilevers, Spring-constant, Intrinsic stresses. Scaling laws in miniaturization. Material for MEMS. Bulk manufacturing, Surface micromachining, LIGA, Microstereo lithography. Microsystem packaging. Bonding techniques. Overview of MEMS areas

v (a) TEXT BOOKS

1. Chang Liu, Foundations of MEMS, Pearson, 2012
2. Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture, TMH, 2002

(b) REFERENCES

1. Chang C Y and Sze S. M., VLSI Technology, McGraw-Hill, New York, 2000
2. Julian W Gardner, Microsensors: Principles and Applications, John Wiley & Sons, 1994

3.	Mark Madou, Fundamentals of Micro fabrication, CRC Press, New York, 1997
4.	Stephen D. Senturia, Microsystem design, Springer (India), 2006.
5.	Thomas B. Jones, Electromechanics and MEMS, Cambridge University Press, 2001
6.	Gregory T.A. Kovacs, Micromachined Transducers Sourcebook, McGraw Hill, 1998

vi. COURSE PLAN

Module	Contents	Hours
I	**Actuation and Sensing techniques:** Thermal sensors and actuators, Electrostatic sensors and actuators, Piezoelectric sensors and actuators, magnetic actuators. **Micro sensors and micro actuators:** comb drives - Micro grippers – micro motors, micro valves, micro pumps, micro accelerometer	9
II	**Review of Mechanical concepts:** Stress, Strain, Modulus of Elasticity, yield strength, ultimate strength – General stress strain relations – compliance matrix. **Mechanical structures in MEMS:** Beams, Types of Beams, longitudinal strain under pure bending, Cantilevers, Spring constant of cantilever, Intrinsic stresses.	9
III	**Scaling laws in miniaturization:** Scaling in geometry, scaling in rigid body dynamics, Trimmer force scaling vector, scaling in electrostatic and electromagnetic forces, scaling in electricity and fluidic dynamics, scaling in heat conducting and heat convection.	9
IV	**Materials for MEMS:** Silicon – Silicon compounds – Silicon Nitride, Silicon Dioxide, Silicon carbide, Poly Silicon, GaAs, Silicon Piezo resistors. Polymers in MEMS. **Overview of Micro manufacturing:** Bulk micro manufacturing, Surface micro machining, LIGA process, Microstereo lithography	9
V	**Micro system Packaging:** General considerations in packaging design, Levels of Micro system packaging. Bonding techniques for MEMS: Surface bonding, Anodic bonding, Silicon-on-Insulator, Wire bonding, Sealing techniques. **Overview of MEMS areas:** RF MEMS, BioMEMS, MOEMS, NEMS	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
23ECL32E	SATELLITE COMMUNICATION	PEC	3	0	0	0	3	2023

i. PREREQUISITE 23ECL30A-Analog and Digital communication

ii. COURSE OVERVIEW

This course aims to impart the basic knowledge of satellite communication and its applications

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the basic concepts of satellite communication and satellite orbits.	Understand
CO2	Describe satellite communication subsystems& launching mechanisms of satellites.	Understand
CO3	Calculate satellite link budget.	Apply
CO4	Explain the fundamental principles of multiple access, spectrum sharing, and onboard processing techniques in satellite communication systems	Understand
CO5	Describe various applications of satellite communications.	Understand

iv. SYLLABUS

Satellite Orbits:

Introduction to Satellite Communication, Basic concepts of Satellite Communications, Kepler's laws of planetary motion, orbital mechanics: orbital elements, orbital equations. Types of satellite orbits. Orbital perturbations, orbital effects on satellite's performance, Eclipses. Look angles: Azimuth angle, Elevation angle.

Satellite System:

The Space Segment: Altitude and orbit control Subsystem: satellite stabilization & station keeping, TT&C Sub-System, Power & Antenna Subsystems, transponders, payload.

The Earth Segment: Transmit-Receive earth station architecture, design considerations, types of earth station, satellite tracking. Satellite launch systems.

Satellite System:

The Satellite Link design:

Transmission Theory, Link budget: basic terminologies, link power budget analysis, factors affecting link budget.

Noise power in satellites, Carrier to Noise Ratio: Design of uplink & Downlink in satellite system (ku band GEO satellite).

Design for Specified CNR: Combining CNR and C/I Values in Satellite Links.

Multiple Access techniques & Satellite on-board processing

Multiple Access techniques: Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA) Spread Spectrum Transmission and Reception, Demand Assignment Multiple Access (DAMA

Packet radio systems & random-access protocols. Spectrum sharing, Satellite onboard processing.

Satellite Application:
Communication Satellites: Introduction, Satellite Telephony, Satellite Television, Satellite radio, regional & national Satellite Systems.
Remote Sensing & Weather forecasting satellites: Classification of remote sensing systems, orbits, Payloads, Navigation Satellite: Basic principles of satellite navigation, GPS Position Location Principle, functional segments of GPS.

Nano satellites

v (a) TEXT BOOKS

1.	Dennis Roddy, Satellite Communications, 4th Edition, McGraw-Hill International edition, 2006.
2.	Timothy Pratt, Jeremy E.Allnutt, Satellite Communications, Wiley, 3rd Edition, October 2019.

(b) REFERENCES

1.	Gerard Maral, Michel Bousquet, Zhili Sun, Satellite Communications Systems: Systems, Techniques and Technology, Wiley,6th edition, April 2020
2.	Anil K. Maini, Varsha Agrawal, Satellite Communications, Wiley India Pvt. Ltd., 2015
3.	TRI T. HA, Digital Satellite Communications, McGraw-Hill, second editio

vi. COURSE PLAN

Module	Contents	Hours
I	Introduction to Satellite Communication, Basic concepts of Satellite Communications, Kepler’s laws of planetary motion, orbital mechanics: orbital elements, orbital equations. Types of satellite orbits. Orbital perturbations, orbital effects on satellite’s performance, Eclipses. Look angles: Azimuth angle, Elevation angle. Limit of visibility.	9
II	The Space Segment: Altitude and orbit control Subsystem: satellite stabilization & station keeping, TT&C Sub-System, Power & Antenna Subsystems, transponders, payload.	8

	The Earth Segment: Transmit-Receive earth station architecture, design considerations, types of earth station, satellite tracking. Satellite launch systems.	
III	Transmission Theory, Link budget: basic terminologies, link power budget analysis, factors affecting link budget. Noise power in satellites, Carrier to Noise Ratio: Design of uplink & Downlink in satellite system (ku band GEO satellite). Design for Specified CNR: Combining CNR and C/I Values in Satellite Links.	9
IV	Multiple Access techniques: Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA) Spread Spectrum Transmission and Reception, Demand Assignment Multiple Access (DAMA) Packet radio systems & random-access protocols. Spectrum sharing: regulatory frame work& spectrum management, interference management & mitigation techniques. Fundamentals of Satellite onboard processing: Introduction, onboard data handling systems, data compression & reduction techniques, onboard image processing, data storage and management.	10
V	Communication Satellites: Introduction, Satellite Telephony, Satellite Television, Satellite radio, regional & national Satellite Systems. Remote Sensing & Weather forecasting satellites: Classification of remote sensing systems, orbits, Payloads. Navigation Satellite: Basic principles of satellite navigation, GPS Position Location Principle, functional segments of GPS. Nano satellites	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL32F	ANTENNA AND WAVE PROPAGATION	PEC	2	1	0	0	3	2023

i. PREREQUISITE 23ECL30C- Electromagnetic Field Theory

ii. COURSE OVERVIEW

This course aims to impart knowledge on the basic working of antennas, to study various antennas, arrays and radiation patterns of antennas, to understand various techniques involved in various antenna parameter measurements, to understand the propagation of radio waves in the atmosphere.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the basic working of antennas.	Understand
CO2	Illustrate radiation pattern of the antenna.	Apply
CO3	Analyze different types of antenna arrays and its property.	Apply
CO4	Explain the operation of different types of antennas.	Understand
CO5	Explain propagation of radio waves in the atmosphere.	Understand

iv. SYLLABUS

Antenna and antenna parameters, Duality of antennas, Derivation of electromagnetic fields and directivity of short dipole and half wave dipole, Measurement of antenna parameters.

Antenna arrays and design of Endfire, broadside, binomial and Dolph-chebyshev arrays, Principles of practical antennas. Traveling wave antennas, principle and applications of V and rhombic antennas Principles of Horn, Parabolic dish antenna and Cassegrain antenna, Log periodic antenna array and Helical antenna.

Design of rectangular Patch antennas. Principle of smart antenna, Radio wave propagation, Different modes, effect of earth's magnetic field. Fading and diversity techniques.

v (a) TEXT BOOKS

1. Balanis, Antenna Theory and Design, 3/e, Wiley Publications.
2. John D. Krauss, Antennas for all Applications, 3/e, TMH.

(b) REFERENCES

1.	Collin R.E, Antennas & Radio Wave Propagation, McGraw Hill. 1985.
2.	Jordan E.C. & K. G. Balmain, Electromagnetic Waves & Radiating Systems, 2/e,PHI.
3.	Raju G.S.N., Antenna and Wave Propagation, Pearson, 2013.
4.	Thomas A. Milligan, Modern Antenna Design, IEEE PRESS, 2/e, Wiley Inter science.

vi. COURSE PLAN

Module	Contents	Hours
I	Basic antenna parameters - gain, directivity, beam solid angle, beam width and effective aperture calculations. Effective height wave polarization - antenna temperature - radiation resistance- radiation efficiency - antenna field zones - principles of reciprocity. Duality of antennas.	9
II	Concept of retarded potential, Radiation from an infinitesimal dipole, total power radiated and its radiation resistance. Field, directivity and radiation resistance of a short dipole and half wave dipole. Mobile phone antenna- base station, hand set antenna, Principle of smart antenna.	10
III	Arrays of point sources - field of two isotropic point sources - principle of pattern multiplication - linear arrays of 'n' isotropic point sources. Grating lobes. Design of Broadside, Endfire & Binomial arrays. Design of Dolph-Chebyshev arrays.	9
IV	Basic principle of beam steering. Travelling wave antennas. Principle and applications of V and rhombic antennas. Principle of Log periodic antenna array and Helical antenna. Parabolic dish antenna. Principles of Horn, Cassegrain antenna, Design of rectangular Patch antennas. (Expression for E, H and Gain without derivation).	9
V	Radio wave propagation, Modes, structure of atmosphere, sky wave propagation, effect of earth's magnetic field, space wave propagation, LOS distance. Field strength of space wave, duct propagation, VHF and UHF, Mobile radio propagation, tropospheric scatter propagation,	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
23ECL32G	MULTI-RATE SYSTEMS	PEC	2	1	0	0	3	2023

i. PREREQUISITE	23ECL20B-Signals and Systems 23ECL30B-Digital Signal Processing

ii. COURSE OVERVIEW

This course provides an in-depth understanding of multi-rate signal processing, covering essential concepts such as decimation, interpolation, polyphase decomposition, and filter banks. Students will explore both theoretical and practical aspects, including applications in modern communication systems, digital audio/video processing, and advanced signal processing techniques used in 5G, software-defined radio (SDR), and cognitive radio networks (CRNs).

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the fundamental principles of multi rate signal processing.	Understand
CO2	Design and analyse decimation and interpolation systems.	Apply
CO3	Implement efficient multistage and polyphase filter structures.	Apply
CO4	Apply wavelet transforms for signal compression and processing.	Apply
CO5	Apply multi-rate techniques in modern engineering applications such as 5G, SDR, and cognitive radio.	Apply

iv. SYLLABUS

Basics of up-sampling and down-sampling and their real-world applications.
Designing efficient decimators and interpolators with filters to prevent signal distortion.
Filter banks and wavelets for breaking signals into multiple frequency bands, used in image/audio processing
Multistage processing for efficiency and adaptive filter banks that adjust based on input signals.
Applications in 5G, software-defined radio (SDR), cognitive radio networks (CRN), and signal compression (MP3, JPEG, etc.).

v (a) TEXT BOOKS

1.	P. P. Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education,First Edition, 1993.
2.	Fredric J. Harris, Multirate Signal Processing for Communication Systems, Pearson Education, First Edition, 2004.
3.	John G. Proakis & Dimitris K. Manolakis, Digital Signal Processing: Principles, Algorithms, and Applications, Pearson Education, Fourth Edition, 2006.
4.	Alan V. Oppenheim & Ronald W. Schafer, Discrete-Time Signal Processing by Third Edition, 2016
(b) REFERENCES	
1.	N. J. Fliege, Multirate Digital Signal Processing: Multirate Systems, Filter Banks, Wavelets, Wiley, First Edition, 1999.
2.	Uwe Meyer-Baese, Digital Signal Processing with Field Programmable Gate Arrays, Springer, FourthEdition, 2021.
3.	Ronald E. Crochiere & Lawrence R. Rabiner, Multirate Digital Signal Processing, Pearson Education, First Edition, 1983

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to Multi-rate Systems** Basics of discrete-time signals and systems, need for multi-rate signal processing, upsampling and downsampling-spectral effects, sampling rate conversion, mathematical foundations of multi-rate systems, polyphase decomposition, applications in audio, video, and communication systems.	8
II	**Signal Impairments in Multi-rate Systems** Aliasing and its spectral effects, Magnitude distortion and passband ripple, Phase distortion and group delay, Trade-offs in filter bank design, Aliasing cancellation, All pass filters, Applications- DFT-based Filter banks, Interpolated FIR filter design, Cascaded-Integrator-Comb (CIC) filters, Transmultiplexer, Filter bank interpretation of Spectral analysis using DFT	9
III	**Filter Banks and Wavelets** Two-channel filter banks, quadrature mirror filters (QMF), perfect reconstruction filter banks, conditions for alias-free reconstruction, introduction to wavelet transforms, multiresolution analysis, applications in signal compression.	9
IV	**Multistage and Adaptive Multi-rate Systems,** Multistage decimation and interpolation, computational efficiency in multistage processing, design of multistage filters, adaptive filter banks, applications in speech and audio processing, efficiency improvements in multi-rate implementations.	9

V	**Applications of Multi-rate Systems,** Multi-rate techniques in 5G and beyond, sub-band coding for audio and image compression, software-defined radio (SDR), cognitive radio networks (CRN), biomedical signal processing applications, real-world case studies and project implementations.	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

S6 MINOR

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3MB	DESIGN FOR IoT	MINOR	3	0	0	0	3	2023

i. PREREQUISITE NIL

ii. COURSE OVERVIEW

This course provides a comprehensive understanding of the Internet of Things (IoT), covering key concepts, technologies, and applications, including data acquisition, cloud computing, sensor technologies, IoT cloud services and prototyping.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the IoT conceptual framework, architectural views, and the technologies behind IoT.	Understand
CO2	Explain the importance of design standardization in IoT/M2M systems.	Understand
CO3	Explain the process of organizing data and the role of business processes and integration in IoT	Understand
CO4	Explain the concept of participatory sensing, RFID, and wireless sensor networks (WSN) in IoT applications.	Understand
CO5	Apply prototyping techniques to design embedded device software and IoT system integration	Apply

iv. SYLLABUS

Internet of Things: An Overview, Internet of Things, IoT Conceptual Framework, IoT Architectural View, Technology Behind IoT, M2M Communication, Examples Design Principles for Connected Devices: Introduction, IoT/M2M Systems Layers and Design Standardization, Communication Technologies

Design Principles for Web Connectivity: Introduction, Web Communication Protocols for Connected Devices, Message Communication Protocols for Connected Devices, Web Connectivity for Connected Devices Network Using Gateway, SOAP, REST, HTTP, RESTful, and WebSocket

Data Acquiring, Organizing, Processing, and Analytics: Data Acquisition and Storage, Organizing the Data, Transactions, Business Processes, Integration and Enterprise Systems, Analytics, Knowledge Acquisition, Managing and Storing Processes

Data Collection, Storage, and Computing Using Cloud Platform: Cloud Computing Paradigm for Data Collection, Storage, and Computing, Cloud Service Models, IoT Cloud-Based Services Using Xively, Nimbits and others.

Sensors, participatory sensing, RFID and WSN: Sensor technologies, Participatory sensing, Industrial IoT and Automotive IoT, Actuators, Sensor data communication Protocol, RFID, WSN Prototyping the Embedded Devices for IoT: Embedded Computing Basics, Embedded Platform for Prototyping

Prototyping and Designing the Software for IoT Applications: Prototyping Embedded Device Software, Device, Gateways, Internet and Web/Cloud Services Software Development

v (a) TEXT BOOKS

1.	Raj Kamal, INTERNET OF THINGS Architecture and Design Principles, McGraw Hill Education (India) Publications 2017.
2.	Arshdeep Bahga, Vijay Madisetti, Internet of Things: A Hands-on Approach, Universities Press, 2014.
3.	Hakima Chaouchi, The Internet of Things (Connecting objects to the web) Wiley Publications, 2010
4.	Pethuru Raj, Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases, CRC Press, 2017.

(b) REFERENCES

1.	The Internet of Things (MIT Press) by Samuel Greengard.
2.	Srinivasa K. G., Internet of Things, CENGAGE Learning, 2020.
3.	Honbo Zhou, The Internet of Things in the Cloud: A Middleware Perspective, CRC Press, 2012.

vi. COURSE PLAN

Module	Contents	Hours
I	**Internet of Things**: An Overview, Internet of Things, IoT Conceptual Framework, IoT Architectural View, Technology Behind IoT, M2M Communication, Examples of IoT. **Design Principles for Connected Devices**: Introduction, IoT/M2M Systems Layers and Design Standardisation, Communication Technologies	9
II	**Design Principles for Web Connectivity:** Introduction, Web Communication Protocols for Connected Devices, Message Communication Protocols for Connected Devices, Web Connectivity for Connected Devices Network Using Gateway, SOAP, REST, HTTP, RESTful, and WebSocket	9
III	**Data Acquiring, Organizing, Processing, and Analytics:** Data Acquisition and Storage, Organizing the Data,	9

	Transactions, Business Processes, Integration and Enterprise Systems, Analytics, Knowledge Acquisition, Managing and Storing Processes **Data Collection, Storage, and Computing Using Cloud Platform:** Cloud Computing Paradigm for Data Collection, Storage, and Computing, Cloud Service Models, IoT Cloud-Based Services Using Xively, Nimbits and others.	
IV	**Sensors, participatory sensing, RFID and WSN:** Sensor technologies, Participatory sensing, Industrial IoT and Automotive IoT, Actuators, Sensor data communication Protocol, RFID, WSN	9
V	**Prototyping the Embedded Devices for IoT:** Embedded Computing Basics, Embedded Platform for Prototyping **Prototyping and Designing the Software for IoT Applications:** Prototyping Embedded Device Software, Device, Gateways, Internet and Web/Cloud Services Software Development	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3MD	COMPUTATIONAL TOOLS FOR AI	MINOR	2	1	0	0	3	2023

i. PREREQUISITE: Basic programming (Python, MATLAB), Mathematics (Linear Algebra, Probability, Statistics)

ii. COURSE OVERVIEW

This course aims to introduce computational tools used in AI and Machine Learning (ML); provide the basics of AI frameworks, libraries, and cloud-based AI tools; implement AI models using optimized tools; and analyze and optimize AI models using computational techniques.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Design machine learning and deep learning algorithms using Python.	Apply
CO2	Design machine learning and deep learning algorithms using MATLAB.	Apply
CO3	Design machine learning and deep learning algorithms using cloud based tools.	Apply
CO4	Illustrate the usage of various libraries in Python, MATLAB and cloud based tools for AI applications.	Understand

vi. Syllabus

Familiarization of Python libraries and programming platform requirements used for developing an AI system.

Familiarization of MATLAB toolboxes and programming platform requirements used for developing an AI system.

Familiarization of cloud based tools and programming platform requirements for AI applications.

Requirement of hardware acceleration tools, optimization techniques, and AI Model Deployment and Monitoring

v (a) TEXT BOOKS

1. Andreas C. Müller & Sarah Guido, Introduction to Machine Learning with Python – A guide for data scientists, 1st e/d, 2016.
2. Aurelien Geron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd e/d, 2019.

3.	Phil Kim, MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence, National Rehabilitation Research Institute of Korea, Apress, 2017.
4.	Christopher M Bishop, Pattern Recognition and Machine Learning, 2009

(b) REFERENCES

1.	https://www.mathworks.com/help/deeplearning/
2.	https://www.tensorflow.org/guide
3.	https://docs.opencv.org/master/

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to Computational Tools for AI -** Role of computational tools in AI, Comparison of Python, MATLAB, and cloud-based tools **Programming Languages for AI** • **Python for AI**: Basics and Advanced Concepts - **Jupyter Notebooks, Google Colab** • **MATLAB for AI**: Introduction to MATLAB programming - MATLAB Live Scripts **AI and Machine Learning Libraries (Python)** • **Python Libraries**: o NumPy, Pandas, Matplotlib, Seaborn – Data handling & visualization o Scikit-Learn – Traditional machine learning algorithms o TensorFlow & PyTorch – Deep Learning frameworks o OpenCV – Computer Vision tools o NLTK & spaCy – Natural Language Processing tools	10
II	**AI and Machine Learning Libraries (MATLAB)** • **MATLAB Toolboxes**: o **Statistics and Machine Learning Toolbox** – Regression, Classification, Clustering o **Deep Learning Toolbox** – Training Neural Networks o **Computer Vision Toolbox** – Image processing for AI o **Reinforcement Learning Toolbox** – Implementing RL models o **Text Analytics Toolbox** – NLP and sentiment analysis o **Optimization Toolbox** – Hyperparameter tuning & model optimization	10
III	**Cloud and Distributed Computing for AI** • **Google Colab, AWS AI Services, Microsoft Azure AI** • MATLAB **Parallel Computing Toolbox** for GPU/CPU processing • Distributed computing with **Apache Spark** and **Dask** • Introduction to **Kubernetes** and **Docker** for AI model deployment	8
IV	**Hardware Acceleration for AI** • **GPU vs CPU** computation • **CUDA programming** for deep learning	8

	• MATLAB **GPU Coder Toolbox** • Tensor Processing Units (TPUs) **Computational Optimization Techniques in AI** • Model optimization using **ONNX** (Python) and **MATLAB Coder** • Hyperparameter tuning: **Optuna, GridSearchCV (Python)** and **Bayesian Optimization (MATLAB)** • Efficient training techniques: **Batch processing, Data Augmentation**	
V	**AI Model Deployment and Monitoring** • **Python-based Deployment**: Flask, FastAPI • **MATLAB-based Deployment**: MATLAB Production Server, Web Apps • Model versioning with **MLflow** • Monitoring AI models in production **Case Studies and Hands-on Projects** • Real-world AI applications using Python or MATLAB toolboxes • Implementing a full AI pipeline from data preprocessing to deployment	9
	Total Hours	**45**

vii. ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments/Simulations	:	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3MF	ARTIFICIAL INTELLIGENCE FOR ROBOTICS	MINOR	3	0	0	0	3	2023

i. PREREQUISITE	Python Programming, Basics of Electrical and Electronics
ii. COURSE OVERVIEW	

This course introduces students to the use of artificial intelligence in robotics. It covers essential topics like robot design, vision, learning algorithms, speech recognition, navigation, and human-like behavior.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the fundamentals of AI techniques and their applications in robotics	Understand
CO2	Design intelligent robotic systems using supervised and reinforcement learning.	Apply
CO3	Implement navigation, obstacle avoidance, and speech recognition in robotic systems.	Apply
CO4	Model robot personality and simulate emotion-aware responses using AI	Apply
CO5	Analyze modern AI technologies and ROS 2 for robotic applications.	Apply

iv. SYLLABUS

Introduction to AI and Robotics: Overview of AI and Robotics, Development environment software components (ROS, Python, and Linux), Robot control system and decision-making frameworks, Robot anatomy,

Practical Robot Design process, Recognising Objects using Neural Networks and Supervised Learning : Understanding the object recognition task, image manipulation, Using Yolo- an object detection model, implementation using supervised learning.

Reinforcement Learning and Genetic Algorithms for Pick and Place Operation: creating interface to the arm, Q learning for graphing the objects, introduction to Genetic Algorithm, comparison of ML approaches. Speech recognition with NLP -understanding speech-to-text (STT) systems, setting up Mycroft voice assistant software.

Navigation and Obstacle Avoidance : SLAM, Neural networks processing images, Training the neural network for navigation, CNN robot control implementation. Decision tree Random forest, GPS path finding.

Artificial Personality in Robots : Introduction to Turing test, chatbots and generative AI, The art and science of simulation, An emotion state machine, Playing the emotion game, creating a model of human behavior Developing the robot emotion engine, Modern AI and ROS 2 Overview.

v (a) TEXT BOOKS

1.	Francis X. Govers, Artificial Intelligence for Robotics: Build intelligent robots that perform human tasks using AI techniques, Packt Publishing, Second Edition, 2024.

(b) REFERENCES

1.	Lentin Joseph, Mastering ROS for Robotics Programming, Packt Publishing, 2021.
2.	Morgan Quigley et al., Programming Robots with ROS, O'Reilly Media, 2015.
3.	Peter Norvig and Stuart Russell, Artificial Intelligence: A Modern Approach, Pearson, 3rd Edition.

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to AI and Robotics:** Overview of AI and Robotics, Intelligent robots: Definitions and applications, History and evolution of AI in robotics, The basic principle of robotics and AI, Artificial intelligence and advanced robotics techniques, Development environment software components (ROS, Python, and Linux), Robot control system and decision-making frameworks, Robot anatomy, Subsumption architecture, Software setup and hardware.	9
II	**Practical Robot Design process :** Understanding the task, use cases, using storyboard, Understanding the scope, identifying the hardware and software needs, writing specification. **Recognising Objects using Neural Networks and Supervised Learning:** Technical requirements, Overview of image processing, Understanding the object recognition task, image manipulation, Using YOLO- an object detection model, implementation using supervised learning.	9
III	**Reinforcement Learning and Genetic Algorithms for Pick**	9

	and Place Operation: Technical requirements, task analysis, designing software, setting up solution, creating interface to the arm, Q learning for graphing the objects, introduction to Genetic Algorithm, comparison of ML approaches. **Speech recognition with NLP** - Understanding speech-to-text (STT) systems, setting up Mycroft voice assistant software.	
IV	**Navigation and Obstacle Avoidance:** SLAM, alternatives to navigation techniques, Floor Finder techniques, Neural networks processing images, Training the neural network for navigation, CNN robot control implementation. Decision tree - Entropy, one-hot encoding, Random forest - A* algorithm, D* Algorithm, GPS path finding.	9
V	**Artificial Personality in Robots:** Introduction to Turing test, chatbots and generative AI, The art and science of simulation, An emotion state machine, Playing the emotion game, creating a model of human behavior - constructing a personality, Adding context. Developing the robot emotion engine - creating human emotion model, creating human information storage, context memory **Modern AI and ROS 2 Overview** : Exploring current state of AI, understanding the risk in AI, ROS 2 features and architecture,	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3MH	BIO SIGNAL AND IMAGE PROCESSING	MINOR	3	0	0	0	3	2023

i. PREREQUISITE Nil

ii. COURSE OVERVIEW

1) To introduce basic Bio signals and concepts of various techniques used to process bio signals.
2) To study the concept of image processing techniques like image enhancement, image reconstruction, image compression, image segmentation and image representation
3) To study the concept and working of various medical imaging techniques and imaging systems.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Describe the concepts of Bio signal analysis, signal conversion and averaging.	Understand
CO 2	Explain the adaptive noise cancellation and digital image representation fundamentals.	Understand
CO 3	Describe the various image processing techniques like Image restoration, and enhancement.	Understand
CO 4	Explain the various image segmentation and compression techniques	Apply
CO 5	Explain the concept various medical imaging techniques and imaging systems	Understand

iv. SYLLABUS

Introduction to Biomedical Signals, Signal Conversion, Signal Averaging, Adaptive Noise Cancelling, Data Compression Techniques, Digital Image Fundamentals, Image Enhancement: Spatial domain methods, Image Restoration, Image segmentation, Morphological Image Processing, Image Compression, Medical Imaging systems (Basic Principle only): X-ray imaging, Computed Tomography, Ultrasonic imaging systems, Magnetic Resonance Imaging.

v (a) TEXT BOOKS	
1.	Willis J. Tompkins, Biomedical Digital Signal Processing, PHI ,1st ed., 1993
2.	Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, Pearson Education, 4^{th} ed., 2018.
3.	Joseph J. Carr and John M. Brown, Introduction to Biomedical Equipment Technology, Pearson Education, 4^{th} ed,2000
(b) REFERENCES	
1.	D.C. Reddy, Biomedical Signal Processing Principles and Techniques, McGraw-Hill education (India), 1^{st} ed., 2005
2.	Anil K. Jain, Fundamentals of Digital Image Processing, PHI, 1^{st} ed., 1989
3.	R.S. Khandpur, Handbook of Biomedical instrumentation, McGraw Hill Education,3^{rd}., 2023
4.	Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice Hall, 2^{nd} ed., 2001

vi. COURSE PLAN

Module	Contents	Hours
I	**Introduction to Biomedical Signals:** The nature of Biomedical Signals, Examples of Biomedical Signals, Objectives and difficulties in Biomedical analysis. **Signal Conversion:** Simple signal conversion systems, Conversion requirements for biomedical signals. **Signal Averaging:** Basics of signal averaging, signal averaging as a digital filter, a typical averager, limitations of signal averaging, ECG signal averaging.	8
II	**Adaptive Noise Cancelling:** Principal noise canceller model, 60-Hz adaptive cancelling using a sine wave model, other applications of adaptive filtering. **Digital Image Fundamentals:** Image representation, basic relationship between pixels, basic properties like brightness, contrast, hue, saturation, RGB model	9
III	**Image Enhancement:** Spatial domain methods: point processing histogram processing, image subtraction, image averaging, Spatial filtering: smoothing filters, sharpening filters. **Image Restoration:** Degradation model, inverse filtering, Wiener filtering. **Morphological Image Processing:** erosion, dilation, opening and closing.	9
IV	**Image segmentation:** Classification of Image segmentation techniques, region approach, Segmentation based on thresholding, edge-based segmentation	10

	Data Compression Techniques: Need for compression, redundancy, transform based compression. Huffman coding - Static Huffman coding, Modified Huffman coding, Data reduction of ECG, Residual differencing, Adaptive Coding, Run Length Coding.	
V	**Medical Imaging systems (Basic Principle only):** X-ray imaging - Properties of X-rays, X-ray machine applications of X-rays in medicine. **Computed Tomography:** Principle, image reconstruction, applications. **Ultrasonic imaging systems:** Basic principle, applications. **Magnetic Resonance Imaging:** Basic NMR components, Biological effects and advantages of NMR imaging.	**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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

S6 HONOURS

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3HB	ELECTRONICS DESIGN AND AUTOMATION	HONOURS	3	0	0	0	3	2023

i. PREREQUISITE Nil

ii. COURSE OVERVIEW

The objective of this course is to provide understanding of graph theory, search algorithms, and VLSI design techniques, including partitioning, layout compaction, placement, floor planning, and routing algorithms. Students will apply these concepts to solve complex design automation and optimization problems in VLSI systems.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain basic graph terminology, search algorithms such as BFS, DFS, Topological Sort, and Dijkstra's shortest path algorithm.	Understand
CO2	Apply partitioning techniques to solve VLSI design problems within the design automation flow	Apply
CO3	Apply layout compaction techniques using graph theoretical approaches and algorithms to optimize physical design.	Apply
CO4	Apply placement and floor planning techniques using algorithms and representations to achieve optimized layout design.	Apply
CO5	Apply routing algorithms and optimization techniques to efficiently design routing solutions.	Apply

iv. SYLLABUS

Graph Terminology: Basic graph theory terminology, Data structures for representation. Graphs Search Algorithms: Breadth First Search, Depth First Search, Topological Sort. Shortest Path Algorithms: Dijkstra's Shortest-Path Algorithm for single pair shortest path.

Design Automation: VLSI Design Flow. Partitioning: Levels of Partitioning, Parameters for Partitioning, Kernighan-Lin Algorithm, Fiduccia-Mattheyses Algorithm, Simulated Annealing.

Layout: Layout Layers and Design Rules, Physical Design Optimizations. Compaction: Applications of Compaction, Informal Problem Formulation, Graph Theoretical

Formulation, Longest Path algorithm for DAG, Liao-Wong Algorithm. Placement: Optimization Objectives, Wirelength Estimation, Weighted Wirelength. Placement Algorithms: Quadratic Placement. Floorplanning: Optimization Objectives, Slicing Floorplan, Non-Slicing Floorplan. Floorplan Representations: Constraint Graph, Sequence Pair. Floorplan Algorithms: Minimum Area Algorithm. Global Routing: Terminology and Definitions, Optimization Goals. Maze Routing Algorithms: Lee's Algorithm. Detailed Routing: Horizontal and Vertical Constraint Graph. Channel Routing Algorithms: Left-Edge algorithm.

v (a) TEXT BOOKS

1.	Jin Hu, Jens Lienig, Igor L. Markov, and Andrew B. Kahng, VLSI Physical Design: From Graph Partitioning to Timing Closure, Springer, 2011.
2.	Sabih H. Gerez, Algorithms for VLSI Design Automation, John Wiley & Sons, 2006.
3.	Naveed A. Sherwani, Algorithms for VLSI Physical Design Automation, Kluwer Academic Publishers, 1999.

(b) REFERENCES

1.	Sadiq M. Sait and H. Youssef, VLSI Physical Design Automation: Theory and Practice, World Scientific, 1999.
2.	Thomas H. Cormen, Charles E. Leiserson, and Ronald L. Rivest, Introduction to Algorithms, 3rd Edition, The MIT Press, 2009.

vi. COURSE PLAN

Module	Contents	Hours
I	Graph Terminology, Search Algorithms and Shortest Path Algorithms: Graph Terminology: Basic graph theory terminology, Data structures for representation. Graphs Search Algorithms: Breadth First Search, Depth First Search, Topological Sort. Shortest Path Algorithms: Dijkstra's Shortest-Path Algorithm for single pair shortest path.	9
II	Design Automation and Partitioning Algorithms: Design Automation: VLSI Design Flow. Partitioning: Levels of Partitioning, Parameters for Partitioning, Kernighan-Lin Algorithm, Fiduccia-Mattheyses Algorithm, Simulated Annealing	9
III	Layout Compaction: Layout: Layout Layers and Design Rules, Physical Design Optimizations Compaction: Applications of Compaction, Informal Problem Formulation, Graph Theoretical Formulation, Longest Path algorithm for DAG, Liao-Wong Algorithm.	9
IV	Placement and Floor planning: Placement: Optimization Objectives, Wirelength Estimation, Weighted Wirelength. Placement Algorithms: Quadratic Placement Floorplanning: Optimization Objectives, Slicing Floorplan, Non-Slicing Floorplan Representations: Constraint Graph, Sequence Pair. Floorplan Algorithms: Minimum Area Algorithm	9

V	Global Routing and Detailed Routing: Global Routing: Terminology and Definitions, Optimization Goals Maze Routing Algorithms: Lee's Algorithm Detailed Routing: Horizontal and Vertical Constraint Graph Channel Routing Algorithms: Left-Edge algorithm	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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3HD	DESIGN AND ANALYSIS OF ANTENNAS	HONOURS	3	0	0	0	3	2023

i. PREREQUISITE 23ECL30C- Electromagnetic Field Theory

ii. COURSE OVERVIEW

This course aims to impart knowledge on the basic parameters, matching techniques, design and working of various broad band antennas, practical antennas, antenna arrays and its radiation patterns. It also introduces standard software to design antennas with a set of given specifications.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the concept of radiation mechanism, antenna parameters and antenna matching techniques.	Understand
CO2	Analyze different types of broad band antennas and its radiation patterns	Apply
CO3	Design of various practical antennas, antenna arrays and field patterns	Apply
CO4	Use Antenna Design Software to design various types of antennas.	Apply
CO5	Explain the concept of Intelligent Reflecting Surfaces and its applications.	Understand

iv. SYLLABUS

Review of Antenna Parameters, Relation between radiation fields and magnetic vector potential, Antenna matching, Review of different antennas, Analysis of Circular Loop and Biconical Antenna, Helical Antennas, Current induced in a dipole antenna, Near fields of linear antennas, self and mutual impedance, arrays of parallel dipoles, Yagi-Uda antennas, Radiation from open ended wave-guides, Designing an antenna with a set of given specifications using standard software,

Parabolic reflector antennas, gain and beam width of reflector antennas, aperture field and current distribution methods, radiation patterns of reflector antenna, Frequency independent antennas, Antenna arrays, Adaptive Beam forming. 2D arrays – Rectangular and Circular array.

v (a) TEXT BOOKS

1.	Sopholes J. Orfanidis – Electromagnetic waves and antennas. Available at: http://eceweb1.rutgers.edu/~orfanidi/ewa/
2.	Consrantive A Balanis -Antenna Theory - Analysis and Design – 2/e John Wiley & Sons.
3.	John D. Krans, Ronald J. Marhefka : Antennas for all Applications , 3/e, TMH
4.	Thomas A Milligan – Modern Antenna Design, 2/e John Wiley & Sons.

(b) REFERENCES

1.	Collin R.E, Antennas & Radio Wave Propagation, McGraw Hill. 1985.
2.	Jordan E.C. & K. G. Balmain, Electromagnetic Waves & Radiating Systems, 2/e, PHI.
3.	Raju G.S.N., Antenna and Wave Propagation, Pearson, 2013.
4.	Sisir K. Das& Annapurna Das, Antenna and Wave Propagation, McGraw Hill,2012

vi. COURSE PLAN

Module	Contents	Hours
I	Antenna Parameters, Relation between radiation fields and magnetic vector potential – Helmholtz equation and Lorentz conditions. Antenna matching –T match, Baluns, Gamma and Omega match. Working of dipole antennas, V and rhombic antenna.	9
II	Helical Antennas (normal mode and axial mode) – relation for far fields, radiation resistance and gain. Current induced in a dipole antenna – Pocklington and Hallen's integral equations. Solution of Hallen's integral equation for current induced in a dipole antenna for delta gap model.	9
III	Aperture antenna – Field equivalence principle. Radiation from open-ended wave-guides, horn antennas, horn radiation fields, horn directivity, optimum horn design, Design of Rectangular micro-strip antennas. Antenna design with a set of given specifications using standard software (MATLAB/HFSS/CST Microwave Studio or any Open software)	9
IV	Parabolic reflector antennas, gain and beam width of reflector antennas, aperture-field and current distribution methods, radiation patterns of reflector antennas, Frequency independent antennas – Rumsey Principle – Spiral Antennas. Design of log periodic dipole arrays.	9
V	Antenna arrays – General expression for array factor. Grating lobes. One dimensional arrays- Broad side, end fire and	9

	Chebyshev arrays. Concept of beam steering. Adaptive Beam forming. 2D Rectangular array. Introduction to Intelligent Reflecting Surfaces, applications in wireless communication, Comparison with traditional technologies (e.g., relays, massive MIMO)	
	Total Hours	**45**

Simulation Assignment

1. Familiarization of HFSS/CST/ MATLAB.
2. Characterization of arrays using HFSS/CST/ MATLAB.
3. Characterization of horn, reflector antenna using HFSS/CST/ MATLAB
4. Characterization of microstrip array antenna using HFSS/CST/ MATLAB.

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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ECL3HF	**MULTIRATE SIGNAL PROCESSING**	**HONOURS**	**2**	**1**	**0**	**0**	**3**	**2023**

i. PREREQUISITE 23ECL30B: Digital Signal Processing

ii. COURSE OVERVIEW

To have an advanced level knowledge on Multirate systems and to apply the mutirate signal processing techniques to the systems which are working in different rates.

iii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO1	Explain the principles of multirate signal processing, encompassing decimation, interpolation, and their effects on signal spectra.	Understand
CO2	Implement two-channel and M-channel filter banks using polyphase structures to achieve desired signal processing objectives.	Apply
CO3	Implement two-channel FIR paraunitary QMF banks and analyze their reconstruction capabilities.	Apply
CO4	Implement scaling techniques to manage dynamic range and minimize quantization errors in digital filter designs.	Apply
CO5	Explain the principles behind cosine modulation in filter banks and how it facilitates efficient subband decomposition and reconstruction.	Understand

iv. SYLLABUS:

Fundamentals of Multirate theory.

The sampling theorem. Basic Multirate operations

Maximally decimated filter, M-channel perfect reconstruction filter banks Polyphase representation

Perfect reconstruction systems Paraunitary PR Filter Banks- Filter Bank Properties induced by paraunitarity

Quantization – types, effects filter banks.

Cosine Modulated filter banks Polyphase structure PR Systems

v (a) TEXT BOOKS

1.	P.P. Vaidyanathan. Multirate systems and filter banks. Prentice Hall. PTR. 1993
2.	N.J. Fliege. Multirate digital signal processing . John Wiley 1994.
3.	Sanjit K. Mitra. Digital Signal Processing: A computer based approach. McGraw Hill. 1998

(b) REFERENCES

1.	R.E. Crochiere. L. R. Multirate Digital Signal Processing, Prentice Hall. Inc.1983.
2.	J.G. Proakis. D.G. Manolakis. Digital Signal Processing: Principles. Algorithms and Applications, 3rd Edn. Prentice Hall India, 1999.

vi. COURSE PLAN

Module	Contents	Hours
I	The sampling theorem - sampling at sub nyquist rate - Basic Formulations and schemes. Basic Multirate operations- Decimation and Interpolation - Digital Filter Banks- DFT Filter Bank- Identities- Polyphase representation	9
II	Maximally decimated filter banks: Polyphase representation - Errors in the QMF bank- Perfect reconstruction (PR) QMF Bank - Design of an alias free QMF Bank M-channel perfect reconstruction filter banks -Uniform band and non uniform filter bank - tree structured filter bank- Errors created by filter bank system- Polyphase representation- perfect reconstruction systems	9
III	Perfect reconstruction (PR) filter banks Paraunitary PR Filter Banks- Filter Bank Properties induced by paraunitarity- Two channel FIR paraunitary QMF Bank- Linear phase PR Filter banks- Necessary conditions for Linear phase property	9
IV	Quantization Effects: -Types of quantization effects in filter banks. - coefficient sensitivity effects, dynamic range and scaling.	9

V	Cosine Modulated filter banks Cosine Modulated pseudo QMF Bank- Alas cancellation- phase - Phase distortion- Closed form expression- Polyphase structure PR 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: 1 ½ hours
- Topics: 2 ½ modules

END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours