

**COURSE STRUCTURE (R23)
AND
DETAILED SYLLABUS
(III YEAR)**

**ELECTRONICS & COMMUNICATION
ENGINEERING**

**For
B.Tech. Third Year Degree Course
(Applicable for the batches admitted from 2023-24)**



LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY

An Autonomous Institution

Approved by AICTE & Permanently Affiliated to JNTUGV, Vizianagaram

Accredited by NAAC with 'A' Grade and NBA (CSE, ECE, EEE & ME)

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R23_COURSE STRUCTURE AND DETAILED SYLLABUS

B.TECH- ELECTRONICS AND COMMUNICATION ENGINEERING

III Year I Semester

S. No	Course Code	Course Name	L	T	P	Credits
1	R23ECE-PC3101	Analog and Digital Communication	3	0	0	3
2	R23ECE-PC3102	Antennas and Wave Propagation	3	0	0	3
3	R23ECE-PC3103	Analog and Digital IC Applications	3	0	0	3
4		Professional Elective-I	3	0	0	3
4	R23ECE-PE3101.1	1. Information Theory and Coding	3	0	0	3
4	R23ECE-PE3101.2	2. Advanced Semiconductor Devices	3	0	0	3
4	R23ECE-PE3101.3	3. Embedded and IoT	3	0	0	3
4	R23ECE-PE3101.4	4. Computer Architecture & Organization	3	0	0	3
4	R23ECE-PE3101.5	5. Fundamentals of Computational Electro Magnetics	3	0	0	3
5	R23ECE-OE3101	Open Elective- I	3	0	0	3
6	R23ECE-PC3104	Analog & Digital Communications Lab.	0	0	3	1.5
7	R23ECE-PC3105	Analog and Digital IC Applications Lab	0	0	3	1.5
8	R23ECE-SC3101	High Frequency and Antenna Design Engineering/Raspberry Pi for Beginners (Skill Oriented Course)	0	1	2	2
9	R23ECE-ES3101	PCB Design and Prototype Development	0	0	2	1
10	R23BSH-MC3101	English and Soft Skills for Job Seekers (Mandatory Course)	0	1	2	0
11	R23ECE-SI3101	Evaluation of Community Service Project Internship	0	0	0	2
Total			15	2	12	23

III Year II Semester						
S.No	Course Code	Course Name	L	T	P	Credits
1	R23ECE-PC3201	Digital Signal Processing	3	0	0	3
2	R23ECE-PC3202	Microwave and Optical Communications	3	0	0	3
3	R23ECE-PC3203	VLSI Design	3	0	0	3
4		Professional Elective-II	3	0	0	3
4	R23ECE-PE3201.1	1. Cellular and Mobile Communication.	3	0	0	3
4	R23ECE-PE3201.2	2. Digital System Design Using Verilog	3	0	0	3
4	R23ECE-PE3201.3	3. Embedded Programming	3	0	0	3
4	R23ECE-PE3201.4	4. Wavelet Transforms	3	0	0	3
4	R23ECE-PE3201.5	5. Phased Array Antennas.	3	0	0	3
5		Professional Elective-III	3	0	0	3
5	R23ECE-PE3202.1	1. Satellite Communications	3	0	0	3
5	R23ECE-PE3202.2	2. VLSI Design for RTL to GDS	3	0	0	3
5	R23ECE-PE3202.3	3. Edge and Cloud Computing	3	0	0	3
5	R23ECE-PE3202.4	4. Bio-Medical Signal Processing.	3	0	0	3
5	R23ECE-PE3202.5	5. R F Circuit Design.	3	0	0	3
6	R23ECE-OE3201	Open Elective - II	3	0	0	3
7	R23ECE-PC3204	Microwave and Optical Communications Lab	0	0	3	1.5
8	R23ECE-PC3205	VLSI Design Lab	0	0	3	1.5
9	R23ECE-SC3201	AI and Signal Processing (Skill Oriented Course)	0	1	2	2
10	R23ECE-MC3201	Technical Paper Writing & IPR (Mandatory Course)	2	0	0	0
Total			20	1	8	23

R23_ECE (Honors)

TRACK 1 : VLSI DESIGN							
S. No	Year - semester	Code	Subject Name	L	T	P	C
1	II-II	R23ECE-HN2201	Digital Athematic Circuits	3	0	0	3
2	III-I	R23ECE-HN3101	FPGA and Digital System Design using Verilog	3	0	0	3
3	III-II	R23ECE-HN3201	Analog and mixed signal IC design	3	0	0	3
4	IV-I	R23ECE-HN4101	LOW POWER VLSI DESIGN	3	0	0	3
5	II Year to IV Year	R23ECE-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23ECE-HM0002	Honors MOOCS-2	0	0	0	3
Total							18

TRACK 2 : EMBEDDED AND IoT DESIGN							
S. No	Year - semester	Code	Subject Name	L	T	P	C
1	II-II	R23ECE-HN2202	Sensors and Actuators	3	0	0	3
2	III-I	R23ECE-HN3102	Data Analytics for IoT	3	0	0	3
3	III-II	R23ECE-HN3202	Robotics for Embedded systems	3	0	0	3
4	IV-I	R23ECE-HN4102	Privacy And Security In IoT	3	0	0	3
5	II Year to IV Year	R23ECE-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23ECE-HM0002	Honors MOOCS-2	0	0	0	3
Total							18

R23 ECE (Minors)

Track- I (EMBEDDED SYSTEMS)							
S.No	Year & Semester	Course Code	Subject title	L	T	P	C
1	II-II	R23ECE-MT2201	Introduction to Microcontrollers	3	0	0	3
2	III-I	R23ECE-MT3101	Embedded system Design	3	0	0	3
3	III-I	R23ECE-ML3101	Programming on Microcontrollers LAB	0	0	3	2
4	III-II	R23ECE-MT3201	Smart Sensors and Actuators	3	0	0	3
5	III-II	R23ECE-ML320	Embedded System Lab	0	0	3	2
6	IV-I	R23ECE-MT4101	Embedded real time operating systems	3	0	0	3
7	II Year to IV Year	R23ECE-MM0001	Minors MOOCS-1	0	0	0	3
Total							18

Track-II (VLSI DESIGN)							
S.No	Year & Semester	Course Code	Subject title	L	T	P	C
1	II-II	R23ECE-MT2202	Introduction to VLSI Programming	3	0	0	3
2	III-I	R23ECE-MT3102	CMOS digital IC design	3	0	0	3
3	III-I	R23ECE-ML3102	VLSI programming Lab	0	0	3	2
4	III-II	R23ECE-MT3202	Introduction VLSI design flow	3	0	0	3
5	III-II	R23ECE-ML3202	CMOS digital IC design Lab	0	0	3	2
6	IV-I	R23ECE-MT4102	Design for Testability	3	0	0	3
7	II Year to IV Year	R23ECE-MM0001	Minors MOOCS-1	0	0	0	3
Total							18

Track-III (COMMUNICATIONS)							
S.No	Year & Semester	Course Code	Subject title	L	T	P	C
1	II-II	R23ECE-MT2203	Basics of Signal Processing	3	0	0	3
2	III-I	R23ECE-MT3103	Communication Systems	3	0	0	3
3	III-I	R23ECE-ML3103	Signal processing Lab	0	0	3	2
4	III-II	R23ECE-MT3203	Advance Communications systems	3	0	0	3
5	III-II	R23ECE-ML3203	Communication Systems Lab	0	0	3	2
6	IV-I	R23ECE-MT4103	Communication Switching and Techniques	3	0	0	3
7	II Year to IV Year	R23ECE-MM0001	Minors MOOCS-1	0	0	0	3
Total							18

Track-IV (QUANTUM TECHNOLOGIES) (Common to All Branches)							
S.No	Year & Semester	Course Code	Subject title	L	T	P	C
1	II-II	R23ECE-MT2204	Foundations of Quantum Computing: Physics, Engineering, and Mathematics Computing	3	0	0	3
2	III-I	R23ECE-MT3104	Survey of Quantum Technologies and Applications	3	0	0	3
3	III-I	R23ECE-ML3104	Quantum Technology-1 Lab	0	0	3	2
4	III-II	R23ECE-MT3204	Foundations of Quantum Technologies	3	0	0	3
5	III-II	R23ECE-ML3204	Quantum Technology-2 Lab	0	0	3	2
6	IV-I		Elective	3	0	0	3
		R23ECE-MT4104.1	Quantum Computation				
		R23ECE-MT4104.2	Quantum Communications				
7	II Year to IV Year	R23ECE-MM0001	Minors MOOCS-1	0	0	0	3
Total							18

III-I B.Tech R23 (ECE) DETAILED SYLLABUS

Subject Code	Subject Name	L	T	P	C
R23ECE-PC3101	Analog and Digital Communication	3	0	0	3

Course Outcomes: After successful completion of the course the student should be able to

- Differentiate various Analog modulation and demodulation schemes and their spectral characteristics (L2)
- Understand the different types of Amplitude modulation and demodulation methods and their characteristics (L2)
- Understand the Angle modulation and demodulation schemes and noise calculation in analog modulation technique. (L2).
- Illustrate the different pulse modulation schemes, transmitters and receivers in Analog Modulation. (L2).
- Analyze different digital modulation techniques and their probability of error calculations. (L3)

Course Objectives:

1. Understand the concept of modulation and demodulation Techniques in AM.
2. Familiarize different types of Amplitude modulation techniques.
3. Introduce the concept of angle modulation technique and noise calculation in analog modulation methods.
4. Familiarize various Transmitters and Receivers and the noise calculation in Analog Modulation.
5. Understand the concept of digital modulation techniques and their error probability.

UNIT – I

Amplitude Modulation: Introduction to communication system, Need for modulation, Amplitude Modulation - Time and frequency domain description, single tone modulation, power relations in AM waves, Generation of AM waves -Switching modulator, Detection of AM Waves - Envelope detector.

Learning Outcomes:

- Compare the trade-offs between different linear modulations in terms of power, efficiency and bandwidth.
- Understand the balanced modulators and their role in generating DSBSC signals by suppressing the carrier
- Understand the principles behind coherent detection of DSB-SC and SSB signals, including the use of a coherent carrier signal for demodulation
- Apply Hilbert Transform to represent SSB Signals in time Domain.
- Apply frequency and phase discrimination methods for generating and detecting SSB signals
- Understand the advantages of VSB in terms of spectral efficiency compared to AM or SSB

Applications:

- SSB is preferred for long-distance communication.
- SSB is preferred for HF (High Frequency) radio communication, satellite communication, and military communication
- VSB is the dominant modulation technique used in analog television systems (NTSC, PAL, SECAM)

UNIT - II

Types of Amplitude Modulation: DSBSC modulation - time and frequency domain description, Generation of DSBSC Waves - Balanced Modulators, Coherent detection of DSB-SC Modulated waves, COSTAS Loop, SSB modulation - time and frequency domain description, frequency discrimination and Phase discrimination methods for generating SSB, Demodulation of SSB Waves, Principle of Vestigial side band modulation, Comparison of AM techniques.

Learning Outcomes:

- Calculate the instantaneous frequency, phase deviation, and frequency deviation in angle modulation.
- Understand the Fourier spectra of angle-modulated signals i.e., the distribution of signal power across frequency components.
- Applying Carson's Rule to estimate bandwidth of angle-modulated signals.
- Understand the methods for generating both narrowband and wideband angle-modulated signals.
- Understand the principles behind demodulation techniques like the frequency discriminator used in FM receivers.
- Understand the operation of superhetrodyne receivers.

Applications:

- Wireless communication systems
- Satellite communication
- Mobile cellular networks

UNIT- III

Angle Modulation: Basic concepts of Phase Modulation, Frequency Modulation: Single tone Frequency modulation, Narrow band FM, Wide band FM, Constant Average Power, Transmission bandwidth of FM signals. Generation of FM - Direct and indirect methods, Detection of FM Signal- Balanced slope detector, Phase locked loop, Comparison of FM and AM, Concept of Pre-emphasis and de-emphasis.

Noise Analysis - Internal and External Noise, Noise Calculation, Noise Figure, Noise analysis in AM receivers, Threshold effect.

Learning Outcomes:

- Explain and compute the **Noise Figure (NF)** to assess system performance.
- Analyze the impact of noise in **Amplitude Modulation (AM)** and **Frequency Modulation (FM)** receivers.
- Differentiate between AM and FM receiver characteristics and evaluate their relative advantages and limitations.

Applications:

- Aviation and Aeronautical Communications:
- Emergency and Public Safety Communications
- Television Broadcasting
- Wireless Microphones and Headsets
- Mobile Communication Systems

UNIT- IV

Transmitters: Classification of Transmitters, AM Transmitters, FM Transmitters.

Receivers: Radio Receiver - Receiver Types -Tuned radio frequency receiver, Super heterodyne receiver, RF section and Characteristics - Frequency changing and tracking, Intermediate frequency, Image frequency, AGC, Amplitude limiting, FM Receiver, Comparison of AM and FM Receivers.

Pulse Analog Modulation techniques – Pulse Amplitude Modulation, Pulse width Modulation, Pulse Position Modulation, Methods of generation and detection.

Learning Outcomes:

- Understand the generation and reception of digital modulation techniques
- Understand the frequency spectrum of digital modulation techniques
- Apply the concept of signal constellation to calculate Probability of Error for PSK, FSK and PSK.

Applications:

- Cellular networks
- satellite communication
- Wi-Fi and Bluetooth.
- Radar systems
- Satellite navigation

UNIT- V

Digital Modulation Techniques and Data Transmission: Introduction, ASK, FSK, PSK, DPSK, QPSK, M-ary PSK, QAM, similarity of BFSK and BPSK. Base band signal receiver, probability of error, the optimum filter, matched filter, Probability of Error for BASK, BPSK, BFSK and QPSK, Comparison of modulation schemes.

Learning Outcomes:

- Comprehend the principles behind optimal reception techniques for digital signals, including baseband signal reception and the use of maximum likelihood detectors and Bayes receivers.
- Calculate the probability of error for digital modulation schemes such as PSK, FSK, and QPSK, employing techniques like matched filtering and correlation.
- Understand the design and characteristics of optimum filters for digital signal reception, including matched filters and correlators, to maximize signal detection performance.

APPLICATIONS:

- DAB (Digital Audio Broadcasting) and DVB (Digital Video Broadcasting)
- Radar and Sonar Systems
- Medical Imaging

TEXT BOOKS:

1. Communication Systems - Simon Haykin, John Wiley & Sons, 2nd Edition.
2. B. P. Lathi, Zhi Ding "Modern Digital and Analog Communication Systems", Oxford press, 2011.
3. Digital Communication- Simon Haykin, John Wiley, 2005.

REFERENCE BOOKS:

1. Digital Communications – John Proakis, TMH, 1983
2. Digital and Analog Communication Systems - Sam Shanmugam, John Wiley & Sons, 1999.
3. Digital Communications: Fundamentals and Applications - Bernard Sklar, F. J. Harris, Pearson Publications, 2020.
4. Principles of Communication Systems- Taub and Schilling, Tata McGraw Hill, 2007

Subject Code	Subject Name	L	T	P	C
R23ECE-PC3102	Antenna and Wave Propagation	3	0	0	3

Course Objectives:

1. To introduce fundamentals of antennas and basic performance assessment parameters.
2. To illustrate the different types of arrays and their radiation patterns.
3. To introduce the design concepts of various antenna types with their geometrical and radiation characteristics.
4. To obtain the knowledge on practical measurements of antenna characteristics
5. To understand the concepts of radio wave propagation in the atmosphere.

Course Outcomes: At the end of the Course, the Student will be able to:

1. Understand the antenna fundamentals and its radiation mechanism (L2).
2. Design antenna arrays for enhanced radiation performance (L3).
3. Distinguish the resonant, non-resonant and broadband antennas (L4).
4. Choose the antennas suitable for VHF, UHF and Microwave applications (L3).
5. Understand the radio wave propagation at different frequencies through various atmospheric layers (L2).

UNIT-I: Antenna Fundamentals And Radiation Mechanism

Introduction, Radiation Mechanism – single wire, 2 wire, dipoles, current distribution on a thin wire antenna. Antenna parameters: Radiation Pattern – patterns in principal planes, radiation lobes, Beamwidths, Polarization, Beam area, Radiation Intensity, Directivity, Antenna Efficiency, Gain, Antenna Apertures, Aperture Efficiency, Effective Height, Input Impedance, Illustrated Problems.

Applications:

1. Antenna parameters can be computed for various antennas.

Learning Outcomes: At the end of this unit, the student will be able to

1. Explain the Radiation mechanism and basic antenna characteristics (L2)
2. Understand the performance of the antenna based on its parameter specifications (L2).

UNIT-II: Thin Linear Wire Antennas And Antenna Arrays

Radiation from Small Electric Dipole, Quarter wave Monopole and Half-wave dipole – Evaluation of field components, and radiation properties. Loop Antennas: Small Loops - Field Components, Comparison of far fields of small loop and short dipole, Concept of short magnetic dipole, D and Rr relations for small loops.

Two Element Arrays, Principal of Pattern Multiplication. N- Element Linear Arrays – BSA, EFA, N-Element Linear Array with Uniform and Non-Uniform Amplitudes, Binomial Arrays, Arrays with parasitic elements, Yagi-Uda Arrays, Concept scanning arrays, Related Problems.

Applications:

1. Dipoles, monopoles are used for mobile and cellular communications as base station antennas.
2. Array antennas can be used for enhanced gain/directivity for long range wireless communications, scanning purposes, see-through wall applications, RADARs.

Learning Outcomes: At the end of this unit, the student will be able to

1. Understand the design principles, radiation mechanism and radiation properties of linear wire antennas (L2)
2. Understand the radiation mechanism of antenna arrays (L2)
3. Design Antenna Array with desired radiation beam characteristics (L3)

UNIT-III: Non-Resonant, Broad Band And Microstrip Antennas

Introduction to non-resonant radiators, Travelling wave Radiators – basic concepts. Broadband Antennas: Helical Antennas – Significance, Geometry, basic properties; Design considerations for Monofilar helical antennas in Axial Mode and Normal Modes. Microstrip Antennas- Introduction, Features, Advantages and Limitations, Rectangular Patch Antennas –Geometry and Parameters.

Applications:

1. Dipoles, monopoles are used for mobile and cellular communications as base station antennas.
2. Array antennas can be used for enhanced gain/directivity for long range wireless communications, scanning purposes, see-through wall applications, RADARs.

Learning Outcomes: At the end of this unit, the student will be able to

1. Analyze the radiation properties of non-resonant antennas, resonant and broadband radiators (L4)
2. Understand the design principles for obtaining the circular polarized antenna through helical antennas (L2)
3. Design microstrip patch antenna for desired specifications (L3)

UNIT-IV: Vhf, Uhf And Microwave Antennas

Reflector Antennas: Flat Sheet and Corner Reflectors. Paraboloidal Reflectors – Geometry, characteristics, types of feeds, F/D Ratio, Spill Over, Back Lobes, Aperture Blocking, Off-set Feeds, Cassegrain Feeds. Horn Antennas – Types, Optimum Horns, Design Characteristics of Pyramidal Horns; Lens Antennas – Geometry, Features, Dielectric Lenses and Zoning, Applications, Measurement of Radiation patterns and Gain in Anechoic chamber.

Applications:

1. Domestic satellite television reception, terrestrial microwave data links, general satellite communication etc.
2. Functional verification of antennas and its quality analysis.

Learning Outcomes: At the end of this unit, the student will be able to

1. Understand the phenomenon of obtaining the directional radiation beams through reflectors, lenses, feed horns (L2)
2. Select antennas for various VHF, UHF, Microwave range of wireless communications (L3).
3. Explain the measurement setup and procedure for testing the various types of antennas after fabrication or manufacturing (L2).

UNIT-V: Wave Propagation

Concepts of Propagation – Frequency ranges and types of propagation. Sky wave propagation – Formation of Ionospheric layers and their characteristics, Mechanism of reflection and refraction, critical frequency, MUF and Skip distance. Space wave propagation – Mechanism, LOS and Radio Horizon – Radius of curvature of path, M-curves and Duct propagation.

Applications:

1. Line-of-sight communication, Aircraft-to-land communication, Tracking using Radars, Satellite communications, Direct-to-home broadcasting, etc.

Learning Outcomes: At the end of this unit, the student will be able to

1. Understand effects of earth's magnetic field on wave propagation (L2)
2. Identify layers in ionosphere and their ionization densities (L1)
3. Understand signal losses/attenuation through various atmospheric layers (L2).

TEXTBOOKS:

1. Antennas and Wave Propagation – John D. Kraus, Ronald J Marhefka, Ahmad S Khan, 5th Edition, McGraw Hill Education (India) Private Limited, SIE, 2018.
2. Antenna Theory: Analysis and Design –C.A. Balanis, 3rd Edition, Wiley India Pvt. Ltd.,2016.

REFERENCE BOOKS:

1. Antennas and Wave Propagation – K.D. Prasad, 2nd Edition, Satya Prakashan, Tech India Publications, New Delhi, 2001.
2. Antennas and Wave Propagation – A.R. Harish, M. Sachidananda, 1st Edition, Oxford University Press, 2007.

Subject Code	Subject Name	L	T	P	C
R23ECE-PC3103	Analog and Digital IC Applications	3	0	0	3

Course Objectives: The main objectives of the course are:

1. To introduce the basic building blocks of linear integrated circuits.
2. To introduce the theory and applications of Analog multipliers and PLL.
3. To introduce the concept sine waveform generation and introduce some special function ICs.
4. To understand and implement the working of basic digital ICs.
5. To introduce the various sequential IC's for various applications.

Course Outcomes: Upon completing this course, the students will be able to

1. Understand the operational amplifiers with linear integrated circuits.
2. Attain the knowledge of functional diagrams and design applications of IC555 and IC565.
3. Acquire the knowledge and design the Data converters.
4. Choose the proper digital integrated circuits by knowing their characteristics.
5. Understand the characteristics of various sequential logic ICs

UNIT-I Operational Amplifier: Ideal and Practical Op-Amp, Op-Amp Characteristics, DC and AC Characteristics, Features of 741 Op-Amp, Modes of Operation-Inverting, Non-Inverting, Differentiators and Integrators, Comparators, Schmitt Trigger, waveform generators (square and triangular).

UNIT-II Op-Amp, IC-555 & IC565 Applications: Introduction to Active Filters, Characteristics of Bandpass, Band reject and All Pass Filters.

IC555 Timer-Functional Diagram, Monostable and Astable Operations, Applications, IC565 PLL-Block Schematic, principle and Applications.

UNIT-III Data Converters: Introduction, Basic DAC techniques, Different types of DACs- Weighted resistor DAC, R-2R ladder DAC, Different Types of ADCs – Parallel Comparator Type ADC, Counter Type ADC, Successive Approximation ADC and Dual Slope ADC, DAC and ADC Specifications.

UNIT-IV Combinational Logic ICs: Specifications and Applications of TTL-74XX & CMOS 40XX Series ICs- Decoders (74x138, 4028), Priority Encoders(74x148), Multiplexer(74x157), Parallel Binary Adder/Subtractor(74x283), Magnitude Comparators (7485, 4008).

UNIT - V Sequential Logic IC's: D flip-flop (IC7474, 4013), JK Flip-flop(IC7476), shift register using IC7474, Universal shift Register (74X194), synchronous counters using flip-flops, Decade counter using (IC 7476, 4017) .

TEXTBOOKS:

1. Ramakanth A. Gayakwad - Op-Amps & Linear ICs, PHI, 2003.
2. Floyd and Jain- Digital Fundamentals, 8th Ed., Pearson Education,2005.

REFERENCE BOOKS:

1. D. Roy Chowdhury – Linear Integrated Circuits, New Age International(p)Ltd,2nd Ed., 2003.
2. John. F. Wakerly – Digital Design Principles and Practices, 3rdEd., Pearson, ,2009.
3. Salivahana -Linear Integrated Circuits and Applications, TMH, 2008.
4. William D.Stanley- Operational Amplifiers with Linear Integrated Circuits, 4thEd., Pearson Education India, 2009.

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3101.1	Information Theory and Coding (Professional Elective-I)	3	0	0	3

Course Objectives:

1. Understand the concept of Entropy and source coding
2. Understand the concept of channel and its capacity
3. Encoding and Decoding of Digital Data Streams
4. Be Aware of Compression and Decompression Techniques
5. Learn the Concepts of Multimedia Communication

Course Outcomes: At the end of the course the student will be able to

1. Understand the concept of information theory and channel capacity (L2)
2. Apply source coding techniques to improve transmission efficiency (L3)
3. Construct the encoder and decoder of the linear block codes to improve the reliability of the system (L3)
4. Analyze encoding and decoding of the cyclic codes to improve the reliability of the system (L4)
5. Analyze encoding and decoding of the convolution and turbo codes to improve system reliability (L4)

UNIT-I INFORMATION THEORY

Uncertainty, Amount of information, Entropy, Joint entropy, Conditional entropy, Relative entropy, Mutual information, Relationship between entropy and mutual information, Chain rules for entropy, Jensen's inequality and its consequences, Fano's inequality, capacity of a noiseless binary channel, binary symmetric channel, Gaussian channel, Bandwidth-SNR trade-off.

Learning outcomes:

At the end of this unit the student will be able to

1. Understand the concept of information (L2)
2. Explain different entropies (L2)
3. Determine the channel capacity for continuous channels (L3)

UNIT-II SOURCE CODING

Classification of codes, Noiseless coding, Kraft and McMillan's inequality, Coding efficiency, Shannon-Fano coding, Huffman coding and its optimality, Shannon-Fano-Elias coding, Arithmetic coding and Universal Coding, The Lempel-Ziv coding, Run-length encoding and PCX format, Applications of source coding, introduction to image compression, JPEG Standard for Lossy Compression.

Learning outcomes:

At the end of this unit the student will be able to

1. Understand source coding (L2)
2. Apply various source coding techniques to improve transmission efficiency (L3)
3. Examine different error detection mechanisms (L3)

UNIT-III Error Control Coding

Introduction to error control codes, error detection and correction, automatic repeat request, forward error correction codes: systematic linear block codes encoding, syndrome decoding, hamming code, Optimal Linear Codes, construction of low-density parity check codes, tanner graph, decoding of LDPC codes, Maximum Distance Separable(MDS) codes, Space Time Block Codes

Learning outcomes:

At the end of this unit the student will be able to

1. Understand the concept of error correction coding (L2)
2. Construct the encoder and decoder of linear block codes (L3)
3. Apply tanner graph for decoding LDPC codes (L3)

UNIT-IV CYCLIC CODES

Introduction, cyclic codes generation, Matrix Description of cyclic codes, Burst error correction, Fire codes, Golay codes, CRC codes, Circuit implementation of cyclic codes.

BCH AND RS CODES: Algebraic Description, Frequency Domain Description, Decoding Algorithms for BCH and RS Codes, BCH and RS Codes Minimal Polynomials, Generator polynomials in terms of Minimal polynomials, Examples of BCH codes, Implementation of RS encoders and decoders.

Learning outcomes:

At the end of this unit the student will be able to

1. Understand the generation of cyclic codes (L2)
2. Understand the implementation of cyclic codes (L2)
3. Analyze decoding of BCH and RS codes (L4)

UNIT-V CONVOLUTIONAL AND TURBO CODES

Encoding of Convolutional codes, state table, trellis structure, decoding using Viterbi algorithm, Iterative design of Turbo codes, Decoding of Turbo codes: Iterative map method, The BCJR algorithm.

Learning outcomes:

At the end of this unit the student will be able to

1. Understand the encoding of convolutional codes (L2)
2. Apply Viterbi algorithm for decoding convolutional codes (L3)
3. Analyze decoding of turbo codes using iterative map and BCJR algorithm (L4)

Text Books:

1. Thomas M. Cover, Joy A Thomas, *Elements of Information Theory*, 2nd Edition, Wiley, 2015.
2. Bose, Ranjan. *Information theory, coding and cryptography*, 2nd Edition, Tata McGraw-Hill Education, 2008.
3. Lin, Shu, and Daniel J. Costello, *Error control coding*, 2nd Edition, Prentice hall, 2001.

References:

1. Simon Haykin, *Communication Systems*, 4th edition, Wiley Publications, 2001.
2. R. P. Singh, S. D. Sapre, *Communication Systems*, 2nd edition, Tata McGraw-Hill Education, 2008.
3. K. Deerga Rao, *Channel coding Techniques for wireless communications*, 2nd edition, Springer, 2019.
4. Biswas, Nripendra N. *Logic design theory*, Prentice-Hall, Inc., 1993.

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3101.2	Advanced Semiconductor Devices (Professional Elective-I)	3	0	0	3

Course Objectives:

- To provide a physics-based understanding of scaling challenges in conventional MOSFETs.
- To explore emerging device architectures beyond the limits of Moore's Law.
- To analyze novel material systems and quantum mechanical phenomena impacting FETs.
- To introduce Moore (MTM) approaches including low-power and high-speed alternatives.
- To evaluate the performance, advantages, and limitations of next-generation transistors.

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

1. CO1: Understand physical mechanisms limiting traditional MOSFETs.
2. CO2: Analyze advanced architectures like FinFETs, GAA, and SOI-based transistors.
3. CO3: Evaluate novel materials and their impact on next-gen FET performance.
4. CO4: Interpret quantum transport and device miniaturization effects.
5. CO5: Assess emerging technologies and More-than-Moore applications for future ICs.

Unit I: Physics of Scaling in Classical MOSFETs: Review of MOSFET, MOS Capacitors MOSFET and Application, MOSFET Spice Models Electrostatics and transport Short-channel effects and drain-induced barrier lowering (DIBL) Scaling limits: sub threshold slope, gate leakage, quantum tunneling International Technology Roadmap for Semiconductors (ITRS) perspective Moore's Law and its breakdown,

Unit II: Advanced MOSFET Architectures: FinFET successor of MOSFET FinFETs: Structure, operation, and scaling behavior Gate-all-around (GAA) FETs 5nm and Nano wire FETs Silicon-on-Insulator (SOI), FD-SOI technologies High- κ / Metal Gate stacks Strain engineering and mobility enhancement techniques, Short Channel Effects, Double Gate MOSFET

Unit III: Materials for Beyond-Silicon FETs: 2D materials: Graphene, MoS₂, and TMDs III-V semiconductors (e.g., InGaAs) and Ge-channel devices Semiconductor Hetero structures devices: Band alignment and modulation Ferroelectric and piezoelectric materials in FETs (FeFETs, NCFETs) Challenges in material synthesis and integration

Unit IV: Novel Device Concepts and Quantum Effects: Tunnel FETs (TFETs): Physics, design, and advantages Negative Capacitance FETs (NCFETs): Landau theory, hysteresis SpinFETs and magneto electric devices Quantum dots and Single-Electron Transistors (SETs) Thermionic and ballistic transport in nano-FETs

Unit V: More-than-Moore Approaches and Applications: Overview of More-than-Moore paradigm Heterogeneous integration and 3D ICs Low-power and flexible electronics Neuromorphic devices and memristors Reliability, variability, and manufacturability challenges Case studies from industrial research (Intel, TSMC, IMEC)

Textbooks

1. Y. Taur and T. Ning, *Fundamentals of Modern VLSI Devices*, Cambridge University Press
2. S. M. Sze and K. K. Ng, *Physics of Semiconductor Devices*, Wiley Mark Lundstrom, *Fundamentals of Carrier Transport*

References:

1. Jean-Pierre Colinge, *FinFETs and Other Multi-Gate Transistors*

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3101.3	Embedded and IOT (Professional Elective-I)	3	0	0	3

Course Objectives:

1. To Basic fundamentals and components of a typical embedded system.
2. To Embedded system development as a hardware design and firmware design methodologies, tools and integration.
3. To IoT system with its various technologies, system management and design.
4. To IoT system with Raspberry Pi platform using python programming.
5. To Connecting devices and use of web-based protocols for IoT system design.

Course Outcomes:

1. Illustrate the working of various components of a typical embedded system. (L2)
2. Develop hardware and firmware design methodologies, tools and integration for a embedded system. (L3)
3. Outline the technologies, system design and platform management of a typical IoT system. (L2)
4. Model Raspberry Pi platform based IoT design with python programming. (L3)
5. Extend the web protocols to IoT system in communicating devices and cloud. (L2)

UNIT-I : Introduction To Embedded System:

Embedded System, Embedded System Vs General Computing System, History of Embedded Systems, Classification of Embedded System, major Application Areas, Purpose of Embedded system, Core of Embedded System, Memory, Sensors and Actuators, Communication Interface, other System components, PCB and passive components, Characteristics of Embedded System, Quality Attributes of Embedded System, application and domain specific embedded systems.

Learning Outcomes:

1. Differentiate embedded system and general computing system (L2)
2. Classify embedded systems based on performance, complexity and era in which they are evolved (L2)
3. Discuss basic hardware and software units used in embedded systems (L2)

UNIT-II : Embedded System Development:

Analog and Digital Electronic components, VLSI and IC Design, EDA tools, PCB Fabrication, Embedded Firmware Design approaches, embedded firmware development languages, Integration of Hardware and Firmware, Board Bring up, Embedded System Development Environment – IDE, Types of File Generated on Cross Compilation- Disassembler/ Decompiler, Simulator, Emulator and Debugging, Target hardware Debugging, Boundary Scan, Embedded Product Development Life cycle.

Learning Outcomes:

1. Understanding and use tools for Embedded Software development(L2)
2. Burning embedded software in to the target system(L3)
3. Apply debugging techniques (L3)

UNIT-III :Introduction To Iot:

Physical design, Logical design, enabling technologies, IoT Levels & Deployment Templates, Domain Specific IoTs, IoT and M2M, difference between IoT and M2M, SDN and NFV for IoT, IoT system management with NETCONF-YANG, IoT platform design management, IoT Design Methodology.

Learning Outcomes:

1. Differentiate Microprocessor, Microcontroller, Embedded System. (L2)
2. Explain the Characteristics of IoT (L2)
3. Explain the physical design and logical design of IoT (L2)

UNIT-IV :Developing IoT:

Logical design using python, python data types & data structures, control flow, functions, modules, packages, file handling, date/time operations, classes, python packages of interest for IoT, IoT physical devices, Raspberry pi, interfaces, programming raspberry pi with python, other IoT Devices.

Learning Outcomes:

1. develop the Raspberry Pi based system design using python programming. (L3)

UNIT-V: CONNECTIVITY OF DEVICE AND WEB:

Communication Technologies, Data Enrichment, data consolidation and Device management at Gateway, Ease of Designing and affordability, web communication protocols for connected devices, message communication protocols for connected devices, web connectivity for connected device network using gateway, SOAP, REST, HTTP RESTful and websockets, internet connectivity, internet based communication, IP addressing in the IoT, media access control, application layer protocols- HTTP, HTTPS, FTP, Telnet and others.

Learning Outcomes:

1. Summarize the different methods and protocols to communicate between devices. (L2)
2. Outline the web protocols that play key role in IoT system. (L2)

TEXTBOOKS:

1. Introduction to Embedded System, Shibu K.V, Tata McGraw-Hill,.
2. Internet of Things - A hands-on approach, ArshdeepBahga, Vijay Madisetti, Universities Press,.
3. Internet of Things- Architecture and Design Principles, Raj Kamal, McGraw Hill Education (India) Private Limited,

REFERENCES:

1. Embedded Systems- Architecture, programming and Design Raj kamal, McGraw Hill Education (India) Private Limited.
2. Internet of Things with Raspberry Pi and Arduino, Rajesh Singh, Anita Gehlot, Lovi Raj Gupta, Bhupendra Singh, Mahendra Swain, CRC Press.

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3101.4	Computer Architecture and Organization (Professional Elective-I)	3	0	0	3

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

1. Understand the fundamental structure and operation of a digital computer system.
2. Analyze the hardware components involved in arithmetic operations.
3. Explore control unit organization and instruction execution methods.
4. Understand the memory hierarchy and its effect on system performance.
5. Learn the input/output organization and communication mechanisms between the CPU and peripherals

Course Outcomes: By the end of this course, students will be able to:

1. Describe the architecture, components, and operations of computer systems.
2. Analyze and design digital circuits for arithmetic operations.
3. Develop control units using hardwired or microprogrammed approaches.
4. Explain memory organization and optimize memory performance using cache and virtual memory.
5. Evaluate I/O mechanisms and their interaction with CPU and memory subsystems.

Unit 1: Basic Structure of Computer

Functional units, Basic operational concepts, Bus structures, Performance measures Machine instructions, and programs. Instruction sets: Addressing modes, instruction formats, instruction cycle, Memory Reference Instructions.

Learning Outcome:

Students will be able to

- Explain the architecture of a basic computer and the steps involved in program execution.

Unit 2: Computer Arithmetic

Data Representation: Data types, Complements, Fixed Point Representation, Floating Point Representation. Arithmetic operations: Binary addition, subtraction, multiplication, and division, Design of an arithmetic logic unit (ALU)

Learning Outcome (U2):

Students will be able to

- Perform and implement basic arithmetic operations in hardware design.

Unit 3: CPU Control Unit Design

Control unit functions, Hardwired control, Micro programmed control Instruction cycle and control signals, RISC, CISC. Introduction to pipelining and pipeline hazards

Learning Outcome (U3):

Students will be able to

- Distinguish and design hardwired and micro programmed control units.

Unit 4: Memory Organization

Memory hierarchy, Main memory (RAM, ROM), Cache memory: Mapping techniques, replacement policies, Virtual memory: Paging and segmentation, Associative memory

Learning Outcome (U4):

Students will be able to

- Describe various memory types and techniques to enhance memory performance.

Unit 5: Input/Output Organization

I/O interface, Modes of data transfer: Programmed I/O, Interrupt-initiated I/O, DMA, I/O processors, Bus structure.

Multiprocessor: Characteristics of Multiprocessors, Interconnection Structures, Inter processor communication and synchronization.

Learning Outcome (U5):

Students will be able to

- Analyze various I/O techniques and interfaces used in computer systems.

TEXT BOOKS:

1. Carl Hamacher, Zvonko Vranesic, Safwat Zaky, Computer Organization and Embedded Systems, 6th Edition, McGraw Hill.
2. Morris Mano, Computer System Architecture, 3rd Edition, Pearson Education.

REFERENCE BOOKS:

1. William Stallings (2010), Computer Organization and Architecture- designing for performance, 8th edition, Prentice Hall, New Jersey.
2. Andrew S. Tanenbaum (2006), Structured Computer Organization, 5th edition, Pearson Education Inc,

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3101.5	Fundamentals of Computational Electro-Magnetics (Professional Elective-I)	3	0	0	3

Course objectives:

- To provide hands-on experience with contemporary numerical approaches in electromagnetic (EM)
- To develop various methods for applications in RF-microwave circuits, High-speed interconnects, MEMS.
- To Understand the different kinds of method of moments.
- To explain the methods of Finite Difference Time Domain (FDTD).
- To Evaluate the advanced finite difference time domain methods.

Course Outcomes: After successful completion of the course, the students are able to

1. Understand the basic electromagnetic principals and wave equations.
2. Develop various formulas for method of moments
3. Interpret the various formulations of advanced method of moments.
4. Explain the basics of methods Finite Difference Time Domain (FDTD) .
5. Analyze the results of advanced Finite Difference Time Domain (FDTD).

UNIT-I :BASIC EM PRINCIPLES

Maxwells equations, Applications of Computational Electromagnetics, Electrostatics and Magnetostatics, Wave equation and propagation, Scalar and vector potentials, Surface equivalence principle, Greens Function, Boundary conditions, Linear algebra for computational EM

UNIT-II :METHOD OF MOMENTS (MOM)-I

2D vs 2.5D vs. 3D Formulations, Electrostatic Formulation: Capacitance matrix extraction, Magnetostatic Formulation: Inductance matrix extraction, Electric Field Integral Equation (EFIE): S-parameter extraction

UNIT-III :METHOD OF MOMENTS (MOM)-II

Partial Element Equivalent Circuit (PEEC) Method, Magnetic Field Integral Equation (MFIE) and Combined Field Integral Equation (CFIE), PMCHWT Formulation: Dielectric modeling, Parallelization techniques

UNIT-IV :FINITE DIFFERENCE TIME DOMAIN (FDTD) METHOD-I

Basics of FDTD: Finite Differences, FDTD Solution of Maxwell Equations in simple cases, Scattered field vs total field formulation, Implementation issues, Outer Radiation Boundary Conditions, Yee cell, Yee algorithm for 3D Formulation of FDTD

UNIT-V :FINITE DIFFERENCE TIME DOMAIN (FDTD) METHOD-II

Perfectly Matched Layer ABC, Frequency Domain Results from Time Domain Output of FDTD, Computational issues: Stair casing errors, numerical dispersion, Frequency Dependent Materials.

TEXT BOOKS:

1. A. Taflov and SC Hagness Computational Electrodynamics: The Finite Difference Time Domain Method, 3rd Ed., Artech House
2. Andrew F. Peterson, Scott L. Ray, Raj Mittra: Computational Methods for Electromagnetics, 1st Ed., IEEE Press Series on Electromagnetic Wave

Subject Code	Subject Name	L	T	P	C
R23ECE-PC3104	Analog and Digital Communication Lab	0	0	3	1.5

Course Objectives: Students under going this course, are expected to

- Outline the basics modulation and demodulation techniques in analog and digital communication systems
- Demonstrate the Significance of multiplexing and De-multiplexing techniques in communications
- Illustrate the importance of Pre-emphasis and De-emphasis circuit to improve the S/N ratio
- Recall different pulse analog modulation and wave form coding techniques
- Understand the operation and characteristics of an Automatic Gain Control (AGC) circuit

Course Outcomes: After undergoing the course, students will be able to

1. Explain various modulation and demodulation circuits in analog and digital communications system using hardware and MATLAB tools (L2)
2. Illustrate multiplex and de-multiplexing techniques in a digital communication system (L2)
3. Explain pre-emphasis and De-emphasis circuits for Frequency Modulation transmitter and receiver. (L2)
4. Illustrate various pulse analog modulation and waveform coding techniques (L2)
5. Analyze the characteristics of an Automatic Gain Control (AGC) circuit (L2)

List of Experiments:

1. AM Modulation and Demodulation
2. DSB-SC Modulation and Demodulation
3. SSB-SC Modulation and Demodulation
4. FM Modulation and Demodulation
5. Phase Locked Loop
6. AGC Characteristics
7. Pre-Emphasis and De-Emphasis
8. Time Division Multiplexing
9. Pulse Width Modulation and Pulse Position Modulation
10. PCM Modulation and Demodulation
11. Delta Modulation and Demodulation
12. Differential Pulse Code Modulation and Demodulation
13. Frequency Shift Keying Modulation and Demodulation
14. Phase shift keying modulation and demodulation.
15. Differential phase shift keying modulation and demodulation

Note: Any ten of the above experiments are to be performed in hardware and any five experiments are to be completed by using MATLAB

Additional Experiments:

1. Linear Block codes
2. Minimum shift keying Modulation and Demodulation

Subject Code	Subject Name	L	T	P	C
R23ECE-PC3105	Analog and Digital IC applications lab	0	0	3	1.5

Course Objectives:

1. Understand the fundamental principles and practical applications of analog and digital integrated circuits (ICs).
2. Design and analyze analog circuits such as amplifiers, filters, waveform generators, and voltage regulators using Op-Amps and ICs.
3. Implement and test digital circuits including adders, flip-flops, counters, and shift registers using standard TTL ICs.
4. Demonstrate the functionality of data converters (DACs/ADCs) and basic interfacing with microcontrollers.
5. Develop hands-on skills in assembling, debugging, and testing analog and digital circuits using electronic lab equipment.

Course Outcomes:

By the end of this lab course, students will be able to:

1. Design and verify the performance of inverting, non-inverting, and other Op-Amp based circuits such as integrators and differentiators.
2. Implement waveform generators (square, triangular), multivibrators, and filters using IC 741 and IC 555.
3. Construct and test digital logic circuits like adders/subtractors, flip-flops, counters, and shift registers using 74XX series ICs.
4. Analyze and verify the specifications of DACs, ADCs, and interfacing techniques with microcontrollers.
5. Demonstrate competence in circuit simulation, assembly, testing, and troubleshooting in a lab environment.

List of Experiments

1. Design and testing of Inverting and Non-Inverting Amplifiers using IC 741.
2. Implementation of Integrator and Differentiator circuits.
3. Instrumentation Amplifier using 3 Op-Amps.
4. Design of Comparator and Schmitt Trigger using Op-Amp.
5. Study of IC 723 Voltage Regulator.
6. Design and implementation of Low Pass and High Pass Active Filters (1st order).
7. Generation of Square and Triangular waveforms using IC 741.
8. Design of Astable and Monostable multivibrators using IC 555 Timer.
9. Frequency multiplication using IC 565 PLL.
10. Verification of DAC/ADC Specifications and parameters.
11. Implementation of a 4-bit Binary Adder/Subtractor using IC 7483.
12. Realization of JK, D and T Flip-flops using 74XX ICs.
13. Design of a 4-bit Synchronous Counter using Flip-Flops.
14. Shift Register implementation using IC 7495.

Note: Any twelve experiments are to be performed

Additional Experiments:

1. Realization of Code Converters (e.g., BCD to 7-segment) using 74XX ICs.
2. Implementation of R-2R Ladder DAC and observation of output waveform.
3. Realization of Successive Approximation ADC using ICs and microcontroller interfacing

Subject Code	Subject Name	L	T	P	C
R23ECE-SC3101	High Frequency and Antenna Design engineering Lab	0	1	2	2

Course Objectives:

- To familiarize the design and simulation various antennas and microwave components using an EM solver.
- To estimate the antenna performance using various metrics in the EM solver.
- To understand various microwave sources and components involved in Microwave Bench setup for Microwave measurements.
- To utilize Electromagnetic solver for the functional verification of various microwave components.
- To identify suitable microwave component for wave propagation.

Course Outcomes: At the end of the course, student will be able to:

1. Design the experimental setup to measure the signal conditioning/controlling characteristics of various microwave devices using bench setup (L3).
2. Design the microwave components and analyze the wave propagation modes (L3).
3. Design various antennas and analyze the performance of the antenna model as per the required operating characteristics (L3).
4. Design of wire type miniaturized printed antennas for the given specifications, to measure its parameters through simulation (L3).
5. Design of printed antennas and wire monopoles (helical) Circular Polarized radiation and High gain applications (L3).

List of Experiments: Minimum of Ten Experiments has to be performed

Part-A Antenna Design and Simulation (with EM Solver). (Any Five experiments)

1. Design and Study of Ultra-High Frequency (UHF) Dipole Antenna.
2. Design of Rectangular Patch Antenna with Probe feed for 2.4 GHz WLAN application. 3
3. Design of Microstrip fed Circular Patch antenna for 2.4 GHz.
4. Design of Meander line antenna for 2.4 GHz.
5. Design of Circularly Polarized Patch Antenna with Microstrip Line Feed.
6. Design and analysis of a Monofilar Helical Antenna
7. Design and Study of broadside & end fire UHF dipole antenna array.
8. Design and Analysis of Conical Horn Antenna
9. Design and Analysis of a Metamaterial Unit Cell.
10. Design and Analysis of Yagi-Uda Antenna
11. Design and Analysis of Rectangular patch MIMO antenna.
12. Design of Analysis of loop Antenna.

(OR)

Raspberry Pi for Beginners Lab (Skill Oriented Course)

Raspberry Pi for Beginners Lab (Skill Oriented Course)

Course Objectives:

1. Gain familiarity with Raspberry Pi, its architecture, and its capabilities for various interfacing applications.
2. Learn to write programs to control and interact with different electronic components such as LEDs, buzzers, push buttons, sensors, motors, and displays.
3. Install and configure MySQL on Raspberry Pi to store and retrieve data, and set up a web server for hosting applications.
4. Interface and process data from sensors like IR, OLED, and battery voltage monitoring to enhance real-world automation applications.
5. Develop practical skills in building interactive embedded systems and applying concepts to real-world problem-solving.

Course Outcomes : After successful completion of the course, students will be able to:

1. Configure and install essential software packages to operate Raspberry Pi efficiently.
2. Integrate components such as LEDs, buzzers, motors, and sensors with Raspberry Pi for hardware interfacing.
3. Develop and troubleshoot Python programs for effective hardware interaction using Raspberry Pi.
4. Manage MySQL databases and deploy functional web applications on Raspberry Pi.
5. Demonstrate the use of Raspberry Pi in real-time applications such as automation, environmental monitoring, and game simulation.

List of Experiments: Minimum of Ten Experiments has to be performed

1. To Familiarization with Raspberry Pi and perform necessary software installation.
2. To Interface LED /BUZZER with Raspberry Pi and write a program to turn ON LED for 1 Sec after every 2 seconds.
3. To Interface Pushbutton with Raspberry Pi and write a program to turn ON LED for 1 Sec after every 2 seconds.
4. To Interface Digital IR sensor with Raspberry Pi and write a program to turn ON LED at sensor detection.
5. To Interface motor using relay with Raspberry Pi and write a program to turn ON motor when PUSH button is pressed
6. To Interface OLED with Arduino/Raspberry Pi and write a program to print
7. temperature and humidity readings
8. To install MySQL database on Raspberry Pi and perform basic SQL queries.
9. To monitor the voltage level of the battery and indicating the same using multiple LED's.
10. Interfacing Chronos eZ430.
11. Dice game simulation.
12. Hosting a website on board.
13. Webcam server

Subject Code	Subject Name	L	T	P	C
R23ECE-ES3101	PCB Design and Prototype Development	0	0	2	1

Course Objectives:

- Turn ideas into reality by brainstorming, modelling and prototyping.
- Inculcate innovative and entrepreneurial mind-set through Design thinking and Hands-on Learning.
- Identify and research problems in their community and beyond, generate relevant and creative solutions, and develop sustainability plans for their solutions.
- Understand the need for PCB Design and steps involved in PCB Design and Fabrication process.
- Develop skills of using hand tools to construct a prototype of an engineering design.

Course Outcomes: Student is able to:

1. Execute basic and advanced Arduino programs.
2. Acquire design thinking capability, ability to design a component with realistic constraints, to solve real world engineering problems and analyse the results.
3. Understand the steps involved in schematic, layout, fabrication and assembly process of PCB design.
4. Develop a own Prototype for their basic and Advanced Embedded and IOT Projects.
5. Interface Different types of Sensors with Arduino and verify the Results.

Course Syllabus:

1. Design a Ring using 3D designs in Tinker CAD Software.
2. Design a Key chain using 3D designs in tinker CAD Software.
3. Simulate and Design the basic Power Supply Circuit used in electronic devices.
4. Simulate and Design the Automatic night lamp Circuit verify the result.
5. Interface an LED with Arduino Make it blink Continuously with a time interval of 1 second.
6. Simulate and Develop a Prototype for Traffic Light System with three different coloured LEDs with help of any one of the controller boards.
7. Simulate and Develop a prototype for Distance Measurement system using Ultrasonic Sensor with help of any one of the controller boards.
8. Simulate and Develop a prototype to Display the numbers from 00 to 99 using Common Cathode Seven Segment Displays with help of any one of the controller boards.
9. Simulate and Develop a prototype to display “HELLO LENDI” on LCD with help of any one of the controller boards.
10. Simulate and Develop a prototype to Display temperature value on LCD using LM35 with help of any one of the controller boards.
11. Simulate and Develop a prototype to Control the Speed direction of two DC motors using the L293D and Arduino.
12. Simulate and Develop a prototype for Voice Activated Home Automation.
13. Simulate and Develop a prototype for Smart Garbage Door Opener.
14. Testing of Motors, cables , capacitors, batteries, overview on Etching process.

Course code	Course Title	L	T	P	Credits
R23BSH-MC3101	English and Soft Skills for Job Seekers (Mandatory Course)	0	1	2	0

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

- To develop proficiency in spoken and written English by effectively using a wide range of grammatical structures and vocabulary, and by mastering skills such as paraphrasing, report and résumé writing, and formal correspondence.
- Communicate fluently and confidently in English through active participation in informal group discussions and formal presentations, leveraging audio-visual aids.
- Understand and apply best practices for successful performance in job interviews, including visume (video resume) preparation.
- Develop essential self-learning, communication, and soft skills that enhance employability through group discussions, teamwork, and case-based tasks.
- To prepare students for international education by building competence in the admission process, application writing, interview skills, and awareness of visa, cultural, and financial aspects.

Course Outcomes:

1. Understand the grammatical forms of English and the use of these forms in specific communicative and professional writing.
2. Improve their speaking ability in English, both in terms of fluency and comprehensibility by participating in Group discussions and oral assignments CO3: master interview skills for effective preparation and confident performance in diverse job scenarios.
3. Demonstrate confidence and professionalism in job interviews and workplace interactions by effectively applying practiced soft skills.
4. Demonstrate readiness for Higher education by effectively navigating its admission process.

Unit I:

Grammar for Professional Writing: Initial Assessment Readiness Articles—Usage, context, and error correction, Prepositions—Functions and contextual use Tenses—Forms, purposes, and corrections, Subject-Verb Agreement (Concord)—Identification and Correction Voice—active and passive usage, conversions, Paraphrasing and Summarizing Techniques of paraphrasing, summarizing key ideas, Report Writing—Elements of formal reports, format and organization, Clarity and coherence in expression, Resume and Visume Creation,

Types of resumes: Chronological, Functional, hybrid Customizing resumes for job applications, Planning and scripting visumes, Recording and reviewing visumes, LOR (Letter of Recommendation)- Purpose, structure, tone, and content, SOP (Statement of Purpose)- Academic/professional goal alignment, personal background, clarity, coherence,

Proof reading and Editing: Common writing errors, strategies for self-editing, peer editing, and collaborative revision.

Learning Outcomes : At the end of the module, the learners will be able to

- Apply appropriate grammar structures—including articles, prepositions, tenses, voice, and subject - verb agreement—in a variety of professional and academic writing contexts.
- Paraphrase and summarise complex texts using accurate language and coherent structures.
- Prepare tailored resumes and visumes suited to specific job roles and presentation styles.
- Draft effective LORs and SOPs, and apply proofreading techniques and editing strategies to identify and correct common writing errors through self-assessment and peer feedback.

Unit II:

Preparing for Oral Assessment:

Group Discussions: Techniques, etiquette, turn-taking, active listening,

Expressing Opinions: Polite agreement /disagreement, clarity in communication,

Oral Presentations: Structure (introduction, body, conclusion), use of transitions, logical flow,

Vocabulary Use: Selecting formal/ semi-formal expressions for interviews, academic and professional discussions,

Clarity & Confidence: Voice modulation, articulation, managing speaking pace, reducing fillers,

Public Speaking: Planning and delivering one –minute speeches, engaging openings and impactful conclusions.

Learning Outcomes: By the end of this unit, learners will be able to:

- Demonstrate effective group discussion skills, including appropriate techniques, turn-taking, active listening, and polite expression of opinions.
- Express agreement and disagreement politely in formal and semi-formal settings while maintaining clarity and professionalism in communication.
- Organise and deliver structured oral presentations using clear introductions, well-developed content, logical transitions, and strong conclusions.
- Select and use appropriate vocabulary suitable for academic discussions, professional interviews, and workplace communication.
- Plan and deliver short public speeches (e.g., one-minute talks) with engaging openings and impactful closing statements tailored to the audience.

Unit III:

Mastering Interview Skills

Purpose of Interviews: Understand recruiter expectations, align personal goals, skills, and achievements.

Interview Preparation: Pre-interview research, behavior, and presentation. FAQs: Framing answers about self, family, strengths, and weaknesses.

Interview Dynamics: Understanding assessment areas and developing effective responses. **Types of**

Interviews: Awareness of formats: one-on-one, panel, telephonic, video/virtual, group discussions, and walk-in interviews; differences between HR and technical interviews. **Mock Interviews and Role Plays:** Practising real-time interview scenarios, peer feedback, video recording for self-review, identifying areas of improvement in verbal and non-verbal communication.

Learning Outcomes : At the end of the module, the learners will be able to:

- Understand recruiter expectations and the interview process.
- Prepare and behave appropriately during interviews.
- Respond confidently to common personal and career-related questions.
- Improve interview skills through mock interviews and feedback.

Unit IV:

Employability through Soft Skills

Teamwork and Collaboration: Importance of teamwork in the workplace, Role-based team challenges and problem-solving tasks, Reflective journaling on team dynamics, Workplace Etiquette and Professionalism, Basics of workplace behavior and grooming, Punctuality, discipline, and digital etiquette,

Decision-Making and Conflict Resolution: Decision-making models and techniques, Conflict styles and resolution strategies,

Emotional Intelligence and Motivation: Self-awareness and empathy in the workplace, Identifying emotional triggers and responses, Time Management and Goal Setting: Prioritizing tasks using the Eisenhower Matrix, SMART goals (Specific, Measurable, Achievable, Relevant, Time-bound),

Adaptability and Flexibility: Managing change in the work place Developing resilience and growth mindset, networking, and building professional relationships.

Learning Outcomes: At the end of the module, the learners will be able to:

- Demonstrate effective teamwork and collaboration in professional settings.
- Exhibit professional behaviour, work place etiquette, and digital discipline.
- Apply decision-making techniques and resolve conflicts constructively.
- Build emotional intelligence, self-awareness, and motivation to perform in diverse work environments.
- Manage time effectively, set achievable goals, and adapt to change with resilience.

UnitV:

English for Abroad Education

Introduction to Studying Abroad: Overview of global education systems and Admission Process, Research and University Selection: How to research courses and universities, Creating an application calendar, Understanding course credits, intakes, and rankings,

Application Documents: SOP (Statement of Purpose): Structure, language, and sample writing ,LOR (Letters of Recommendation): Types, tone, and formatting, Admission and Visa Interview Skills Types of admission interviews (in-person, video), FAQs and model responses, Justifying candidature and demonstrating motivation,

Visa Process: Documentation, interview preparation,

English Proficiency and Entrance Tests: Overview of TOEFL, IELTS, GRE, GMAT, SAT, ACT, Preparation strategies and practice samples.

Learning Outcomes: By the end of the module, learners will be able to:

- Understand and plan the international university admission process.
- Research and shortlist suitable universities by evaluating courses, intakes, credits, and global rankings
- Prepare essential application documents such as SOPs ,LORs, and admission essays using appropriate academic language
- Demonstrate effective communication in admission and visa interviews by confidently responding to FAQs and justifying candidature
- Gain awareness of visa procedures, cultural expectations, financial planning, and student safety for successful transition to higher education.

III-II B.Tech R23 (ECE) DETAILED SYLLABUS

Subject Code	Subject Name	L	T	P	C
R23ECE-PC3201	Digital Signal Processing	3	0	0	3

Course Objectives:

1. To describe discrete time signals and systems.
2. To teach importance of FFT algorithm for computation of Discrete Fourier Transform.
3. To learn the basic design and structure of FIR Filters
4. To familiarize the design procedure of IIR filters with desired frequency responses
5. To outline need of Multi-rate Processing.

Course Outcomes: At the end of the course, the student will be able to

1. Illustrate the concept of discrete time signals and systems for analyzing the response of LTI system in Time domain and Frequency domain (L4).
2. Construct the Decimation-in-Time Fast Fourier Transform and Decimation-in-Frequency Fast Fourier Transform for reducing computational complexity of DFT (L3).
3. Develop digital IIR filters and their realization structures using various transformation techniques(L3)
4. Develop FIR digital filters using Windowing techniques for the given specifications and their realization structures(L3)
5. Develop algorithms for performing various Multi-rate Digital Signal Operations (L3).

UNIT-I: Discrete Time Signals, Systems and Discrete Fourier series: Discrete time signals & sequences, Classification of Discrete time systems, stability of LTI systems, LTI system Properties, frequency domain representation of discrete time signals and systems, analysis of linear time-invariant systems in the z-domain, pole-zero stability, Convolution of Discrete Time Signals and sequences.

Discrete Fourier series: DFS Representation of periodic sequences and Properties of Discrete Fourier Series.

Applications:

1. Finding of frequency response of the given system
2. Analysis of discrete time signals and systems

Learning Outcomes:

At the end of the unit, the student will be able to

1. Explain importance of Digital Signal processing (L2)
2. Outline LTI system Properties (L2)
3. Summarize properties of Discrete time systems and Z-transforms (L2)

UNIT-II:Discrete Fourier Transform (DFT): Definition and Properties of Discrete Fourier Transforms, Convolution of sequences using DFT.

Fast Fourier Transforms (FFT): Definition, Radix-2 decimation in time and decimation in frequency FFT Algorithms and Inverse FFT(Radix-2).

Applications:

1. The detection of the frequencies of a pair of sinusoidal signals, called tones, employed in telephone signaling
2. Equalizer in audio and video signal processing.
3. FFT algorithms in video and audio signal processing

Learning Outcomes:

At the end of the unit, the student will be able to

1. Explain the properties of DFT (L2)
2. Make use of the convolution methods to compute DFT of a given sequence (L3)
3. Solve the DFT computation problems using FFT and inverse FFT algorithms (L3)

UNIT-III: IIR Digital Filters & Structures of IIR: Introduction to digital filters, Analog filter approximations – Butterworth and Chebyshev, Design of IIR Digital filters from analog filters by Impulse invariant and bilinear transformation methods, Frequency transformations, Basic structures of IIR Filters - Direct form-I, Direct form-II, Cascade form and Parallel form realizations. Transposed forms.

Applications:

1. The applications of IIR filters include the removal of the noise or interference, passing of certain frequency components.
2. an equalization of a small monitor loudspeaker

Learning Outcomes:

At the end of the unit, the student will be able to

1. Build IIR filter from the given analog transfer function (L3)
2. Illustrate the features of IIR Filter structures (L2)

UNIT-IV: FIR Filters-Introduction, Characteristics of FIR filters with linear phase, Frequency response of linear phase FIR filters, Design of FIR filters using Fourier series and windowing methods (Rectangular, Triangular, Kaiser, Hanning, Hamming, Blackman), Comparison of IIR & FIR filters, Basic structures of FIR Filters – Direct form, Cascade form, Linear phase realizations.

Applications:

1. Equalizer for audio and video processing

Learning Outcomes:

At the end of the unit, the student will be able to

2. Build the FIR Digital Filter using windowing techniques for the given specifications (L3)
3. Identify basic structures of given FIR systems (L3)

UNIT-V: MultiRate Digital Signal Processing: Introduction, down sampling, Decimation, up sampling, Interpolation, Sampling Rate Conversion, Applications of Multi Rate Signal Processing.

Applications:

1. Implementation of a narrow band low-pass filter
2. Filter banks

Learning Outcomes:

At the end of the unit, the student will be able to

1. Explain the down sampled & Up sampled signal (L2)
2. Outline the interpolation and decimation concepts (L2)
3. Explain the sampling rate conversion (L2)

Text Books:

1. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing, Principles, Algorithms, and Applications, Pearson Education, 2007.
2. A.V.Oppenheim and R.W. Schaffer, Discrete Time Signal Processing ,PHI.

References:

1. Andreas Antoniou, Digital Signal Processing, TATA McGraw Hill, 2006
2. Robert J. Schilling, Sandra L. Harris, Fundamentals of Digital Signal Processing using Matlab, Thomson, 2007.

Subject Code	Subject Name	L	T	P	C
R23 ECE-PC3202	Microwave and Optical Communications	3	0	0	3

Course Objectives:

At the end of the course the student will be

- To get familiarized with microwave frequency bands, their applications and to understand the Limitations and losses of Solid state devices at these frequencies.
- To impart the knowledge of Scattering Matrix, its formulation and utility, and establish the S-Matrix for various types of microwave junctions.
- To an ability to perform microwave measurements.
- To understand the utility of Optical Fibers in Communications.
- To apply the optical networks into satellite systems.

Course Outcomes:

- Understand all basic Microwave and Optical devices and Amplifiers.
- Understand the utility of S-parameters in microwave component design and learn the Measurement procedure of various microwave parameters.
- Analyze the microwave measurements and parameters.
- Explain the fundamentals, advantages, Ray theory transmission in Optical Communication and effect of dispersion of the signal, types of fiber materials, different losses in fibers
- Observe knowledge about Optical transmitters, receivers and estimation of link and power budget analysis

Unit-1

MICROWAVE AMPLIFIERS: Introduction to microwave transmission, Application and limitation, Klystron amplifier, Reflex Klystron Oscillator TWT amplifiers

MICROWAVE SOLID STATE DEVICES: Introduction, Classification, Applications. TEDs Introduction, Gunn Diodes Principle, RWH Theory, Characteristics, Modes of Operation - Gunn Oscillation Modes, Principle of operation of IMPATT and TRAPATT Devices. Magnetron Oscillator.

Unit-2

MICROWAVE COMPONENTS: Directional coupler , E plane Tee, H- plane Tee, Magic Tee, Circulators, Isolators, Attenuators, Phase Shifters, Avalanche breakdown devices, PIN diode and TUNNEL diode, Power, VSWR, Impedance Measurement.

SCATTERING MATRIX: Scattering Matrix Properties, Directional Couplers 2 Hole, Bethe Hole, s-matrix of Magic Tee and Circulator.

Unit-3

MICROWAVE MEASUREMENTS: Description of Microwave Bench Different Blocks and their Features, Errors and Precautions, Measurement of Attenuation, Frequency. Standing Wave Measurements, measurement of Low and High VSWR, Cavity Q, Impedance Measurements.

UNIT 4

Introduction To Optical Fibers And Transmission Characteristics: Evolution of optical fiber communication, spectral bands, Block diagram of optical fiber communication system, advantages and applications of optical communications, Light propagation: Total internal reflection, acceptance angle, numerical aperture, Modes in cylindrical fiber – Linearly polarized modes, Classification of optical fibers- Step index and Graded index fiber, Single mode and Multi mode fibers, Attenuation-Absorption, Scattering, Bending losses, Dispersion- material dispersion, waveguide dispersion, Polarization Mode Dispersion, inter model dispersion.

Unit 5:

Optical Sources, Detectors, and Communication Systems: Optical sources-LED and Laser Diodes (structures, characteristics), Optical detectors-Basic principle of operation of PIN photodiode, Avalanche photodiode (APD), Fiber Jointing Techniques-couplers, connectors, splicing techniques, Optical communication systems: point to point link, rise time budget analysis, link power budget analysis, WDM, Introduction to optical networks (SONET/SDH), FTTH, Optical Ethernet.

Text Books:

1. Electronic Communications Systems- Wayne Tomasi, Pearson, 5th Edition
2. Samuel Y. Liao, "Microwave Devices and Circuits", 3rd edition, Pearson education, 2011 reprint.
3. Collin.R.E, "Foundations for Microwave Engineering", 2nd edition, Tata McGraw Hill, 2006.
4. Gerd Keiser, "Optical Fiber Communications", the McGraw Hill Companies, 4th Edition, 2008.

Reference Books:

1. Microwave Engineering - David M. Pozar, John Wiley & Sons (Asia) Pvt Ltd., 1989, 3rd ed., 2011 Reprint.
2. Microwave Engineering - G.S. Raghuvanshi, Cengage Learning India Pvt. Ltd., 2012.
3. Electronic Communication System George Kennedy, 6th Ed., McGrawHill.
4. John. M. Senior, "Optical Fiber Communications Principles and Practice", Second Edition, PHI, 1992.

Subject Code	Subject Name	L	T	P	C
R23ECE-PC3203	VLSI Design	3	0	0	3

Course Objectives:

1. To explain the MOS transistor structure, operation, and parameters associated with it.
2. To introduce the various steps involved in the MOS transistor fabrication process.
3. To introduce MOS inverter characteristics.
4. To study the behavior of combinational and sequential circuits.
5. To provide an overview of dynamic logic and memory elements.

Course Outcomes:

At the end of the course, the student will be able to

1. Explain the MOS transistor structure and parameters relations. (L2)
2. Illustrate the steps involved in MOS transistor fabrication process.(L2)
3. Model MOS inverters with different loads and it's electrical parameters. (L3)
4. Make combinational and sequential logic circuits by using transmission gate and pass transistors. (L3)
5. Classify different types of dynamic logics and semiconductor memories. (L2)

UNIT-I MOS TRANSISTOR

The Metal Oxide Semiconductor (MOS) Structure, The MOS System under External Bias, Structure and Operation of MOS Transistor (MOSFET), MOSFET Current-Voltage Characteristics, MOSFET Scaling and Small-Geometry Effects, MOSFET Capacitances.

Application:

1. After understanding basic concepts of MOSFET, students could design some basic logic gates.

Learning Outcomes:

At the end of the unit, the student will be able to

1. Remember the basic structure and operation of MOSFET(L1)
2. Explain the V-I and VTC of MOS transistor (L2)
3. Demonstrate the scaling of MOS transistor parameters(L2)

UNIT-II FABRICATION OF MOSFET

Introduction, Fabrication Process Flow: Basic Steps, NMOS Fabrication, PMOS fabrication, The CMOS n-Well Process, Schematic Design of NMOS depletion load and CMOS based inverter, NAND, NOR and their Layout, General observations on the Design rules, 2 μ m Double Metal, Double Poly, CMOS rules, 1.2 μ m Double Metal, Double Poly CMOS rules, Layout Diagrams of NAND and NOR gates and CMOS inverter, Symbolic Diagrams Translation to Mask Form., Full-Custom Mask Layout Design

Application:

1. Students could design layout diagram of complex logic circuits.

Learning Outcomes:

At the end of the unit, the student will be able to

1. Outline MOS design rules (L2)
2. Draw stick and layout diagrams for MOS transistor based logic Gates (L2)

UNIT-III MOS INVERTERS

Inverters with resistive load, MOSFET load; CMOS inverter, Delay-Time Definitions, Calculation of Delay Times, Inverter Design with Delay Constraints, Estimation of Interconnect Parasitic, Calculation of Interconnect Delay, Switching Power Dissipation of CMOS Inverters.

Application:

1. The knowledge of electrical parameters on inverters could help in analyzing complex circuits.

Learning Outcomes:

At the end of the unit, the student will be able to

1. Model the MOS inverter characteristics. (L3)
2. Understand the delay constraints and static and dynamic power associated with MOS transistors.(L2)
3. Design inverters and other logic circuits by taking MOS transistor electrical properties into account.(L3)

UNIT-IV COMBINATIONAL MOS LOGIC CIRCUITS

Introduction, MOS Logic Circuits with Depletion nMOS Loads, CMOS Logic Circuits, Complex Logic Circuits, CMOS Transmission Gates (Pass Gates)

SEQUENTIAL MOS LOGIC CIRCUITS: Introduction, Behavior of Bistable Elements The SR Latch Circuit Clocked Latch and Flip-Flop Circuits CMOS D-Latch and Edge-Triggered Flip-Flop.

Applications:

1. Students could design complex digital circuits at transistor level.

Learning Outcomes:

At the end of the unit, the student will be able to

1. Compare the pros and cons of TG logic and Pass Transistor logic gates. (L2)
2. Experiment with combinational and sequential logic circuits. (L3)
3. Optimize combinational and sequential circuits at transistor level. (L3)

UNIT-V DYNAMIC LOGIC CIRCUITS

Introduction, Basic Principles of Pass Transistor Circuits, Voltage Bootstrapping, Synchronous Dynamic Circuit Techniques, High-Performance Dynamic CMOS Circuits

SEMICONDUCTOR MEMORIES: Introduction, Read-Only Memory (ROM) Circuits, Static Read-Write Memory (SRAM) Circuits, Dynamic Read-Write Memory (DRAM) Circuits.

Application:

1. The knowledge on basic memory cells help to make complex memory cells like, content addressable memory (CAM).

Learning Outcomes:

At the end of the unit, the student will be able to

1. Explain the significance of dynamic logic design (L2)
2. Understand the usage of semiconductor memories. (L2)
3. Compare different semiconductor memories (SRAM & DRAM). (L2)

Text Books

1. CMOS Digital Integrated Circuits Analysis and Design SUNG-MO (STEVE) KANG
University of Illinois 2nd Edition, Mc Graw-Hill, 2003

2. Essentials of VLSI Circuits and Systems Kamran Eshraghian, Douglas and A. Pucknell and Sholeh Eshraghian, Prentice-Hall of India Private Limited, 2005 Edition.

Reference Books

1. Neil H.E. Weste and David Harris, CMOS VLSI Design: A circuits and systems perspective, 4th Edition, Pearson Education, 2015.
2. P.K. Lala: Digital circuit Testing and Testability, Academic Press, 1997.

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3201.1	Cellular and Mobile Communication. (Professional Elective-II)	3	0	0	3

Course Objectives: The main objectives of this course are given below:

- Familiarize the basic Elements of Cellular Mobile Radio System design and its performance criteria.
- Introduce the different antenna system design for reduction of interference and cell coverage in different terrains.
- Familiarize various cell site and mobile antennas for cellular mobile communication system.
- Illustrate the concepts of frequency management and channel assignments mechanism in mobile communications.
- To know the fundamentals of basic & advanced cellular systems..

Course Outcomes:

- Explain the fundamentals of cellular radio system design and its basic elements. (L2)
- Analyze the concepts of different co-channel, non-cochannel interference and cellular coverage on signal & traffic of a designed system. (L4)
- Identify the various types of antenna system design suitable for mobile communications. (L3)
- Explain the radio channel assignment and frequency management used in mobile communications. (L2)
- Understand the fundamentals of mobile cellular systems such as GSM, CDMA, 3G, 4G, 5G, 6G (L2)

Unit-1: Introduction to Cellular Mobile Radio Systems:

Evolution of Mobile Radio Communication, Examples of Wireless Communication Systems, Cellular concept: Frequency reuse, Co-channel Interference Reduction Factor, desired C/I from a normal case in an Omni directional Antenna system, Hand off strategies, Types of Handoff, Dropped Call rate and their evaluation, Performance criteria, uniqueness of mobile radio environment, operation of cellular system, Hexagonal shaped cells

Learning outcomes:

- Identify the difference between Mobile and Cellular communication. (L2)
- Measure the performance of a cellular system. (L2)
- Understand why to use Hexagonal shaped cells. (L2)
- Understand what is Handoff and different types of handoffs.(L2)
- Derive the formula for dropped call rate and evaluation.(L2)

Applications:

- Provides a wireless connection to the public telephone network for an user location within the radio range of the system.
- For planning and analysis of cellular networks in any area.

UNIT –II: Interference:

Introduction to Co-Channel Interference (CCI), real-time Co Channel interference, design of Antenna system for CCI measurement, diversity receiver, different types of non-co channel interference.

Cell Coverage for Signal and Traffic: Lee Point to point model, phase difference between direct and reflected paths, mobile propagation over water and flat open area.

Learning outcomes:

- Understand the concept of Co-Channel and Non-cochannel Interference. (L2)

Applications:

- To get peer to peer communication applications, instant messaging services in communication networks.
- To get signal broadcasting over flat open areas as well as over water.

UNIT –III Cell Site and Mobile Antennas:

Sum and difference patterns and their synthesis, Cell Site Antennas: omni directional antennas, directional antennas for interference reduction, space diversity antennas, umbrella pattern antennas, Macrocell Antennas, Microcell Antennas, Picocell Antennas and Femtocell antennas, minimum separation of cell site antennas, Mobile Antennas: Mobile high gain antennas.

Learning outcomes:

- Understand the concept of sum and difference patterns and their synthesis. (L2)
- Understand basics of different types of cellsite and mobile antennas. (L2)

Applications:

- Desired antenna configurations can be considered for any network
- To get more efficiency in any communication network, antenna can be pointed in different directions and with different spacing.

UNIT-IV Frequency Management & Channel Assignment:

Numbering and grouping, setup access and paging channels channel assignment to cell sites and mobile units, channel sharing and borrowing, sectorization, overlaid cells, non-fixed channel assignment.

Learning outcomes:

- Understand the concept of numbering and grouping, setup access and paging channels.(L2)
- Understand the concepts of channel assignments to cell sites and mobile units.(L2)
- Differentiate between fixed and non-fixed channel assignment strategies(L2)

Applications:

- Effective usage of frequency allocated in any network
- Improve frequency spectrum reuse, spectrum efficiency time
- Invalid calls load reduced and improve the network efficiency.

UNIT –V BASIC MOBILE CELLULAR SYSTEMS: GSM, CDMA

GSM: Historical overview, System overview, GSM Architecture, GSM Logical and physical channels. CDMA: Historical overview, System overview, Air interface, Coding, Spreading and Modulation, Handover.

ADVANCED MOBILE CELLULAR SYSTEMS:

Need of 3G, IMTS-2000, UMTS Technology, Overview of 4G and its features, 4G Architecture, 4G-LTE, Overview of 5G requirements, spectrum sharing for 5G, 5G System concepts, Single and multi user MIMO, Overview of 6G.

Learning outcomes:

- Understand the basic concepts of concepts of basic mobile cellular systems such as GSM, CDMA(L2)

- Understand the basic concepts of concepts of advanced mobile cellular systems such as 3G,4G,5G,6G(L2)

Applications:

- Wide area communication services
- Uninterrupted mobile conversations

Text Books:

1. Mobile Cellular Tele communications –W.C.Y. Lee, TataMcGrawHill, 2rdEdn.,2006.
2. Principles of Mobile Communications–Gordon L. Stuber, Springer International 2nd Edition, 2007.

Reference Books:

1. Wireless Communications –Theodore. S. Rapport, Pearson education, 2nd Edn.,2002.
2. Wireless and Mobile Communications Lee McGraw Hills, 3rd Edition, 2006.
3. Mobile Cellular Communication –G Sasibhushana Rao Pearson education

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3201.2	Digital System Design Using Verilog (Professional Elective-II)	3	0	0	3

Course Objectives:

- To introduce the basics and programming fundamentals of Verilog HDL
- To describe the primitive instances of gates and explain the various modeling constructs of Verilog.
- To familiarize various behavioral and switch level modeling constructs of Verilog essential for designing digital circuits.
- To Design and implement various combinational logic circuits in Verilog HDL
- To Design and implement various sequential logic circuits in Verilog HDL.

Course Outcomes:

At the end of the Course, the Student will be able to:

1. Understand the fundamentals of Digital System Design flow using Verilog HDL. (L2)
2. Construct logic circuits with Gate Level and Dataflow modelling (L3)
3. Construct logic circuits with Behavioral modelling and switch level modelling. (L3)
4. Make use of Verilog programming to design Combinational digital circuits. (L3)
5. Develop synthesizable Verilog codes for sequential digital circuits. (L3)

UNIT-I

Introduction to Verilog HDL: Verilog as HDL, Levels of Design Description, Concurrency, Simulation and Synthesis Tools. Language Constructs and Conventions: Introduction, Keywords, Identifiers, Comments, Tasks and functions, Numbers, Strings, Logic Values, Data Types, Scalars and Vectors, Parameters, Operands and Operators

Applications:

1. Applied to design of electronic system modules.
2. Verilog HDL is used for timing analysis and for logic synthesis.

Learning Outcomes:

At the end of this unit the student will be able to

1. Understand the fundamentals of Verilog HDL. (L2)
2. Understand the essentiality of various Verilog design parameters in the design of digital Systems. (L2)

UNIT-II

Gate Level Modeling: Introduction, AND Gate Primitive, Module Structure, Other Gate Primitives, Illustrative Examples, Tri-State Gates, Array of Instances of Primitives, Design of Basic Circuits. Design of Flip-flops with Gate Primitives.

Data Flow Modeling: Introduction, Continuous Assignment Structure, Delays, and Assignment to Vectors, Operators and Examples.

Applications:

1. Verilog HDL Programming language is used to model any digital system using various modeling techniques.

Learning Outcomes:

At the end of this unit the student will be able to

1. Understand the modeling of digital systems suiting various applications (L2).
2. Understand the utility of modeling techniques to design logic circuits (L2)

UNIT-III

Behavioral Modeling: Procedural constructs Timing Controls, Blocking and Non-Blocking Assignments, The case statement, Simulation Flow if and if-else constructs, Assign-De-Assign construct, Repeat loop, for loop, while loop, Forever loop, Force-Release construct.

Switch Level Modeling: Basic Transistor Switches, CMOS Switch, Bi-directional switches.

Applications:

1. Behavioral modeling attempts to explain why an individual makes a decisions and the model is then used to help predict future behavior.
2. Behavioral models in Verilog contain procedural statements which control the simulation and manipulate variables of the data types.

Learning Outcomes:

At the end of this unit the student will be able to

1. Understand high level abstraction of digital systems with behavioral modeling of systems (L2).
2. Learn modeling of various behavioral constructs essential for designing digital systems (L2).

UNIT IV

Design of combinational circuits Elements: Logic design of combinational circuits using Verilog HDL: Logic gates, Half Adders, Full Adders, Subtractors, Decoders, Encoders, Multiplexers, and De-multiplexers & Comparators, verification using Test-bench.

Applications:

1. Combinational circuits are used in calculators, digital measuring techniques, and computers, digital processing, automatic control of machines etc.
2. Combinational circuits are used in ALU's, data transmission, home alarm, car parking slot systems, multiple access techniques.

Learning Outcomes:

At the end of this unit the student will be able to

1. Implement logic functions with decoders and multiplexers (L3)
2. Design combinational circuits such as adders, subtractors, multipliers, comparators etc.

UNIT-V

Design of Sequential circuits Elements: Logic design of Sequential circuits using Verilog HDL: RS, D, T, JK Latches & Flip Flops, Registers and Counters, Verification using Test-bench.

Applications:

1. Sequential Logic circuits are used in design of digital systems.
2. Sequential Logic circuits are employed in CPLD & FPGA architectures.

Learning Outcomes:

At the end of this unit the student will be able to

1. Understand applicability of sequential elements in design of digital systems (L2).
2. Construct complex digital systems based on flip-flops and registers (L3)

Text Books

1. T.R Padmanabhan, B.Bala Tripura Sundari Design through Verilog HDL, Wiley India Publications, 2009
2. J.Bhaskar, A Verilog HDL Primer, BS Publications, 3rd Edition.

Reference Books

1. Verilog HDL – Samir Palnitkar, 2nd Edition, Pearson Education, 2009
2. John F.Wakerly , Digital Design, Pearson, 4th Edition.
3. Zainalabdien Navabi, Verilog Digital System Design, TMH, 2nd Edition

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3201.3	Embedded Programming (Professional Elective-II)	3	0	0	3

Course objectives:

- Provide python packages and their applications for IoT design.
- Apply python as a integrated programming tool for microcontrollers.
- Understand linux system and its internals as part of embedded operating system design.
- Identify the importance of shell scripting for process control in a system design.
- Working of STM32 microcontroller with C/C++ IDE development for embedded peripheral interfacing.

Course Outcomes:

1. Develop embedded and IoT applications using python packages of pyfirmata, Tinkter, matplotlib. (L3)
2. Identify the microcontroller application design using Micro Python as programming language. (L3)
3. Outline the linux system structure and shell commands needed for embedded application development. (L2)
4. Interpret the shell scripting language basics for system administration and automation as needed for embedded system. (L2)
5. Develop peripheral integrated application of STM32 embedded C/C++ programming. (L3)

UNIT-I

Python for IoT: python with Arduino, controlling Arduino with python, reading an Arduino digital input with pyfirmata, Reading an Analog input with pyfirmata, line-following robot with pyfirmata, Tkinter for GUI design- LED brightness control, selection from multiple options, reading a PIR sensor, reading an Analog Sensor, Data acquisition with python and Tkinter- CSV file, storing Arduino data with CSV file, plotting random numbers using matplotlib, plotting real-time from Arduino, integrating the plots in the Tkinter window.

Learning outcomes:

1. Python for communication between pc and Arduino using pyfirmata package. (L3)
2. Tinkter GUI development package for dashboard interface for embedded applications. (L3)

UNIT-II

Python for Microcontrollers: What is micropython, micropython Genesis, typical hardware- ESP8266/ESP32, blinking lights, neopixels, Text-image and animation, input and sensing, GPIO, Networking- ESP8266/ESP32 Wifi, MQTT programming, sound and music, robots.

Learning outcomes:

1. Micropython for embedded application design. (L3).
2. Wifi, GPIO based programming using micropython. (L3)

UNIT-III

Linux command line: starting with linux shells, getting to shell, basic bash shell commands, more bash shell commands, using linux environment variables, understanding linux file permissions, working with editors.

Learning outcomes:

1. Understanding linux commands and environment as a operating system. (L2)
2. Demonstrating bash shell commands for application development. (L2)

UNIT-IV

Shell scripting basics: basic script building, using multiple commands, creating a script file, displaying messages, using variables, redirecting input and output, pipes, performing math, working with structured commands, handling user input, presenting data, script control.

Learning outcomes:

1. Shell scripting for simple system management operations. (L2)
2. Handling different structure of the operating system for optimization. (L2)

UNIT-V

Embedded C/C++ for STM32: C for Embedded System, C data types for Embedded Systems, Bit-wise Operations in C, STM ARM I/O programming, STM32 Microcontrollers, GPIO programming and interfacing, seven-segment LED interface and programming, I/O port programming with Assembly language, LCD and keyboard interfacing, UART serial port programming, STM Timer programming, ADC/DAC and Sensor Interfacing, SPI protocol and I2C protocol-based interfacing.

Learning outcomes:

1. Develop C/C++ programming of STM32 for different GPIO based peripheral applications. (L3)
2. Make use of STM32 special features for embedded application development. (L3).

TEXT BOOKS:

1. Internet of Things with Raspberry Pi and Arduino, Rajesh Singh, Anita Gehlot, Lovi Raj Gupta, Bhupendra Singh, Mahendra swain, CRC press, 2020.
2. Programming with micropython- embedded programming with microcontrollers & python, Nicholas H.Tollervey, O'Reilly, 2018.
3. Linux command line and shell scripting bible- Richard blum- wiley publishing, 2008
4. STM32 ARM programming for Embedded Systems- using C language with STM32F4 ARM, by Muhammad alimazidi, Shujen Chen, EshraghGhaemi, MicrodigtaEd, 2018

REFERENCES:

1. Practical Python Programming for IoT, Gary Smart, Packt Pub, 2020.
2. Micro python for Internet of Things- Charles Bell, Apress, 2017.
3. Programming with STM32, getting started with the nucleo board and C/C++, by Donald Norris, McGraw Hill Education, 2018

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3201.4	Wavelet Transforms (Professional Elective-II)	3	0	0	3

Course Objectives:

- To introduce students to the theory and applications of wavelet transforms and their properties.
- To enable students to understand the discrete wavelet transform algorithms for multi resolution analysis.
- To provide hands-on experience in implementing wavelet transforms for image processing.
- To explore wavelet transforms techniques for various signal processing applications.
- To encourage critical thinking and problem-solving skills in utilizing advanced wavelet transforms for real-world applications.

Course Outcomes:

1. Demonstrate a deep understanding of the theory and principles of wavelet transforms. (L2)
2. Illustrate discrete wavelet transforms and related algorithms for different applications. (L2)
3. Apply wavelet transforms for de-noising, compression, and feature extraction in image processing. (L3)
4. Develop analytical and computational skills necessary for solving problems in signal processing using wavelet transforms. (L3)
5. Apply wavelet-based methods in interdisciplinary areas such as biomedical signal processing, audio processing, and machine learning. (L3)

UNIT-I

Introduction to Wavelet Transforms Overview of signal processing and the need for wavelet transforms, Basics of time-frequency analysis, Introduction to continuous and discrete wavelet transforms (CWT and DWT), Properties of wavelets: orthogonality, compact support, and multi resolution analysis.

Applications:

1. Wavelets are used in Data Analysis and Pattern Recognition

Learning Outcomes:

- Understand the fundamental concepts of signal processing and the necessity of wavelet transforms in addressing complex signal analysis problems.
- Explain the principles behind continuous wavelet transforms (CWT) and discrete wavelet transforms (DWT), including their respective advantages and limitations.
- Describe key properties of wavelets such as orthogonality, compact support, and multiresolution analysis, and their significance in signal processing tasks.

UNIT-II

Discrete Wavelet Transform (DWT) Multiresolution analysis (MRA) and filter banks, Construction of orthogonal and biorthogonal wavelets, DWT algorithms: Mallat's algorithm, lifting scheme, Implementation of DWT in 1D and 2D signal processing

Applications:

1. DWT Multiresolution analysis (MRA) are used in Geophysical Applications

Learning Outcomes:

- Apply multiresolution analysis (MRA) and filter banks to decompose signals into different frequency bands using the DWT.
- Demonstrate proficiency in constructing orthogonal and bi-orthogonal wavelets suitable for various signal processing applications.
- Implement DWT algorithms, including Mallat's algorithm and the lifting scheme, for efficient signal decomposition in both one-dimensional and two-dimensional signal processing contexts.

UNIT-III

Wavelet transforms in Image processing: Image compression using DWT: JPEG2000 standard, Denoising and restoration of images using wavelet thresholding techniques, Edge detection and feature extraction in images, Applications of wavelet transforms in medical image processing and computer vision.

Applications:

1. Used in image compression, denoising and edge detection.

Learning Outcomes:

- Apply DWT-based image compression techniques compliant with the JPEG2000 standard to achieve efficient compression while maintaining image quality.
- Utilize wavelet thresholding techniques for denoising and restoring images corrupted by noise or artifacts.
- Demonstrate proficiency in edge detection and feature extraction in images using wavelet transforms.

UNIT-IV

Wavelet transforms in signal processing: Time-frequency localization of signals. Wavelet packet decomposition and its applications, Adaptive signal processing using wavelet transforms, Wavelet-based methods for biomedical signal analysis and audio processing

Applications:

1. Used in signal noise reduction, compression of a signal processing.

Learning Outcomes:

- Understand the concept of time-frequency localization of signals and its importance in analyzing non-stationary signals using wavelet transforms.
- Apply wavelet packet decomposition to achieve more flexible signal representation and explore its applications in signal processing tasks.
- Implement adaptive signal processing techniques using wavelet transforms to address dynamic signal characteristics and changing environments.

UNIT-V

Advanced topics in wavelet transforms: Sparse representations and compressive sensing, Nonlinear and complex wavelet transforms, Wavelet transforms in machine learning and data analysis, Recent trends and emerging applications of wavelet transforms

Applications:

1. Used in feature extraction, anomaly detection of a machine learning.

Learning Outcomes:

- Understand sparse representations and compressive sensing principles and their application in signal and image processing using wavelet transforms.
- Explore nonlinear and complex wavelet transforms and their suitability for handling non-linear signal characteristics and complex data structures.
- Apply wavelet transforms in machine learning and data analysis tasks such as feature extraction, dimensionality reduction, and pattern recognition.

Text books :

1. "Wavelet Transforms and Their Applications" by Lokenath Debnath and Firdous Ahmad Shah
2. "A Wavelet Tour of Signal Processing: The Sparse Way" by Stéphane Mallat

References:

1. "Wavelet Methods for Time Series Analysis" by Donald B. Percival and Andrew T. Walden
2. "Wavelet Transforms: Introduction to Theory and Applications" by Raghuveer M. Rao and Ajit S. Bopardikar

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3201.5	Phased Array Antennas. (Professional Elective-II)	3	0	0	3

COURSE OBJECTIVES:

1. To develop understanding of various types of Scanning Techniques.
2. To provide the knowledge of basic understanding of antenna operation through the application of Maxwell's equations.
3. To provide the basic knowledge to feed networks.
4. To introduce the students various types of frequency scanned array antennas and their performance Characteristics.
5. To develop the students ability to apply modern mathematical techniques to the solutions of antenna search patterns.

COURSE OUTCOMES: After successful completion of the course, the students are able to

1. Understand the scanning principles and techniques of EM waves by antennas and their radiation patterns.
2. Understand the different antenna arrays and their radiation characteristics.
3. Interpret the different feed networks.
4. Analyze the different frequency scanned arrays.
5. Understand the search pattern mechanism at different frequencies

UNIT – I:

Conventional Scanning Techniques: Mechanical versus electronic scanning, Techniques of Electronic scanning, Frequency, Phase and time delay scanning principle, Hybrid scanning techniques.

Learning Outcomes:

At the end of this unit, the student will be able to

1. Explain the phase, frequency and basic antenna characteristics (L2)
2. Understand the performance of the mechanical and electronic scanning techniques (L2).

UNIT – II:

Array Theory: Linear and Planar arrays, various grid configurations, Concept of cell and grid, Calculation of minimum number of elements, Radiation pattern, Grating lobe formation, Rectangular and triangular grid design of arrays.

Learning Outcomes:

At the end of this unit, the student will be able to

1. Design Antenna Array with desired radiation beam characteristics (L3)
2. Understand the radiation mechanism of antenna arrays (L2)

UNIT – III

Feed Networks for phased Arrays: Corporate Feed, Lens and Reflect feed Techniques, Optimum f/d ratio, basic building block for corporate feed network, Series, Parallel feed networks, Comparison of various feeding techniques, Antenna Array feeding Architecture, Brick/ Tile Type construction.

Learning Outcomes:

At the end of this unit, the student will be able to

1. Understand the phenomenon of obtaining the parameters through various networks (L2)
2. Understand the performance of the antenna by various feeding techniques (L2).

UNIT – IV

Frequency Scanned Array Design: Snake feed, Frequency-phase scanning, Phase scanning, Digital phase shifter PIN diode and Ferrite phase shifters for phased arrays, Beam pointing errors due to digitization, Beam pointing accuracy.

Learning Outcomes:

At the end of this unit, the student will be able to

1. Identify the phase scanning and shifters in array design (L1)
2. Understand the performance of the beam pointing in scanned arrays (L2).

UNIT – V

Search Patterns: Calculation of search frame time, airborne phased array design, Electronic scanning radar, parameter calculation, Application of phased arrays, Phased Array Radar Systems, Active Phased Array, TR/ATR Modules.

Learning Outcomes:

At the end of this unit, the student will be able to

1. Understand various search patterns in phased arrays (L2)
2. Understand the performance of the ATR modules (L2).

Text books:

1. Olliner, A.A, and G.H. Knittel, “Phased Array Antennas”, Artech House, 1972.
2. Kahrilas. PJ, “Electronic Scanning Radar Systems Design Handbook”, Artech House, 1976.

Reference books:

1. Skolnik. MI, “Radar Handbook”, Mc Graw Hill, NY, Mc Graw Hills-2007
2. Galati,G-(editor), “Advanced Radar Technique and Systems”, Peter Peregrinus Ltd, London, 1993.

Subject Code	Subject Name	L	T	P	C
R23 ECE-PE3202.1	Satellite Communications (Professional Elective-III)	3	0	0	3

Course Objectives:

1. Explain the basic concept in the field of Satellite Communication and familiarize the parameters of orbital mechanics and different types of launchers.
2. Interpret the earth and space sub systems in satellite communication.
3. Explain link power budget and different satellite access schemes.
4. Illustrate earth station technology, low earth orbit and geostationary satellite system.
5. Explain principle of satellite navigation and Global Position System.

Course Outcomes:

1. Interpret the basic concepts of satellite communication and different Frequency allocations for satellite services.
2. Categorize various satellite sub systems and its functionality
3. Choose appropriate multiple access technique for a given satellite communication application
4. Design satellite communication system using Geo satellites
5. Illustrate about the basic principles of radio and satellite navigation

UNIT-I

Introduction: Origin of Satellite Communications, Historical Back-ground, Basic Concepts of Satellite Communications, Frequency allocations for Satellite Services, Applications, Future Trends of Satellite Communications.

Orbital Mechanics and Launchers: Orbital Mechanics, Newton's Law, Kepler's laws, Orbital parameters, Look Angle determination, Orbital perturbations, Limits of Visibility, Sub Satellite Point, Sun Transit Outage, Orbit determination, Launching Procedures, Launch Vehicles and Propulsion., Orbital effects in communication.

Learning outcomes: At the end of this unit, the student will be able to

1. discuss about Geostationary Orbits (L2)
2. summarize Launch procedures and Launch Vehicles (L2)
3. explain the concepts Visibility, Eclipse, Sub Satellite Point, Sun Transit Outage (L2)

Applications:

- Satellite communication services
- Orbit Mechanisms

UNIT-II

Satellite Subsystems: Altitude and orbit control system, telemetry, tracking, Command and monitoring, power systems, communication sub systems, Thermal Subsystem, Propulsion Subsystem, Communication Payload and Support Subsystems, Satellite antenna Equipment reliability and Space qualification.

Learning outcomes

- Categorize various satellite sub systems and its functionality

Applications

- Control systems and telemetry
- Connection between the space and ground

UNIT-III

Satellite Link Design: Basic transmission theory, system noise temperature and G/T ratio, Noise Figure and Noise Temperature, Design of down links, up link design, Design of satellite links for specified C/N, System design example.

Multiple Access: Satellite Switched TDMA on board processing, TDMA Frame Structure DAMA, Code Division Multiple access (CDMA), Spread spectrum transmission and reception.

Learning outcomes

- Analyze the satellite orbits and link design for transmission & reception of signals
- Choose appropriate multiple access technique for a given satellite communication application

Applications

Satellite Communication Service

UNIT-IV

EARTH SEGMENT:

Earth Station Technology—Transmitter and Receiver, Terrestrial Interface, Antenna Systems, Design considerations of Earth segment

Low Earth Orbit and Geo-Stationary Satellite Systems: Orbit consideration, coverage and frequency considerations, Delay & Throughput considerations, System considerations, Operational NGSO constellation Designs.

Learning outcomes

- Design satellite communication system using geo satellites

Applications

- Antennas tracking systems
- Surface imaging, Weather Forecasting

UNIT-V

SATELLITE APPLICATIONS

Overview of VSAT Systems, Network architecture, Mobile satellite services, Digital DBS TV, Block diagram of DBS-TV, INTELSAT Series, INSAT, Uplink earth station, Satellite Navigation and global Positioning system (GPS): GPS Position Location Principle, GPS Receivers and Codes, GPS Navigation Message, GPS signal levels, Satellite Signal Acquisition, GPS C/A Code Accuracy, Differential GPS.

Learning outcomes: At the end of this unit, the student will be able to

1. Discuss about VSAT System and its Architecture (L2)
2. Describe the concept of Digital DBS TV (L2)
3. Illustrate the Satellite Navigation and Global Positioning System (L3)

Applications

- Satellite navigation services
- GPS user location finding

Text Books:

1. Satellite Communications—Timothy Pratt, Charles Bostian and Jeremy Allnutt, WSE, Wiley Publications, 2nd Edition, 2003.
2. Satellite Communications Engineering—Wilbur L. Pritchard, Robert A. Nelson and Henri G. Suyderhoud, 2nd Edition, Pearson Publications, 2003.

Reference Books:

1. Satellite Communications: Design Principles—M. Richharia, BS Publications, 2nd Edition, 2003.
2. Satellite Communication—D.C Agarwal, Khanna Publications, 5th Ed
3. Fundamentals of Satellite Communications K.N. Raja Rao, PHI, 2004 Satellite Communications—Dennis Roddy, McGrawHill, 2nd Edition, 1996

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3202.2	VLSI Design for RTL to GDS (Professional Elective-III)	3	0	0	3

Course objectives:

- To understand the steps involved in RTL to GDS VLSI design flow.
- To introduce the various stages of verification and testing techniques.
- To describe Post-GDS Processes and formal verification.
- To familiarize Logic Optimization techniques & Static Timing Analysis.
- Discuss the concept of Physical Design, ASIC design flow (RTL-to-GDS)

Course Outcomes: At the end of the Course, the Student will be able to:

1. Understand the fundamental principles of VLSI design, from RTL abstraction to GDS implementation (L2)
2. Compare the concepts of verification and testing techniques. (L2)
3. Outline the Post-GDS Processes and different types of hardware level verification. (L2)
4. Acquire skills in synthesis and optimization to enhance circuit performance and area efficiency with a potential to resolve timing issues. (L3)
5. Identify the steps involved in ASIC and FPGA executions during Physical Design. (L3)

Unit 1: Pre-RTL Methodologies

A System Perspective, Hardware–Software Partitioning, Functional Specification to RTL Reusing Existing RTLs, Behavioral Synthesis, RTL to GDS Implementation Flow: Abstraction in VLSI Design Flow, Logic Synthesis, Physical Design.

Application:

1. Understand the requirements for IC development prior to start design process

Learning Outcomes: At the end of the unit, the student will be able to

1. Pre-RTL (Register Transfer Level) methodologies in digital design refer to the techniques and processes used before the detailed RTL design phase.
2. Ensuring a successful transition to the RTL design phase and overall project success.

Unit 2: verification and testing techniques

Simulation, Property Checking, Combinational Equivalence Checking, Static Timing Analysis Rule Checking, Physical Verification, Manufacturing Defects, Yield, Testing Methodology, Fault Coverage and Defect Level, Design for Testability.

Application:

1. Students are need to develop extra circuitry inside their design for testing purpose after tape out.

Learning Outcomes: At the end of the unit, the student will be able to

1. Differentiate between various verification and testing techniques and methodologies.
2. Understanding how to define test objectives, scope, and criteria for success.

Unit 3: Post-GDS Processes

Mask Fabrication, Resolution Enhancement Techniques, Wafer Fabrication and Testing, Packaging, Formal Verification: Limitations of Simulation-based Verification, Simulation versus Formal Verification, Representation of a Boolean Function, Binary Decision Diagrams, Boolean Satisfiability Problem, Formal Verification in VLSI Design Flow, Model Checking, Equivalence Checking.

Application:

1. Development of Si-wafer, mask, oxidation process, etching process, photo lithography process and final tape-out process.

Learning Outcomes: At the end of the unit, the student will be able to

1. Learning about the tape-out process and its significance in the semiconductor manufacturing lifecycle.
2. Learning about various packaging options and their impact on performance, reliability, and cost.

Unit 4: Logic Optimization & Static Timing Analysis

Two-level Logic Optimization, Multi level Logic Optimization, FSM Optimization, Behavior of Synchronous Circuit, Timing Requirements, Data Paths and Clock Paths, Timing Graph Delay Calculation, Arrival Time Computation, Slack Computation.

Application:

1. Timing analysis of the DUT is essential in order to avoid bugs after final tape out.

Learning Outcome: At the end of the unit, the student will be able to

1. Gain proficiency in performing static timing analysis (STA), including the steps involved in setting up and running STA tools.
2. Understand the principles of clock tree synthesis (CTS) and how it impacts timing.
3. Learn to analyse and mitigate clock skew, jitter, and latency issues.

Unit 5: Physical Design

Integrated Circuit Fabrication, Interconnects, Antenna Effect, Signal Integrity, Physical Design Methodologies, Partitioning, Floor planning, Global Placement, Timing-driven Placement, Global Routing, Detailed Routing, Post-routing Optimization, Layout Extraction,

Application:

1. Partitioning a complex chip design into smaller, functional blocks (such as processors, memory units, and I/O controllers) to simplify the design process and improve performance.

Learning Outcomes: At the end of the unit, the student will be able to

1. Understand the methodologies and best practices in floor-planning, including manual and automated techniques.
2. Familiar with various algorithms used in global placement, such as simulated annealing, force-directed placement, and partitioning-based methods.
3. Learn the objectives of global routing, such as defining routing regions, minimizing congestion, and estimating wire lengths.

Text books:

1. **SnehSaurabh**, *Introduction to VLSI Design Flow: RTL to GDS* (Cambridge University Press, 2023)
2. **Sanjay Churiwala&Sapan Garg**, *Principles of VLSI RTL Design: A Practical Guide* (Springer, 2011)

Reference Books:

1. **Neil Weste & David Harris**, *Principles of CMOS VLSI Design: A Circuits and Systems Perspective* (Addison-Wesley, 4th ed., 2010).
2. **Jan M. Rabaey, Anantha Chandrakasan & Borivoje Nikolić**, *Digital Integrated Circuits* (2nd ed., Prentice–Hall, 2002)

Subject Code	Subject Name	L	T	P	C
R23 ECE-PE3202.3	Edge And Cloud Computing (Professional Elective-III)	3	0	0	3

Course objectives :

1. Learn about different edge computing definitions and their applications.
2. Discuss edge computing basics.
3. Introduce to cloud technology concepts.
4. Understand the services provided cloud system.
5. Discuss about edge to cloud protocols.

Course outcomes :

1. Summarize the definitions and use cases of edge computing system. (L2)
2. Illustrate the edge architecture, support technologies, networking for IoT applications. (L2)
3. Interpret the characteristics, technologies, concepts in a typical cloud system. (L2)
4. Outline the various services of cloud. (L2)
5. Explain about the various protocols to bridge edge and cloud systems in IoT. (L2)

UNIT-I

IoT and Edge Computing Definition and Use Cases: History of the IoT, IoT Potential, Definitions of Internet of Things- Industry and manufacturing, consumer, transportation and logistics, agricultural and environment, Smart city, military and government, case study- Telemedicine.

Learning outcomes:

1. Learn the definitions of edge computing. (L2)
2. Understand the use cases of IoT and Edge computing in general. (L2)

UNIT-II

Edge Computing: Edge purpose and definition, edge use cases, edge hardware architectures, operating systems, edge platforms, use cases for edge computing.

Edge Routing and networking: TCP/IP network functions at the edge, Edge-level network security, software-defined networking.

Learning outcomes:

1. List the characteristics, platforms for edge computing. (L2)
2. Understand routing and networking for a edge to end device (L2)

UNIT-III

Cloud concepts & Technologies: Introduction, characteristics of cloud computing, cloud models, cloud service examples, cloud-based services & applications, Virtualization, Load Balancing, Scalability & elasticity, Deployment, replication, Monitoring, Software Defined Networking, Network Function Virtualization, mapreduce, identity and access management, Service level agreements, billing.

Learning outcomes:

1. Provide the cloud computing characteristics for a IoT system. (L2)
2. Visualize the models and systems in cloud computing. (L2)

UNIT-IV

Web services from cloud: Hardware Evolution, Internet software evolution, server virtualization. Communication -as-a-service (CaaS), Infrastructure-as-a-Service(IaaS), Monitoring-as-a-Service(MaaS), Platform-as-a-Service(PaaS), Software-as-a-Service(SaaS). Compute services, storage services, database services, application services, content delivery services, analytics services, deployment & management services, identity & access management services, open source private cloud software.

Learning outcomes:

1. Identify the various services provided by the cloud. (L2)
2. Summarize the different web services offered by the cloud. (L2)

UNIT-V

Edge to cloud Protocols: protocols, MQTT, MQTT-SN, constrained application protocol, other protocols.

Learning outcomes:

1. Understand the MQTT protocol connecting edge to cloud. (L2)
2. Understand CoAP protocol connecting edge to cloud. (L2)

Text books:

1. IoT and Edge computing for Architects, 2e, Perry Lea, Packt Publishing, 2020.
2. Cloud computing- implementation, management and security, John W.Rittinghouse, James F. Ransome, CRC Press, 2010.
3. Cloud Computing - A hands-on approach, ArshdeepBahga, Vijay Madisetti, Universities Press, 2015.

References:

1. Cloud Computing, A Practical Approach-Toby Velte, Anthony Velte, Robert Elsenpeter-McGraw-Hill Osborne Media-2009
2. Fog and edge computing_ principles and paradigms-Buyya, Rajkumar_ Srirama, Satish Narayana-John Wiley-201

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3202.4	Bio medical signal processing (professional elective-iii)	3	0	0	3

Course Objectives:

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

1. Explain the importance of various sources of bio-electric potentials in the human body.
2. Enhance knowledge of the different types of electrodes and transducers used to measure bio-electrical signals.
3. Familiarize with the structure and functioning of the cardiovascular and respiratory systems and their corresponding measurement instruments.
4. Introduce the elements of patient care systems, monitoring devices, therapeutic instruments, and prosthetic devices.
5. Provide foundational understanding of diagnostic techniques and introduce concepts of bio-telemetry and electrical safety in biomedical applications.

Course Outcomes (COs):

After successful completion of the course, students will be able to:

1. **Identify** various sources of bio-electric potentials used in man-instrumentation systems. (L2)
2. **Interpret** the role of electrodes and transducers in biomedical signal acquisition and processing. (L2)
3. **Outline** the anatomy and measurement techniques of the cardiovascular and respiratory systems. (L2)
4. **Summarize** the functionality of patient care and monitoring equipment for detecting abnormalities in the human body. (L2)
5. **Identify** different diagnostic imaging techniques, biomedical recorders, and electrical safety methods. (L2)

UNIT-I

Introduction to Biomedical Instrumentation:

Introduction to Wavelet Transforms Overview of signal processing and the need for wavelet transforms, Basics of time-frequency analysis, Introduction to continuous and discrete wavelet transforms (CWT and DWT), Properties of wavelets: orthogonality, compact support, and multiresolution analysis.

Applications:

1. Biomedical instrumentation is used in many applications such as ECG, EEG, EMG, etc.

Learning Outcomes:

- Understand the fundamental concepts of signal processing and the necessity of wavelet transforms in addressing complex signal analysis problems.
- Explain the principles behind continuous wavelet transforms (CWT) and discrete wavelet transforms (DWT), including their respective advantages and limitations.
- Describe key properties of wavelets such as orthogonality, compact support, and multiresolution analysis, and their significance in signal processing tasks.

UNIT-II

Electrodes and Transducers: Introduction, Electrode Theory, Biopotential Electrodes, Examples of Electrodes, Basic Transducer Principles, Biochemical Transducers, The Transducer and Transduction Principles, Active Transducers, Passive Transducers, Transducers for Biomedical Applications, Pulse Sensors, Respiration Sensor, Transducers with Digital Output.

Applications:

1. The transducers are mainly used in every biomedical instruments to study the pulse rate, respiration and heart beat etc.

Learning Outcomes:

- Illustrate the origin of bio potentials and explain the role of biopotential electrodes.
- Classify various Transducers.

UNIT-III

Cardiovascular System and Measurements: The Heart and Cardiovascular System, Electro Cardiography, Blood Pressure Measurement, Measurement of Blood Flow and Cardiac Output, Measurement of Heart Sound, Plethysmography.

Measurements in the Respiratory System: The Physiology of the Respiratory System, Tests and Instrumentation for The Mechanics of Breathing, Respiratory Therapy Equipment.

Applications:

1. The main application of this unit is to measurement of the heartbeat, BP and ECG
2. The respiratory system and breathing.

Learning Outcomes:

- Explain and contrast measurement principles for blood flow, pressure and volume as well as respiratory variables (L2)
- Understand various tests and equipment of Respiratory system (L2)

UNIT-IV

Patient Care and Monitoring: Elements of Intensive-Care Monitoring, Patient Monitoring Displays, Diagnosis, Calibration and Repair ability of Patient-Monitoring Equipment, Other Instrumentation for Monitoring Patients, Organization of the Hospital for Patient-Care Monitoring, Pacemakers, Defibrillators, Radio Frequency Applications of Therapeutic use.

Therapeutic and Prosthetic Devices: Audiometers and Hearing Aids. Myoelectric Arm, Laparoscope, Ophthalmology Instruments, Anatomy of Vision, Electro physiological Tests, Ophthalmoscope, Tonometer for Eye Pressure Measurement. Diathermy, Clinical Laboratory Instruments, Biomaterials, Stimulators.

Applications:

In every hospital, patient care and monitoring system consist of biomedical instruments such as transducers, pacemakers, and sensors etc.

Learning Outcomes:

- Outline the design of cardiac pacemakers, Stimulators and defibrillators (L2)
- List various instruments to perform physiological tests (L2)

UNIT-V

Diagnostic Techniques and Bio-Telemetry: Principles of Ultrasonic Measurement, Ultrasonic Imaging, Ultrasonic Applications of Therapeutic Uses, Ultrasonic Diagnosis, X- Ray and Radio-Isotope Instrumentations, CAT Scan, Emission Computerized Tomography, MRI, Introduction to Biotelemetry, Physiological Parameters Adaptable to Biotelemetry, The Components of Biotelemetry System, Implantable Units, Telemetry for ECG Measurements during Exercise, Telemetry for Emergency Patient Monitoring.

Monitors, Recorders and Shock Hazards: Biopotential Amplifiers, Monitors, Recorders, Shock Hazards and Prevention, Physiological Effects and Electrical Current, Shock Hazards from Electrical Equipment, Methods of Accident Prevention, Isolated Power Distribution System.

Applications:

1. X-rays image, MRI, ECG, etc instruments are used in hospitals.
2. Recorders, Amplifiers, and power distributed systems etc are used in hospitals.

Learning Outcomes:

- Explain basic principles of Ultrasonic Imaging
- Explain the components of Biotelemetry system
- Identify, explain and judge patient safety issues related to biomedical instrumentation

Text books

1. Bio-Medical Electronics and Instrumentation, Onkar N. Pandey, Rakesh Kumar, Katson Books.
2. Bio-Medical Instrumentation, Cromewell ,Wiebell, Pfeiffer

Reference books

1. Introduction to Bio-Medical Equipment Technology, 4th Edition, Joseph J. Carr, John M. Brown, Pearson Publications.
2. Hand Book of Bio-Medical Instrumentation, Instrumentation, Kandahar. McGraw Hill

Subject Code	Subject Name	L	T	P	C
R23ECE-PE3202.5	R F Circuit Design. (Professional Elective-iii)	3	0	0	3

Course Objectives:

- Define the characteristics of passive components of RF Circuits.
- Understand the design principles of different stages of RF Amplifiers.
- Characterization of LNA Design.
- Design various RF Power amplifiers.
- Analyze various analog communication Circuits.

Course Outcomes:

1. Understand the characteristics of passive components of RF Circuits (L1)
2. Design various Radio Frequency (RF) Amplifiers (L6).
3. Construct LNA to integrate in a communication systems suitable for industrial applications (L6).
4. Classify various types of RF Power amplifiers (L2)
5. Apply system design skills to develop analog communication circuits to build up a complex RF system (L3).

UNIT-I

Characteristics of passive components for RF circuits: Passive RLC networks. Transmission lines. Two-port network modeling, S-parameter model, The Smith Chart and its applications.

Active devices for RF circuits: SiGe MOSFET, GaAsP HEMT, HBT and MESFET. PIN diode. Device parameters and their impact on circuit performance.

Learning Outcomes:

1. Understand the characteristics of passive RLC Circuits (L1)
2. Construct transmission line and S-Parameter models for various passive components (L3).
3. Understand the characteristics of various active devices for RF Circuits (L1)

UNIT-II

RF Amplifier Design: single and multi-stage amplifiers. Review of analog filter design. Low-pass, high-pass, band pass and band-reject filters. Bandwidth Estimation Methods. Voltage references and biasing.

Learning Outcomes:

1. Classify various stages of Radio Frequency (RF) Amplifiers (L2).
2. Build and review different types of analog filters (L3)

UNIT-III

Low Noise Amplifier design: noise types and their characterization, LNA topologies, power match vs. noise match. Linearity and large-signal performance.

Learning Outcomes:

Develop an LNA to integrate in a analog communication systems (L6).

UNIT-IV

RF Power amplifiers: General properties. Class A, AB and C PAs. Class D, E and F amplifiers.

Learning Outcomes:

Design various types of RF Power amplifiers (L2)

UNIT-V

Analog communication circuits: Modulation of power amplifiers. Mixers, phase-locked loops, oscillators and synthesizers. Design and performance characterization. Trans-receiver design.

Learning Outcomes:

Experiment with various RF Circuit components to develop analog communication circuits to build up a complex RF system (L3).

Textbooks:

1. **Behzad Razavi**, *Design of Analog CMOS Integrated Circuits*, McGraw-Hill, 1st Edition, 2000.
2. **Thomas H. Lee**, *The Design of CMOS Radio-Frequency Integrated Circuits*, Cambridge University Press, 2nd Edition.

Reference Books:

1. **Bosco Leung**, *VLSI for Wireless Communication*, Pearson Education, 2002.
2. **R. Jacob Baker**, *CMOS: Circuit Design, Layout, and Simulation*, Wiley-IEEE Press, 3rd Edition, 2010.

Subject Code	Subject Name	L	T	P	C
R23ECE-PC3204	Microwave and Optical Communications Lab	0	0	3	1.5

Course outcomes:

- Identify and demonstrate the working of various microwave components.
- Demonstrate the characteristics of directional couplers.
- Analyze the microwave measurement procedures
- Analyze the characteristics of optical sources by conducting experiments and measuring various parameters
- Design an optical fiber communication link and Demonstrate the losses of optical fiber links

LIST OF EXPERIMENTS:

Microwave Lab (PART – A)

1. Reflex Klystron Characteristics.
2. Gunn Diode Characteristics
3. Attenuation Measurement.
4. Directional Coupler Characteristics.
5. Scattering parameters of Circulator.
6. Scattering parameters of Magic Tee
7. Radiation pattern of horn and parabolic antennas
8. Synthesis of micro strip antennas using HFSS

Optical Fiber Lab (PART – B)

1. Characterization of Laser Diode
2. Intensity modulation of Laser output through an optical fiber
3. Measurement of Data rate for Digital Optical link.
4. Measurement of NA
5. Measurement of losses for Analog Optical link

Subject Code	Subject Name	L	T	P	C
R23ECE-PC3205	VLSI Design Lab	0	0	3	1.5

Course Objectives:

1. To Train on mentor graphics environment for design of VLSI circuits
2. To design different VLSI circuits using Mentor Graphics Tool.
3. To draw corresponding layout to perform simulation and verification of designed circuits.
4. To familiarize the design rules in layout drawing in tool.
5. To perform LVS and analyze the performance metrics of designed circuits.

Course Outcomes:

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

1. Understand the environment of mentor graphics and its design flow (L2)
2. Construct CMOS logic circuits and analyze the parameters (L3)
3. Develop the layout of digital circuits (L3)
4. Apply the design rules and analyze their significance on MOS circuits (L3)
5. Develop custom logic circuits/systems (L3)

List of Experiments

1. Design and Implementation of an Inverter
2. Design and Implementation of Universal logic Gates
3. Design and Implementation of XOR Gate using NAND/NOR logic
4. Design and Implementation of Half Adder and Half Subtractor
5. Design and Implementation of Full Adder
6. Design and Implementation of Full Subtractor
7. Design and Implementation of multiplexer
8. Design and Implementation of Decoder
9. Design and Implementation of RS-Latch
10. Design and Implementation of JK Flip-flop
11. Design and Implementation of D Flip-flop
12. Design and Implementation of Static RAM Cell
13. Design and Implementation of Asynchronous counter
14. Design and Implementation of Shift Register

Subject Code	Subject Name	L	T	P	C
R23ECE-SC3201	AI and Signal Processing	0	1	2	2

Course Objectives By the end of this lab, students will be able to:

1. Understand the implementation of basic and advanced machine learning algorithms using real-time datasets.
2. Apply appropriate preprocessing and feature extraction techniques for various data types.
3. Design, implement, and evaluate ML models for classification, regression, and clustering tasks.
4. Analyze and process signals using MATLAB or Python for time and frequency domain analysis.
5. Implement various signal processing algorithms such as filtering, convolution, and transforms on 1D signals.

Course Outcomes: On successful completion, students will be able to:

1. Apply supervised and unsupervised learning techniques using tools like Python or MATLAB.
2. Evaluate ML models using standard metrics and visualize their performance.
3. Design signal processing systems for filtering and spectral analysis.
4. Perform time-frequency analysis and apply FFT, DFT, and convolution.
5. Integrate machine learning and signal processing for practical ECE applications like noise filtering or classification.

List of Experiments (14 Total)

AI Experiments (Using Python – scikit-learn, pandas, matplotlib)

1. **Data Preprocessing**
 - Handling missing data, normalization, encoding categorical variables.
2. **Linear Regression**
 - Implement simple and multiple linear regression on real-world data.
3. **Logistic Regression**
 - Classification on a binary dataset (e.g., spam detection or cancer diagnosis).
4. **K-Nearest Neighbors (KNN) Classification**
 - Apply KNN on Iris or MNIST dataset and evaluate using confusion matrix.
5. **Decision Trees and Random Forests**
 - Train and visualize decision trees on a labeled dataset.
6. **K-Means Clustering**
 - Apply K-means to group unlabeled data; visualize clusters.
7. **Support Vector Machines (SVM)**
 - Classify datasets using linear and kernel-based SVMs.

Signal Processing Experiments (Using MATLAB or Python - NumPy/SciPy)

8. Basic Signal Generation

- Generate sinusoidal, square, and triangular waveforms.

9. Convolution and Correlation

- Implement linear convolution and cross-correlation of signals.

10. Discrete Fourier Transform (DFT) and FFT

- Compute and plot DFT/FFT of a signal.

11. Digital Filtering (IIR/FIR)

- Design and apply FIR and IIR filters to a noisy signal.

12. Noise Removal using Filtering

- Denoise a signal using band-pass or low-pass filters.

13. Time-Frequency Analysis (STFT)

- Perform Short-Time Fourier Transform on speech/audio signal.

14. Voice/Speech Signal Feature Extraction

- Extract features like MFCC or spectral centroid for ML integration.

Subject Code	Subject Name	L	T	P	C
R23ECE-MC3201	Technical Writing & Intellectual Property Rights (Mandatory Course)	2	0	0	0

Course Objectives:

- Build the knowledge on principles and characteristics of technical writing, including clarity, conciseness, and precision. (L3)
- Formulate clear and focused research objectives and research proposal(L2)
- Outline the significance of Intellectual Property Rights (L2)
- Provide knowledge of Copyright and patent law, registration process and grants, protects in India and abroad.(L3)
- Assess and maintain the protection of trademark and trade secret in the organisation and also emerging trends in cybersecurity(L2)

Course Outcomes:

1. Develop the technical writing skills, evaluate sources and properly cite references using appropriate citation styles.(L3)
2. Construct clear and focused research proposal that address a specific gap in the advancement of knowledge in their field of study.(L2)
3. Assess needful elements, agencies responsible for Registration of Intellectual Property elements (L2)
4. Analyze Copyright subject matters, Patent requirements, Infringement and Litigation.(L3)
5. Outline the registration Processes of Trade Mark and Legal procedures to prevent cyber crimes. (L2)

UNIT-I: Introduction To Technical Paper Writing:

Technical paper writing-Objectives-Components-Pre-requisites of good technical report- Format of technical report and its applicability- Significance of technical report and its applicability to end users- Types of technical writing

Learning Outcomes: At the end of this unit student will be able to

- Analyse key aspects of structural technical paper writing effectively.(L2)
- Recognize how to plan and complete report for maximum impact.(L2)

Application: Apply while preparing user manual, technical reports, proposals, online help documentations, and scientific articles.

UNIT-II: Information and Communication of Technical paper writing:

7 C's of technical writing- Difference between technical writer and technical editor-Legal and ethical communication and its description in technical paper-Usage of contemporary technologies in technical paper writing

Learning Outcomes: At the end of this unit student will be able to

- Technical editing as about refining and polishing that content to ensure it is clear, error-free, and effective in covering the intended message. (L2)
- Apply report writing techniques that will reduce their report writing time and improve the quality of their writing.

Application: Analyse accurate information for ethical decision making process.

Unit-III: Introduction to Intellectual Property Rights:

Introduction to Intellectual Property Rights – International Instruments and IPR - WIPO - TRIPS -Laws Relating to IPR - IPR Tool Kit -Agencies for IPR Registration – Emerging trends in IPR.

Learning Outcomes:

At the end of this unit student will be able to:

- Knowledge about the elements of IPR (L2)
- Learn International Instruments and emerging areas of IPR (L1)

Application: Applicability and relativity between elements of Intellectual property rights and Creating innovative ideas.

Unit-IV: Copyrights and Patents

Introduction to Copyrights – Principles of Copyright Protection – Copy Registration Process - Subject Matters of Copyright – Right to Copy rights – Copyright Infringement - Patents – Patent Search - Patent Registration and Granting of Patent - Infringement of Patent – Patent Cooperation Treaty – New developments in Patents.

Learning Outcomes: At the end of this unit student will be able to:

- Support the various concepts related to protection, promotion and enforcement of copyrights (L2)
- Describe the registration process of Patents (L2)
- Gain knowledge of infringement of patents and their remedies (L3)

Application:

- Practice of copy rights case and Identification of the infringement.
- Checking the eligibility for several patents and suggest remedies for problems through case study.

Unit V: Trademarks, Trade secrets and Cybercrimes:

Introduction to Trademarks – Trade Mark Registration – Transfer of rights - Trademarks Claims and Infringement – Remedies - Trade Secrets – Physical Security – Employee Confidentiality Agreements – Breach of Contract – Trade Secret Litigation. Introduction to Cyber Law - Cyber Crimes - Prevention and Punishment.

Learning Outcomes: At the end of this unit student will be able to:

- Knowledge on registration and maintenance of trade marks (L3)
- Outline Physical security and Employee Confidentiality Agreements (L2)
- Gain knowledge of prevention and punishment of cyber crimes (L3)

Application:

1. Compare and contrast different trademarks and know how to register trademark
2. Identify the physical protection of trade secret.

Contemporary Practices:

- E-filing Applications
- Digital Piracy

Text Books:

1. Fundamentals of IPR for Engineers- Kompal Bansal & Parishit Bansal, B. S.Publications, 2013
2. Research Methodology –C .R. Kothari, Gaurav Garg,NEW AGE International Publishers, 2019
3. Developing Research Proposals (Paperback-2023),Pam Denicolo, Sage Publications 2023
4. IntellectualProperty-DeborahE.Bouchoux,CengageLearning,New Delhi.,2012
5. V.ScopleVinod,ManagingIntellectualProperty,PrenticeHallofIndiapvtLtd,2012
6. Essentials of Technical Communication- Elizabeth Tebeaux Sam Dragga, Oxford University Press, 4th Edition

Reference Books:

1. Intellectual property rights-Prabuddha Ganuli.,Tata Mcgraw hill, 2012.
2. Intellectual property rights M.Ashok kumar and Mohd.Iqbal Ali:, Serials Publications, 2015
3. Developing Research Proposals -English, Paperback, Denicolo Pam ,Sage South Asia edition,2012
4. Intellectual Property Rights (Patents & Cyber Law), Dr.A. Srinivas. OxfordUniversityPress, NewDelhi,2015.
5. Intellectual Property- Richard Stim,Cengage Learning, New Delhi, 2012.
6. S.V.Satakar,—Intellectual Property Rights and Copy Rights, Ess Ess Publications, New Delhi, 2002
7. Technical Communication – Mike Markel-Publisher: Bedford/St. Martin’s, 12th Edition.

Web links:

1. <http://www.ipindia.gov.in/patents.htm>
2. <http://www.ipindia.gov.in/trade-marks.htm>
3. <https://copyright.gov.in/>
4. <http://www.wipo.int/portal/en/index.html>
5. <https://indiankanoon.org/>

COURSE OUT COMES VS PO s MAPPING (DETAILED;HIGH:3;MEDIUM:2;LOW:1):

SN O	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO1 2	PS O1	PSO 2	PSO 3
CO1	-	-	-	-	-	2	1	-	-	-	-	1	-	1	
CO2	-	-	-	-	-	2	1	1	-	-	-	1	-	1	
CO3	-	-	-	-	-	2	2	2	-	-	-	1	-	1	
CO4	-	-	-	-	-	2	2	1	-	-	-	1	-	1	
CO5	-	-	-	-	-	2	1	2	-	-	-	1	-	1	
CO*	-	-	-	-	-	2	2	2	-	-	-	1	-	1	

R23_ECE (Honors)

TRACK 1 : VLSI DESIGN							
S. No	Year - semester	Code	Subject Name	L	T	P	C
1	II-II	R23ECE-HN2201	Digital Athematic Circuits	3	0	0	3
2	III-I	R23ECE-HN3101	FPGA and Digital System Design using Verilog	3	0	0	3
3	III-II	R23ECE-HN3201	Analog and mixed signal IC design	3	0	0	3
4	IV-I	R23ECE-HN4101	LOW POWER VLSI DESIGN	3	0	0	3
5	II Year to IV Year	R23ECE-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23ECE-HM0002	Honors MOOCS-2	0	0	0	3
Total							18

TRACK 2 : EMBEDDED AND IoT DESIGN							
S. No	Year - semester	Code	Subject Name	L	T	P	C
1	II-II	R23ECE-HN2202	Sensors and Actuators	3	0	0	3
2	III-I	R23ECE-HN3102	Data Analytics for IoT	3	0	0	3
3	III-II	R23ECE-HN3202	Robotics for Embedded systems	3	0	0	3
4	IV-I	R23ECE-HN4102	Privacy And Security In IoT	3	0	0	3
5	II Year to IV Year	R23ECE-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23ECE-HM0002	Honors MOOCS-2	0	0	0	3
Total							18

Subject Code	Subject Name	L	T	P	C
R23ECE-HN2201	Digital Arithmetic Circuits	3	0	0	3

Course Objectives:

- To study digital representation of Various number systems
- To understand the redundant and residue number system and application
- To understand the concept of binary addition, multiplication and division circuits
- To understand concept of floating point arithmetic
- To understand the concept of floating point arithmetic circuits

Course Outcomes: At the end of the Course, the Student will be able to:

- Describe the different representation of number systems
- Concept of redundant number and residue number system and implementation concept
- Familiarization of different adder architectures
- Familiarization of different architectures of multipliers and dividers
- Familiarization with floating point number representation in digital domain and architectures of floating point circuits

Unit-1

Review of the Number Representation: Numbers and their encodings, Fixed-radix positional number systems, Number radix conversion, Classes of number representations, Signed-magnitude representation, Biased representations, Complement representations, Direct and indirect signed arithmetic.

Application:

1. Students could design their own number system and develop new algorithms for signed magnitude representation.

Learning Outcomes:

At the end of the Course, the Student will be able to:

1. Understand the methods for converting numbers between binary, octal, and hexadecimal systems.
2. Understand the practical applications of different number systems in computing, digital electronics, and data representation.

Unit-2

Redundant Number Systems: Coping with the carry problem, Redundancy in computer arithmetic, Digit sets and digit-set conversions, generalized signed-digit numbers, Carry-free addition algorithms, Conversions and support functions. Introduction to Residue Number systems.

Applications:

1. Students could expertise in high speed arithmetic circuits, cryptography, error correction and detection, scientific computing, parallel computing, etc.

Learning Outcomes:

At the end of the Course, the Student will be able to:

1. Explain the principles and structure of redundant binary number systems and differentiate between standard binary representation and redundant binary representation.
2. Understand the algorithms that take advantage of redundant binary representation for faster arithmetic operations.

Unit-3

Addition / Subtraction: Bit-serial and ripple-carry adders, Conditions and exceptions, Analysis of carry propagation, Carry completion detection, Manchester carry chains adders. Carry-look-ahead adder design, Ling adder and related designs, Carry determination as prefix computation, Alternative parallel prefix networks, VLSI implementation aspects, Modular two-operand adders

Applications:

1. Students could do their research work on approximate, reversible adder/ subtractor circuits.

Learning Outcomes:

At the end of the Course, the Student will be able to:

1. Understand the estimation of carry before computations.
2. Apply higher-end adders and subtractions for faster computation.

Unit-4

Multiplication: Shift /add multiplication algorithms, Programmed multiplication, Basic hardware multipliers, Multiplication of signed numbers, Multiplication by constants, and Preview of fast multipliers. Radix-4 multiplication, Modified Booth's recoding, Radix-8 and radix-16 multipliers, Multi-bit multipliers, VLSI complexity issues. Full-tree multipliers, Alternative reduction trees, Treemultipliers for signed numbers, Partial-tree and truncated multipliers, Array multipliers, Pipelined tree and array multipliers.

Applications:

1. Students could develop some fast and low power multiplier algorithms and architectures.

Learning outcomes:

At the end of the Course, the Student will be able to:

1. Develop some higher level multipliers like CRT, etc., for high end applications.
2. Compare signed and unsigned multiplication using different multiplier architectures.

Unit-5

Division: Shift/ subtract division algorithms, Programmed division, Restoring hardware dividers, Non-restoring and signed division, Division by constants, Radix-2 SRT division. Basics of high-radix division, Using carry-save adders, Radix-4 SRT division, General high radix dividers, Quotient digit selection, Using p-d plots in practice.

Applications:

1. Students could design restoring and non-restoring dividers.

Learning Outcomes:

At the end of the Course, the Student will be able to:

1. Understand the concept of combinational and sequential multipliers.
2. Develop some fast computational divider circuits.

Text Books

1. B. Parhami, "Computer Arithmetic: Algorithms and Hardware Designs", Oxford University Press, 2nd Edition, 2010
2. I. Koren, Computer Arithmetic Algorithms, Prentice Hall Publications, 2nd Edition, 2003

Reference Books

1. M. D. Ercegovac, Digital Arithmetic, The Morgan Kaufmann Series in Computer Architecture and Design. 1st Edition, 2003.
2. D. A. Patterson and J. L. Hennessy, Computer Organization and Design, Morgan Kaufmann Publishers Inc. San Francisco, 5 th Edition, 2014

Subject Code	Subject Name	L	T	P	C
R23ECE-HN3101	FPGA and Digital System Design using Verilog	3	0	0	3

Course Objectives:

- To introduce the basics and programming fundamentals of Verilog HDL
- To describe the primitive instances of gates and explain the various modeling constructs of Verilog.
- To familiarize with various high-level to low level modeling constructs of Verilog essential for designing digital circuits.
- To Design and implement various combinational and sequential logic circuits in Verilog HDL
- To Design and implement a Finite State Machine (FSM) and non-arithmetic digital systems using Verilog HDL.

Course Outcomes: At the end of the Course, the Student will be able to:

1. Understand the fundamentals of Verilog HDL (L2)
2. Apply various Gate Level modeling and Data flow modeling techniques to design logic circuits (L3)
3. Apply various Behavioral and switch level modeling elements to design different logic circuits(L3)
4. Design and analysis of combinational and sequential digital systems using Verilog HDL programming constructs (L4)
5. Design and analysis of real time FSM and non-arithmetic digital system design using Verilog HDL programming constructs(L4)

Unit-1

Introduction to Verilog HDL: Verilog as HDL, Levels of Design Description, Concurrency, Simulation, and Synthesis Tools. Language Constructs and Conventions: Introduction, Keywords, Identifiers, Comments, Tasks and functions, Numbers, Strings, Logic Values, Data Types, Scalars and Vectors, Parameters, Operands and Operators.

Applications:

1. Applied to design of electronic system modules.
2. Verilog HDL is used for timing analysis and for logic synthesis.

Learning Outcomes:

At the end of this unit the student will be able to

1. Understand the fundamentals of Verilog HDL (L2)
2. Understand the essentiality of various Verilog design parameters in the design of digital Systems (L2).

Unit-2

Gate Level Modeling: Introduction, AND Gate Primitive, Module Structure, Other Gate Primitives, Illustrative Examples, Tri-State Gates, Array of Instances of Primitives, Digital Designs in Gate Level Modeling: Design of Adders, Decoders, Encoders, Multiplexer, Demultiplexer, Flip-flops, Counters, and Registers.

Data Flow Modelling: Introduction, Continuous Assignment Structure, Delays, Assignment to Vectors, Operators and Examples of Digital Designs in Data Level Modeling.

Applications:

1. Verilog HDL is a Programming language used to model any digital system using various modeling techniques.

Learning Outcomes:

At the end of this unit the student will be able to

1. Understand the modeling of digital systems suiting various applications (L2).
2. Analyzing digital systems using Gate and Data flow modeling techniques (L4).

Unit-3

Behavioral Modeling: Procedural constructs, Timing Controls, Blocking and Non-Blocking Assignments, The case statement, Simulation Flow *if* and *if-else* constructs, Assign-De-Assign construct, Repeat loop, for loop, While loop, Forever loop, Force-Release construct. Modeling of Digital Designs in Behavioral Level.

Switch Level Modeling: Basic Transistor Switches, CMOS Switch, Bi-directional switches.

Applications:

1. Behavioral modeling attempts to explain why an individual makes a decision and the model is then used to help predict future behavior.
2. Behavioral model sin Verilog contain procedural statements that control the simulation and manipulate variables of the data types.

Learning Outcomes:

At the end of this unit, the student will be able to

1. Understand high-level abstraction of digital systems with behavioral modeling of systems (L2).
2. Applying various behavioral constructs essential for designing d igital systems(L3).

Unit-4

Design of Finite State Machine (FSM) Elements: Introduction to FSM, Implementation methodology of FSMs. Implementation of FSM using Verilog. Testing of FSM.

Applications:

1. FSMs are used in the design of digital systems.
2. FSM circuits are employed in Sequence detectors, traffic light controllers, and elevator controllers.

Learning Outcomes:

At the end of this unit, the student will be able to

1. Understand the applicability of FSMs in the design of digital systems (L2).
2. Construct complex digital systems based on FSM systems(L4)

Unit-5

Clock Synchronization, Timing Issues and Non-Arithmetic Systems Design: Clock distribution, Flip-flop timing parameters, Asynchronous inputs to Flipflops, Switch debouncing. Introduction to Non-Arithmetic Digital Designs, Implementation of 7 segment display decoder, Traffic light controller using Verilog.

Applications:

1. Real time digital systems used for event triggering.
2. Real time non-arithmetic digital display decoder, traffic light controller.

Learning Outcomes:

At the end of this unit, the student will be able to

1. Understand the necessary of clock distribution and switch debouncing(L2).
2. Analyzing complex non arithmetic digital systems(L4)

Text Books:

1. JohnF. Wakerly, Digital Design, Pearson, 4th Edition.
2. J. Bhaskar, AVerilog HDL Primer, BS Publications, 3rd Edition.

Reference Books:

1. Verilog HDL – Samir Palnitkar, 2nd Edition, Pearson Education, 2009

2. Zainalabdien Navabi –Verilog Digital System Design, TMH, 2nd Edition.
3. Charles H. Roth, Lizy Kurian John – Digital Systems Design Using Verilog, Cengage Learning, 2014.
4. Stephen Brown and Zvonko Vranesic - Fundamentals of Digital Logic With Verilog Design.

Subject Code	Subject Name	L	T	P	C
R23ECE-HN3201	Analog and mixed signal IC design	3	0	0	3

Course Objectives:

- To know about the practical implementation of Mixed Signal Design Circuits.
- To know about CMOS comparators and analog multipliers.
- To know about Analog to Digital Convertors CMOS based design
- To know about Digital to Analog Convertors CMOS based design
- To know about Phase lock loop and Delay lock loop

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

- Understand Mixed Signal Design Circuits.
- Develop CMOS based comparators and multipliers.
- Illustrate Analog to Digital Convertors CMOS based design
- Illustrate Digital to Analog Convertors CMOS based design
- Gain knowledge on Phase lock loop and Delay lock loop

Unit-1

Analog and Discrete-Time Signal: Analog and discrete-time signal processing, introduction to sampling theory, Analog continuous-time filters: passive and active filters, Basics of analog discrete-time filters and Z-transform, Switched-capacitor filters

Applications:

1. Students could design active and passive filters for analog applications.

Learning Outcomes:

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

1. Understand the role of analog and discrete time signals in VLSI design.
2. Develop skills to design analog filters.

Unit-2

Non-linear & Dynamic Analog Circuits: Basic CMOS Comparator Design, Adaptive Biasing, Analog Multipliers.

Applications:

1. Students could design 16-bit comparators and 16-bit and above analog multipliers.

Learning Outcomes:

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

1. Understand the basics of comparator to implement using CMOS.
2. Develop analog multipliers using CMOS and other dynamic logic styles.

Unit-3

Basics of Analog to Digital Converters (ADC): Basics of data converters, Successive approximation ADCs, Dual slope ADCs, High-speed ADCs (flash ADC, pipeline ADC and related architectures), High-resolution ADCs (delta-sigma converters)

Applications:

1. Students could design analog to digital converter circuits in CMOS.

Learning Outcomes:

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

1. Understand conventional ADCs and high speed ADCs.

Unit-4

Basics of Digital to Analog Converters (DAC): DAC specifications, DAC Architectures, Mixed-signal layout issues.

Applications:

1. Students could design digital to analog converter circuits in CMOS.

Learning Outcomes:

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

1. Understand conventional DACs and high speed DACs.

Unit-5

Phase Locked Loops: Voltage-mode signaling and data transmission, Current-mode signaling and data transmission, Introduction to frequency synthesizers and synchronization, Basics of PLL, Analog PLL, Digital PLL, Delay locked loops (DLL)

Applications:

1. Students could design phase locked loop circuits in CMOS for different analog based applications.

Learning Outcomes:

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

1. Understand the concept of signalling and data transmission.
2. Design analog and digital PLLs and delay locked loops.

Text Books:

1. Baker, Li, Boyce, "CMOS Circuits Design, Layout and Simulation", TMH.
2. Allen Halburg, "Analog Integrated Circuits", Oxford
3. David A. Johns, Ken Martin, John , "Analog Integrated Circuit Design" Wiley & Sons.

Reference Books:

1. B.Razavi, "Design of AnalogCMOS Circuits" ,TMH
2. R. Gregorian, Gabor. C. Temes , "Analog MOS ICs for Signal Processing " , John Wiley & Sons

Subject Code	Subject Name	L	T	P	C
R23ECE-HN4101	Low Power VLSI Design	3	0	0	3

Course Objectives:

- To introduce the basic low-voltage VLSI design.
- To describe the role of power in determining VLSI system efficiency and reliability.
- To familiarize with multiple low-power design techniques applied in VLSI circuits.
- To analyze different approaches for minimizing energy loss in sequential and combinational circuits.
- To develop knowledge of CMOS low-power design strategies and power evaluation approaches.

Course Outcomes: At the end of the Course, the Student will be able to:

1. Understand the fundamentals of low-power techniques in VLSI system design (L2)
2. Apply different low-power design methodologies and power estimation techniques in combinational and sequential circuits (L3)
3. Utilize suitable low-power techniques such as voltage scaling, clock gating, and transistor sizing in CMOS circuit design (L3)
4. Examine trade-offs between performance, area, and power in VLSI design approaches (L4)
5. Assess the effectiveness of various low-power design strategies for given VLSI applications (L5)
6. Design and implement low-power VLSI circuits using appropriate EDA tools and propose optimized solutions. (L5)

Unit-1

Introduction to Low Power VLSI: Significance of Low Power in VLSI, Various Sources of Power Dissipation – Short Circuit Power Dissipation, Leakage Power Dissipation, and Switching/Active Power Dissipation, Introduction to Short Channel Effects (SCEs) – Velocity Saturation, Drain Induced Barrier Lowering, Body Effect, Impact Ionization, Hot Electron Effect, Punch Through. Importance of Low Power VLSI Design in relation to SCEs.

Applications:

1. The study of power dissipation and short-channel effects drives real-world portable electronics applications.

Learning Outcomes:

At the end of this unit the student will be able to

1. Recall different sources of power dissipation in CMOS circuits (short-circuit, leakage, and switching power) (L1)
2. Explain the significance of low power in VLSI and the impact of short channel effects (L2).

Unit-2

Physics of Power Dissipation in MOS Devices: Introduction, MIS structure, Long Channel MOSFET, Power Dissipation in CMOS circuits, Load Capacitance.

Low Power VLSI Design Limits: Principles of Low Power Designs, Hierarchy of limits, Fundamental Limits, Device Limits, Circuit Limits, System Limits, Practical Limits, Quasi-adiabatic.

Applications:

1. Applying quasi-adiabatic techniques and system-level optimizations in SoCs and ASICs.

Learning Outcomes:

At the end of this unit the student will be able to

1. Apply fundamental equations to estimate power dissipation at device, circuit, and system levels (L3).
2. Differentiate between various limits of low power design (fundamental, device, circuit, system, and practical). (L4).

Unit-3

Low Power Design Approaches: Introduction, Low power design through voltage scaling: VTCMOS circuit and their functionality, MTCMOS circuits. Architecture level Approach – Pipelining and Parallel Processing Approaches.

Power Reduction in Clock Networks: Basic Clock Gating, Reduced Swing Clock, Oscillator Circuit for Clock Generation, Frequency Division, and Multiplication.

Applications:

1. Architecture-level low power approach applied in **high-speed computing applications**.
2. Clock network power reduction techniques are widely used in wearable electronics and IoT chips.

Learning Outcomes:

At the end of this unit, the student will be able to

1. Understand the functionality of VTCMOS and MTCMOS circuits for voltage scaling and leakage reduction (L2).
2. Examine trade-offs between power, performance, and area in architectural-level low-power approaches (L4).

Unit-4

Low Power Transistors and Gate Sizing: Introduction to Sizing an Inverter, Transistor Sizing for Leakage Power Reduction - Network Restructuring and Reorganization: Transistor Network Restructuring, Transistor Network Partitioning and Reorganization.

Special Low Power Combinational and Sequential Systems: CMOS Adders Architectures – Carry Look Ahead Adder, Carry Select Adders, Carry Save Adders, Types of Multiplier Architectures, Baugh-Wooley Multiplier, Booth Multiplier, Introduction to Wallace Tree Multiplier, Self-gated Flip-Flops, Double Edge Triggered Flip-Flop.

Applications:

1. Network Restructuring & Partitioning: Enhances performance and power efficiency in datapath circuits, arithmetic logic units, and memory design.
2. Special-purpose adders and multipliers applied in machine learning accelerators with reduced power-delay products.

Learning Outcomes:

At the end of this unit, the student will be able to

1. Apply transistor sizing and restructuring methods in designing leakage-aware CMOS logic networks. (L3)
2. Design and optimize combinational and sequential subsystems (adders, multipliers, flip-flops) for low-power applications in portable and high-performance VLSI systems. (L5)

Unit-5

Low-Voltage Low-Power Memories: Basics of ROM, Low-Power ROM Technology, Future Trend and Development of ROMs, Basics of SRAM, Memory Cell, Precharge and Equalization Circuit, Low Power SRAM Technologies, Basics of DRAM, Self-Refresh Circuit, Future Trend, and Development of DRAM.

Applications:

1. On-chip cache memory – Used in processors (CPUs, GPUs, AI accelerators) where low power and high speed are critical.
2. Emerging DRAM alternatives for ultra-low-power computing.

Learning Outcomes:

At the end of this unit, the student will be able to

1. Explain low-power techniques in ROM, SRAM, and DRAM (e.g., self-refresh, precharge, equalization). (L2)
2. Apply circuit-level techniques for reducing dynamic and leakage power in memory cells. (L3)

Text Books:

1. JKiat-Seng Yeo, Kaushik Roy, “Low-Voltage, Low-Power VLSI Subsystems”, TMH Professional Engineering.
2. Low Power CMOS VLSI Circuit Design – Kaushik Roy, Sharat C. Prasad, John Wiley & Sons, 2000.
3. Gary Yeap, “Practical low power digital VLSI design”, Kluwer, 1998.
4. Neil H. E. Weste, David Money Harris “CMOS VLSI Design 4e: A circuits and systems”, Pearson, 2015

Reference Books:

1. Abdelatif Belaouar, Mohamed.I.Elmasry, “Low power digital VLSI design”, Kluwer, 1995
2. James B.Kulo, Shih-Chia Lin, “Low voltage SOI CMOS VLSI devices and Circuits”, John Wiley and sons, inc. 2001
3. Leakage in Nanometer CMOS Technologies – Siva G. Narendran, Anatha Chandrakasan, Springer, 2005

Subject Code	Subject Name	L	T	P	C
R23ECE-HN2202	Sensors and Actuators	3	0	0	3

Course Objectives: The course aims to:

- Introduce the basic principles of sensors and actuators used in engineering systems.
- Explain different types of sensors for measuring physical, chemical, and biological variables.
- Familiarize with actuators based on electrical, mechanical, thermal, and smart material principles.
- Provide understanding of interfacing sensors and actuators with electronic systems.
- Highlight real-world applications of sensors and actuators in industrial, biomedical, and consumer systems.

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

1. Classify and explain the working principles of different types of sensors.
2. Analyze the characteristics and performance parameters of sensors.
3. Describe various actuator mechanisms and their selection criteria.
4. Demonstrate the integration of sensors and actuators with control systems.
5. Apply knowledge of sensors and actuators in designing embedded/automation-based applications.

UNIT-I: Introduction to Sensors

Definition, classification of sensors; static and dynamic characteristics; accuracy, sensitivity, linearity, resolution, hysteresis; types of errors; signal conditioning and calibration techniques.

Applications: Industrial process monitoring, robotics, automotive systems.

Learning Outcomes:

1. Explain sensor classification and performance parameters (L2).
2. Analyze sensor errors and calibration methods (L4).

UNIT-II: Mechanical and Thermal Sensors

Displacement, position and proximity sensors: potentiometric, capacitive, inductive, ultrasonic; pressure sensors: piezoelectric, strain gauge; flow sensors; temperature sensors: thermocouples, RTDs, thermostats, pyroelectric sensors.

Applications: HVAC, automotive safety, industrial machines.

Learning Outcomes:

1. Describe mechanical and thermal sensor types with applications (L2).
2. Compare pressure and temperature sensing techniques (L4).

UNIT-III: Optical, Acoustic and Chemical Sensors

Optical sensors: photodiodes, phototransistors, LDR, fiber optic sensors; acoustic sensors: microphones, ultrasonic sensors; chemical sensors: pH, gas, biosensors.

Applications: Medical diagnostics, environmental monitoring, industrial quality control.

Learning Outcomes:

1. Explain optical and acoustic sensors with operating principles (L2).
2. Apply chemical and biosensors in real-world systems (L3).

UNIT-IV: Actuators – Principles and Types

Actuator fundamentals; electrical actuators: DC/AC motors, stepper motors, servomotors; solenoids; hydraulic and pneumatic actuators; piezoelectric actuators.

Applications: Robotics, aerospace, industrial drives.

Learning Outcomes:

1. Describe the principle and operation of different actuators (L2).
2. Select suitable actuators for given applications (L4).

UNIT-V: Smart Sensors and Actuators

Smart sensors: integration of sensing, signal processing, and communication; MEMS-based sensors and actuators; wireless sensor networks; IoT-enabled sensing systems.

Applications: Smart homes, biomedical devices, automotive electronics.

Learning Outcomes:

1. Explain the concept of smart sensors and MEMS technology (L2).
2. Analyze applications of IoT-enabled sensing systems (L4).

Textbooks:

1. D. Patranabis, *Sensors and Transducers*, PHI Learning.
2. W. Bolton, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, Pearson.

Reference Books:

1. John G. Webster, *Measurement, Instrumentation and Sensors Handbook*, CRC Press.
2. Ian R. Sinclair, *Sensors and Transducers*, Newnes.

Subject Code	Subject Name	L	T	P	C
R23ECE-HN3102	Data Analytics for IoT	3	0	0	3

Course Objectives: The course aims to:

- Introduce the fundamentals of IoT data, sources, and challenges in analytics.
- Explain data preprocessing, cleaning, and feature extraction techniques for IoT systems.
- Provide knowledge of statistical analysis, machine learning, and big data tools for IoT.
- Familiarize students with cloud/edge-based analytics frameworks.
- Demonstrate real-world applications of IoT data analytics in healthcare, smart cities, and industry.

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

1. Describe IoT data characteristics, formats, and challenges in analytics.
2. Apply preprocessing and transformation techniques to IoT data.
3. Implement statistical and machine learning models for IoT data analysis.
4. Evaluate cloud and edge computing frameworks for real-time IoT analytics.
5. Develop IoT analytics solutions for smart applications.

UNIT-I: Introduction to IoT Data Analytics

IoT data: types, sources, formats, and characteristics; data lifecycle in IoT; big data aspects of IoT; challenges in IoT data analytics (volume, velocity, variety, veracity, value).

Learning Outcomes:

1. Explain IoT data sources and formats (L2).
2. Identify challenges in IoT big data analytics (L3).

UNIT-II: Data Preprocessing for IoT

Data acquisition, cleaning, transformation, normalization, dimensionality reduction; handling missing data; feature extraction and selection for IoT applications.

Learning Outcomes:

1. Apply preprocessing and feature extraction methods for IoT data (L3).
2. Analyze methods for dealing with noisy and incomplete data (L4).

UNIT-III: Analytical Methods for IoT

Descriptive, predictive, and prescriptive analytics; statistical models; regression, classification, clustering; anomaly detection; time-series analysis for IoT.

Learning Outcomes:

1. Implement statistical and ML techniques for IoT datasets (L3).
2. Apply anomaly detection and time-series models in IoT systems (L4).

UNIT-IV: Platforms and Frameworks for IoT Analytics

Big data frameworks: Hadoop, Spark; cloud-based IoT analytics platforms: AWS IoT Analytics, Google Cloud IoT, Microsoft Azure IoT; edge analytics concepts; data visualization tools.

Learning Outcomes:

1. Compare cloud and edge frameworks for IoT analytics (L4).
2. Use data visualization tools for IoT decision-making (L3).

UNIT-V: Applications of IoT Data Analytics

Case studies: smart cities, healthcare monitoring, industrial IoT (IIoT), smart agriculture, energy management; security and privacy issues in IoT analytics.

Learning Outcomes:

1. Apply IoT analytics in real-world domains like healthcare and agriculture (L3).
2. Evaluate security and privacy challenges in IoT data analytics (L5).

Textbooks:

1. Pethuru Raj & Anupama C. Raman, *The Internet of Things: Enabling Technologies, Platforms, and Use Cases*, CRC Press.
2. Charu C. Aggarwal, *Machine Learning for IoT Big Data Analytics*, Springer.

Reference Books:

1. John C. Dunn, *Data Analytics for IoT: A Complete Guide*, Wiley.
2. David Easley & Jon Kleinberg, *Networks, Crowds, and Markets: Reasoning about a Highly Connected World*, Cambridge University Press.

Subject Code	Subject Name	L	T	P	C
R23ECE-HN3202	Robotics for Embedded Systems	3	0	0	3

Course Objectives: The course aims to:

- Introduce the fundamentals of robotics and their integration with embedded systems.
- Familiarize students with robot kinematics, dynamics, and motion control principles.
- Explain the role of sensors, actuators, and microcontrollers in robotic systems.
- Develop knowledge of embedded programming and real-time control in robotics.
- Demonstrate applications of robotics in automation, industry, and intelligent systems.

Course Outcomes: At the end of the course, the student will be able to:

1. Explain the basics of robotics and embedded hardware/software integration.
2. Analyze robot kinematics and motion control strategies.
3. Apply sensors and actuators for robotic perception and movement.
4. Design embedded controllers for real-time robotic operations.
5. Develop robotic applications for industrial and intelligent systems.

UNIT-I: Introduction to Robotics and Embedded Systems

Definition and scope of robotics; classification of robots; embedded systems in robotics; microcontrollers and processors for robots; hardware–software co-design.

Learning Outcomes:

1. Understand basic concepts and classifications of robots (L2).
2. Explain the role of embedded systems in robotic platforms (L3).

UNIT-II: Robot Kinematics and Dynamics

Forward and inverse kinematics of robotic arms; Denavit-Hartenberg (D-H) parameters; trajectory planning; dynamics of manipulators; control laws.

Learning Outcomes:

1. Apply kinematic equations for robot motion (L3).
2. Analyze trajectory planning and robot dynamics (L4).

UNIT-III: Sensors and Actuators in Robotics

Sensors: position, velocity, force/torque, vision sensors; Actuators: DC/servo/stepper motors, pneumatic and hydraulic actuators; interfacing with embedded controllers.

Learning Outcomes:

1. Identify and use appropriate sensors and actuators for robotic systems (L3).
2. Integrate sensors and actuators with embedded controllers (L4).

UNIT-IV: Embedded Control for Robotics

Microcontroller programming for robot control; real-time operating systems (RTOS) for robotics; communication protocols (I2C, SPI, CAN, UART); feedback and closed-loop control.

Learning Outcomes:

1. Develop microcontroller code for robotic control (L3).
2. Implement real-time embedded control for robots (L4).

UNIT-V: Applications of Robotics with Embedded Systems

Mobile robots, robotic arms, industrial automation, autonomous vehicles, service robots; case studies in embedded robotics applications; trends in AI-driven robotics.

Learning Outcomes:

1. Apply embedded robotics concepts to industrial and autonomous systems (L3).
2. Evaluate the impact of AI and embedded intelligence in robotics (L5).

Textbooks:

1. John J. Craig, *Introduction to Robotics: Mechanics and Control*, Pearson.
2. Raj Kamal, *Embedded Systems: Architecture, Programming and Design*, McGraw Hill.

Reference Books:

1. Bruno Siciliano & Lorenzo Sciavicco, *Robotics: Modelling, Planning and Control*, Springer.
2. Mikell P. Groover, *Industrial Robotics: Technology, Programming and Applications*, McGraw Hill.

Subject Code	Subject Name	L	T	P	C
R23ECE-HN4102	Privacy and Security in IoT	3	0	0	3

Course Objectives: The course aims to:

- Provide an understanding of privacy and security challenges in Internet of Things (IoT).
- Familiarize students with cryptographic techniques, authentication, and access control in IoT.
- Explain security protocols and architecture for constrained IoT devices and networks.
- Explore threats, attacks, and vulnerabilities in IoT systems.
- Discuss privacy-preserving methods, trust management, and future IoT security trends.

Course Outcomes : At the end of the course, the student will be able to:

1. Identify security and privacy requirements in IoT applications.
2. Apply cryptographic primitives and authentication mechanisms in IoT.
3. Analyze IoT threats, vulnerabilities, and attack scenarios.
4. Design secure IoT architectures with access control and trust management.
5. Evaluate privacy-preserving methods and emerging IoT security solutions.

UNIT-I: Introduction to IoT Security and Privacy

IoT security fundamentals: scope, requirements, and challenges; differences between traditional IT security and IoT security; IoT architecture and security implications; IoT threat models.

Learning Outcomes:

1. Understand IoT security challenges (L2).
2. Explain IoT threat models and architectures (L3).

UNIT-II: Cryptographic Primitives for IoT

Symmetric and asymmetric cryptography for constrained devices; lightweight cryptography; key generation, distribution, and management; random number generation; hash functions.

Learning Outcomes:

1. Apply lightweight cryptographic techniques to IoT devices (L3).
2. Analyze key management in constrained environments (L4).

UNIT-III: Authentication, Access Control and Trust in IoT

Authentication methods for IoT devices and users; identity management; role-based and attribute-based access control; trust models and reputation systems in IoT.

Learning Outcomes:

1. Implement authentication and access control in IoT systems (L3).
2. Evaluate trust management approaches for IoT (L5).

UNIT-IV: IoT Network Security Protocols and Vulnerabilities

Security in IoT communication protocols (MQTT, CoAP, 6LoWPAN, RPL); secure routing; DoS and replay attacks; intrusion detection in IoT; case studies of IoT vulnerabilities.

Learning Outcomes:

1. Demonstrate knowledge of secure IoT communication protocols (L3).
2. Analyze common IoT attacks and countermeasures (L4).

UNIT-V: Privacy and Emerging IoT Security Solutions

Privacy- preserving data aggregation; anonymity and pseudonymity in IoT; secure cloud and fog-based IoT architectures; block chain for IoT security; AI and ML in IoT security; future research trends.

Learning Outcomes:

1. Apply privacy-preserving methods in IoT (L3).
2. Evaluate modern IoT security techniques using blockchain and AI (L5).

Textbooks:

1. Fei Hu (Ed.), Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations, CRC Press.
2. Rajeev Piyare & Seung-Hoon Lee, Internet of Things: Security and Privacy Issues, Springer.

Reference Books:

1. Shancang Li & Li Da Xu, Securing the Internet of Things, Syngress.
2. Debasis Bandyopadhyay & Jaydip Sen, Internet of Things: Applications and Security, Springer.

R23 ECE (Minors)

Track- I (EMBEDDED SYSTEMS)							
S.No	Year & Semester	Course Code	Subject title	L	T	P	C
1	II-II	R23ECE-MT2201	Introduction to Microcontrollers	3	0	0	3
2	III-I	R23ECE-MT3101	Embedded system Design	3	0	0	3
3	III-I	R23ECE-ML3101	Programming on Microcontrollers LAB	0	0	3	2
4	III-II	R23ECE-MT3201	Smart Sensors and Actuators	3	0	0	3
5	III-II	R23ECE-ML320	Embedded System Lab	0	0	3	2
6	IV-I	R23ECE-MT4101	Embedded real time operating systems	3	0	0	3
7	II Year to IV Year	R23ECE-MM0001	Minors MOOCS-1	0	0	0	3
Total							18

Track-II (VLSI DESIGN)							
S.No	Year & Semester	Course Code	Subject title	L	T	P	C
1	II-II	R23ECE-MT2202	Introduction to VLSI Programming	3	0	0	3
2	III-I	R23ECE-MT3102	CMOS digital IC design	3	0	0	3
3	III-I	R23ECE-ML3102	VLSI programming Lab	0	0	3	2
4	III-II	R23ECE-MT3202	Introduction VLSI design flow	3	0	0	3
5	III-II	R23ECE-ML3202	CMOS digital IC design Lab	0	0	3	2
6	IV-I	R23ECE-MT4102	Design for Testability	3	0	0	3
7	II Year to IV Year	R23ECE-MM0001	Minors MOOCS-1	0	0	0	3
Total							18

Track-III (COMMUNICATIONS)							
S.No	Year & Semester	Course Code	Subject title	L	T	P	C
1	II-II	R23ECE-MT2203	Basics of Signal Processing	3	0	0	3
2	III-I	R23ECE-MT3103	Communication Systems	3	0	0	3
3	III-I	R23ECE-ML3103	Signal processing Lab	0	0	3	2
4	III-II	R23ECE-MT3203	Advance Communications systems	3	0	0	3
5	III-II	R23ECE-ML3203	Communication Systems Lab	0	0	3	2
6	IV-I	R23ECE-MT4103	Communication Switching and Techniques	3	0	0	3
7	II Year to IV Year	R23ECE-MM0001	Minors MOOCS-1	0	0	0	3
Total							18

Track-IV (QUANTUM TECHNOLOGIES) (Common to All Branches)							
S.No	Year & Semester	Course Code	Subject title	L	T	P	C
1	II-II	R23ECE-MT2204	Foundations of Quantum Computing: Physics, Engineering, and Mathematics Computing	3	0	0	3
2	III-I	R23ECE-MT3104	Survey of Quantum Technologies and Applications	3	0	0	3
3	III-I	R23ECE-ML3104	Quantum Technology-1 Lab	0	0	3	2
4	III-II	R23ECE-MT3204	Foundations of Quantum Technologies	3	0	0	3
5	III-II	R23ECE-ML3204	Quantum Technology-2 Lab	0	0	3	2
6	IV-I		Elective	3	0	0	3
		R23ECE-MT4104.1	Quantum Computation				
		R23ECE-MT4104.2	Quantum Communications				
7	II Year to IV Year	R23ECE-MM0001	Minors MOOCS-1	0	0	0	3
Total							18

Course code	Subject	L	T	P	C
R23ECE-MT2201	Introduction to Microcontrollers	3	0	0	3

Course Objectives:

1. To introduce the architecture and programming of microcontrollers.
2. To study instruction sets and assembly/C programming for microcontrollers.
3. To understand interfacing techniques for input/output devices.
4. To explain timers, interrupts, and communication protocols.
5. To familiarize students with applications of microcontrollers in real-time systems.

Course Outcomes:

After completion, students will be able to:

1. Explain microcontroller architecture and its features. (L2)
2. Write programs using assembly and embedded C. (L3)
3. Interface I/O devices, sensors, and actuators with microcontrollers. (L3)
4. Apply timers, interrupts, and serial communication in embedded applications. (L4)
5. Develop simple microcontroller-based application systems. (L5)

UNIT-I: Introduction to Microcontrollers

Microprocessor vs. Microcontroller; features and applications of microcontrollers; overview of popular families (8051, AVR, PIC, ARM Cortex-M); architecture of 8051 microcontroller – ALU, registers, program counter, stack, memory organization.

Applications:

1. Used in consumer electronics such as washing machines and microwave ovens.
2. Applied in automotive systems like engine control and airbags.

Learning Outcomes:

1. Differentiate between microprocessors and microcontrollers. (L2)
2. Explain the architecture and internal blocks of 8051. (L2)

UNIT-II: Programming the 8051 Microcontroller

Instruction set categories: data transfer, arithmetic, logical, branch, and bit manipulation instructions; addressing modes; assembly programming examples; introduction to embedded C programming for 8051.

Applications:

1. Used for developing control logic in small embedded devices.
2. Applied in robotics for sensor interfacing and movement control.

Learning Outcomes:

1. Write assembly language programs using 8051 instructions. (L3)
2. Apply embedded C for microcontroller-based applications. (L4)

UNIT–III: I/O Ports, Timers and Interrupts

I / O port structure and interfacing concepts; timers and counters – operation modes, generation of delays, waveform generation; interrupts – types, priority, enabling and handling.

Applications:

1. Used for time-critical applications like PWM motor control.
2. Applied in real-time response systems with interrupts.

Learning Outcomes:

1. Explain the use of timers and counters in microcontrollers. (L2)
2. Implement interrupt-driven applications. (L4)

UNIT–IV: Serial Communication and Peripheral Interfacing

Serial communication basics: UART, SPI, I2C; interfacing with LEDs, seven-segment displays, LCDs, keyboards; ADC and DAC interfacing; sensor and actuator connections.

Applications:

1. Used in IoT devices for communication with sensors and cloud.
2. Applied in industrial automation with serially connected devices.

Learning Outcomes:

1. Describe communication protocols in microcontrollers. (L2)
2. Interface sensors and actuators with microcontrollers. (L3)

UNIT–V: Applications of Microcontrollers

Case studies: traffic light controller, temperature monitoring system, digital voltmeter, motor speed control, security systems; introduction to ARM Cortex-M based microcontrollers for advanced applications.

Applications:

1. Used in home automation systems.
2. Applied in medical devices such as glucose monitors and ECG systems.

Learning Outcomes:

1. Develop small applications using microcontrollers. (L5)
2. Understand emerging trends in advanced microcontroller architectures. (L2)

Textbooks

1. Muhammad Ali Mazidi, *The 8051 Microcontroller and Embedded Systems*, Pearson.
2. Kenneth J. Ayala, *The 8051 Microcontroller: Architecture, Programming and Applications*, Cengage.

Reference Books

1. Raj Kamal, *Microcontrollers: Architecture, Programming, Interfacing and System Design*, Pearson.
2. Mazidi&Naimi, *AVR Microcontroller and Embedded Systems*, Pearson.
3. Joseph Yiu, *The Definitive Guide to ARM Cortex-M3 and M4 Processors*, Newnes.

Course code	Subject	L	T	P	C
R23ECE-MT3101	Embedded system Design	3	0	0	3

Course Objectives:

1. To introduce the fundamentals of embedded systems and their design challenges.
2. To study hardware and software components of embedded systems.
3. To understand embedded system architectures, real-time operating systems, and programming.
4. To analyze system design methodologies, verification, and testing.
5. To apply embedded system design concepts in real-world applications.

Course Outcomes: After completing this course, students will be able to:

1. Explain the characteristics and requirements of embedded systems. (L2)
2. Understand embedded hardware and software components. (L2)
3. Develop programs for embedded systems using C/assembly. (L3)
4. Analyze embedded system design issues such as reliability, performance, and power. (L4)
5. Apply embedded design methodologies to real-time applications. (L3)

UNIT–I: Introduction to Embedded Systems

Definition of embedded system; characteristics; categories; examples of embedded products; design challenges – speed, power, size, cost; applications in consumer, automotive, industrial, and healthcare sectors.

Applications:

1. Used in consumer electronics like smart TVs, washing machines.
2. Applied in automotive systems like ABS, engine control.

Learning Outcomes:

1. Describe the role and importance of embedded systems. (L2)
2. Identify applications of embedded systems in real life. (L2)

UNIT–II: Embedded Hardware Components

Processor classification: microprocessor, microcontroller, DSP, and SOC; memory types: RAM, ROM, Flash, cache; I/O devices; sensors and actuators; buses and interfacing basics.

Applications:

1. Used in data acquisition and control applications.
2. Applied in robotics and automation systems.

Learning Outcomes:

1. Explain hardware components of an embedded system. (L2)
2. Differentiate between processor types and their applications. (L2)

UNIT–III: Embedded Software Components

Embedded programming languages (C, Embedded C, Assembly); device drivers; firmware; bootloaders; middleware; role of compilers, assemblers, and linkers in embedded systems.

Applications:

1. Used in firmware programming for IoT devices.
2. Applied in software-controlled industrial automation.

Learning Outcomes:

1. Develop simple embedded programs. (L3)
2. Explain the role of embedded software and tools. (L2)

UNIT–IV: Real-Time Operating Systems (RTOS)

Concept of RTOS; tasks, processes, and threads; task scheduling; inter-process communication; synchronization; overview of real-time kernels (FreeRTOS, VxWorks, μ C/OS-II).

Applications:

1. Used in mission-critical defense and aerospace systems.
2. Applied in real-time medical devices such as pacemakers.

Learning Outcomes:

1. Explain the importance of RTOS in embedded systems. (L2)
2. Analyze task scheduling and synchronization. (L4)

UNIT–V: Embedded System Design Methodology

Design flow: specification, hardware-software co-design, partitioning, verification, and validation; low-power design; testing and debugging strategies; case studies in automotive, healthcare, and industrial automation.

Applications:

1. Used in low-power wearable medical devices.
2. Applied in smart manufacturing and Industry 4.0 solutions.

Learning Outcomes:

1. Understand the embedded system design flow. (L2)
2. Apply design methodology for real-world case studies. (L3)

Textbooks

1. Raj Kamal, *Embedded Systems: Architecture, Programming and Design*, McGraw Hill.
2. Frank Vahid & Tony Givargis, *Embedded System Design: A Unified Hardware/Software Approach*, Wiley.
3. Shibu K.V., *Introduction to Embedded Systems*, McGraw Hill.

Reference Books

1. Marilyn Wolf, *Computers as Components – Principles of Embedded Computing System Design*, Morgan Kaufmann.
2. Steve Heath, *Embedded Systems Design*, Elsevier.
3. David E. Simon, *An Embedded Software Primer*, Pearson.

Course code	Subject	L	T	P	C
R23ECE-ML3101	Programming on Microcontrollers LAB	0	0	3	2

Course Objectives:

1. To introduce the basic programming concepts of microcontrollers.
2. To provide hands-on experience with I/O interfacing techniques.
3. To familiarize students with timers, interrupts, and serial communication.
4. To develop skills in interfacing sensors and actuators with microcontrollers.
5. To enable students to design and implement simple embedded applications.

Course Outcomes: After completion of the lab, students will be able to:

1. Write and execute programs for microcontroller-based applications.
2. Demonstrate the use of timers, interrupts, and communication protocols.
3. Interface sensors and actuators effectively with microcontrollers.
4. Analyze real-time data acquisition and control through microcontrollers.
5. Design and develop mini embedded projects using microcontrollers.

List of Experiments:

1. Introduction to microcontroller development environment and LED blinking.
2. Digital Input / Output interfacing (switches and LEDs).
3. Seven-segment display interface.
4. LCD display interface.
5. Timer programming for delay generation.
6. Interrupt programming.
7. Serial communication (UART).
8. PWM signal generation.
9. ADC interfacing (e.g., potentiometer/temperature sensor).
10. DAC programming and waveform generation.
11. Stepper motor interfacing.
12. DC motor control using PWM.
13. Sensor interfacing (IR / LDR / Ultrasonic).
14. Mini project using sensors and actuators.

Course code	Subject	L	T	P	C
R23ECE-MT3201	Smart Sensors and Actuators	3	0	0	3

Course Objectives

1. To introduce the fundamentals of sensors and actuators.
2. To understand smart sensor technologies and signal conditioning.
3. To study micro electro mechanical systems (MEMS) in sensing and actuation.
4. To analyze interfacing and communication of smart sensors.
5. To apply smart sensors and actuators in real-world systems.

Course Outcomes: After completing this course, students will be able to:

1. Explain principles of different types of sensors and actuators. (L2)
2. Understand the role of signal conditioning and smart sensing. (L2)
3. Apply MEMS-based devices for sensing and actuation. (L3)
4. Analyze communication interfaces for smart sensors. (L4)
5. Evaluate applications of smart sensors and actuators in modern industries. (L5)

UNIT–I: Introduction to Sensors and Actuators

Definition and characteristics of sensors; classification of sensors – resistive, capacitive, inductive, optical, piezoelectric; static and dynamic characteristics of sensors; overview of actuators – mechanical, electrical, thermal, hydraulic, pneumatic.

Applications:

1. Sensors in automotive crash detection systems.
2. Actuators in robotic manipulators.

Learning Outcomes:

1. Explain working principles of sensors and actuators. (L2)
2. Identify the applications of basic sensing and actuation. (L2)

UNIT–II: Smart Sensors

Concept of smart sensors; self-calibration, self-diagnosis, and self-compensation; on-chip signal processing; integration with microcontrollers/ DSPs; digital sensors; examples – smart temperature, pressure, and motion sensors.

Applications:

1. Smart sensors in wearable health monitoring devices.
2. Smart pressure sensors in aerospace applications.

Learning Outcomes:

1. Describe features and functions of smart sensors. (L2)
2. Apply smart sensors in real-time systems. (L3)

UNIT–III: Signal Conditioning and MEMS Technologies

Signal conditioning: amplification, filtering, ADC/DAC conversion; noise reduction; MEMS-based sensors and actuators: accelerometers, gyroscopes, pressure sensors, micro-mirrors; fabrication basics.

Applications:

1. MEMS accelerometers in smartphones and airbags.
2. MEMS gyroscopes in drones and navigation.

Learning Outcomes:

1. Explain the importance of signal conditioning. (L2)
2. Apply MEMS technology in smart systems. (L3)

UNIT–IV: Interfacing and Communication

Sensor interfacing techniques; digital interfaces – I2C, SPI, UART, CAN, LIN; wireless sensor communication – ZigBee, Bluetooth, Wi-Fi; sensor networks; power requirements and energy harvesting.

Applications:

1. Wireless sensors in smart homes.
2. Industrial automation with CAN-based sensor networks.

Learning Outcomes:

1. Describe communication protocols for smart sensors. (L2)
2. Analyze interfacing challenges in sensor networks. (L4)

UNIT–V: Applications of Smart Sensors and Actuators

Case studies: automotive (ABS, airbag), healthcare (wearables, prosthetics), aerospace (altitude sensing, avionics), robotics (grippers, motion control), smart cities (environmental monitoring).

Applications:

1. Wearable smart prosthetic limbs using actuators.
2. Smart sensors in environmental pollution monitoring.

Learning Outcomes:

1. Identify real-world applications of smart sensors and actuators. (L2)
2. Evaluate performance in case studies. (L5)

Textbooks

1. D. Patranabis, *Sensors and Transducers*, PHI.
2. Ramon Pallas-Areny & John G. Webster, *Sensors and Signal Conditioning*, Wiley.
3. Clarence W. de Silva, *Sensors and Actuators: Control System Instrumentation*, CRC Press.

Reference Books

1. H.S. P. Wong, *Introduction to MEMS*, Oxford University Press.
2. John G. Webster, *Measurement, Instrumentation and Sensors Handbook*, CRC Press.
3. Ernest O. Doebelin, *Measurement Systems: Application and Design*, McGraw-Hill.

Course code	Subject	L	T	P	C
R23ECE-ML3201	Embedded System Lab	0	0	3	2

Course Objectives:

1. To provide practical exposure to embedded system hardware and software tools.
2. To familiarize students with programming microcontrollers for embedded applications.
3. To develop skills in interfacing peripheral devices with embedded processors.
4. To introduce real-time data acquisition and control using embedded platforms.
5. To encourage design of small-scale embedded applications and prototypes.

Course Outcomes: After completion of the lab, students will be able to:

1. Write, compile, and execute embedded programs for microcontroller-based systems.
2. Demonstrate peripheral interfacing with embedded processors.
3. Implement real-time control using timers, interrupts, and communication interfaces.
4. Integrate sensors and actuators into embedded systems.
5. Design and evaluate simple embedded applications.

List of Experiments:

1. Study of embedded development tools and environment setup.
2. LED blinking program on an embedded development board.
3. Digital input/output control (switches and LEDs).
4. Seven-segment display interfacing.
5. LCD display interfacing.
6. Timer programming for delay and periodic tasks.
7. Interrupt handling in embedded systems.
8. Serial communication using UART.
9. PWM generation for motor control.
10. ADC interfacing (e.g., temperature or light sensor).
11. DAC interfacing for waveform generation.
12. Stepper motor interfacing and control.
13. DC motor interfacing and speed control.
14. Mini project: Integration of multiple sensors and actuators for a real-time application.

Course code	Subject	L	T	P	C
R23ECE-MT4101	Embedded real time operating systems	3	0	0	3

Course Objectives :

1. To introduce the fundamentals of real-time systems and operating system concepts.
2. To study RTOS architecture, scheduling algorithms, and task management.
3. To understand inter-task communication, synchronization, and resource sharing.
4. To explore memory management and device drivers in real-time systems.
5. To analyze case studies and applications of RTOS in embedded systems.

Course Outcomes: After completing this course, students will be able to:

1. Explain the fundamentals of real-time systems and constraints. (L2)
2. Analyze scheduling algorithms for real-time tasks. (L4)
3. Apply inter-task communication and synchronization mechanisms. (L3)
4. Understand memory management and device driver concepts in RTOS. (L2)
5. Evaluate RTOS applications in real-world embedded systems. (L5)

UNIT–I: Introduction to Real-Time Systems

Definition and characteristics of real-time systems; hard vs soft real-time systems; examples; RTOS vs general-purpose OS; kernel functions; real-time performance metrics – latency, jitter, response time.

Applications:

1. Real-time OS in automotive braking systems.
2. RTOS in avionics flight control.

Learning Outcomes:

1. Differentiate between real-time and general-purpose OS. (L2)
2. Identify performance metrics in RTOS. (L2)

UNIT–II: RTOS Architecture and Scheduling

RTOS structure – kernel, scheduler, clock, tasks; types of scheduling – cyclic, preemptive, priority-based, round robin; real-time scheduling algorithms – Rate Monotonic Scheduling (RMS), Earliest Deadline First (EDF).

Applications:

1. Task scheduling in robotics controllers.
2. RMS in real-time multimedia systems.

Learning Outcomes:

1. Explain the architecture of RTOS. (L2)
2. Analyze scheduling algorithms for real-time tasks. (L4)

UNIT–III: Task Management and Synchronization

Task creation, deletion, and states; inter-task communication – shared memory, message queues, mailboxes, semaphores, signals; synchronization – mutexes, critical sections, deadlocks, priority inversion and solutions.

Applications:

1. Task synchronization in wireless sensor networks.
2. Deadlock handling in industrial automation.

Learning Outcomes:

1. Apply inter-task communication techniques. (L3)
2. Analyze synchronization and resource-sharing problems. (L4)

UNIT–IV: Memory Management and Device Drivers

Memory organization in RTOS; fixed and dynamic partitioning; memory allocation strategies; memory protection; device drivers in RTOS; interrupt handling and ISR management.

Applications:

1. Memory protection in medical monitoring devices.
2. ISR handling in embedded IoT devices.

Learning Outcomes:

1. Describe memory management strategies in RTOS. (L2)
2. Apply interrupt handling in real-time devices. (L3)

UNIT–V: Case Studies and Applications

Case studies of RTOS: FreeRTOS, VxWorks, QNX, RTLinux, MicroC/OS-II; RTOS applications in automotive, robotics, aerospace, healthcare, and consumer electronics.

Applications:

1. FreeRTOS in smart home devices.
2. VxWorks in Mars rovers.

Learning Outcomes:

1. Compare popular RTOS implementations. (L4)
2. Evaluate RTOS applications in different domains. (L5)

Textbooks

1. Rajib Mall, *Real-Time Systems: Theory and Practice*, Pearson.
2. Qing Li & Caroline Yao, *Real-Time Concepts for Embedded Systems*, CMP Books.
3. Jean J. Labrosse, *MicroC/OS-II: The Real-Time Kernel*, CRC Press.

Reference Books

1. Raj Kamal, *Embedded Systems: Architecture, Programming and Design*, McGraw-Hill.
2. Krishna & Shin, *Real-Time Systems*, McGraw-Hill.
3. Jane W. S. Liu, *Real-Time Systems*, Pearson.
4. Phillip A. Laplante, *Real-Time Systems Design and Analysis*, Wiley.

Course code	Subject	L	T	P	C
R23ECE-MT2202	Introduction to VLSI Programming	3	0	0	3

Course Objectives:

1. To introduce the fundamentals of VLSI design and the role of Hardware Description Languages (HDLs).
2. To familiarize students with Verilog/VHDL syntax and simulation techniques.
3. To develop skills in modeling combinational and sequential digital circuits.
4. To understand test benches, verification methods, and synthesis flow.
5. To encourage design of small-scale digital systems using HDL and FPGA/CPLD boards.

Course Outcomes: After completion of the course, students will be able to:

1. Understand the basics of VLSI design and HDLs.
2. Write Verilog/VHDL programs for combinational and sequential circuits.
3. Simulate, synthesize, and verify digital designs.
4. Apply test benches for functional verification of designs.
5. Implement small digital systems on FPGA/CPLD hardware.

UNIT-I: Introduction to VLSI Design and HDL

VLSI design flow: system specification, RTL design, logic synthesis, physical design; Role of HDLs; Levels of abstraction – behavioral, dataflow, structural, gate level; Introduction to Verilog and VHDL basics: identifiers, operators, data types, and modules.

UNIT-II: Combinational Circuit Design in HDL

Modeling of logic gates; Dataflow modeling using assign statements; Behavioral modeling with always blocks/process statements; Design examples: adders, subtractors, multiplexers, comparators, encoders, decoders.

UNIT-III: Sequential Circuit Design in HDL

Flip-flop modeling (D, T, JK, SR); Registers and shift registers; Counters (synchronous, asynchronous, up, down); FSM modeling: Moore and Mealy machines; HDL code examples and test benches.

UNIT-IV: Simulation, Synthesis, and Verification

Simulation tools and flow; Test bench writing; Stimulus generation; Synthesis constraints; Timing considerations; Functional and gate-level verification; Case study of an RTL to gate-level synthesis.

UNIT-V: FPGA/CPLD Implementation

Introduction to FPGA/CPLD architectures; FPGA design flow; Mapping HDL designs onto FPGA; Basic FPGA experiments – LED blink, counter, traffic light controller; Overview of EDA tools (Xilinx/Altera/Intel).

Textbooks

1. Samir Palnitkar, *Verilog HDL: A Guide to Digital Design and Synthesis*, Pearson.
2. J. Bhasker, *A VHDL Primer*, PHI.
3. S. Brown and Z. Vranesic, *Fundamentals of Digital Logic with VHDL Design*, McGraw Hill.

Reference Books

1. Wayne Wolf, *Modern VLSI Design: System-on-Chip Design*, Pearson.
2. Douglas Perry, *VHDL Programming by Example*, McGraw Hill.
3. M. J. Sebastian Smith, *Application-Specific Integrated Circuits*, Addison-Wesley.

Course code	Subject	L	T	P	C
R23ECE-MT3102	CMOS digital IC design	3	0	0	3

Course Objectives

1. To introduce MOS transistor fundamentals and CMOS process technology.
2. To understand static and dynamic characteristics of CMOS circuits.
3. To design and analyze combinational and sequential CMOS logic circuits.
4. To familiarize with power dissipation, delay, and scaling issues in CMOS design.
5. To introduce VLSI design flow using CMOS design principles.

Course Outcomes

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

1. Explain the operation of MOS transistors and fabrication process (L2).
2. Analyze CMOS inverter characteristics and switching behavior (L4).
3. Design combinational and sequential circuits using CMOS logic (L3).
4. Evaluate power, delay, and area trade-offs in CMOS circuits (L4).
5. Apply CMOS design techniques for real-world VLSI circuits (L3).

Unit-I: MOS Transistor Theory

MOS structure and I-V characteristics; Threshold voltage; MOS capacitances; MOSFET scaling; Second-order effects; Overview of CMOS fabrication process.

Applications:

1. MOS transistors form the building blocks of modern ICs.
2. Used in digital circuits, memory cells, and analog building blocks.

Learning Outcomes:

1. Explain MOSFET operation and electrical characteristics (L2).
2. Analyze the role of threshold voltage and scaling in MOS circuits (L4).

Unit-II: CMOS Inverter

CMOS inverter static characteristics; Noise margins; Switching characteristics; Power dissipation – static and dynamic power; Delay analysis; Sizing of transistors.

Applications:

1. CMOS inverters are widely used in logic gates and buffers.
2. Critical in high-speed and low-power VLSI design.

Learning Outcomes:

1. Interpret inverter transfer characteristics and noise margins (L2).
2. Analyze power-delay trade-offs in CMOS inverters (L4).

Unit-III: Combinational CMOS Logic Circuits

Static CMOS logic – NAND, NOR, AOI, OAI, XOR gates; Pseudo-NMOS logic; Pass transistor logic; Transmission gates; Power and delay considerations.

Applications:

1. Used to implement Boolean functions in processors and controllers.
2. Basis for arithmetic circuits like adders, multiplexers, comparators.

Learning Outcomes:

1. Design and simulate CMOS logic gates (L3).
2. Compare static CMOS, pass-transistor, and pseudo-NMOS styles (L4).

Unit–IV: Sequential CMOS Circuits

Static latches and flip-flops; Dynamic latches and registers; Sense-amplifier circuits; Timing issues – setup and hold time, clock skew; Synchronous vs Asynchronous sequential design.

Applications:

1. Used in memory design, counters, and clocked storage elements.
2. Key in building synchronous processors and digital systems.

Learning Outcomes:

1. Design CMOS latches and flip-flops with timing constraints (L3).
2. Analyze clocking strategies for sequential CMOS design (L4).

Unit–V: CMOS Design Issues and VLSI Design Flow

Power dissipation in CMOS – sources and reduction techniques; Delay estimation and optimization; Scaling and technology trends; CMOS design flow – RTL to GDSII; Introduction to CAD tools.

Applications:

1. Low-power and high-speed design in portable and high-performance systems.
2. Used in ASIC and SoC development for modern electronic products.

Learning Outcomes:

1. Explain power dissipation and delay optimization in CMOS circuits (L2).
2. Apply CMOS design principles in complete VLSI design flow (L3).

Textbooks

1. Neil H.E. Weste, David Harris, *CMOS VLSI Design: A Circuits and Systems Perspective*, Pearson.
2. Sung-Mo Kang, Yusuf Leblebici, *CMOS Digital Integrated Circuits: Analysis and Design*, McGraw Hill.

Reference Books

1. Rabaey, Chandrakasan, Nikolic, *Digital Integrated Circuits: A Design Perspective*, Pearson.
2. Jan M. Rabaey, *Low Power Design Essentials*, Springer.

Course code	Subject	L	T	P	C
R23ECE-ML3102	VLSI programming Lab	0	0	3	2

Course Objectives:

1. To provide hands-on experience with Hardware Description Languages (HDLs) like Verilog/VHDL.
2. To develop skills in modeling and simulation of combinational and sequential logic circuits.
3. To understand test bench creation and verification of HDL programs.
4. To introduce synthesis and implementation of designs on FPGA/CPLD boards.
5. To encourage mini-project based learning using HDL design flow.

Course Outcomes: After completion of the lab, students will be able to:

1. Write HDL programs for basic logic circuits.
2. Model and simulate combinational and sequential digital systems.
3. Develop and apply test benches for verifying digital designs.
4. Synthesize HDL designs and map them to FPGA/CPLD hardware.
5. Design and demonstrate small VLSI-based digital applications.

List of Experiments:

1. Design and simulation of basic logic gates in HDL
2. HDL program for half adder and full adder
3. HDL program for subtractor circuits (half and full subtractor)
4. Design of 4:1 multiplexer and 1:4 demultiplexer using HDL
5. Design of 4-bit comparator using HDL
6. HDL modeling of decoder and encoder
7. HDL implementation of priority encoder
8. HDL program for D, T, JK, and SR flip-flops
9. HDL design of shift register (SISO, SIPO, PISO, PIPO)
10. HDL program for synchronous and asynchronous counters
11. HDL modeling of finite state machine (Moore & Mealy)
12. HDL simulation of 4-bit ALU
13. HDL design of a traffic light controller
14. FPGA implementation of a mini-project (e.g., digital clock, sequence detector)

Course code	Subject	L	T	P	C
R23ECE-MT3202	Introduction VLSI design flow	3	0	0	3

Course Objectives:

1. To introduce VLSI system design concepts, IC technologies, and applications.
2. To explain fabrication steps and CMOS process technology.
3. To describe design rules, stick diagrams, and layout fundamentals.
4. To analyze MOS transistor modeling, scaling, and performance issues.
5. To demonstrate the complete VLSI design flow from RTL to layout.

Course Outcomes: By the end of the course, students will be able to:

1. Explain VLSI design methodologies and system hierarchy (L2).
2. Illustrate CMOS fabrication steps and process flow (L3).
3. Apply design rules to construct layouts and stick diagrams (L3).
4. Analyze MOS transistor scaling effects and performance trade-offs (L4).
5. Understand the complete RTL-to-layout VLSI design flow (L2).

UNIT-I: Introduction to VLSI Systems

VLSI Design process: Levels of abstraction; VLSI design styles – full custom, standard cell, gate array, FPGA; Applications of VLSI in processors, memories, DSPs, and communication ICs.

Learning Outcomes:

- Describe IC design methodologies and system hierarchy.
- Compare different VLSI design styles and their applications.

UNIT-II: VLSI Fabrication Technology

NMOS, PMOS, CMOS processes; Silicon wafer preparation; Oxidation; Lithography; Diffusion and ion implantation; Metallization; CMOS process integration.

Learning Outcomes:

- Understand CMOS fabrication process and steps.
- Illustrate how process technology impacts IC design.

UNIT-III: MOS Transistor Modeling and Scaling

MOSFET operation and characteristics; Threshold voltage; MOS capacitances; Scaling of MOS circuits – constant field scaling, voltage scaling, power density issues.

Learning Outcomes:

- Explain MOSFET operation and derive I-V equations.
- Analyze the effect of scaling on power and performance.

UNIT-IV: Stick Diagrams and Layout Design Rules

Design rules – lambda-based layout design; Stick diagrams for logic gates; Examples of inverter, NAND, NOR, multiplexer layouts; Parasitics in layout.

Learning Outcomes:

- Apply lambda-based design rules for layout.
- Construct stick diagrams for CMOS logic gates.

UNIT-V: VLSI Design Flow (RTL to Layout)

Design abstraction levels – behavioral, RTL, gate, layout; HDL-based design entry; Functional simulation; Logic synthesis; Placement, routing, and floorplanning; Layout generation; Verification – DRC and LVS.

Learning Outcomes:

- Understand step-by-step VLSI design flow from RTL to GDSII.
- Apply HDL tools for design, simulation, and verification.

Textbook (Single Source)

- **Douglas A. Pucknell & Kamran Eshraghian, “Basic VLSI Design,” PHI.**

Textbooks:

1. Jan M. Rabaey, *Digital Integrated Circuits: A Design Perspective*, Pearson.
2. S.M. Kang & Y. Leblebici, *CMOS Digital Integrated Circuits: Analysis and Design*, McGraw Hill.
3. Wayne Wolf, *Modern VLSI Design: Systems on Silicon*, Pearson.

Reference Books:

1. Douglas A. Pucknell & Kamran Eshraghian, *Basic VLSI Design*, PHI.
2. John P. Uyemura, *Introduction to VLSI Circuits and Systems*, Wiley.

Course code	Subject	L	T	P	C
R23ECE-ML3202	CMOS digital IC design Lab	0	0	3	2

Course Objectives:

1. To provide practical exposure to CMOS device characteristics and modeling.
2. To design and simulate CMOS combinational and sequential circuits.
3. To analyze inverter transfer characteristics, noise margins, and power-delay trade-offs.
4. To study dynamic and static CMOS logic implementations.
5. To familiarize with CAD tools for CMOS circuit simulation and layout design.

Course Outcomes: After completing the lab, students will be able to:

1. Demonstrate MOSFET characteristics using simulation tools (L2).
2. Design and analyze CMOS inverters and logic gates (L3).
3. Implement combinational and sequential circuits using CMOS logic styles (L3).
4. Measure power consumption, propagation delay, and noise margins in CMOS circuits (L4).
5. Develop layouts and verify design rules in CMOS VLSI design flow (L3).

List of Experiments (14):S

1. Study of CMOS design tools – Introduction to schematic entry, simulation, and layout editor.
2. DC characteristics of MOS transistor – ID–VDS and ID–VGS curves.
3. CMOS Inverter static characteristics – Transfer curve, threshold voltage, noise margins.
4. Transient response of CMOS Inverter – Rise time, fall time, propagation delay.
5. Power dissipation analysis in CMOS Inverter – Static and dynamic power.
6. Design of basic logic gates (NAND, NOR, XOR) using CMOS logic.
7. Complex CMOS logic design – AOI and OAI circuits.
8. Pass-transistor and transmission gate logic design – XOR/XNOR implementation.
9. Sequential circuits – Design of latches and flip-flops (SR, D, JK).
10. Static and dynamic registers – Timing analysis (setup/hold time, clock skew).
11. Design of combinational blocks – Full adder, multiplexer using CMOS logic.
12. Layout design of CMOS inverter – Stick diagram, layout verification, DRC.
13. Layout of CMOS logic gates – NAND, NOR, XOR with LVS check.
14. Mini project – Low-power CMOS design (e.g., 4-bit adder, counter, or memory cell).

Tools Recommended

- Cadence Virtuoso / Synopsys Custom Designer / Mentor Graphics Tanner EDA
- Microwind + DSCH for educational setup
- SPICE simulation tools (NgSpice, LTSpice, HSpice)

Course code	Subject Name	L	T	P	C
R23ECE-MT4102	Design for Testability	3	0	0	3

Course Objectives:

1. To introduce the need for testing and fault modeling in VLSI circuits.
2. To study design for testability techniques for combinational and sequential circuits.
3. To understand Built-In Self-Test (BIST) and boundary scan testing.
4. To analyze automatic test pattern generation (ATPG) methods.
5. To provide hands-on exposure to test and verification tools.

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

1. Explain fault models and testing principles for digital circuits.
2. Apply testability measures to combinational and sequential logic.
3. Design BIST and scan-based architectures.
4. Generate test patterns using ATPG algorithms.
5. Evaluate trade-offs between testability, performance, and cost in VLSI systems.

UNIT-I: Fundamentals of Testing

Basic concepts of testing; Role of testing in VLSI design flow; Types of faults – stuck-at faults, bridging faults, delay faults; Fault equivalence and dominance; Fault simulation techniques.

Learning Outcomes:

- Explain the importance of testing in IC design.
- Classify different fault models.

UNIT-II: Testability Measures and Combinational Circuit Testing

Controllability and observability; SCOAP measures; Combinational circuit test generation; Testability enhancement techniques; Random and deterministic test patterns.

Learning Outcomes:

- Apply testability metrics to digital circuits.
- Generate tests for combinational logic faults.

UNIT-III: Sequential Circuit Testing and Scan Design

Testing of sequential circuits; State-table verification; Scan design – level-sensitive scan design (LSSD), partial scan, boundary scan (IEEE 1149.1 standard).

Learning Outcomes:

- Differentiate between combinational and sequential test strategies.
- Design scan architectures for improved testability.

UNIT-IV: Built-In Self-Test (BIST)

BIST concepts; Pattern generation – LFSR, cellular automata; Response compaction; Signature analysis; Memory BIST; Logic BIST.

Learning Outcomes:

- Design LFSR-based test pattern generators.
- Apply BIST for logic and memory circuits.

UNIT-V: Automatic Test Pattern Generation (ATPG)

ATPG problem formulation; Path sensitization method; D-algorithm; PODEM; Fault coverage; Design verification with ATPG.

Learning Outcomes:

- Generate test patterns using ATPG algorithms.
- Evaluate fault coverage efficiency.

Textbooks:

1. M.L. Bushnell & V.D. Agrawal, *Essentials of Electronic Testing for Digital, Memory, and Mixed-Signal VLSI Circuits*, Springer, 2000.
2. Charles E. Stroud, *A Designer's Guide to Built-In Self-Test*, Springer, 2002.

Reference Books:

1. Michael L. Bushnell, Vishwani D. Agrawal, *VLSI Test Principles and Architectures: Design for Testability*, Morgan Kaufmann, 2006.
2. Abramovici, Breuer & Friedman, *Digital Systems Testing and Testable Design*, Wiley-IEEE, 1990.
3. Miron Abramovici, *Fault Tolerant Systems*, Springer, 2009.

Course code	Subject	L	T	P	C
R23ECE-MT2203	Basics of Signal Processing	3	0	0	3

Course Objectives:

1. To introduce fundamental concepts of signals and systems.
2. To analyze signals in both time and frequency domains.
3. To study Fourier series, Fourier transform, and Laplace/Z-transform techniques.
4. To understand the design principles of basic digital filters.
5. To develop problem-solving skills in signal representation and processing.

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

1. Classify signals and systems and understand their properties.
2. Apply Fourier analysis techniques for signal representation.
3. Analyze systems using convolution, correlation, and transforms.
4. Perform sampling and reconstruct signals without distortion.
5. Design simple digital filters for signal enhancement.

UNIT-I: Introduction to Signals and Systems

Classification of signals: continuous-time and discrete-time signals; deterministic and random signals; periodic and aperiodic signals. Basic operations on signals: scaling, shifting, folding. Classification of systems: linear/non-linear, time-invariant/time-variant, causal/non-causal, stable/unstable systems.

Learning Outcomes:

- Differentiate between various types of signals and systems.
- Apply basic signal operations in problem-solving.

UNIT-II: Time-Domain Analysis

Impulse response, convolution sum and integral, correlation functions, properties of convolution and correlation. Analysis of Linear Time Invariant (LTI) systems.

Learning Outcomes:

- Analyze LTI systems using convolution.
- Compute auto-correlation and cross-correlation for signal analysis.

UNIT-III: Fourier Analysis

Fourier series representation of periodic signals; Fourier transform of continuous and discrete-time signals; Properties of Fourier transform; Applications in communication and filtering.

Learning Outcomes:

- Represent periodic and aperiodic signals using Fourier analysis.
- Apply Fourier transform properties in system analysis.

UNIT-IV: Signal Transforms

Laplace transform – definition, properties, ROC, inverse transform. Z-transform – definition, properties, ROC, inverse transform. Application of Laplace and Z-transforms in system analysis.

Learning Outcomes:

- Use Laplace transform for analyzing continuous-time systems.
- Apply Z-transform for discrete-time signal and system analysis.

UNIT-V: Sampling and Digital Filter Basics

Sampling theorem, aliasing, reconstruction of signals from samples. Basics of digital filters – FIR and IIR filters, design considerations, simple filter examples.

Learning Outcomes:

- Explain the concept of sampling and aliasing.
- Design and analyze basic FIR and IIR filters.

Textbooks

1. A.V. Oppenheim & A.S. Willsky, *Signals and Systems*, PHI.
2. Simon Haykin & Barry Van Veen, *Signals and Systems*, Wiley.

Reference Books

1. John G. Proakis & Dimitris G. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*, Pearson.
2. B.P. Lathi, *Signal Processing and Linear Systems*, Oxford University Press.
3. Alan V. Oppenheim & Ronald W. Schaffer, *Discrete-Time Signal Processing*, Pearson.

Course code	Subject	L	T	P	C
R23ECE-MT3103	Communication Systems	3	0	0	3

Course Objectives

1. To introduce the fundamental concepts of analog and digital communication systems.
2. To analyze amplitude, frequency, and phase modulation techniques.
3. To study digital modulation methods and their performance in noise.
4. To understand information theory, coding, and data transmission aspects.
5. To familiarize with modern communication systems including cellular and satellite.

Course Outcomes

After undergoing the course, students will be able to:

1. Analyze the performance of analog communication techniques. (L4)
2. Compare various digital modulation schemes with respect to efficiency. (L4)
3. Understand the impact of noise in communication systems. (L2)
4. Apply coding and information theory principles for reliable transmission. (L3)
5. Explain the principles of cellular, satellite, and wireless communication systems. (L2)

UNIT-I: Introduction to Communication Systems

Elements of communication system; Need for modulation; Baseband vs Passband signals; Analog vs Digital communication; Electromagnetic spectrum; Noise in communication (thermal, shot, white noise).

Applications:

1. Used in radio, television, and satellite broadcasting.
2. Applicable in wireless and wired digital transmission.

Learning Outcomes:

1. Explain the need and role of modulation. (L2)
2. Classify noise types and their impact on signals. (L3)

UNIT-II: Analog Modulation

Amplitude Modulation (AM), DSB-SC, SSB, VSB; Frequency Modulation (FM), Phase Modulation (PM); Demodulation methods; Spectrum and bandwidth considerations; Superheterodyne Receiver.

Applications:

1. AM/FM used in broadcasting systems.
2. Applied in aircraft and marine communication.

Learning Outcomes:

1. Analyze modulation techniques with spectrum efficiency. (L4)
2. Explain the working of radio receivers. (L2)

UNIT-III: Digital Modulation

Pulse modulation: PAM, PWM, PPM; PCM, Delta modulation, Adaptive Delta modulation. Digital carrier modulation: ASK, FSK, PSK, QPSK, QAM. Signal-to-noise ratio, Bit error rate.

Applications:

1. Used in telephony, computer networks, and cellular systems.
2. Applied in modern digital TV and satellite transmission.

Learning Outcomes:

1. Compare digital modulation techniques for data transmission. (L4)
2. Analyze error probability in different modulation schemes. (L3)

UNIT-IV: Information Theory and Coding

Entropy, mutual information, channel capacity (Shannon theorem); Source coding (Huffman, Shannon-Fano); Error control coding: Linear block codes, CRC, convolutional codes.

Applications:

1. Used in data compression (audio, video, text).
2. Applied in error-free transmission over noisy channels.

Learning Outcomes:

1. Apply Shannon's theorem to calculate channel capacity. (L3)
2. Explain various coding methods for error detection/correction. (L2)

UNIT-V: Modern Communication Systems

Cellular concepts: frequency reuse, handoff, multiple access techniques (FDMA, TDMA, CDMA, OFDM); Satellite communication: orbits, link design; Optical communication basics.

Applications:

1. Used in 2G/3G/4G/5G mobile systems.
2. Applied in DTH and satellite internet services.

Learning Outcomes:

1. Explain cellular communication principles. (L2)
2. Describe satellite and optical communication systems. (L2)

Textbooks

1. Simon Haykin, *Communication Systems*, Wiley, 4th Edition.
2. B.P. Lathi, *Modern Digital and Analog Communication Systems*, Oxford, 4th Edition.

Reference Books

1. Taub & Schilling, *Principles of Communication Systems*, McGraw Hill.
2. John G. Proakis & Masoud Salehi, *Fundamentals of Communication Systems*, Pearson.

Course code	Subject	L	T	P	C
R23ECE-ML3103	Signal processing Lab	0	0	3	2

Course Objectives:

1. To practice time- and frequency-domain analysis of signals.
2. To implement convolution, correlation, and system characterization.
3. To explore Fourier, Laplace/Z, and discrete transforms computationally.
4. To apply sampling, reconstruction, and spectral estimation techniques.
5. To design and test basic FIR/IIR digital filters.

Course Outcomes: After completing the lab, students will be able to:

1. Analyze and visualize signals in time and frequency domains.
2. Implement convolution/correlation and interpret system behavior.
3. Compute and interpret DFT/FFT, DTFT, and spectra.
4. Apply sampling theory, windowing, and spectral estimation.
5. Design, implement, and evaluate FIR/IIR filters.

List of Experiments (S. No & Name Only)

1. Signal Generation and Basic Operations (shift, scale, fold)
2. Discrete Convolution (Linear vs Circular)
3. Auto- and Cross-Correlation of Signals
4. DTFT Sampling and Reconstruction Insight
5. DFT/FFT Computation and Spectral Leakage
6. Window Functions (Rect/Hann/Hamming/Blackman) and Effects
7. Filtering in Frequency Domain (Ideal Low/High/Band Filters)
8. FIR Filter Design using Windows (LP/HP/BP/BS)
9. IIR Filter Design (Butterworth/Chebyshev) and Stability
10. z-Plane Poles–Zeros and Frequency Response Visualization
11. Sampling Theorem Demo: Aliasing and Reconstruction
12. System Identification: LTI Impulse & Step Response Estimation
13. Short-Time Fourier Transform (STFT) and Spectrograms
14. Mini-Project: End-to-End DSP Chain (Acquisition → Processing → Output)

Want this customized for **MATLAB** or **Python** with starter code templates and datasets?

Course code	Subject	L	T	P	C
R23ECE-MT3203	Advance Communications systems	3	0	0	3

Course Objectives:

1. To introduce the fundamental principles of advanced communication domains such as optical, satellite, microwave, wireless, and radar systems.
2. To understand the basic working, design issues, and performance parameters of each communication system.
3. To provide knowledge of modulation, multiplexing, and link budget concepts used in modern communication.
4. To expose students to the applications of different communication technologies in real-time scenarios.
5. To prepare students with a broad understanding of integrated advanced communication systems.

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

1. Explain the basics of satellite communication including orbits, transponders, and link budget.
2. Analyze the working of microwave communication systems and their propagation characteristics.
3. Demonstrate understanding of optical fiber communication fundamentals such as attenuation, dispersion, and optical components.
4. Describe the principles of wireless communication and evaluate multiplexing and access schemes.
5. Understand radar system operation and applications in defense, navigation, and remote sensing.

UNIT-I: Satellite Communication

Satellite orbits; geostationary and non-geostationary systems; earth stations; satellite transponders; link budget analysis; applications: broadcasting, navigation, remote sensing.

UNIT-II: Microwave Communication

Microwave spectrum, LOS communication, tropospheric scatter links, repeaters, and fading effects; microwave antennas; applications in terrestrial and space communication.

UNIT-III: Optical Fiber Communication

Optical fiber structures and types; light propagation; attenuation and dispersion mechanisms; optical sources (LED, Laser) and detectors (PIN, APD); optical link design basics.

UNIT-IV: Wireless Communication

Basics of wireless communication systems; propagation models (free space, multipath, fading); multiplexing and multiple access techniques (FDMA, TDMA, CDMA); cellular system basics.

UNIT-V: Radar Systems

Radar fundamentals: basic principle, block diagram; radar range equation; types of radar – pulse, CW, Doppler, synthetic aperture radar; applications in aviation, defense, and weather monitoring.

Textbooks

1. Simon Haykin, *Communication Systems*, Wiley, 5th Edition.
2. Dennis Roddy, *Satellite Communications*, McGraw Hill, 4th Edition.

Reference Books

1. John G. Proakis & Masoud Salehi, *Communication Systems Engineering*, Pearson, 2nd Edition.
2. Anokh Singh, *Microwave Engineering*, S. Chand.
3. B.P. Lathi & Zhi Ding, *Modern Digital and Analog Communication Systems*, OUP, 4th Edition.
4. Merrill Skolnik, *Introduction to Radar Systems*, McGraw Hill, 3rd Edition.

Course code	Subject	L	T	P	C
R23ECE-ML3203	Communication Systems Lab	0	0	3	2

Course Objectives:

1. To familiarize students with the generation and detection of analog modulation schemes (AM, FM, PM).
2. To study and implement various pulse modulation techniques such as PAM, PWM, PPM, and PCM.
3. To understand and analyze digital modulation techniques like ASK, FSK, PSK, and QPSK.
4. To introduce multiplexing techniques and evaluate their role in communication systems.
5. To provide hands-on exposure to error detection and correction coding schemes in digital communication.

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

1. Demonstrate the working of basic analog modulation and demodulation techniques.
2. Analyze and compare the characteristics of various pulse modulation techniques.
3. Implement and evaluate different digital modulation schemes for data transmission.
4. Design and perform experiments on multiplexing techniques used in communication.
5. Apply error control coding techniques to ensure reliable communication.

List of Experiments:

1. Amplitude Modulation and Demodulation.
2. Frequency Modulation and Demodulation.
3. Phase Modulation and Demodulation.
4. Spectrum Analysis of AM, FM, and PM Signals.
5. Pulse Amplitude Modulation (PAM) and Demodulation.
6. Pulse Width Modulation (PWM) and Demodulation.
7. Pulse Position Modulation (PPM) and Demodulation.
8. Pulse Code Modulation (PCM) and Demodulation.
9. Delta Modulation and Adaptive Delta Modulation.
10. Amplitude Shift Keying (ASK) Modulation and Demodulation.
11. Frequency Shift Keying (FSK) Modulation and Demodulation.
12. Phase Shift Keying (PSK) and Quadrature PSK.
13. Time Division Multiplexing (TDM) and Demultiplexing.
14. Simulation of Error Detection and Correction using Linear Block Codes / CRC.

Course code	Subject	L	T	P	C
R23ECE-MT4103	Communication Switching and Techniques	3	0	0	3

Course Objectives: The course aims to:

1. Introduce the fundamentals of switching systems and their evolution.
2. Develop understanding of traffic engineering and performance measures in communication networks.
3. Explain the principles of circuit, message, and packet switching with architectures.
4. Provide knowledge of signaling techniques including SS7 and ISDN.
5. Familiarize students with modern switching concepts such as ATM, Frame Relay, and IP-based networks.

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

1. Describe the evolution and operation of various switching systems.
2. Apply traffic engineering concepts to analyze and design switching networks.
3. Differentiate between circuit, packet, and message switching techniques.
4. Demonstrate understanding of signaling protocols such as SS7 and ISDN.
5. Analyze modern switching methods and compare their performance in communication networks

UNIT-I: Introduction to Switching Systems

Evolution of telecommunications; Basics of switching systems – Manual, Electromechanical and Electronic switching; Concept of space and time switching; Stored Program Control (SPC) – architecture and advantages.

UNIT-II: Telecommunication Traffic

Traffic engineering concepts: Arrival patterns, Holding time distribution, Load and Grade of Service (GoS); Blocking probability models – Erlang B and Erlang C formulas; Delay systems; Dimensioning of switching systems.

UNIT-III: Circuit Switching

Circuit switched networks – principles, features, and architectures; Space division switching – crossbar, multistage, blocking and non-blocking systems; Time division switching – TSI, time and space combination, TST switches.

UNIT-IV: Packet and Message Switching

Message switching and its limitations; Packet switching – concepts, datagram and virtual circuit switching, routing, congestion control; Comparison with circuit switching; Introduction to Frame Relay and ATM switching principles.

UNIT-V: Signalling and Modern Switching Techniques

Signalling systems – In-channel, Common Channel Signaling (CCS), SS7 protocol; Integrated Services Digital Network (ISDN) – architecture, services, and protocols; Evolution towards Next Generation Networks (NGN); IP-based switching concepts.

Text books

1. J.E. Flood – *Telecommunications Switching, Traffic and Networks*, Pearson.
2. Thiagarajan Viswanathan – *Telecommunication Switching Systems and Networks*, PHI.

Reference Books

1. J.C. Bellamy – *Digital Telephony*, Wiley.
2. Wayne Tomasi – *Introduction to Data Communications and Networking*, Pearson.

Course code	Subject	L	T	P	C
R23ECE-MT2204	Foundations of Quantum Computing: Physics, Engineering, and Mathematics Computing	3	0	0	3

Course Objectives:

- To develop a strong foundation in linear algebra, essential for quantum states and operators.
- To understand probability and statistics for quantum measurement and noise analysis.
- To explore Hamiltonian and Lagrangian mechanics as a bridge to quantum mechanics.
- To introduce electromagnetic theory relevant to quantum waveguides and optical systems.
- To study classical computing and digital logic as a stepping stone to quantum circuits.

Course Outcomes:

After successful completion of the course, the student should be able to:

- Apply concepts of vector spaces, matrices, and eigenvalue problems to quantum system modeling. (L3)
- Analyze statistical behavior of qubits using probability and interpret quantum measurement outcomes. (L3)
- Apply classical mechanics principles (Hamiltonian/Lagrangian) to understand quantum evolution. (L3)
- Explain EM wave propagation and field quantization for quantum hardware applications. (L2)
- Compare classical digital logic and architecture with quantum gates and processors. (L3)

UNIT – I: Mathematical Foundations for Quantum Systems

- Vector spaces, basis, and dimension
- Inner product, orthogonality, Hilbert spaces
- Complex matrices and linear transformations
- Eigenvalues, eigenvectors, and diagonalization
- Applications to quantum state representation and gate operations

Learning Outcomes:

- Understand how quantum states are represented in Hilbert space using linear algebra.
- Compute eigenvalues/eigenvectors for describing quantum observables.

UNIT – II: Probability, Statistics, and Classical Mechanics Foundations

- Descriptive statistics and probability basics
- Random variables and common distributions
- Lagrangian and Hamiltonian formulations
- Relation between classical Hamiltonians and quantum operators

Learning Outcomes:

- Apply statistical models to interpret qubit state probabilities and measurement results.
- Describe the transition from classical to quantum systems using Hamiltonian formalism.

UNIT – III: Electromagnetic Theory in Quantum Context

- Maxwell's equations (time and phasor domain)
- Wave propagation in dielectric and conducting media
- EM waves in optical fibers and waveguides
- Energy transport and quantization of EM waves

Learning Outcomes:

- Analyze EM wave behavior in classical and quantum transmission media.
- Relate classical EM theory to quantum field quantization in optics and waveguides.

UNIT – IV: Computer Architecture: Classical vs Quantum

- Von Neumann architecture and CPU design
- Memory hierarchy and instruction cycles
- Comparison with quantum computer models (control and memory)
- Limitations of classical systems for quantum operations

Learning Outcomes:

- Explain the working of classical processors and memory systems.
- Differentiate between classical and quantum architecture principles.

UNIT – V: Digital Logic and Circuit Fundamentals for Quantum Systems

- Number systems and data representation
- Basic logic gates and Boolean algebra
- Combinational circuit design
- Reversible logic and its relevance to quantum computation

Learning Outcomes:

- Design basic digital logic circuits and understand their role in classical computing.
- Explain the need for reversible logic in quantum gates and circuits.

Text Books

1. **Bernard Kolman & David Hill**, *Elementary Linear Algebra with Applications*, Pearson, 2013.
2. **Ron Larson**, *Elementary Statistics: Picturing the World*, 8th Edition, Pearson, 2023.

Reference Books

1. **Herbert Goldstein**, *Classical Mechanics*, 3rd Edition, Addison Wesley.
2. **D.J. Griffiths**, *Introduction to Electrodynamics*, 4th Edition, Cambridge University Press, 2020.
3. **M. Morris Mano**, *Computer System Architecture*, Prentice Hall.
4. **Thomas L. Floyd**, *Digital Fundamentals*, 11th Edition, Pearson.
5. **M. Morris Mano**, *Digital Logic and Computer Design*, Pearson.

Course code	Subject	L	T	P	C
R23ECE-MT3104	Survey of Quantum Technologies and Applications	3	0	0	3

Course Objectives:

- To introduce the four foundational verticals of quantum technologies: computation, communication, sensing, and materials.
- To provide students with qualitative understanding of key quantum physics principles behind modern quantum tech.
- To explore the real-world hardware platforms used to build quantum systems.
- To introduce applications and potential impact of quantum technologies in real systems.
- To build awareness of India's and global quantum research directions and strategic roadmaps.

Course Outcomes:

After successful completion of the course, students will be able to:

- Describe the basic physical principles of quantum phenomena such as superposition, entanglement, and tunneling. (L2)
- Explain different physical implementations of qubits and their applications in quantum computing. (L2)
- Understand the working and application of quantum sensing devices such as atomic clocks and magnetometers. (L2)
- Explain core principles and real-world implementations of quantum communication systems. (L2)
- Discuss recent advances and future directions in quantum technologies across multiple domains. (L2)

UNIT – I: Introduction to Quantum Technologies and Principles of Quantum Physics

- Overview of the four verticals in quantum technology
- Motivation for quantum technologies in India and globally
- Quantum states and wavefunctions
- Measurement and observables, Hermitian operators
- Heisenberg uncertainty, Schrödinger equation
- Key quantum phenomena: Superposition, Entanglement, No-cloning theorem
- Feynman's quantum simulator idea

Learning Outcomes:

- Identify fundamental differences between classical and quantum systems.
- Describe core quantum mechanical concepts necessary for technological applications.

UNIT – II: Quantum Computation: Qubits, Circuits, and Implementations

- What is a qubit ? Comparison with classical bits
- Review of classical logic gates
- Di Vincenzo criteria
- Basic quantum gates and circuits
- Hardware implementations (qualitative):
 - Superconducting qubits (charge, flux, phase)
 - Semiconductor qubits (quantum dots, spins)
 - Topological qubits

- Trapped ions, Rydberg atoms, NV centers, NMR qubits
- Photonic and integrated photonic qubits
- Applications: RSA breaking with Shor's algorithm, Grover's algorithm
- Quantum error correction overview

Learning Outcomes:

- Identify and describe various types of physical qubits.
- Explain the structure and use of basic quantum circuits.

UNIT – III: Quantum Sensing: Theory and Applications

- Introduction to quantum sensing and metrology
- Single-photon and entangled-photon detection
- Quantum-enhanced measurements
- Gravimetry, Magnetometry, Atomic clocks
- Real-world quantum sensing platforms and global status

Learning Outcomes:

- Explain the working principles of quantum sensors.
- List practical applications of quantum-enhanced measurement systems.

UNIT – IV: Quantum Communication: Principles and Platforms

- Basics of classical digital communication
- Shannon entropy and classical information theory
- Quantum key distribution (QKD) and security principles
- Eavesdropping and no-cloning
- Quantum communication via fiber and satellite
- Overview of major global projects (Micius satellite, India's QKD experiments)

Learning Outcomes:

- Describe how quantum mechanics ensures secure communication.
- Differentiate fiber-based and satellite-based QKD systems.

UNIT – V: Integration, Roadmaps and Future Trends

- Overview of cross-domain quantum technologies
- National and global roadmaps (India Quantum Mission, EU QT Flagship, IBM, Google)
- Research challenges in scaling, error correction, and decoherence
- Interdisciplinary role of quantum materials (brief integration)
- Quantum advantage and commercialization of quantum systems

Learning Outcomes:

- Summarize current national/global strategies in quantum tech development.
- Identify open problems and future research opportunities in quantum systems.

Textbooks:

1. **Manenti R., Motta M.**, *Quantum Information Science*, 1st Edition, Oxford University Press, 2023
2. **M. A. Nielsen & I. L. Chuang**, *Quantum Computation and Quantum Information*, 10th Anniversary Edition, Cambridge University Press, 2010

Reference Books:

1. **A. Pathak**, *Elements of Quantum Computation and Quantum Communication*, CRC Press, 2015
2. **Phillip Kaye, Raymond Laflamme, Michele Mosca**, *An Introduction to Quantum Computing*, Oxford University Press, 2006
3. **David McMahon**, *Quantum Computing Explained*, Wiley, 2008

Course code	Subject	L	T	P	C
R23ECE-ML3104	Quantum Technology-1 Lab	0	0	3	2

Course Objectives

1. To equip students with computational techniques (Python/Julia/Matlab) for solving matrix problems, eigenvalue problems, and data fitting.
2. To enable understanding of quantum mechanical systems through simulations of two-level systems, Rabi oscillations, and the Jaynes–Cummings model.
3. To provide exposure to classical experiments such as the Zeeman effect, RLC circuits, and polarization optics.
4. To introduce finite element and numerical methods for solving electromagnetism-related problems.
5. To integrate hardware and computational experiments to develop problem-solving and analytical skills.

Course Outcomes: After completing this lab, students will be able to:

1. Implement numerical methods (matrix operations, SVD, Monte Carlo methods, least squares fitting) and validate with simulations.
2. Analyze and simulate quantum phenomena like coupled two-level systems, Rabi oscillations, and light–matter interaction models.
3. Perform and interpret classical physics experiments such as the Zeeman effect, diffraction, interference, and polarization optics.
4. Apply computational methods to solve problems in electromagnetism, such as electrostatic charge distributions.
5. Design, build, and test simple electronic and digital circuits (RLC resonance, digital logic circuits).

List of experiments:

A. Numerical Techniques (Computational – Python/Julia/Matlab)

1. Matrix Inverse & Eigenvalue Problem – Implement numerical methods to compute inverse and eigenvalues of matrices; validate with built-in libraries.
2. Singular Value Decomposition (SVD) – Decompose a matrix, demonstrate data compression/denoising applications.
3. Monte Carlo Sampling & Random Number Generation – Generate pseudo-random numbers and apply Monte Carlo integration for estimating π or other functions.
4. Least Squares Fitting & Error Analysis – Fit experimental/synthetic data to models; analyze errors and residuals.

B. Applications to Quantum Mechanics (Computational Quantum Physics)

5. Eigen Energies of Coupled Two-Level Systems – Numerical diagonalization to find eigen energies and eigenstates.
6. Jaynes-Cummings Model Simulation – Study eigen energies of a two-level system coupled to an oscillator.
7. Rabi Oscillations in Driven Two-Level System – Simulate time evolution of population inversion under resonant drive.
8. ZEEMAN EFFECT experiment.
Tools: Zeeman effect kit

C. Applications to Electromagnetism & Optics (Simulation + Bench Experiments)

9. Electrostatic Charge Distributions (Finite Element Simulation) – Solve Laplace's equation for simple geometries (parallel plates, spheres).

10. Diffraction & Interferometry – Experimental setup for single-slit diffraction and interferometric measurement of wavelength.
11. Polarization Optics – Study of Polarizing Beam Splitter (PBS), Half-Wave Plate (HWP), and Quarter-Wave Plate (QWP).

D. Circuits & Digital Systems (Hardware)

12. Series & Parallel RLC Circuits – Measure resonance curves, extract quality factor and intrinsic losses.
13. Digital Circuits with ICs – Implementation of Adder, Encoder/Decoder, and D Flip-Flop using IC chips.

Reference Books :

1. Numerical Recipes in C/Python/Fortran, W.H. Press et al., Cambridge University Press.
2. Computational Physics, N. J. Giordano & H. Nakanishi, Pearson Education.
3. Principles of Quantum Mechanics, R. Shankar, Springer.
4. Optics, Eugene Hecht, Pearson.
5. Fundamentals of Electric Circuits, Charles K. Alexander & Matthew N.O. Sadiku, McGraw Hill

Course code	Subject	L	T	P	C
R23ECE-MT3204	Foundations of Quantum Technologies	3	0	0	3

Course Objectives:

- To introduce the key principles of quantum mechanics in a simple and intuitive manner.
- To connect quantum ideas with real-life applications in communication, computing, and sensing.
- To expose students to basic concepts from quantum information, statistical physics, and computational models relevant to emerging technologies.
- To develop problem-solving skills by applying quantum principles to simplified models of physical systems.
- To create a foundational platform for students to pursue advanced courses or research in quantum technologies

Course Outcomes:

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

1. Explain key differences between classical and quantum systems using real-world examples.
2. Describe quantum mechanical concepts such as superposition, uncertainty, and entanglement.
3. Understand the role of spin and entanglement in modern technologies like quantum communication.
4. Recognize how noise and decoherence impact quantum devices.
5. Appreciate the potential of quantum computing and the need for post-quantum cryptography.

Unit 1: Introduction to Quantum Ideas

Classical to quantum thinking is introduced using experiments like the photoelectric effect and blackbody radiation. Key discoveries such as Planck's quantum hypothesis, Bohr's atomic model, and wave-particle duality (de Broglie) are covered with real-world relevance (e.g., LEDs, solar cells).

Learning Outcomes:

- Understand the origin of quantum theory from experimental evidence.
- Relate quantum ideas to practical devices like photovoltaics and optoelectronics.

Unit II: Basics of Quantum Mechanics

Concept of quantum states, wave functions, and probabilities. Dirac notation (bra-ket), superposition, and measurement. Real-life examples such as electron in an atom, and quantum tunneling,. Simple models like a particle in a box and harmonic oscillator,

Learning Outcomes:

- Represent quantum states mathematically using wavefunctions and Dirac notation.
- Apply quantum concepts to simple physical systems.

Unit III: Spin, Entanglement, and Quantum Applications

Using simple models (like spin- $\frac{1}{2}$ particles), and how entanglement plays a role in quantum communication. Quantum teleportation and quantum key distribution,. The no-cloning theorem and quantum superposition, secure data sharing and quantum sensing.

Learning Outcomes:

- Describe spin and entanglement with simple quantum models.
- Demonstrate how entanglement underpins quantum communication and sensing.

Unit IV: Basics of Quantum Information and Noise

Quantum information differs. Shannon entropy, and its quantum counterpart (von Neumann entropy) noise, decoherence, and the challenge of maintaining quantum states in real systems, communication channels and qubit errors.

Learning Outcomes:

- Compare classical and quantum information measures.
- Analyze the effects of decoherence and errors in practical quantum devices.

Unit V: Introduction to Quantum Computation and Post-Quantum Ideas

Quantum computers powerful is provided, including the idea of quantum parallelism. The concept of computational problems (like searching and factoring) ,. Complexity classes such as P, NP, and BQP. The importance of quantum-safe encryption and post-quantum cryptography .

Learning Outcomes:

- Explain the principles that make quantum computing powerful.
- Appreciate the importance of post-quantum cryptography in modern security

Text/Reference Books:

1. Griffiths, D. J., *Introduction to Quantum Mechanics*, Cambridge Univ. Press (2024)
2. A. Pathak, *Elements of Quantum Computation and Quantum Communication*, CRC Press (2015)
3. Nielsen & Chuang, *Quantum Computation and Quantum Information*, Cambridge Univ. Press (2010)
4. Quantum Physics for Beginners – *NPTEL Video Lectures*, Prof. V. Balakrishnan (IIT Madras)
5. Manenti& Motta, *Quantum Information Science*, Oxford Univ. Press (2023)

Course code	Subject	L	T	P	C
R23ECE-ML3204	Quantum Technology-2 Lab	0	0	3	2

Course Objectives

1. To introduce the principles of RF measurements, including transient response, S-parameters, and spectrum analysis.
2. To develop the ability to design and analyze basic digital logic circuits and understand their timing characteristics.
3. To expose students to advanced signal processing techniques such as homodyne and heterodyne detection.
4. To provide hands-on experience with quantum computing simulators, quantum gates, and entanglement.
5. To apply concepts of quantum cryptography through simulation of secure key distribution protocols.

Course Outcomes

After completing this lab, students will be able to:

1. Perform RF characterization using oscilloscope, vector network analyzer, and spectrum analyzer.
2. Design, test, and troubleshoot digital logic circuits for real-world applications.
3. Implement and compare homodyne and heterodyne detection for weak signal recovery.
4. Simulate and analyze quantum states, superposition, measurements, and entanglement using Qiskit.
5. Demonstrate secure communication by implementing the BB84 quantum key distribution protocol.

LIST OF EXPERIMENTS

A. Radio Frequency Technology (Measurement & Analysis)

1. Oscilloscope-Based Ring-Up & Ring-Down in RLC Circuits – Study transient response and measure damping.
2. Vector Network Analyzer (VNA) Characterization – Transmission/reflection measurements of coaxial cables (open, short, matched); extract S-parameters and plot VSWR.
3. Spectrum Analyzer—Noise from a Resistor
Aim: Measure thermal noise vs temperature/bandwidth; compare theory.
Tools: Spectrum analyzer, precision resistors, temp control (optional).
4. Digital Logic: Adder, Decoder & D Flip-Flop
Aim: Build/test basic IC logic blocks; timing & hazards.
Tools: Breadboard, TTL/CMOS ICs, DSO, PSU.
5. Data Acquisition and Demodulation: Homodyne vs Heterodyne Detection
Objective: Compare two demodulation schemes for weak signal recovery
Tools: ADC, MATLAB/Python, signal generator
Learning: Quantum signal detection techniques
6. Introduction to Qiskit and IBM Quantum Lab
 - Objective: Familiarize with the quantum circuit composer and running circuits on simulators.
 - Tools: Qiskit, IBM Quantum Composer
 - Equipment: PC with internet, Python + Qiskit
7. Quantum States and Superposition

- Objective: Construct single-qubit circuits to observe $|0\rangle$, $|1\rangle$, and superposition states.
 - Tools: QiskitStatevector simulator
 - Output: Visualize Bloch sphere and probability amplitudes
8. Measurement and Probability in Quantum Systems
 - Objective: Implement basic measurement circuits and interpret probabilistic outcomes.
 - Tools: Qiskit Aer
 - Equipment: Online IDE or Jupyter Notebook
 9. Quantum Gates and Reversibility
 - Objective: Construct and verify effects of X, H, Z, and composite gates.
 - Output: Truth table comparison with classical logic
 10. Entanglement Using Bell States
 - Objective: Create and measure Bell pairs using H and CNOT gates.
 - Verification: Bell inequality simulation
 11. BB84 Quantum Key Distribution (Quantum Cryptography) Objective: Simulate BB84 protocol for secure key generation
Output: Compare error rate with and without eavesdropper
 12. QKD with Eavesdropper Detection
Objective: Model Eve in BB84, simulate her measurement, and detect error rate.
Discussion: Quantum no-cloning theorem implications

Reference Books:

1. David M. Pozar, *Microwave Engineering*, Wiley, 4th Edition, 2011.
2. Guillermo Gonzalez, *Microwave Transistor Amplifiers: Analysis and Design*, Prentice Hall, 2nd Edition, 1996.
3. Michael A. Nielsen & Isaac L. Chuang, *Quantum Computation and Quantum Information*, Cambridge University Press, 2010.
4. Chris Bernhardt, *Quantum Computing for Everyone*, MIT Press, 2019.
5. Robert A. Meyers (Ed.), *Encyclopedia of Complexity and Systems Science – Quantum Computing Section*, Springer, 2009

Course code	Subject	L	T	P	C
R23ECE-MT4104.1	Quantum Computation	3	0	0	3

Course Objectives:

- Introduce quantum computing concepts in comparison to classical computing.
- Explain how qubits work and how they are physically realized.
- Teach students fundamental quantum algorithms and their applications.
- Familiarize students with current quantum processors and platforms.
- Highlight practical uses and industry trends in quantum computing.

Course Outcomes:

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

1. Understand and differentiate classical bits from qubits.
2. Build simple quantum circuits and simulate them using open-source tools.
3. Implement and explain beginner-level quantum algorithms.
4. Gain awareness of real-world quantum processors and their applications.
5. Recognize the challenges and opportunities in quantum error correction and NISQ devices.

Unit 1: Introduction to Quantum Information

- Classical vs Quantum bits (Qubits)
- Real-world examples: Spin systems, photon polarisation
- Practical technologies: Trapped ions, superconducting circuits, quantum dots
- Bloch sphere visualization
- One and two-qubit gates (CNOT, Hadamard, Pauli gates)

Unit 2: Quantum Logic and Entanglement

- Basic quantum gates and circuits
- Reversible computation vs classical irreversible logic
- Entanglement explained with simple visual examples
- Bell's inequality and its experimental significance

Unit 3: Quantum Algorithms - Basics

- Deutsch and Deutsch-Jozsa algorithm
- Bernstein-Vazirani algorithm
- Grover's Algorithm: Introduction to quantum search
- Simon's Algorithm: Application in pattern discovery

Unit 4: Quantum Algorithms – Advanced

- Shor's algorithm: Integer factorisation and RSA cracking
- Quantum Fourier Transform (QFT)
- Variational Quantum Eigensolver (VQE) for chemistry problems
- Quantum Approximate Optimization Algorithm (QAOA)

Unit 5: Real-World Quantum Computing

- NISQ era – What does it mean?
- IBM Quantum, Google Sycamore, IonQ – hands-on introduction
- Quantum error correction basics – simple 3-bit code
- Fault-tolerant computing: Intuitive understanding
- Roadmap to future quantum computers

TEXT / REFERENCE BOOKS:

- Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023)
- Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010)
- A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015)
- Quantum error correction and Fault tolerant computing, Frank Gaitan, 1st edition, CRC Press (2008)
- Quantum computing explained, David McMahon, Wiley (2008)

Course code	Subject	L	T	P	C
R23ECE-MT4104.2	Quantum Communications	3	0	0	3

Course Objectives: This course aims to

1. Introduce the fundamental principles of polarization optics and photo detection relevant to quantum communications.
2. Develop an understanding of classical information theory and its extension into quantum information.
3. Familiarize students with fundamental no-go theorems and quantum resources such as entanglement, quantum memories, and repeaters.
4. Provide a deep understanding of quantum communication protocols such as teleportation, dense coding, and QKD.
5. Explore real-world implementations of quantum communication through fiber, free-space, and satellite-based systems.

Course Outcomes: After completing this course, students will be able to:

1. Explain the basics of electromagnetic theory and polarization optics in communication systems.
2. Demonstrate knowledge of linear and square-law photodetectors for quantum communication applications.
3. Apply concepts of classical and quantum information theory to understand data transmission.
4. Analyze and explain key quantum communication protocols including teleportation, dense coding, and QKD.
5. Evaluate and compare hardware implementations of quantum networks and the emerging quantum internet.

Unit I – Polarization Optics and Photodetection

- Basics of polarization optics: principles, applications.
- Quarter-wave and half-wave plates.
- Polarizing beam splitters and their role in quantum optics.
- Basics of linear and square-law detectors.
- Photodetection fundamentals: photomultipliers, avalanche photodiodes.

Learning Outcomes:

- Understand polarization states and optical components used in quantum communication.
- Explain the operation and applications of photodetectors.

Unit II – Detection and Modulation Techniques

- Quadrature amplitude modulation.
- Heterodyne and homodyne demodulation.
- Intensity measurements and square-law detectors.
- Noise in photodetection and its impact on measurements.

Learning Outcomes:

- Demonstrate the principles of modulation and detection in optical/quantum systems.
- Compare linear vs square-law detection methods.

Unit III – Information Theory Foundations

- Basics of digital communication and information theory.
- Information entropy and mutual information.
- Noiseless channel encoding.
- Noisy channel encoding and Shannon's theorem.

Learning Outcomes:

- Define entropy and its significance in communication.
- Apply encoding schemes for reliable information transfer.

Unit IV – Quantum Principles and Protocols

- No-cloning theorem.
- Quantum memories and quantum repeaters.
- Entanglement and Bell's Theorems.
- Bell measurements and experimental tests.
- Quantum teleportation protocol.
- Quantum dense coding.

Learning Outcomes:

- Explain the no-cloning principle and its implications for security.
- Analyze entanglement-based communication protocols.
- Demonstrate understanding of quantum teleportation and dense coding.

Unit V – Quantum Cryptography and Quantum Networks

- Quantum key distribution (QKD) protocols: BB84, E91, BBM92, B92, COW, DPS.
- Quantum networks and the concept of the quantum internet.
- Survey of hardware implementations:
 - Free-space quantum communication.
 - Satellite-based quantum links.
 - Fiber-optic-based communication systems.

Learning Outcomes:

- Compare and contrast various QKD protocols.
- Evaluate implementation strategies for large-scale quantum networks.
- Discuss the feasibility and progress toward a quantum internet.

References:

1. Nielsen, M. A., & Chuang, I. L., *Quantum Computation and Quantum Information*, Cambridge University Press, Cambridge (2010).
2. Pathak, A., *Elements of Quantum Computation and Quantum Communication*, CRC Press, Boca Raton (2015).

R23_Open Electives Courses for ECE

Offering Department: Electrical and Electronics Engineering						
S.No	Course Code	Course Name	L	T	P	Credits
1	R23EEE-OE0001	Renewable Energy Sources	3	0	0	3
2	R23EEE-OE0002	Energy Conservation and Management	3	0	0	3
3	R23EEE-OE0003	Electrical Safety & Standards	3	0	0	3
4	R23EEE-OE0004	Utilization of Electrical Energy	3	0	0	3

Offering Department: Mechanical Engineering						
S.No	Course Code	Course Name	L	T	P	Credits
1	R23MEC-OE0001	Operations Research	3	0	0	3
2	R23MEC-OE0002	3D Printing Technology	3	0	0	3
3	R23MEC-OE0003	Statistical quality control	3	0	0	3
4	R23MEC-OE0004	Hybrid Vehicle Technologies	3	0	0	3
5	R23MEC-OE0005	Industrial Robotics	3	0	0	3
6	R23MEC-OE0006	Nano Materials	3	0	0	3
7	R23MEC-OE0007	AI and ML In Manufacturing	3	0	0	3
8	R23MEC-OE0008	Automation in Manufacturing	3	0	0	3

Offering Department: Computer Science and Engineering & Allied Branches

S.No	Course Code	Course Name	L	T	P	Credits
1	R23CSE-OE0001	Python Programming	3	0	0	3
2	R23CSE-OE0002	Data Structures Using C	3	0	0	3
3	R23CSE-OE0003	Operating System Concepts	3	0	0	3
4	R23CSE-OE0004	Introduction to Java Programming	3	0	0	3
5	R23CSE-OE0005	Database Management Systems Concepts	3	0	0	3
6	R23CSE-OE0006	Unix & Shell Programming	3	0	0	3
7	R23CSE-OE0007	Software Engineering	3	0	0	3
8	R23CSE-OE0008	Introduction to Data mining	3	0	0	3
9	R23CSE-OE0009	Fundamentals of Web Technologies	3	0	0	3
10	R23CSE-OE0010	Fundamentals of Computer Networks	3	0	0	3
11	R23CSE-OE0011	Basics of Cloud Computing	3	0	0	3
12	R23CSE-OE0012	Introduction to Machine Learning	3	0	0	3
13	R23CSE-OE0013	Essentials of Cyber Security	3	0	0	3
14	R23CSE-OE0014	Introduction to React JS	3	0	0	3
15	R23CSE-OE0015	Deep Learning	3	0	0	3
16	R23CSE-OE0016	DevOps	3	0	0	3
17	R23CSE-OE0017	Mobile Computing	3	0	0	3
18	R23CSE-OE0018	Java Full Stack Development	3	0	0	3
19	R23CSE-OE0019	Human Computer Interface	3	0	0	3
20	R23CSE-OE0020	Cryptography and Network Security	3	0	0	3
21	R23CSE-OE0021	Quantum Computing	3	0	0	3
22	R23CSE-OE0022	Big data Analytics	3	0	0	3
23	R23CSE-OE0023	Block Chain Technology	3	0	0	3
24	R23CSE-OE0024	Multimedia Application Development	3	0	0	3
25	R23CSE-OE0025	Mobile Adhoc Networks	3	0	0	3
26	R23CSS-OE0001	Operating Systems	3	0	0	3
27	R23CSS-OE0002	Redhat Linux	3	0	0	3
28	R23CSS-OE0003	Cloud Computing	3	0	0	3
29	R23CSS-OE0004	Distributed Operating System	3	0	0	3
30	R23CIT-OE0001	Basics of Computer Networks	3	0	0	3
31	R23CIT-OE0002	Cryptography and Network Security	3	0	0	3
32	R23CIT-OE0003	Mobile Computing	3	0	0	3
33	R23CIT-OE0004	Wireless sensor networks	3	0	0	3
34	R23CSM-OE0001	An Introduction to Artificial Intelligence	3	0	0	3
35	R23CSM-OE0002	Introduction to Machine Learning with Python	3	0	0	3
36	R23CSM-OE0003	Foundation of Deep Learning for Engineering Applications	3	0	0	3
37	R23CSM-OE0004	Natural Language Processing- Frontiers Approach	3	0	0	3

OPEN ELECTIVES

Course code	Course Title	L	T	P	Credits
R23ECE-OE0001	Basics of Communication Systems (Open Elective)	3	0	0	3

Course Objectives:

- Introduce the fundamental principles of analog and digital communication systems.
- Understand the representation and transmission of signals.
- Learn the basics of amplitude, frequency, and phase modulation techniques.
- Study noise performance in communication systems.
- Introduce multiplexing and multiple access techniques.

Course Outcomes:

1. Understand the fundamental elements of communication systems. (L2)
2. Explain various analog and digital modulation techniques. (L2)
3. Analyze the effect of noise on communication signals. (L4)
4. Understand bandwidth and power requirements in modulation schemes. (L2)
5. Describe basic multiplexing techniques and system applications. (L2)

UNIT – I

Introduction to Communication Systems: Basic block diagram of a communication system, types of communication (analog and digital), electromagnetic spectrum, frequency bands, and applications in daily life.

UNIT – II

Amplitude Modulation: Principles of amplitude modulation (AM), modulation index, power and bandwidth of AM, generation and detection of AM signals, DSB-SC and SSB modulation.

UNIT – III

Angle Modulation: Frequency modulation (FM) and phase modulation (PM), modulation index, bandwidth of FM (Carson's Rule), generation and demodulation techniques of FM signals.

UNIT – IV

Noise and Performance Analysis: Types of noise, noise figure, signal-to-noise ratio (SNR), effect of noise on AM and FM systems, pre-emphasis and de-emphasis.

UNIT – V

Multiplexing and Digital Communication Basics: Time Division Multiplexing (TDM), Frequency Division Multiplexing (FDM), basic digital communication concepts (PCM, ASK, FSK, PSK), comparison of analog and digital systems.

Textbooks

1. Simon Haykin, Communication Systems, Wiley.
 2. B.P. Lathi, Modern Digital and Analog Communication Systems, Oxford University Press.
 3. Sanjay Sharma, Communication Systems, S.K. Kataria & Sons. (Indian Author)
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Course code	Course Title	L	T	P	Credits
R23ECE-OE0002	Micro Processors and Interfacing (Open Elective)	3	0	0	3

Course Objectives: students are provided with

- 8085 8-bit architecture and register organization.
- 8086 architecture, memory segmentation & organization and features of minimum and maximum mode operations.
- Programming of 8086 in assembly language and tools.
- Interfacing memory and various peripheral control devices with 8086.

Course Outcomes: Student is able to

1. Outline the architecture and working diagram of 8085 microprocessors. **(L2)**
2. Interpret the 8086 functioning in minimum mode and maximum mode with its architecture, memory segmentation and organization. **(L2)**
3. Construct Assembly language program for 8086 using assembler directives, addressing modes and instruction set. **(L3)**
4. Develop Interface circuits with various peripheral control ICs for 8086 system. **(L3)**
5. Designing various memory interfacing Circuits with 8086 system. **(L3)**

UNIT 1

Introduction to 8085 Microprocessor: Basic microprocessor system-working, 8085 Microprocessor Architecture, register organization, Pin Diagram, Flag Register, Instruction Cycle, Timing Diagram, Interrupts of 8085.

UNIT 2

8086 Microprocessor: Evolution of Microprocessors, Register Organization of 8086, Architecture, Pin Diagram, Memory segmentation and organization, Stack implementation, Interrupt structure of 8086. minimum and maximum mode microprocessor system, Timing diagram and General Bus operation.

UNIT 3

8086 Programming: Addressing Modes, Instruction Set of 8086, Assembly Language Programming: Assembler Directives, Simple programs, Procedures and Macros Program.

UNIT 4

Data Transfer Schemes and Principle Interfacing: IO Interfacing: Programmable Peripheral Interface 8255 and its applications, Programmable Interrupt Controller 8259 with examples, Programmable Communication Interface 8251 USART, DMA Controller 8257, Programmable Keyboard and Display Interface 8279.

UNIT-5

Memory and IO Interfacing 8086: Address decoding techniques, Interfacing Static RAM and ROM chips, ADC and DAC Interfacing.

Text Books:

1. Microprocessor Architecture Programming and Applications with the 8085, 6th edition, Ramesh S Gaonkar, Penram International Publishing, 2013
2. Advanced Microprocessors and Peripherals, 3e, K M Bhurchandi, A K Ray, McGraw Hill Education, 2017.

References:

1. The Intel Microprocessors: Architecture, Programming and Interfacing, Barry B.Brey, PHI, 6th Edition.
2. Microprocessors and Interfacing, 2e, Douglas.V.Hall, Tata McGrawhill.

Course code	Course Title	L	T	P	Credits
R23ECE-OE0003	Digital System Design using Verilog (Open Elective)	3	0	0	3

Course Objectives:

- To introduce the basics and programming fundamentals of Verilog HDL
- To describe the primitive instances of gates and explain the various modeling constructs of Verilog.
- To familiarize various behavioral modeling constructs of Verilog essential for designing digital circuits.
- To Design and implement various combinational logic circuits in Verilog HDL
- To Design and implement various sequential logic circuits in Verilog HDL.

Course Outcomes:

At the end of the Course, the Student will be able to:

1. Understand the fundamentals of Digital System Design flow using Verilog HDL. (L2)
2. Construct logic circuits with the concept of Gate Level and Dataflow modelling (L3)
3. Construct logic circuits with the concept of Behavioral modelling. (L3)
4. Make use of Verilog programming to design Combinational digital circuits. (L3)
5. Develop synthesizable Verilog codes for sequential digital circuits. (L3)

UNIT-I

Introduction to Verilog HDL: Introduction, Verilog as HDL, Basic elements: Keywords, Identifiers, Comments, Tasks and functions, Numbers, Strings, Logic Values, Data Types, Scalars and Vectors, Parameters, Operands and Operators. Simulation and Synthesis Tools.

UNIT-II

Gate Level Modeling: Introduction, Module Structure, Different Gate Primitives, Array of Instances of Primitives, Illustrative Examples,

Data Flow Modeling: Introduction, Continuous Assignment Structure, Delays, and Assignment to Vectors, Operators and different Examples.

UNIT-III

Behavioral Modeling: Blocking and Non-Blocking Assignments, Simulation Flow : if and if-else constructs, case statement, Assign-De-Assign construct, different loop constructs, Examples

UNIT IV

Design of combinational circuits Elements using HDL models: Logic gates, Half Adders, Full Adders, Subtractors, Decoders, Encoders, Multiplexers, and De-multiplexers & Comparators,

UNIT-V

Design of Sequential circuits Elements using HDL models: RS, D, T, JK Latches & Flip Flops, Registers and Counters.

Text Books

1. T.R Padmanabhan, B.Bala Tripura Sundari Design through Verilog HDL, Wiley India Publications, 2009
2. J.Bhaskar, A Verilog HDL Primer, BS Publications, 3rd Edition.

Reference Books

1. Verilog HDL – Samir Palnitkar, 2nd Edition, Pearson Education, 2009
2. John F.Wakerly , Digital Design, Pearson, 4th Edition.
3. Zainalabdien Navabi, Verilog Digital System Design, TMH, 2nd Edition.

Course code	Course Title	L	T	P	Credits
R23ECE-OE0004	Fundamentals of Digital Image Processing (Open Elective)	3	0	0	3

Course Objectives:

- Introduce the basic concepts and techniques of digital image processing.
- Understand image acquisition, sampling, and quantization processes.
- Study image enhancement and filtering techniques in spatial and frequency domains.
- Explore image segmentation and representation techniques.
- Learn the basics of morphological processing and image compression.

Course Outcomes:

1. Understand image formation, sampling, and quantization techniques. (L2)
2. Apply spatial and frequency domain enhancement methods. (L3)
3. Analyze filtering and edge detection techniques. (L4)
4. Understand image segmentation and morphological operations. (L2)
5. Identify compression techniques and their applications. (L2)

UNIT – I

Introduction and Image Fundamentals: Definition of digital image, image sensing and acquisition, image sampling and quantization, basic relationships between pixels, color image fundamentals, and image file formats.

UNIT – II

Image Enhancement in Spatial Domain: Intensity transformations, histogram processing, spatial filtering, smoothing and sharpening filters, and contrast enhancement techniques.

UNIT – III

Image Enhancement in Frequency Domain: Fourier Transform, frequency domain filtering, low-pass and high-pass filters, homomorphic filtering, and enhancement using Discrete Cosine Transform (DCT).

UNIT – IV

Image Segmentation and Morphology: Edge detection using gradient operators, thresholding techniques, region-based segmentation, morphological operations like dilation, erosion, opening, and closing.

UNIT – V

Image Compression and Representation: Lossless and lossy compression techniques, run-length coding, Huffman coding, JPEG, wavelet-based compression, and basics of image representation and description.

Textbooks:

1. Rafael C. Gonzalez & Richard E. Woods, Digital Image Processing, Pearson.
 2. Anil K. Jain, Fundamentals of Digital Image Processing, PHI Learning. (Indian Author)
 3. S. Jayaraman, S. Esakkirajan, and T. Veerakumar, Digital Image Processing, McGraw-Hill. (Indian Author)
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Course code	Course Title	L	T	P	Credits
R23ECE-OE0005	Introduction to Internet of Things (Open Elective)	3	0	0	3

Course Objectives:

- To Understand the Architectural Overview of IoT and layers involved in Architecture.
- To Understand Real World Design Constraints of IOT and Various Protocols.
- To familiarize the students to the basics of Internet of things and protocols.
- To expose the students to some of the hardware and Software applications areas where Internet of Things can be applied.

Course Outcomes:

The students should be able to:

1. Understand the architecture of IoT systems, including the components and their roles.(L2)
2. Interface various electronic components, including LEDs, push buttons, buzzers, and LCD displays, with the Arduino board.(L3).
3. Establish remote access to the Raspberry Pi for control and management.(L3)
4. Apply knowledge to develop basic IoT applications using the ESP8266.(L3)

Understand the fundamentals of virtualization and cloud computing architecture.(L2)

UNIT - I

Introduction to IOT: Understanding IoT fundamentals, IOT Architecture and protocols, Various Platforms for IoT, Real time Examples of IoT , Overview of IoT components and IoT Communication Technologies ,Challenges in IOT.

UNIT - II

Arduino Simulation Environment: Arduino Uno Architecture, Setup the IDE, Writing Arduino Software, Arduino Libraries, Basics of Embedded C programming for Arduino, Interfacing LED, push button and buzzer with Arduino, Interfacing Arduino with LCD. Sensor & Actuators with Arduino

UNIT - III

Raspberry Pi Programming: Installing and Configuring the Raspberry Pi, Getting Started with the Raspberry Pi, Using the Pi as a Media Centre, Productivity Machine and Web Server, Remote access to the Raspberry Pi. Preparing Raspberry Pi for IoT Projects.

UNIT - IV

Basic Networking with ESP8266 WiFi module : Basics of Wireless Networking, Introduction to ESP8266 Wi-Fi Module ,Various Wi-Fi library , Web server introduction, installation, configuration ,Posting sensor(s) data to web server .IoT Protocols ,M2M vs. IOT Communication Protocols.

UNIT - V

Cloud Platforms for IOT : Virtualization concepts and Cloud Architecture , Cloud computing, benefits ,Cloud services -- SaaS, PaaS, IaaS , Cloud providers & offerings ,Study of IOT Cloud platforms , ThingSpeak API and MQTT , interfacing ESP8266 with Web services

Text Books:

1. Simon Monk, Programming Arduino: Getting Started with Sketches, Second Edition McGraw- Hill Education
2. Peter Waher, Learning Internet of Things, Packt publishing.
3. Ovidiu Vermesan, Peter Friess, IoT-From Research and Innovation to Market deployment, River Publishers

Reference Books:

1. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2014.
2. Peter Waher, "Learning Internet of Things", PACKT publishing, BIRMINGHAM – MUMBAI
3. Bernd Scholz-Reiter, Florian Michahelles, "Architecting the Internet of Things", ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer.

Course code	Course Title	L	T	P	Credits
R23ECE-OE0006	Wireless Sensor Networks (Open Elective)	3	0	0	3

Course Objectives:

- Emphasize the basic WSN technology and sensor node architecture with its unique constraints and challenges in design of WSN for different applications.
- Summarize the transceiver design and network technologies used in wireless sensor and networks.
- Explains various key MAC protocols for sensor networks with their merits and demerits.
- Provide knowledge of different routing protocols with their advantages.
- Create awareness on transport layer protocols, security considerations, sensor network platforms and tools with a brief study of different WSN applications.

Course Outcomes:

1. Illustrate the wireless sensor node architectures.
2. Outline the physical layer design.
3. Inspect MAC protocols of wireless sensor and networks.
4. Infer various network layer routing protocols of wireless sensors.
5. Summarize the network security requirements.

UNIT-I

Overview of Wireless Sensor Networks: Key definitions of sensor networks, advantages of sensor networks, unique constraints and challenges, driving application, enabling technologies for wireless sensor networks.

Architectures:

Single-node architecture - hardware components, energy consumption of sensor nodes, operating system and execution environments, network architecture- sensor network scenarios, optimization goals and figures of merit, gateway concepts.

UNIT - II

Networking Technologies: Physical layer and transceiver design consideration, personal area networks (PANs), hidden node and exposed node problem, topologies of PANs, MANETs, and WANETs.

UNIT - III

MAC Protocols for Wireless Sensor Networks: issues in designing a MAC protocol for Ad Hoc Wireless Networks, Design goals of a MAC protocol for Ad Hoc Wireless Networks, Classifications of MAC Protocols, Contention -Based Protocols, contention - based protocols with reservation mechanism, contention - based MAC protocols with scheduling Mechanisms, MAC protocols that use directional antennas, others MAC protocols.

UNIT - IV

Routing Protocols: introduction, issues in designing a routing protocols for Ad Hoc Wireless Networks, classification of routing protocols, table- driven routing protocols, On-Demand routing protocols, Hybrid routing protocols, routing protocols with efficient flooding mechanisms, hierarchical routing protocols, power- aware routing protocols, proactive routing.

UNIT-V

Transport Layer and Security Protocols: Introduction, issues in designing a transport layer protocol for Ad Hoc wireless networks, design goals of a transport layer protocol for Ad Hoc wireless networks, Security in Ad Hoc wireless networks, network security requirements, issues and challenges in security provisioning, network security attacks, key management, secure routing in Ad Hoc wireless Networks.

Sensor Network Platforms and Tools:

Sensor node hardware - Berkeley motes, programming challenges, node- level software platforms, node-level simulators, state - centric programming.

Textbooks

1. Ad Hoc wireless networks: Architectures and protocols - C.Siva Ram Murthy and B.S.Manoj, 2004, PHI.
2. Wireless Ad - Hoc and Sensor Networks: Protocols, Performance and Control - Jagannathan Sarangapani, CRC Press.
3. Holger Karl & Andreas Willig, Protocol and Architectures for Wireless Sensor Networks, John Wiley, 2005.

References

1. Kazem Sohraby, Daniel Minoli, & Taieb Zanti, "Wireless Sensor Networks - Technology, Protocols and Applications", John Wiley, 2007.
 2. Feng Zhao & Leonidas J.Guibas, "Wireless Sensor Networks - An Information Processing Approach", Elsevier, 2007.
 3. Ad Hoc Mobile Wireless Networks: Protocols & Systems, C.K.Toh, 1ed, Pearson Education.
 4. Wireless Sensor Networks - C.S.Raghavendra, Krishna M.Sivalingam, 2004, Springer.
 5. Wireless Sensor Networks - S Anandamurugan, Lakshmi Publications
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Course code	Course Title	L	T	P	Credits
R23ECE-OE0007	Satellite Communication (Open Elective)	3	0	0	3

Course Objectives:

- Introduce the basic concepts and architecture of satellite communication systems.
- Understand satellite orbits, launch methods, and positioning techniques.
- Study satellite subsystems including transponders and antennas.
- Learn about satellite link design and signal propagation.
- Explore multiple access techniques and satellite applications.

Course Outcomes:

1. Understand satellite system architecture and functions. (L2)
2. Analyze orbital mechanics and satellite positioning. (L4)
3. Understand the design and working of satellite subsystems. (L2)
4. Analyze satellite link budgets and signal propagation. (L4)
5. Understand access techniques and applications in communication systems. (L2)

UNIT – I

Overview of Satellite Communications: Introduction to satellite communication, advantages and limitations, types of satellites, satellite applications in communication, broadcasting, navigation, and remote sensing.

UNIT – II

Orbital Mechanics and Launchin: Kepler's laws, orbital elements, types of satellite orbits (LEO, MEO, GEO), look angle determination, eclipse effects, and satellite launching methods.

UNIT – III

Satellite Subsystems: Space segment and ground segment, transponders, antenna systems, telemetry, tracking and command (TT&C), and power systems.

UNIT – IV

Satellite Link Design and Propagation: Link power budget, system noise temperature, C/N ratio, G/T ratio, propagation effects such as rain attenuation, free-space loss, and ionospheric effects.

UNIT – V

Access Techniques and Applications: FDMA, TDMA, CDMA in satellite communication, VSAT systems, satellite mobile communication, GPS, and DTH systems.

Textbooks:

1. Dennis Roddy, Satellite Communications, McGraw-Hill.
2. Timothy Pratt et al., Satellite Communications, Wiley India.
3. T. K. Bandopadhyay, Satellite Communication, PHI Learning. (Indian Author)

Course code	Course Title	L	T	P	Credits
R23ECE-OE0008	Fundamentals of Embedded Systems (Open Elective)	3	0	0	3

Course Objectives

- Basic fundamentals and components of a typical embedded system.
- Embedded system development as a hardware design and firmware design methodologies, tools and integration.
- Understand the need and development of hardware software codesign.
- Aware of the interrupt service mechanism and device driver programming.
- Understand the working of real time operating systems.

Course Outcomes

1. Illustrate the working of various components of a typical embedded system. (L2)
2. Develop hardware and firmware design methodologies, tools and integration for a embedded system. (L3)
3. Discuss the importance and development using hardware software codesign. (L2)
4. Summarize the interrupt service mechanism and device driver programming. (L2)
5. Outline the real time operating system functions and study of a deployed RTOS. (L2)

UNIT-I

Introduction to Embedded System: Embedded System, Embedded System Vs General Computing System, History of Embedded Systems, Classification of Embedded System, major Application Areas, Purpose of Embedded system, Core of Embedded System, Memory, Sensors and Actuators, Communication Interface, other System components, PCB and passive components, Characteristics of Embedded System, Quality Attributes of Embedded System, application and domain specific embedded systems.

UNIT-II

Embedded system Development: Analog and Digital Electronic components, VLSI and IC Design, EDA tools, PCB Fabrication, Embedded Firmware Design approaches, embedded firmware development languages, Integration of Hardware and Firmware, Board Bring up, Embedded System Development Environment – IDE, Types of File Generated on Cross Compilation- Disassembler/ Decompiler, Simulator, Emulator and Debugging, Target hardware Debugging, Boundary Scan,

UNIT-III

Hardware Software Co-design and program modelling: Fundamental Issues in Hardware and Software Co-Design, Computational Models in Embedded Design, Introduction to Unified Modelling Language (UML), hardware Software Trade-offs, embedded product development life cycle- objectives, different phases, approaches of EDLC.

UNIT-IV

Device Drivers and Interrupt service mechanism: Programmed I/o, busy-wait approach without interrupt service mechanism, ISR concepts, interrupt sources, interrupt service handling mechanism, multiple interrupts, context and periods for context switching, interrupt latency and deadline. Classification of processors interrupt service mechanism from context saving, direct memory access, device driver programming.

UNIT-V

Real time operating system: operating system basics, types of operating systems, tasks, process and threads, multiprocessing and multitasking, task scheduling, threads, processes and scheduling, task communication, task synchronization, how to choose an RTOS, case study of ucos-II and vxworks.

Textbooks:

1. Introduction to Embedded System, Shibu K.V, Tata McGraw-Hill, 2014.

References:

1. Embedded Systems- Architecture, programming and Design, 2e, Raj kamal, McGraw Hill Education (India) Private Limited.
2. Embedded System Design- Frank vahid, Tony Givargis, Wiley publications, 2002.

Course code	Course Title	L	T	P	Credits
R23MEC-OE0001	Operations Research (Open Elective)	3	0	0	3

Course Objectives:

The objectives of the course are to

- Explore advanced methodologies in Operations Research to model and optimize decision-making processes in complex systems.
- Comprehend the theoretical foundations and practical applications of Linear Programming to address challenges in industrial and operational domains.
- Develop effective solutions for Transportation and Assignment Problems by applying optimization techniques to enhance productivity in manufacturing and efficiency in logistics.
- Impart knowledge of strategic tools in Game Theory and Network Analysis to evaluate and improve competitive scenarios and project management systems.
- Evaluate Queuing models and Simulation models to address uncertainty and improve the system performance.

Course Outcomes

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

1. **construct** mathematical models for allocation problems to find the optimal solutions. (L3)
2. **determine** optimal solutions for transportation and assignment problems and **test** for optimality to obtain the optimal solutions. (L4)
3. **design** simulation models for discrete systems under uncertainties to obtain the solutions for decision making. (L4)
4. **apply** the concepts of PERT and CPM for scheduling the projects. (L3)
5. **determine** strategic solutions for competitive scenarios in two-person zero-sum games (L4)

UNIT I

Introduction to Operations Research (OR): OR definition - Classification of Models, **Linear Programming (LP):** Problem Formulation, Graphical Method, Special Cases of LP- Degeneracy, Infeasibility and Multiple Optimal Solutions; Simplex Method, Big- M simplex Method, application of L.P.P. in manufacturing firms. Software solutions

Applications: Determination of Production quantities of different products in manufacturing industries

UNIT II

Transportation and Assignment Problems: Transportation Problem – Formulation; Different Methods of Obtaining Initial Basic Feasible Solution –North West Corner Rule, Least Cost Method, Vogel's Approximation Method; Optimality Method – Modified Distribution (MODI) Method; Special Cases – Unbalanced Transportation Problem, Degenerate Problem. Assignment Problem – Formulation, Hungarian Method for Solving Assignment Problems, Traveling Salesman problem. application of Transportation and Assignment Problems in manufacturing firms. Software solutions.

Applications: Optimizing transportation costs in distribution of goods

UNIT III

Queuing Theory: Introduction – Basic queuing process, basic structure of queuing models terminology: arrival Pattern, service channel, population, departure pattern, queue discipline, Kendall's notation.

Single Channel model with poisson arrivals, exponential service times with infinite queue length

Simulation: Basic concept of simulation, discrete event simulation, applications of simulation, merits and demerits of simulation, Monte Carlo simulation, simulation of Inventory system, simulation of Queuing system. Simulation languages

Applications: Decision making in uncertainty situations

UNIT IV

Network Analysis: Network Representation, rules for drawing network, Fulkerson's Rule, Determination of Earlier Starting Time and Earliest Finishing Time in the Forward Pass – Latest Starting Time and Latest Finishing Time in Backward Pass, determination of critical path, total float calculation, Time estimates in PERT, Probability of completing the project, project cost, project crashing, Optimum project duration, Project management.

Applications: Project planning control in manufacturing and maintenance

UNIT V

Game Theory: Optimal solution of two-person zero sum games, the max min and min max principle. Games without saddle points, mixed strategies. algebraic method, Reduction by principles of dominance, graphical method for $[2 \times n]$ and $[m \times 2]$ game problems, Linear programming model

Applications: Determination of optimal strategies in competition between industries

Text books:

1. Sharma S.D., Operations Research: Theory, Methods and Applications, Kedar Nath Ram Nath.
2. Prem kumar Gupta and Hira, Operations Research, S Chand Company Ltd., New Delhi.

Reference books:

1. Hiller F.S., and Liberman G.J., Introduction to Operations Research, Tata McGraw Hill.
2. Sharma J.K., Operations Research: Theory and Applications, Laxmi Publications.
3. Taha H.A., Operations Research, Prentice Hall of India, New Delhi.
4. Pannerselvam R., Operations Research, Pentice Hall of India, New Delhi.
5. Sundaresan.V, and Ganapathy Subramanian.K.S, Resource Management Techniques: Operations Research, A.R Publications.

Web Source References:

1. https://onlinecourses.nptel.ac.in/noc22_mg15
 2. https://onlinecourses.nptel.ac.in/noc22_ma48
 3. https://onlinecourses.nptel.ac.in/noc24_mg30
 4. <https://www.britannica.com/topic/operations-research>
 5. <https://www.theorsociety.com/about-or>
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Course code	Course Title	L	T	P	Credits
R23MEC-OE0002	3D Printing Technology (Open Elective)	3	0	0	3

Course Objectives:

The objectives of the course are

- To exploit technology used in 3D printing.
- To understand importance of 3D printing in advance manufacturing process.
- To acquire knowledge, techniques and skills to select relevant 3D Printing process.
- To explore the potential of 3D Printing in different industrial sectors.

Course Outcomes

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

1. **Know** the importance of 3D printing in Manufacturing (L1)
2. **Understand** the liquid-based 3D printing system(L2)
3. **Illustrate** the solid-based 3D printing system (L2)
4. **Explain** the powder-based 3D printing system (L2)
5. **Elucidate** the application 3D printing in medical field (L2)

UNIT-I

Introduction: 3D Printing, Generic 3D Printing Process, Benefits of 3D Printing, Distinction Between 3D Printing and CNC Machining, Classification of 3D Printing Processes, Metal Systems, Hybrid Systems, Milestones in 3D Printing Development, 3D Printing around the World.

UNIT-II

LIQUID-BASED 3D PRINTING SYSTEM: Stereo lithography Apparatus (SLA): models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages.

UNIT-III

SOLID-BASED 3D PRINTING SYSTEMS: Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Fused deposition modelling (FDM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT-IV

POWDER BASED 3D PRINTING SYSTEMS: Selective laser sintering (SLS): models and specifications, process, working principle, applications, advantages, disadvantages and case studies.

UNIT-V

MEDICAL APPLICATIONS & FUTURE DIRECTION FOR 3D PRINTING - Use of 3D Printing to Support Medical Applications, Limitations of 3D Printing for Medical Applications, Further Development of Medical 3D Printing Applications. Use of Multiple Materials in 3D Printing - Discrete Multiple Material Processes, Blended Multiple Material Processes, Commercial Applications Using Multiple Materials, Business Opportunities and Future Directions

Text Books

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, Springer.
2. 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, LeongKah Fai, World Scientific.

References

1. Rapid Prototyping: Laser-based and Other Technologies, Patri K. Venuvinod and Weiyin Ma, Springer.
 2. Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, D.T. Pham, S.S. Dimov, Springer.
 3. Rapid Prototyping: Principles and Applications in Manufacturing, Rafiq Noorani, John Wiley & Sons.
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4. Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC PressTaylor & Francis Group.
5. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGraw Hill.

Web resources

1. <https://www.nist.gov/additive-manufacturing>
 2. <https://www.metal-am.com/>
 3. <http://additivemanufacturing.com/basics/>
 4. <https://www.3dprintingindustry.com/>
 5. <https://www.thingiverse.com/>
 6. <https://reprap.org/wiki/RepRap>
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Course code	Course Title	L	T	P	Credits
R23MEC-OE0003	Statistical quality control (Open Elective)	3	0	0	3

Course Objectives:

The Objectives of this course are to

- Explore the techniques for identifying customer needs, gathering customer feedback, and using that information to drive quality improvements.
- develop skills in analyzing quality control data and making data-driven decisions to maintain or improve product quality
- Design and apply TQM tools and techniques such as control charts, process capability analysis, and Kaizen for continuous process improvement.
- Comprehend Six Sigma methodologies and acceptance sampling plans for quality excellence and reduce operational costs.
- foster a culture of quality and support quality management initiatives to ensure compliance, sustainability, and competitive advantage.

Course outcomes:

Upon completion of this course students will be able to

1. **apply** the concept of Quality function deployment to meet the customer quality requirements in product development (**L3**)
2. **apply** tools and techniques of Quality Management to identify the assignable causes for process variations to control the manufacturing process (**L3**)
3. **construct** control charts for variables and attributes for controlling manufacturing process (**L3**)
4. **develop** acceptance sampling plan to minimize producer risk and consumer risk. (**L4**)
5. **comprehend** Six Sigma methodologies and ISO quality systems to achieve quality excellence (**L2**)

UNIT –I

Introduction: Introduction to quality – Definition of Quality, Dimensions of Quality, Quality Planning, Total quality management – history – stages of evolution– objectives –Inspection and quality control, Quality Management versus TQM, Reliability engineering –reliability as a parameter of quality for sustainability -bathtub curve, MTBF, System reliability calculations, Quality Loss Function, Quality function deployment (QFD). applications, real life examples

Application:

Quality control concepts used to meet customer requirements in manufacturing industries

UNIT II

Tools and Techniques of TQM: Process capability, Natural Tolerance limits, Process capability index. Check Sheets, Histograms, Scatter Diagrams, Cause and Effect Diagrams, Pareto Chart, control charts, TPM, Kaizen, JIT, Quality Circles, Seven wastes elimination in manufacturing industries for sustainable development, Five S principle

Application: Perform Process capability studies in machine tool industries

UNIT III

Statistical Process Control: Control charts: Statistical basis of the Control Charts-principles, Control limits for X and R-Charts, analysis of pattern on control charts, Type I and Type II errors, p chart, c chart construction. Simple Numerical Problems, revised control limits

Application:

Identify the assignable causes Quality control in manufacturing to control the processes

UNIT- IV

ACCEPTANCE SAMPLING: Fundamental concept in acceptance sampling, Need of acceptance sampling, operating characteristics curve. Producer risk and consumer risk in sampling plans. Acceptance plans, single sampling plan, double sampling plan –exercises.

Application: Selection of sampling plan to minimize risk in purchasing parts, components from the suppliers

UNIT- V

Quality Systems: The Concept of Six Sigma, Objectives of Six Sigma, The Frame-Work of Six Sigma Programme, Six Sigma Problem Solving Approach, The DMAIC Model: Cost of Poor Quality, Benefits and Costs of Six Sigma.

Need for ISO 9000 and Other Quality Systems, ISO 9000: 2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 – Concept, Requirements and Benefits.

Case Studies of TQM projects and Six Sigma projects.

Application: Systems followed in manufacturing units for quality excellence

Text books:

1. Subburaj Ramaswamy, Total Quality Management, Tata Mcgraw Hill Publishing Company Ltd.
2. Statistical Quality Control, M.Mahajan, Dhanpat Rai Publishing Co Pvt Ltd

Reference Books:

1. Introduction to statistical quality control: By D.C. Montgomery, John Wiley & Sons Inc.
2. Forrest W. Breyfogle, Implementing Six Sigma, John Wiley & Sons, Inc.
3. Statistical Quality Control – R.C. Gupta– Khanna Publishers, Delhi
4. Grant, E.L. and LavenWorth, R.S.: Statistical Quality Control, McGraw Hill.
5. Evans, J R and W M Lindsay, An Introduction to Six Sigma and Process Improvement, Cengage Learning.

Web Source References:

1. [https://nptel.ac.in/courses/112/107/112107259/-](https://nptel.ac.in/courses/112/107/112107259/) Inspection and Quality control manufacturing.
 2. <https://nptel.ac.in/courses/110105039>
 3. <https://www.youtube.com/watch?v=qb3mvJ1gb9g>
 4. <https://nptel.ac.in/courses/110104085>
 5. https://onlinecourses.nptel.ac.in/noc20_mg19
-

Course code	Course Title	L	T	P	Credits
R23MEC-OE0004	Hybrid Vehicle Technologies (Open Elective)	3	0	0	3

Course Objectives:

The course is intended to

- Familiarize the fundamentals of conventional and hybrid electric vehicle components.
- Understand the configurations and working of hybrid and electric drive-trains.
- Understand the architecture, operation and energy management of PHEVs
- Study and understand different power converters used in hybrid and electrical vehicles.
- Familiarize with different batteries and other energy storage systems.

Course outcomes:

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

1. *Understand* the fundamentals of conventional and hybrid electric vehicle components.
2. *Describe* hybridization of power sources in hybrid electric vehicles.
3. *Apply* the principles of power management and fuel economy to optimize the PHEV performance
4. *Explain* the working principle of power electronics in hybrid vehicles.
5. *Describe* the different battery technologies and other energy storage systems.

UNIT-I:

Introduction: Fundamentals of vehicle, components of conventional vehicle and propulsion load, drive cycles and drive terrain; concept of electric vehicle and hybrid electric vehicle; history of hybrid vehicles, advantages and applications of electric and hybrid electric vehicles, different motors suitable for electric and hybrid electric vehicles.

UNIT-II:

Architectures of Hybrid, Plug-in Hybrid, Fuel Cell and Electric Vehicles

Hybrid Electric Drive-trains: Architectures of HEVs, Series and parallel HEVs complex HEVs. Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV- Fuel Cell vehicles and its constituents.

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies.

UNIT-III:

Plug-in Hybrid Electric Vehicle: PHEVs and EREVs blended PHEVs, PHEV Architectures, equivalent electric range of blended PHEVs; Fuel economy of PHEVs, power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology(V2G), PHEV battery charging.

Applications:

- Optimizing fuel economy by managing the switch between electric and combustion power in PHEVs.
- Using PHEV batteries to support the grid during peak demand through Vehicle-to-Grid (V2G) technology.

UNIT-IV:

Power Electronics in HEVs: Rectifiers used in HEVs, voltage ripples, Buck converter used in HEVs, non- isolated bidirectional DC-DC converter, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.

UNIT-V:

Battery and Storage Systems: Energy storage parameters; lead acid, li-ion and Ni-MH batteries, ultracapacitors, flywheels- superconducting magnetic storage system; pumped hydroelectric energy storage; compressed Air energy storage-storage heat; energy storage as an economic resource.

Applications:

- Battery selection in EVs: Selecting Li-ion or Ni-MH batteries for EVs based on battery cost and performance.

- Supporting the power grid with pumped hydro or compressed air energy storage systems.

Text Books:

1. Ali Emadi, Advanced Electric Drive Vehicles, 1st Edition, CRC Press.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, 2nd Edition, CRC Press, 2010.

Reference Books:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2009.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3. H.Partab: Modern Electric Traction-DhanpatRai &Co,2007.

Web link:

1. <https://archive.nptel.ac.in/courses/108/103/108103009/>
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Course code	Course Title	L	T	P	Credits
R23MEC-OE0005	Industrial Robotics (Open Elective)	3	0	0	3

Course Objectives:

The objectives of the course are

- To understand the Geometrical Configuration and Components of Industrial Robots (Anatomy)
- To analyze the factors influencing gripper selection and design.
- To grasp the concept of rotation matrices and their significance in robotics.
- To understand forward and inverse kinematics of robot manipulator
- To familiarize the students with the fundamentals of sensors and various drive systems.
- To develop Program Robot for applications in various fields.

Course Outcomes:

At the end of the course, the student will be able to

1. Understand the anatomy of robots including the components and structure. (L2)
2. Design the grippers considering grasping force, Engelberger-g-factors, and actuation mechanisms (L2)
3. Apply basic transformation and rotation matrices in robot kinematics (L3)
4. Explain the function of feedback components such as position sensors (potentiometers, resolvers, encoders) and velocity sensors. (L2)
5. Understand the use of robots in manufacturing, inspection and quality control applications. (L2)

Unit- I

Robotics: Introduction, classification with respect to geometrical configuration (Anatomy), Controlled system & chain type, Serial manipulator & Parallel Manipulator. Components of Industrial robotics, precession of movement, resolution, accuracy & repeatability,

Dynamic characteristics: speed of motion, load carrying capacity & speed of response, Sensors, Internal sensors: Position sensors, & Velocity sensors, External sensors: Proximity sensors, Tactile Sensors, & Force and Torque sensors.

Unit-II

Grippers & End effectors: Mechanical Gripper, Grasping force, Engelberger-g-factors, mechanisms for actuation, Magnetic gripper, vacuum cup gripper, considerations in gripper selection & design, specifications. Selection of gripper based on Application.

Applications:

1. Wall climbing robot
2. Vacuum cups

Unit- III

Motion Analysis:

Basic Rotation Matrices, Equivalent Axis and Angle, Euler Angles, Composite Rotation Matrices. Homogeneous transformations as applicable to rotation and translation.

Manipulator Kinematics- Assignment of frames, D-H Transformation Matrix, joint coordinates and world Coordinates, Forward and inverse kinematics.

Applications:

1. Robot trajectory generation by forward kinematics.
2. Welding robots by inverse kinematics by root multiplicity.

Unit-IV

Robot actuators and Feedback components: Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors, comparison of Actuators, Feedback components: position sensors, potentiometers, resolvers, encoders, Velocity sensors, Tactile and Range sensors, Force and Torque sensors, End Effectors and Tools.

Applications:

1. Automated Assembly Lines in Automotive Manufacturing
2. Surgical Robotics (e.g., Da Vinci System)

Unit-V

Robot Programming & Applications: Material Transfer - Material handling, loading and unloading- Processing spot and continuous arc welding & spray-painting Assembly and Inspection. Robotic Programming Methods - Languages: Lead Through Programming, Textual Robotic Languages such as APT, MCL.

Applications:

1. Automated Car Body Assembly
2. Electronics Manufacturing (e.g., PCB Assembly)

Text Books

1. Industrial Robotics / Groover M P /Mc Graw Hill
2. Introduction to Robotics / John j.Craig / Pearson

References

1. Introduction to Industrial Robotics / Ramachandran Nagarajan / Pearson
2. Robot Dynamics and controls / Spony and Vidyasagar / John Wiley

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc23_me143/preview
 2. https://www.youtube.com/results?search_query=1.%09Robotics+Programming+in+Just+30+Days!+%7C+Industrial+Robotics+Programming+in+Bangalore+%7C+RVM+CAD
 3. <https://www.youtube.com/watch?v=QiFbrmJTib4&t=11s>
 4. https://www.youtube.com/watch?v=hL_GKapQd1k
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Course code	Course Title	L	T	P	Credits
R23MEC-OE0006	Nano Materials (Open Elective)	3	0	0	3

Course objectives:

The objectives of the course are

- To understand the nano-structured materials and their applications.
- To learn about the nano-crystalline materials, their properties and defects.
- To understand various techniques of nanofabrication.
- To identify the tools to characterize nano materials.
- To analyze the applications of nano materials.

Course Outcomes:

At the end of the course, the student will be able to

1. **Explain** nano-structured materials and their applications (L2)
2. **Apply** knowledge about the nano-crystalline materials, their properties and defects (L3)
3. **Demonstrate** various techniques of nanofabrication (L2)
4. **Apply** the tools to characterize nano materials (L3)
5. **Analyze** the applications of nano materials (L4)

UNIT-I

Introduction to Nanomaterials: History and Scope, Classification of Nano structured Materials, Distinction between nanomaterials and bulk materials, Classification of nanomaterials: 0D, 1D, 2D, 3D, Fascinating Nanostructures, and applications of nanomaterials, challenges and future prospects.

Learning outcomes:

At the end of this unit students will be able to:

1. **Understand** the fundamental concepts of nanomaterials and how they differ from bulk materials (L2)
2. **Identify** and describe various nanostructures (0D, 1D, 2D, 3D) and their unique properties at the nanoscale (L2)

Application:

Semiconductors , Nano sensors, Memory storage devices, Hydrogen fuel cells.

UNIT-II

Properties Of Nano Materials: Microstructure and Defects in Nano crystalline Materials: Dislocations, Twins, stacking faults and voids, Grain Boundaries, triple and declinations. Effect of Nano-dimensions on Materials Behaviour: Elastic properties, Melting Point, Diffusivity, Grain growth characteristics, enhanced solid solubility. Magnetic Properties: Soft magnetic nanocrystalline alloy, Permanent magnetic nanocrystalline materials, Giant Magnetic Resonance, Electrical Properties, Optical Properties, Thermal Properties and Mechanical Properties.

Application: high-density data storage and magnetic sensors

UNIT-III

Manufacturing Methods: Bottom-up approaches: Physical Vapour Deposition, Inert Gas Condensation, Laser Ablation, Chemical Vapour Deposition, Molecular Beam Epitaxy, Sol-gel method, Self-assembly. Top-down approaches: Mechanical alloying, Nano-lithography. Consolidation of Nano powders: Shock wave consolidation, Hot isostatic pressing, Cold isostatic pressing, Spark plasma sintering.

Application:

Bulk nanostructured alloys for aerospace and automotive applications

UNIT-IV

Characterization of Nanomaterials: X-Ray Diffraction (XRD), Small Angle X-ray scattering, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscope (STM), Field Ion Microscope (FIM), Three-dimensional Atom Probe, Nano indentation.

Application:

Measures the hardness and elastic modulus of individual nanoparticles

UNIT-V

Applications of Nano Materials: Nano-electronics, Micro- and Nano electromechanical systems (MEMS/NEMS), Nano sensors, Nano catalysts, Food and Agricultural Industry, Cosmetic and Consumer Goods, Structure and Engineering, Automotive Industry, Water Treatment and the environment, Nano-medical applications, Textiles, Paints, Energy, Defense and Space Applications, Concerns and challenges of Nanotechnology.

Application:

Solar cells, Batteries and water purification systems

Textbooks

1. Charles. P. Poole Jr & Frank J. Owens, Introduction to Nanotechnology, Wiley-Inter science.
2. A.K. Bandyopadhyay, Nano Materials, New Age International Pvt Ltd Publishers.
3. T. Pradeep, Nano: The Essentials, McGraw Hill Education.

References

1. S.O. Pillai, Solid State Physics, New Age International Private Limited.
2. Charles Kittel, Introduction to solid state physics, Wiley & Sons (Asia) Pvt Ltd.

Web Sources References:

1. <https://www.youtube.com/watch?v=oN1I09LpygE&list=PLMlC7Vx5awsenMs5y02xcW6i5NmdEIRGx&index=2>
 2. <https://www.youtube.com/watch?v=jryDvx7VNxw&list=PLyqSpQzTE6M8682dGkNTN8936vSY4CbqZ&index=15>
 3. https://www.youtube.com/watch?v=mva_njonj2Y&list=PLbMVogVj5nJTdeiLvuGSB_AE8hloTAHWJ&index=3
 4. <https://www.youtube.com/watch?v=JffF6AqWCHE>
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Course code	Course Title	L	T	P	Credits
R23MEC-OE0007	AI and ML In Manufacturing (Open Elective)	3	0	0	3

Course Objectives:

The main objectives of this course are to:

- Introduce the fundamentals of Artificial Intelligence (AI) and its relevance to modern manufacturing systems.
- Enable students to understand and apply AI techniques like Machine Learning, Expert Systems, and Fuzzy Logic in industrial scenarios.
- Familiarize students with AI applications in predictive maintenance, quality control, process optimization, and robotics.
- Develop the ability to analyze manufacturing data using AI-based decision-making tools.
- Encourage innovation in smart manufacturing by integrating AI with Industry 4.0 technologies.

Course Outcomes:

After completing this course, the students will be able to:

1. Explain the role and benefits of Artificial Intelligence in modern manufacturing and Industry 4.0. (L2)
2. Apply machine learning algorithms to real-world problems like fault detection and predictive maintenance in manufacturing. (L3)
3. Develop expert systems to support manufacturing decision-making and diagnostics. (L6)
4. Analyze and implement fuzzy logic and neural network models for manufacturing process control. (L4)
5. Evaluate advanced AI applications in smart robotics, digital twins, and AI-driven production systems. (L5)

UNIT I:

Introduction to AI in Manufacturing: Definition and scope of AI in engineering, Evolution of AI and its relationship with automation, Traditional automation vs. AI-based decision-making, Role of AI in Industry 4.0 and Smart Factories, Cyber-Physical Systems (CPS) and AI, Benefits and limitations of AI in manufacturing, Case studies: AI in production lines, real-time process control

UNIT II:

Machine Learning for Manufacturing Systems: Overview of ML algorithms and relevance to manufacturing, Supervised, unsupervised, and reinforcement learning, Classification (SVM, Decision Trees, k-NN) and Regression models, Clustering techniques (K-means, Hierarchical) for pattern detection, Feature engineering and preprocessing of sensor data, Predictive maintenance using historical data, Intro to deep learning: CNN and RNN applications in fault detection, Tools: Python, Scikit-learn, TensorFlow, MATLAB

UNIT III:

Expert Systems and Knowledge Representation: Components of an expert system: knowledge base, inference engine, user interface, Rule-based reasoning and IF-THEN rule chaining, Certainty factors and decision trees, Knowledge acquisition methods: interviews, machine learning, simulations, Semantic networks, ontologies, and frames, AI-based troubleshooting and fault diagnostic systems, Case study: Expert systems in CNC, PLCs, and maintenance management

UNIT IV:

Fuzzy Logic and Neural Networks in Manufacturing : Fundamentals of fuzzy logic and fuzzy inference systems, Designing fuzzy rule-based controllers, Integration of fuzzy logic with PLCs and SCADA, Neural networks: architecture, activation functions, training algorithms, Backpropagation and real-time adaptation, Process optimization using neural networks and fuzzy hybrid models, Applications: welding control, casting defect prediction, tool wear monitoring

UNIT V:

AI Applications in Smart Manufacturing: Intelligent robotics and AI-based path planning, Machine vision systems and defect detection, Digital twins and virtual commissioning, AI in production planning and real-time scheduling, Role of AI in quality assurance and adaptive control, AI in smart inventory management and logistics, Ethical implications and challenges in AI implementation, Case studies: AI in aerospace, automotive, and healthcare manufacturing

Textbooks:

1. **Russell, Stuart J., and Peter Norvig**, *Artificial Intelligence: A Modern Approach*, Pearson Education, 3rd Edition, 2019.
2. **Dan W. Patterson**, *Introduction to Artificial Intelligence and Expert Systems*, PHI Learning, 2009.
3. **M. Gopal**, *Applied Machine Learning*, McGraw-Hill Education, 2018.
4. **Ramesh Babu**, *Artificial Intelligence in Mechanical and Industrial Engineering*, SciTech Publications, 2022 (Indian Author)

Reference Books:

1. **V.S. Janakiraman, K. Sarukesi, P. Gopalakrishnan**, *Foundations of AI and Expert Systems*, Macmillan India, 2019 (Indian Author)
2. **David Forsyth**, *Applied Machine Learning*, Springer, 2019.
3. **Donald A. Waterman**, *A Guide to Expert Systems*, Pearson, 2018.
4. **S. N. Sivanandam**, *Principles of Soft Computing*, Wiley India, 2nd Edition, 2011 (covers fuzzy logic and neural networks)

Online Resources:

Coursera – AI for Everyone (by Andrew Ng)

<https://www.coursera.org/learn/ai-for-everyone>

edX – Artificial Intelligence in Manufacturing (by RWTH Aachen University)

<https://www.edx.org>

MIT OpenCourseWare – Artificial Intelligence

<https://ocw.mit.edu>

Google AI – Research and Tools

<https://ai.google>

YouTube – AI in Industry by Analytics Vidhya / Siemens

<https://www.youtube.com>

Course code	Course Title	L	T	P	Credits
R23MEC-OE0008	Automation in Manufacturing (Open Elective)	3	0	0	3

Course Objectives:

The main objectives of this course are to:

- Understand the concept of automation and process control systems.
- Classify the automated flow lines and analyze automated flow lines
- Able to balance the operations on assembly line.
- Design automated material handling systems.
- Understand the level of automation in continuous and discrete manufacturing systems.

Course Outcomes:

1. **Understand** the characteristics of Automated Systems. (L2)
2. **Illustrate** operational aspects of flow lines.(L2)
3. **apply** the methods to balance the assembly line(L3)
4. **Compare** conventional and automated material transport, storage system.(L2)
5. **Explain** the level of automation in continuous and discrete manufacturing industries.(L2)

Unit-I

Introduction To Automation: Automated Manufacturing Systems, Computerized Manufacturing Support Systems, Reasons for Automation, Automation Principles and Strategies, levels of automation, Basic elements of an automated system, Types of production, pneumatic and hydraulic components, circuits, automation in foundry industries, automation in machine tools, mechanical feeding and tool changing and machine tool control. Economical and technological factors for automation. Barriers of automation in manufacturing industries.

Applications:

- Automated Material Handling System in Manufacturing
- Automation in Machine Tools for Precision Manufacturing

Unit-II

Automated Flow Lines: Methods of part transport, transfer mechanism, buffer storage, control function, design and fabrication considerations. Analysis of automated flow lines - General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines.

Applications:

- Automated Conveyor Systems in Assembly Lines
- Buffer Storage in Automotive Manufacturing

Unit-III

Assembly Line Balancing: Assembly process and systems, assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.

FMS: Types of FMS, components of FMS, Types of flexibility, types of FMS layouts, applications, scope for FMS in manufacturing today, group technology, hierarchy of computer control in FMS, economic justification of FMS planning, scheduling and control of FMS

Applications:

- Optimized Assembly Line Balancing in Electronics Manufacturing
- Flexible Manufacturing Systems (FMS) in Automotive Production

Unit-IV

Material Handling Systems: Introduction to Material Handling, Basic Principles, Material Transport equipment, analysis of material transport systems, Automated Guided Vehicle Systems, Generalized Theories Governing the Mechanical Design Parameters of Handling Systems storage systems–storage system performance and location strategies, Conventional storage methods and equipment, Automated Storage and Retrieval System (ASRS) and Its Types, Applications of ASRS,Engineering analysis of storage systems. ASRS and Industry 4.0

Automatic Identification Methods: Overview of Identification Methods, Barcode technology, Radio frequency identification, other AIDC technologies, benefits of AIDC.

Applications:

- Automated Storage and Retrieval System (ASRS) in Warehousing
- Radio Frequency Identification (RFID) in Supply Chain Management

Unit-V

Industrial Control Systems: Process industries Vs Discrete manufacturing industries, levels of automation in the two industries, variables and parameters in the two industries. Continuous Vs Discrete control –continuous control system, discrete control system.

Automated Inspection And Assembly: Fundamentals, inspection principles, types of inspection methods and equipment, Quality function deployment, Coordinate Measuring Machines, Machine Vision, Automated Assembly Systems, Design for Automated Assembly, and Quantitative Analysis of Assembly Systems, Multi- Station Assembly Machines, Single Station Assembly Machines.

Applications:

- Industrial Control Systems in Chemical Processing Plants
- Machine Vision-Based Automated Inspection in Automotive Manufacturing

Text Books:

1. M.P. Groover, Automation, Production systems and Computer Integrated Manufacturing, 3/e, PHI
2. Learning.
3. Geoffrey Boothroyd, Assembly Automation and Product design, Taylor and Francis Publishers.

Reference Books:

1. Krishna Kant, Computer based industrial control, Prentice Hall of India.
 2. Tiess Chiu chang and A. W. Richard, An introduction to automated process planning systems, Tata Mc Graw Hill.
 3. Mikell P. Groover and Mitchell Weiss, Roger N. Nagel, Nicholas, G. Odrey, IndustrialRobotics, McGraw Hill.
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Course Code	Subject Name	L	T	P	C
R23CSE-OE0001	PYTHON PROGRAMMING	3	0	0	3

Course Objectives:

- Understand the structure and data types of Python script.
- Implement iterations and functions in Python.
- Implement modules and understand packages.
- Implement data structures using mutable & immutable objects.
- Understand object-oriented concepts and Exception handling.

Course Outcomes:

- Implement Basic Python programming Fundamentals for Computation of Expression [L3]
- Apply Iterators and functions in data processing.[L3]
- Understand modules and packages to leverage powerful libraries for data science tasks.[L2]
- Implement sequences and data structures for data organization.[L3]
- Implement object-oriented principles in Python, handling run-time errors.[L3]

Unit I:

Hours:10

Introduction: History of Python, Features of Python, Applications, Python Using the REPL (Shell), Running Python Scripts, Variables, Assignment forms, Keywords, Input-Output, Indentation.

Operators and Type Conversion: Data Types: Numeric, Booleans, Sequence, Strings, Type Conversions, Operators, Operator Precedence, Evaluation of Expressions.

Learning Outcomes: After completing this chapter, students will be able to

- Understand the environment of Python. (L2)
- Write and run simple scripts in Python. (L3)
- Implement Type conversion techniques. (L3)

Unit II:

Hours:10

Control Flow: Conditional statements (if, else, elif), Looping structures (for, while, for-else, while-else) Transfer Control Statements: break, continue, pass.

Functions: Defining Functions, Calling Functions, Types of Arguments: Keyword Arguments, Default Arguments, Variable-length arguments, Fruitful Functions (Function Returning Values), Scope of the Variables in a Function - Global and Local Variables, Anonymous Functions, Lambda, map, reduce and filter.

Learning Outcomes: After completing this chapter, students will be able to

- Understand the iterations using looping structures.(L2)
- Implement Python functions.(L3)

Unit III:**Hours:9**

Modules: Creating modules, import statement, from import statement, namespace, built-in modules- OS, random, Math, JSON, request, date, RegEx, itertools

Packages: Introduction to PIP, Installing packages using PIP.

Exploring Data Science Libraries: NumPy, Pandas, Data visualization: Matplotlib

Learning Outcomes: After completing this chapter, student will be able to

- Understand modules (L2)
- Understand data science libraries.(L2)

Unit IV:**Hours:10**

Strings & Data Structures: String, String Formatting, List, String and List Slicing, Tuple, Sets, Frozen Sets, Dictionaries, Comprehensions, Built-in methods of all sequences, File Handling: Reading and writing files, File modes and file objects

Learning Outcomes: After completing this chapter, student will be able to

- Implement different data structures in Python.(L3)
- Understand different file handling Operations.(L2)

Unit V:**Hours:09**

Object Oriented Programming OOP in Python: Classes, 'self- variable', Methods, Constructor, Inheritance, Polymorphism, and Data Abstraction.

Errors and Exceptions: Syntax Errors, Exceptions, Exception Handlers, Raising Exceptions, User-defined Exceptions.

Learning Outcomes: After completing this chapter, student will be able to

- Understand Object oriented concepts with real world scenarios.(L2)
- Implement exceptions in Python.(L3)

TEXT BOOKS:

1. Let Us Python by Yashavant Kanetkar ,Aditya Kanetkar ,6th edition, BPB Publication
2. Python Programming: Using Problem Solving Approach by Reema Theraja, 2nd edition, Oxford publications.

REFERENCE BOOKS:

1. Python Programming: A Modern Approach, Vamsi Kurama, Pearson.
2. Learning Python, Mark Lutz, Orielly.
3. Python Programming, S Sridhar, J Indumathi, V M Hariharan, 2nd Edition, Pearson, 2024

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
	3	2	2	2	3				3			1	2	3	3
	3	3	2	2	3				3			1	2	3	3
	3	3	2	2	3				3			1	2	3	3
	3	3	3	2	3				3			1	2	3	3
	3	3	3	3	3				3			1	2	2	3
	3	3	3	2	3				3			1	2	3	3

* For Entire Course, PO & PSO Mapping

Course Code	Subject Name	L	T	P	C
R23CSE-OE0002	DATA STRUCTURES USING C	3	0	0	3

Course Objectives:

1. To teach efficient storage mechanisms of data for an easy access.
2. To develop application using data structures.
3. To improve the logical ability

Course Outcomes: On completion of this course, the student will be able to:

1. Compare the performances of various Searching and Sorting techniques in terms of time and space complexities.
2. Illustrate the applications of Stacks.
3. Implement various types of Queues and their efficient operations.
4. Demonstrate the advantages of dynamic memory allocation via linked lists.
5. Implement the basic operations, search and traversals on Trees.

UNIT-I

Time and space complexity, Data Structures – Introduction to Data Structures, abstract data types, Searching and Sorting – Sorting- selection sort, bubble sort, insertion sort, quick sort, merge sort, shell sort, radix sort, Searching-linear and binary search methods, comparison of sorting and searching methods.

UNIT –II

Linear list – singly linked list implementation, insertion, deletion and searching operations on linear list, circular linked list implementation, Double linked list implementation, insertion, deletion and searching operations. Applications of linked lists.

UNIT-III

Stacks-Operations, array and linked representations of stacks, stack applications -infix to postfix conversion, postfix expression evaluation, recursion implementation.

UNIT-IV

Queues-operations, array, and linked representations. Circular Queue operations, Dequeues, applications of queues.

UNIT-V

Trees – Definitions, tree representation, properties of trees, Binary tree, Binary tree representation, binary tree properties, binary tree traversals, binary tree implementation, applications of trees.

Text Books:

1. Fundamentals of Data structures in C, 2nd Edition, E.Horowitz, S.Sahniand Susan Anderson-Freed, Universities Press, 2008.
2. Data structures A Programming Approach with C, 2nd Edition D.S.Kushwaha and A.K.Misra, PHI, 2007.

References:

1. Data structures: A Pseudocode Approach with C, 2nd edition, R.F.GilbergAndB.A.Forouzan, CengageLearning.
2. Data structures and Algorithm Analysis in C, 2nd edition, M.A.Weiss, Pearson.
3. Data Structures using C& C ++,2nd Edition A.M.Tanenbaum,Y. Langsam, M.J.Augenstein, Pearson.
4. Data structures and Program Design in C, 2nd edition, R.Kruse, C.L.TondoandB.Leung,Pearson

Course Code	Subject Name	L	T	P	C
R23CSE-OE0003	OPERATING SYSTEM CONCEPTS	3	0	0	3

Course Objectives

1. Provide knowledge about the services rendered by operating systems.
2. Present detail discussion on processes, threads and scheduling algorithms.
3. Discuss various file-system implementation issues and memory management techniques.

Course Outcomes:

1. Understand the importance of operating systems and different types of system calls.
2. Analyze the communication between processes and various process scheduling algorithms.
3. Understand the process synchronization, different ways for deadlocks handling.
4. Analyze various memory mapping techniques and different page replacement methods.
5. Evaluate various file allocation and disk scheduling algorithms.

UNIT-I: Operating Systems Overview:

Introduction: what is an operating system, Types of operating systems, operating systems concepts, operating systems services, Introduction to System call, System call types, Operating System Generation.

UNIT-II: Process Management:

Process concept: Process Concept, Process Scheduling, Operations on Processes, Inter process Communication.

Multithreaded Programming: Overview, Multithreading models, Threading Issues.

Process scheduling: Basic Concepts, Scheduling Criteria, Scheduling Algorithms.

UNIT-III: Synchronization:

Process Synchronization: The Critical-Section Problem, Synchronization Hardware, Semaphores, Classic Problems of Synchronization, Monitors, Synchronization examples.

Principles of deadlock – System Model, Deadlock Characterization, Deadlock Prevention, Detection and Avoidance, Recovery from Deadlock.

UNIT-IV: Memory Management:

Memory Management strategies: Swapping, Contiguous Memory Allocation, Segmentation, Paging, Structure of the Page Table.

Virtual Memory Management: Virtual Memory, Demand Paging, Page-Replacement Algorithms, Thrashing.

UNIT-V: File system Interface- The concept of a file, Access Methods, Directory and Disk structure, File system mounting.

File System implementation: File system structure, allocation methods, free-space management.

Mass-storage structure: Overview of Mass-storage structure, Disk scheduling, Device drivers.

Text Books:

1. Silberschatz A, Galvin P B, and Gagne G, Operating System Concepts, 10th edition, Wiley, 2013.
2. Tanenbaum A S, Modern Operating Systems, 4th edition, Pearson Education, 2008.
(for Interprocess Communication and File systems).

References:

- i. Tanenbaum A S, Woodhull A S, Operating Systems Design and Implementation, 3rd edition, PHI, 2006.
- ii. Dhamdhare D M, Operating Systems A Concept Based Approach, 3rd edition, Tata McGraw-Hill, 2012.
- iii. Stallings W, Operating Systems -Internals and Design Principles, 6th edition, Pearson Education, 2009.
- iv. Nutt G, Operating Systems, 3rd edition, Pearson Education, 2004.

Course Code	Subject Name	L	T	P	C
R23CSE-OE0004	INTRODUCTION TO JAVA PROGRAMMING	3	0	0	3

Course Objectives

1. Understand the structure and environment of Java.
2. Implement the relationship between objects.
3. Understand the Strings and Organize data using different data
4. Implement text processes and error handling.
5. Understand to create multi threading applications and GUI applications.

Course Outcomes:

1. Understand the environment of JRE and Control Statements. (L2)
2. Implement real world objects using class Hierarchy (L3)
3. Implement generic data structures for iterating distinct objects (L3)
4. Implement error handling through exceptions and file handling through streams. (L3)
5. Design thread-safe GUI applications for data communication between objects (L4)

Unit I: Java Environment and Program Structure (10 Hours)

History of Java, Features, Applications, Java Installation - JDK and JRE, JVM Architecture, OOPS Principles, Class and Object, Naming Convention, Data Types, Type Casting, Type Conversion, Wrapper classes, Operators, instance of operator, Command Line Arguments, Decision making, Arrays, and Looping statements.

Learning Outcomes: Student will be able to

1. Understand architecture of Java Virtual Machine. (L2)
2. Understand the structure of java program and its environment. (L2)

Unit II: Class Hierarchy & Data Hiding (10 Hours)

Property, Method, Constructor, Inheritance (IS-A) , Aggregation and Composition (HAS-A), this and super, static and initialize blocks, Method overloading and overriding, static and final keywords, Types of Inheritance, Compile time and Runtime Polymorphism, Access Specifiers and scope, packages and access modifiers, Abstract class, Interface, Interface Inheritance, Achieving Multiple Inheritance, Class casting, Object Cloning, Inner Classes.

Learning Outcomes: Student will be able to

1. Understand the class hierarchy and their scope. (L2)
2. Implement relationship between objects. (L3)
3. Understand data hiding and nested classes. (L2)
4. Implement data type casting and cloning of objects. (L3)

Unit III: Strings and Collections (10 Hours)

String: Methods, StringBuffer and StringBuilder, StringTokenizer

Collections: Exploring java.util.*, Scanner, Iterable, Collection Hierarchy, Set, List, Queue and Map, Comparable and Comparator, Iterators: foreach, Enumeration, Iterator and ListIterator.

Learning Outcomes: Student will be able to

1. Understand the usage of String and its properties and methods.(L2)
2. Understand data structures and Iterators. (L2)
3. Create the data structures and implement different utility classes. (L3)

Unit IV: IO and Error Handling (10 Hours)

IO Streams: Exploring java.io.*, Character and Byte Streams, Reading and Writing, Serialization and De-serialization, Error Handling: Error vs Exception, Exception hierarchy, Types of Exception, Exception handlers, User defined exception, Exception propagation.

Learning Outcomes: Student will be able to

1. Understand character and byte streams. (L2)
2. Understand the hierarchy of errors and exceptions. (L2)
3. Implement data streams and exception handlers. (L3)

Unit V: Threads and GUI (8 Hours)

Multi-Threading: Process vs Thread, Thread Life Cycle, Thread class and Runnable Interface, Thread synchronization and communication.

GUI: Component, Container, Applet, Applet Life Cycle, Event delegation model, Layouts, Menu, MenuBar, MenuItem.

Learning Outcomes: Student will be able to

1. Understand the Thread Life Cycle and its scheduling.(L2)
2. Implement the synchronization of threads. (L2)

TEXT BOOKS:

1. The complete Reference Java, 8th edition, Herbert Schildt, TMH.
2. Programming in JAVA, Sachin Malhotra, SaurabhChoudary, Oxford.
3. Introduction to java programming, 7th edition by Y Daniel Liang, Pearson.
4. Java: How to Program, 9th Edition (Deitel) 9th Edition.
5. Core Java: An Integrated Approach, Java 8 by R. Nageswara Rao.

REFERENCE BOOKS:

1. Swing: Introduction, JFrame, JApplet, JPanel, Componets in Swings, Layout Managers
2. Swings, JList and JScrollPane, Split Pane, JTabbedPane, JTree, JTable, Dialog Box.

Weblinks:

1. <https://www.javapoint.com/>
2. <https://www.sitesbay.com/java/index>
3. <https://www.tutorialspoint.com/java/index.htm>
4. <https://www.w3schools.com/java/>
5. <https://www.programiz.com/java-programming>

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1):

SNO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	2	1	2				1			1	3	1	2
CO2	3	3	2	2	2				2			1	3	1	2
CO3	3	3	2	1	2				2			1	3	1	2
CO4	3	3	2	1	2				2			1	3	1	2
CO5	3	3	2	1	2				2			1	3	1	2

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0005	DATA BASE MANAGEMENT SYSTEMS CONCEPTS	3	0	0	3

Course Objectives:

1. Train in the fundamental concepts of database management systems, database modeling and design, SQL, PL/SQL, and System implementation techniques.
2. Enable students to model ER diagram for any customized applications.
3. To learn the principles of systematically designing and using large scale Database Management Systems for various applications.

Course Outcomes:

1. Understand the usage of Key Constraints on Database.
2. Describe ER model and normalization for database design.
3. Create, maintain, and manipulate a relational database using SQL.
4. Understand efficient data storage and retrieval mechanism, recovery techniques.
5. Design and build database system for a given real world problem.

UNIT-I:

An Overview of Database Management: Introduction- Importance of Database System, Data Independence- Relation Systems and Others- Summary, Database system architecture, Introduction- The Three Levels of Architecture-The External Level- the Conceptual Level- the Internal Level- Mapping- the Database Administrator-The Database Management Systems- Client/Server Architecture.

UNIT-II:

The E/R Models: The Relational Model, Relational Calculus, Introduction to Database Design, Database Design and ER Diagrams-Entities Attributes, Entity Sets-Relationship and Relationship Sets-Conceptual Design with the ER Models.

The Relational Model: Integrity Constraints Over Relations- Key Constraints –Foreign Key Constraints-General Constraints, Relational Algebra and Calculus, Relational Algebra- Selection and Projection- Set Operation, Renaming – Joins- Division- More Examples of Queries, Relational Calculus - Tuple Relational Calculus, Domain Relational Calculus.

UNIT-III:

Queries, Constraints, Triggers: The Form of Basic SQL Query, Union, Intersect, and Except, Nested Queries, Aggregate Operators, Null Values, Complex Integrity Constraints in SQL, Triggers and ActiveDatabase.

Schema Refinement (Normalization) : Purpose of Normalization or Schema Refinement, Concept of Functional Dependency, Normal Forms Based on Functional Dependency(1NF, 2NF and 3 NF), Concept of Surrogate Key, Boyce-Codd Normal Form(BCNF), Lossless Join and Dependency Preserving Decomposition, Fourth Normal Form(4NF).

UNIT-IV:

Transaction Management and Concurrency Control:

Transaction, Properties of Transactions, Transaction Log, Transaction Management with SQL using Commit Rollback and Save Point, Concurrency Control for Lost Updates, Uncommitted Data, Inconsistent Retrievals, and the Scheduler.

Concurrency Control with Locking Methods: Lock Granularity, Lock Types, Two Phase Locking For Ensuring Serializability, Deadlocks, Concurrency Control with Time Stamp Ordering: Wait/Die and Wound/Wait Schemes, Database Recovery Management : Transaction Recovery.

UNIT-V:

Overview of Storages and Indexing: Data on External Storage- File Organization and Indexing – Clustered Indexing – Primary and Secondary Indexes, Index Data Structures, Hash-Based Indexing – Tree- Based Indexing, Comparison of File Organization.

Text Books:

1. Introduction to Database Systems, 8th Edition CJ Date, Pearson, 2004.
2. Data base Management Systems, Raghurama Krishnan, Johannes Gehrke, TATA McGraw Hill 3rd Edition.

References Books:

1. Data base Systems design, Implementation, and Management, Peter Rob & Carlos Coronel 13th Edition.
2. Fundamentals of Database Systems, 7th Edition Elmasri Navrate Pearson Education.
3. Database Systems - The Complete Book, 2nd edition H G Molina, J D Ullman, J Widom Pearson.
4. Data base System Concepts, 7th edition, Silberschatz, Korth, McGraw Hill (TMH).

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0006	UNIX and Shell Programming	3	0	0	3

Course Objectives:

- To provide an overview of the history, development, and significance of UNIX/Linux in computing.
- To provide skills in diagnosing common problems, log analysis, and troubleshooting techniques in a UNIX/Linux environment.
- To provide an overview of system administration tasks such as user management, backup and restore, system monitoring, and software installation.
- To explain file systems, mounting, disk usage, file permissions (chmod), and file attributes (chown).

Course Outcomes:

- Understand the architecture and features of UNIX. (L2)
- Apply the commands for implementation of the File System. (L3)
- Understand the Streams, Pipes and Filters. (L2)
- Apply the pattern reorganization commands and scripting concepts. (L3)
- Implementation of system calls for file system. (L3)

Unit 1 (10 Hours)

Introduction to Unix:

Introduction to Unix-Brief History-What is Unix-Unix Components-Using Unix-Commands in Unix-Some Basic Commands-Command Substitution-Giving MultipleCommands.

Learning Outcomes: Student will be able to

- Understand the origins and development of Unix. (L2)
- Learn the key milestones in the evolution of Unix (L3)
- Learn how to use command substitution to streamline tasks. (L3)

Unit 2 (8 Hours)

Unix Utilities:

Introduction to Unix file system, vi editor, file handling utilities, security by file permissions, process utilities, disk utilities, networking commands, unlink, du, df, mount, unmount, find, unmask, ulimit, ps, w, finger, Arp, ftp, telnet, rlogin. Text processing utilities and backup utilities , detailed commands to be covered are tail, head , sort, nl, uniq, grep, egrep, fgrep, cut, paste, join, tee, pg, comm, cmp, diff, tr, awk, cpio

Learning Outcomes: Student will be able to

1. Learn the organization and layout of the Unix directory hierarchy. (L2)

2. File Attributes and Permissions: Understand the various file attributes and how permissions work. (L2)

Unit 3 (10 Hours)

Introduction to Shells:

Using the Shell-Command Line Structure-Met characters- Creating New Commands-Command Arguments and Parameters-Program Output as Arguments-Shell Variables- -More on I/O Redirection- Looping in Shell Programs.

Filters:

Filters and Pipes, Concatenating files, Display Beginning and End of files, Cut and Paste, Sorting, Translating Characters, Files with Duplicate Lines, Count characters, Words or Lines, Comparing Files.

Learning Outcomes: Student will be able to

1. Understand the role and management of variables in the Unix shell. (L2)
2. Gain advanced knowledge of input/output redirection in Unix. (L3)
3. Learn how to implement loops in shell scripts. (L3)

Unit 4 (12 Hours)

Grep: Operation, grep Family, Searching for File Content.

Sed:Scripts, Operation, Addresses, commands, Applications, grep and sed.

Shell Programming:

Basic Script concepts, Expressions, Decisions: Making Selections, Repetition, special Parameters and Variables, changing Positional Parameters, Argument Validation, Debugging Scripts, Script Examples.

Learning Outcomes: Student will be able to

1. Understand the basics of awk for pattern scanning and text processing (L2)
2. Learn best practices for creating and using effective filters and well-structured files in Unix. (L3)

Unit 5 (8 Hours)

File Management:

File Structures, System Calls for File Management – create, open, close, read, write, lseek, link, symlink, unlink, stat, fstat, lstat, chmod, chown, Directory API – opendir, readdir, closedir, mkdir, rmdir, umask.

Learning Outcomes: Student will be able to

1. Learn how to change file ownership using the chown command.(L2)
2. Understand how to change the group ownership of a file using the chgrp command.(L2)

TEXT BOOKS:

1. Unix and shell Programming Behrouz A. Forouzan, Richard F. Gilberg.Thomson
2. Your Unix the ultimate guide, Sumitabha Das, TMH. 2nd Edition.

REFERENCE BOOKS:

- Unix for programmers and users, 3rd edition, Graham Glass, King Ables, Pearson Education.
- Unix programming environment, Kernighan and Pike, PHI. / Pearson Education.
- The CompleteReference Unix, Rosen, Host, Klee, Farber, Rosinski, Second Edition, TMH.

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1):

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	3				1		1	1	2	3	3
CO2	3	2	2	1	3				1		1	1	2	3	3
CO3	3	3	3	2	3				1		1	2	3	3	3
CO4	3	3	3	2	3				2		1	2	3	3	3
CO5	2	2	2	2	2				2		1	1	2	2	2

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0007	SOFTWARE ENGINEERING	3	0	0	3

Course Objectives:

1. Explain the phases of Software Development.
2. Teach the customer requirement gathering techniques.
3. Teach Software Design techniques
4. Demonstrate coding standards
5. Apply the testing techniques on software

Course Outcomes:

Students will be able to:

1. Understand the need of Software Life Cycle Models (L1)
2. Demonstrate the Requirements of the Software Systems process (L2)
3. Summarize the system models of software engineering (L2)
4. Choose appropriate software architecture style for real-time software projects (L3)
5. Analyze various testing techniques, Risk management and Software quality of the software products(L4)

UNIT-1

Introduction: Introduction to Software Engineering, Evolving role of Software, Software Crisis, Changing Nature of Software, Software myths, Process Models for Software Development, Waterfall, prototyping Evolutionary models: Incremental model, Spiral model, Agile developmental process.

Learning Outcomes:

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

1. List the steps involved in software development. (L1)
2. Explain myths of software. (L2)
3. Apply various software process models (L3)

UNIT-2

Software Requirements Engineering: Functional & Non-functional requirements, Feasibility studies, Requirements Elicitation and Analysis, requirements validation, Software Requirements Specification, Process and System Models, context models, behavioural model, Data model.

Learning Outcomes:

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

1. Explain software development model (L2)
2. Define functional and non-functional requirements for software development (L1)
3. Analyse user requirements for a software(L4)

UNIT-3

Design Engineering: Design concepts, data design, software architecture, Architectural styles and patterns, User interface design - Golden rules, User interface analysis and design, Effective Modular Design.

Learning Outcomes:

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

1. List the software architecture style for the given problem. (L1)
2. Build Golden rules for the given problem (L3)
3. User Interface Analysis and Design (L5)

UNIT-4

Coding&Testing: Coding standards, code review and verification, Testing levels: Unit testing, integration testing, system testing . alpha and beta testing, black box and white box testing, debugging.

Learning Outcomes:

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

1. Implementation of coding standards(L6)
2. Apply different Testing concepts (L3)

UNIT-5

Risk Management: Risk types, strategies, Estimation and Planning. Software Quality .McCall Quality factors, Six Sigma for Software Quality, Quality Assurance and its techniques.

Applications: analyze the risks in any software project

Learning Outcomes:

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

1. Evaluate different Risk management techniques. (L5)

Text books:

1. Roger S. Pressman, Software Engineering, A practitioner.s Approach, 7thEdition, McGraw-Hill International Edition, 2009
2. Rajib Mal, Fundamentals of software Engineering, 3rdEdition, Eastern Economy Edition, 2009

Reference books:

1. Sommerville, Software Engineering, 7thEdition, Pearson education, 2004
2. K KAggarwal and Yogeshsingh, Software engineering,3rd Edition,New age International publication,2008

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0008	Introduction to Data Mining	3	0	0	3

COURSE OBJECTIVES:

- Students will be enabled to understand and implement classical models and algorithms in data warehousing and data mining.
- They will learn how to analyze the data, identify the problems, and choose the relevant models and algorithms to apply.
- They will further be able to assess the strengths and weaknesses of various methods and algorithms and to analyze their behavior.

COURSE OUTCOMES:

- Understand the process of knowledge discovery from data.
- Analyze the Data Pre-processing techniques.
- Apply classification techniques to various data sets.
- Apply the association rule mining to real time applications
- Apply the clustering algorithms to various data sets.

UNIT –I:

Introduction: Why Data Mining? What Is Data Mining? What Kinds of Data Can Be Mined? What Kinds of Patterns Can Be Mined? Which Technologies Are Used? Which Kinds of Applications Are Targeted? Major Issues in Data Mining. Data Objects and Attribute Types, Basic Statistical Descriptions of Data, Data Visualization, Measuring Data Similarity and Dissimilarity

Learning Outcomes: Student should be able to

1. Summarize the process of Data mining.(L2)
2. Classify various kinds of Data Mining techniques.(L2)
3. Memorize different visualization techniques.(L1)
4. Differentiate a data warehouse with data mining(L4)

UNIT –II:

Data Pre-processing: Data Preprocessing: An Overview, Data Cleaning, Data Integration, Data Reduction, Data Transformation and Data Discretization

Learning Outcomes: Student should be able to

1. Recognize various steps in Data Preprocessing.(L1)
2. Identify the process of handling noisy data.(L1)

UNIT –III:

Classification: Basic Concepts, General Approach to solving a classification problem, Decision Tree Induction: Working of Decision Tree, building a decision tree, methods for expressing an attribute test conditions, measures for selecting the best split, Algorithm for decision tree induction.

Classification: Alternative Techniques, Bayesian Classifier: Bayes theorem, using bayes theorem for classification, Native Bayes Classifier: Bayes error rate, Bayesian Belief Networks: Model representation, model building (Tan)

Learning Outcomes: Student should be able to

1. Summarize the process of classification.(L2)
2. Apply the process of classification on sample data.(L3)
3. Construct a decision tree for any sample data.(L3)
4. Calculate Bayes probability for any given data(L3)
5. Calculate Naïve Bayes probability.(L3)

UNIT –IV:

Association Analysis: Basic Concepts and Algorithms: Problem definition, Frequent Item Set generation, Rule generation, compact representation of frequent item sets, FP-Growth Algorithm. **(Tan & Vipin)**

Learning Outcomes: Student should be able to

1. Apply the Apriori algorithm on any sample data.(L3)
2. Construct an FP tree for any sample data. (L3)

UNIT –V

Cluster Analysis: Basic Concepts and Algorithms: Overview: What Is Cluster Analysis? Different Types of Clustering, Different Types of Clusters; K-means: The Basic K-means Algorithm, K-means Additional Issues, Bisecting K-means, Strengths and Weaknesses; Agglomerative Hierarchical Clustering: Basic Agglomerative Hierarchical Clustering Algorithm DBSCAN: Traditional Density Center-Based Approach, DBSCAN Algorithm, Strengths and Weaknesses. **(Tan & Vipin)**

Learning Outcomes: Student should be able to

1. Identify the data objects and partition them into different clusters.(L2)
2. Apply the different clustering techniques on sample data.(L3)
3. Acquire the knowledge of The strength and weakness of clustering algorithms.(L2)

TEXT BOOKS:

1. Introduction to Data Mining: Pang-Ning Tan & Michael Steinbach, Vipin Kumar, Pearson.
2. Data Mining concepts and Techniques, 3/e, Jiawei Han, Michel Kamber, Elsevier.

REFERENCE BOOKS:

1. Data Mining Techniques and Applications: An Introduction, Hongbo Du, Cengage Learning.
2. Data Mining : VikramPudi and P. Radha Krishna, Oxford.
3. Data Mining and Analysis - Fundamental Concepts and Algorithms; Mohammed J. Zaki, Wagner Meira, Jr, Oxford
4. Data Warehousing Data Mining & OLAP, Alex Berson, Stephen Smith, TMH.

MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1):

COs	P O 1	P O2	P O3	P O4	P O5	P O6	P O7	P O8	P O9	P O1 0	P O1 1	P O1 2	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	2				1			2	2	1	2
CO2	2	3	2	1	2				1			2	2	1	1
CO3	3	2	2	1	2				1			2	2	1	1
CO4	3	3	2	2	2				1			2	2	1	3
CO5	3	2	3	1	2				1			2	2	1	2

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0009	FUNDAMENTALS OF WEB TECHNOLOGIES	3	0	0	3

COURSE OBJECTIVES:

1. Creating Web User Interfaces
2. Creating dynamic Web pages
3. Implementing the usage of Scripts in Web Pages
4. Analyzing real world objects into Web Pages as Scripts Handlers
5. Analyzing look and feel kind of applications which are useful for real world
6. Web framework implementation using Model View Controller
7. Writing background scripts to run the virtual machines and servers

COURSE OUTCOMES:

1. Demonstrate knowledge on web page design elements.
2. Design web pages with dynamic content
3. Create Responsive layout with customized forms
4. Implement simple client-side scripts using AJAX
5. Build web applications using PHP

UNIT-I:

HTML: Introduction: Fundamentals of HTML, Working with text, Organizing text in HTML, Working with links and URLs, Creating tables, Working with images, Canvas, Forms, Frames and Multimedia.

HTML5: Introduction, HTML5 document structure, Creating editable content, Checking spelling mistakes.

Learning Outcomes:

After completion of this unit, student will be able to

- Identify basic steps that are followed to develop web applications [L2]
- Understand the functions of different HTML5 tags and how to use them [L2]
- Design and develop basic web pages using HTML5[L3]

UNIT-II:

CSS AND JAVASCRIPT: CSS: Introduction, CSS selectors, Inserting CSS in an HTML document, Backgrounds, Fonts and Text styles, Creating boxes, Displaying, Positioning and floating elements, Features of CSS3,Media queries. JavaScript: Overview of JavaScript, JavaScript functions, Events, Image maps and animations, JavaScript objects, working with browser and document objects.

Learning Outcomes:

After completion of this unit, student will be able to

- Learn the basic syntax of the CSS Style rule[L2]
- Get an idea about different CSS Selectors[L2]
- Use style rules to apply styles to different elements[L3]
- Understand HTML5 DOM object hierarchy[L2]
- Understand java script event handling mechanism[L2]

UNIT -III:

JQUERY and BOOTSTRAP: JQuery: Introduction, JQuery selectors, Events, Methods to access HTML elements and attribute. Bootstrap: Getting started with Bootstrap, Creating responsive layouts using Bootstrap CSS - Basic HTML structure for Bootstrap, Responsive classes, Rendering images, the grid system, Constructing data entry forms.

Learning Outcomes:

After completion of this unit, student will be able to

- Understanding the Bootstrap file structure[L2]
- Learning the basics of responsive design[L2]
- Understanding the all-important grid system in Bootstrap[L2]
- Introduce Bootstrap as a responsive design framework[L2]

UNIT –IV:

XML: Document type Definition, XML schemas, Document object model, XSLT, DOM and SAX Approaches, AJAX A New Approach: Introduction to AJAX, Integrating PHP and AJAX.

Learning Outcomes:

After completion of this unit, student will be able to

- Learn the basic building blocks of XML Documents [L1]
- Understand how name clashes are avoided using namespaces [L2]
- Learn how to create forms dynamically [L2]
- Learn how to generate dynamic tables[L2]
- Write interactive web applications using AJAX [L3]

UNIT-V:

INTRODUCTION TO PHP: Introduction, Data types, Variables, Constants, Expressions, String interpolation, Control structures, Functions, Arrays, Embedding PHP code in web pages, Object Oriented PHP.PHP Web forms: PHP and web forms, Sending form data to a server, Working with cookies and session handlers PHP with MySQL: Interacting with the database, Prepared statement, Database transactions.

Learning Outcomes:

After completion of this unit, student will be able to

- Examine the relationship between PHP and MySQL L2]
- Plan a PHP Web application [L4]
- Create and use a Logon Window [L6]
- Manage User sessions using cookies and sessions [L3]

Text Books:

1. Kogent Learning Solutions Inc, HTML 5 Black Book: Covers CSS3, JavaScript, XML, XHTML, AJAX, PHP and JQuery, Dreamtech Press, Second Edition, 2016.
2. W. Jason Gilmore, Beginning PHP and MySQL, APress, Fourth Edition, 2011.

Reference Books:

1. Snig Bahumik, Bootstrap Essentials, PACKT Publishing, 2015 (e-book).
2. Thomas A. Powell, The Complete Reference: HTML and CSS, Tata McGraw Hill, Fifth Edition, 2010
3. Andrea Tarr, PHP and MySQL, Willy India, 2012.
4. Ruby on Rails Up and Running, Lightning fast Web development, Bruce Tate, Curt Hibbs, Oreilly (2006)

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1):

COs	P O 1	P O 2	P O 3	P O 4	P O 5	P O 6	P O 7	P O 8	P O 9	P O 10	P O 11	P O 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	2				1			2	2	1	2
CO2	2	3	2	1	2				1			2	2	1	1
CO3	3	2	2	1	2				1			2	2	1	1
CO4	3	3	2	2	2				1			2	2	1	3
CO5	3	2	3	1	2				1			2	2	1	2

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0010	FUNDAMENTALS OF COMPUTER NETWORKS	3	0	0	3

Course Objectives:

1. To introduce the fundamental various types of computer networks.
2. To understand state-of-the-art in network protocols, architectures, and applications.
3. To explore the various layers of OSI Model.

Course Outcomes:

The students can

1. Understand OSI and TCP/IP reference models with an emphasis to Physical Layer, Data Link Layer and Network Layer.
2. Analyze the issues related to data link, medium access and transport layers by using channel allocation and connection management schemes. Analyze MAC layer protocols and LAN technologies.
3. Solve problems related to Flow control, Error control, Congestion control and Network Routing.
4. Design and compute subnet masks and addresses for networking requirements.
5. Understand how internet works

UNIT-I:

Introduction: Network Hardware and software Reference models- The OSI Reference Model- the TCP/IP Reference Model - A Comparison of the OSI and TCP/IP Reference Models, Examples of Networks: Novell Networks, Arpanet, Internet, Network Topologies WAN, LAN, MAN.

Physical Layer: Guided Transmission Media, Digital Modulation and Multiplexing: frequency division multiplexing, wavelength division multiplexing, synchronous time division multiplexing, statistical time division multiplexing.

UNIT-II:

The Data Link Layer - Design Issues, Services Provided to the Network Layer – Framing – Error Control – Flow Control, Error Detection and Correction – Error-Correcting Codes – Error Detecting Codes, Elementary Data Link Protocols, Sliding Window Protocols.

Channel allocation methods: TDM, FDM, ALOHA, Carrier sense Multiple access protocols, Collision Free protocols – IEEE standard 802 for LANS – Ethernet, Token Bus, Token ring, Bridges and IEEE 802.11 and 802.16. Data link layer switching, virtual LANs.

UNIT-III:

Network layer Routing Algorithms: Design Issues, Routing Algorithms-Shortest path, Flooding,

Flow based Distance vector, Link state, Hierarchical, Broadcast routing, Congestion Control algorithms-General principles of congestion control, Congestion prevention policies, Choke packets, Load shedding, and Jitter Control.

Internet Working: Tunnelling, internetworking, Fragmentation, Network layer in the internet– IP protocols, IP address, Subnets, Internet control protocols, OSPF, BGP, Internet multicasting, Mobile IP, IPV6.

UNIT IV:

The Transport Layer: Elements of transport protocols – addressing, establishing a connection, releasing connection, flow control and buffering and crash recovery, End to end protocols: UDP, Real Time Transport Protocol.

The Internet Transport Protocol: TCP- reliable Byte Stream (TCP) end to end format, segment format, connection establishment and termination, sliding window revisited, adaptive retransmission, TCP extension, Remote Procedure Call.

UNIT – V:

Application Layer: WWW and HTTP: Architecture- Client (Browser), Server, Uniform Resource Locator HTTP: HTTP Transaction, HTTP Operational Model and Client/Server Communication, HTTP Generic Message Format, HTTP Request Message Format, HTTP Response Message Format.

The Domain Name System: The DNS Name Space, Resource Records, Name Servers, Electronic Mail: Architecture and Services, The User Agent, Message Formats, Message Transfer, Final Delivery.

Text Books:

1. Data Communications and Networks – Behrouz A. Forouzan, Third Edition ,TMH.
2. Computer Networks, 5ed, David Patterson,Elsevier
3. Computer Networks: Andrew S Tanenbaum, 5th Edition. PearsonEducation/PHI
4. Computer Networks, Mayank Dave, CENGAGE

References:

1. Tanenbaum and David J Wetherall, Computer Networks, 5th Edition, Pearson Edu, 2010
2. Computer Networks: A Top Down Approach, Behrouz A. Forouzan, FirouzMosharraf, McGraw Hill Education
3. An Engineering Approach to Computer Networks-S.Keshav, 2nd Edition, PearsonEducation.
4. Understanding communications and Networks, 3rd Edition, W.A. Shay, ThomsonThe TCP/IP Guide, by Charles M. Kozierok, Free online Resource,<http://www.tcpipguide.com/free/index.htm>.

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0011	BASICS OF CLOUD COMPUTING	3	0	0	3

Course Objective :

1. To provide students with the fundamentals and essentials of Cloud Computing.
2. To provide students a sound foundation of the Cloud Computing so that they are able to start using and adopting Cloud Computing services and tools in their real life scenarios.
3. To enable students exploring some important cloud computing driven commercial systems and applications.

Course Outcomes :

Upon completion of the course, it is expected that student will be able to:

1. Understand and analyze different computing paradigms
2. Understand the basics of cloud computing and different cloud deployment models.
3. Understand different cloud implementation and management strategies.
4. Understand and evaluate different cloud service models.
5. Identify, analyze and use different cloud services /applications/tools available from key cloud providers.

UNIT-I:

Computing Paradigms: High-Performance Computing, Parallel Computing, Distributed Computing, Cluster Computing, Grid Computing, Cloud Computing, Bio computing, Mobile Computing, Quantum Computing, Optical Computing, Nano computing..

UNIT-II:

Cloud Computing Fundamentals: Motivation for Cloud Computing, The Need for Cloud Computing, Defining Cloud Computing, Definition of Cloud Computing, Cloud Computing is a Service, Cloud Computing is a Platform, Principles of Cloud computing, Five Essential Characteristics, Four Cloud Deployment Models

UNIT-III:

Cloud Computing Architecture and Management: Cloud architecture, Layer, Anatomy of the Cloud, Network Connectivity in Cloud Computing, Applications on the Cloud, Managing the Cloud, Managing the Cloud Infrastructure, Managing the Cloud Application, Migrating Application to Cloud, Phases of Cloud Migration Approaches for Cloud Migration.

UNIT-IV:

Cloud Service Models: Infrastructure as a Service, Characteristics of IaaS. Suitability of IaaS, Pros and Cons of IaaS, Summary of IaaS Providers, Platform as a Service, Characteristics of PaaS, Suitability of PaaS, Pros and Cons of PaaS, Summary of PaaS Providers, Software as a Service, Characteristics of SaaS, Suitability of SaaS, Pros and Cons of SaaS, Summary of SaaS Providers, Other Cloud Service Models.

UNIT-V:

Cloud Providers and Applications : EMC, EMC IT, Captiva Cloud Toolkit, Google Cloud Platform, Cloud Storage, Google Cloud Connect, Google Cloud Print, Google App Engine, Amazon Web Services, Amazon Elastic Compute Cloud, Amazon Simple Storage Service, Amazon Simple Queue service, Microsoft, Windows Azure, Microsoft Assessment and Planning Toolkit, SharePoint, IBM, Cloud Models, IBM Smart Cloud, SAP Labs, SAP HANA Cloud Platform, Virtualization Services Provided by SAP, Sales force, Sales Cloud, Service Cloud: Knowledge as a Service, Rack space, VMware, Manjra soft, Aneka Platform.

Text Book:

- i. Essentials of Cloud Computing, K. Chandra sekhran, CRC press.

Reference Books:

- i. Cloud Computing: Principles and Paradigms, Rajkumar Buyya, James Broberg and Andrzej M. Goscinski, Wiley.
- ii. Distributed and Cloud Computing, Kai Hwang, Geoffery C. Fox, Jack J. Dongarra, Elsevier.
- iii. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, Tim Mather, Subra Kumara swamy, Shahed Latif, O'Reilly.

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0012	INTRODUCTION TO MACHINE LEARNING	3	0	0	3

Course Objectives:

- To familiarize with a set of well-known Machine Learning (ML) algorithms.
- The ability to implement machine learning algorithms.
- To understand how machine learning algorithms are evaluated.
- To formulate machine learning problems corresponding to different applications.
- To understand a range of machine learning algorithms with their pros and cons.

Course Outcomes:

- Illustrate the characteristics of machine learning algorithms.
- Summarize the process of classification using decision tree approach.
- Apply Bayesian classifier to label data points an ML approach.
- Understand computational and instance-based learning.
- Understand advanced computational and types of learning.

UNIT I: (10 Hours)

Introduction: Well- posed learning problems, designing a learning system, perspectives, and issues in machine learning. Applications of machine learning. **Concept Learning:** Concept learning and the general to specific ordering. Concept learning task, Concept learning as search, Find-s: finding a maximally specific hypothesis, version spaces and the candidate elimination algorithm, Remarks on version spaces and candidate elimination, Inductive bias.

Learning Outcomes: Student will be able to

- Summarize the process of machine learning.
- Recognize various machine learning Applications.
- Understand various candidate elimination algorithms

UNIT II: (09 Hours)

Decision Tree Learning: Decision tree representation, Appropriate problems for decision tree learning, the basic decision tree learning algorithm, Hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning

Learning Outcomes: Student will be able to

- Summarize the process of classification.
- Construct a decision tree for any sample data.

UNIT III: (11 Hours)

Bayesian learning: Bayes theorem, Bayes theorem and concept learning, Maximum likelihood and least squared error hypotheses, Maximum likelihood hypotheses for predicting probabilities, Bayes optimal classifier, An example learning to classify text, Bayesian belief networks

Learning Outcomes: Student will be able to

- Calculate Bayes probability for any given data.
- Calculate Naïve Bayes probability.
- Distinguish the process of Bayes and Naïve Bayes probability calculation.

UNIT IV: (09 Hours)

Computational learning theory – 1: Probability learning an approximately correct hypothesis, Sample complexity for infinite Hypothesis spaces, The mistake bound model of learning- Instance- Based learning- Introduction.

Learning Outcomes: Student will be able to

- Understand Probability learning and Instance- Based learning.

UNIT V: (09 Hours)

Computational learning theory – 2: K- Nearest Neighbour Learning, Locally Weighted Regression, Radial Basis Functions, Case-Based Reasoning, Remarks on Lazy and Eager Learning

Learning Outcomes: Student will be able to

- Understand the concept of classification.
- Distinguish lazy Lazy and Eager Learning.

Contemporary Problems:

Explore Modern Tools- Altair Rapid Miner Tools- Scalability Issues- Regularity Complex-Black Box Problem

Text Books

1. Tom M. Mitchell, —Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.
2. Raschka, Sebastian and Mirjalili, Vahid, Python Machine Learning, 3rd Edition, Packt Publishing., 2019
3. Stephen Marsland- Machine Learning – An Algorithmic Perspective – Second Edition – Chapman & Hall CRC Press, 2015

References

1. Ethem Alpaydin, Introduction to machine learning, 2nd edition, PHI.
2. Kevin P. Murphy, "Machine Learning," A Probabilistic Perspective, MIT Press, 2012

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1):

CO	PO1	PO2	P O3	P O4	P O5	P O6	P O7	P O8	P O9	PO 10	PO 11	PO 12	PS O1	PS O 2	PS O 3
CO1	3	3	1	2	2			1	2	1		2	1	2	1
CO2	3	3	1	2	2			1	2	1		2	1	2	1
CO3	3	3	3	3	3			1	2	1		2	1	2	1
CO4	3	3	1	2	2			1	2	1		2	1	2	1
CO5	3	3	1	2	2			1	2	1		2	1	2	1

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0013	ESSENTIALS OF CYBER SECURITY	3	0	0	3

Course Objectives:

1. Understand the fundamental concepts and principles of cyber security.
2. Understand Security architecture, risk management, attacks, incidents, and emerging IT and IS technologies.
3. To Provide the importance of Cyber Security and the integral role of Cyber Security professionals.
4. Recognize the importance of cybersecurity in protecting digital assets and information.
5. Analyze real-world cyber-attack scenarios and case studies.

Course Outcomes:

1. Understand Cyber Security architecture principles
2. Analyze the System and application security threats and vulnerabilities
3. Estimate operational cyber security strategies and policies.
4. Apply security model to handle mobile, wireless devices and related security issues.
5. Analyze the functionality of Security Technologies and Controls in Cybersecurity

UNIT - I: (8 Hours)

Introduction to Cyber Security: Need for Cyber security - History of Cyber security - Defining Cyberspace and Cyber security, scope of Cyber security, Importance of Cyber security in the modern world, Evolution of cyber threats, Importance of Cybersecurity in the digital age.

Foundations of Cyber Security: Cyber Security principles, threat models, and cyber laws. Confidentiality, integrity, and availability (CIA) Triad– Cyber security Framework, Security principles and concepts, Risk management. to better understand the dynamics of Cyber Security.

Learning Outcomes: student will be able to

- Outline the Importance of Cyber security. (L2)
- Understand the Security architecture principles and concepts. (L2)
- Understand the Design of Cyber security Framework. (L2)

UNIT-II: (10 Hours)

Common Threats and Attack Vectors: Introduction, Proxy Servers and Anonymizers, Password Cracking, Key loggers and Spywares, Virus and Worms, Trojan Horses and Backdoors, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Overflow, Attacks on Wireless Networks, Social Engineering attacks: Introduction, Phishing, spear phishing, pretexting, Identity Theft (ID Theft).

Learning Outcomes: student will be able to

- Understand about the Cyber security Threats and Attacks. (L2)
- Summarize the various types of application security vulnerabilities (L2)
- Analyze the System and application security threats and vulnerabilities (L4)

UNIT-III: (12 Hours)

Introduction to Cyber Crime, law and Investigation: Introduction to Cybercrime, Definition and scope of cybercrime, Categories of cybercrimes, Impact of cybercrime, Cybercrime and Information Security, classifications of cybercrimes, Cybercrime: The Legal Perspectives, cybercrime and the Indian IT Act 2000, a Global perspective on Cybercrimes.

Cyber laws: Introduction to Cyber Laws, Need for Cyber laws The Indian Context, The Indian IT Act, Challenges to Indian Law and Cybercrime Scenario in India, Consequences of Not Addressing the Weakness in Information Technology Act, Digital Signatures and the Indian IT Act, Information Security Planning and Governance, Information Security Policy Standards.

Learning Outcomes: student will be able to

- Extend The Categories of cybercrimes and Impact of cybercrime(L2)
- Understand about the Need for Cyber laws and Cybercrime Scenario in India(L2)
- Estimate operational cyber security strategies and policies(L5)
- Develop an understanding of cybercrimes and various legal perspectives involved(L3)

UNIT-IV: (10 Hours)

Cybercrime-Mobile and Wireless Devices: Introduction, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Authentication Service Security, Attacks on Mobile/Cell Phones.

Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops.

Learning Outcomes: student will be able to

- Understand Various devices and related security issues (L2)
- Develop a security model to handle Policies and Measures in Computing era(L3)
- Develop a security model to handle mobile, wireless devices and related security issues of an organization (L3)

UNIT-V: (8 Hours)

Security Technologies and Controls in Cyber security: Access control mechanisms, Encryption, Firewalls, intrusion detection systems (IDS), intrusion prevention systems (IPS), Network Security, Security Information and Event Management (SIEM), functionality of cyber security tools.

Legal and Ethical Aspects of Cyber Security: Laws and regulations governing cyber security, Ethical considerations in cyber security practices, Privacy issues.

Learning Outcomes: student will be able to

- Analyze the functionality of Security Technologies and Controls in Cyber security(L4)
- Outline the Ethical considerations in cyber security practices(L2)
- Understand the functionality of cyber security tools(L2)

Text Books:

1. Computer Security: Principles and Practice, Third Edition, William Stallings, Lawrie Brown, Pearson Education, 2014.
2. Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Nina Godbole, SunitBelapure, 1st Edition Publication Wiley, 2011.
3. William Stallings, Effective Cyber security: A Guide to Using Best Practices and Standards, 1st edition, 2019.
4. Mark Rhodes, Ousley, Information Security, 1st Edition, MGH, 2013.

Reference Books:

1. Principles of Information Security, Michael E. Whitman and Herbert J. Mattord, Cengage Learning.
2. Charles J. Brooks, Christopher Grow, Philip A. Craig, Donald Short, Cybersecurity Essentials, Wiley Publisher, 2018.
3. Yuri Diogenes, Erdal Ozkaya, Cyber security - Attack and Defense Strategies, Packt Publishers,

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1):

CNO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
	3	2	1	-	-	-	-	-	-	-	-	1	-	-	1
	3	3	2	2	-	-	-	-	-	-	-	1	2	-	1
	3	2	2	-	-	-	-	-	-	-	-	2	2	-	-
	3	2	1	1	2	-	-	-	-	1	-	1	-	-	1
	3	2	2	2	2	-	-	-	-	1	-	1	1	2	-
	3	2	2	2	2	-	-	-	-	1	-	1	2	2	1

** For Entire Course, PO & PSO Mapping*

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0014	INTRODUCTION TO REACT JS	3	0	0	3

Course Objectives:

- To learn essential React JS skills for front-end development.
- To explore client-side JavaScript application development and the React library.
- To implement React components, hooks, and state management for building interactive UIs.
- To gain experience with React.js, JSX, HTML, CSS, and JavaScript.
- To create a functional front-end web application using React.

Course Outcomes:

1. Understand the anatomy of React Java Script. (L2)
2. Understand the life cycle methods of React JS. (L2)
3. Implement React components for building applications. (L3)
4. Apply React hooks for component reusability and monitoring. (L3)
5. Implement React rendering for interactive applications. (L3)

Unit 1 (10 Hours)

React JS: Introduction to React JS, React vs Angular, React Version History, Architecture of the React Application, Installation, Creating and Running React App, Anatomy of React Project.

Templating using JSX: Expressions, Operators, Attributes, Fragments.

Learning Outcomes: Student will be able to

- Understand react framework for building applications. (L2)
- Understand the installations of react packages. (L2)
- Implement templates in react applications. (L3)

Unit 2 (8 Hours)

React Core: Props, State, Event Handling, Lists and Keys, Styling, Pagination, React Life Cycle, Life Cycle Methods, State Management, Mounting Life Cycle.

Learning Outcomes: Student will be able to

- Understand event handling in React. (L2).
- Implement life cycle methods in react. (L3).
- Implement props and states in building react apps. (L3)

Unit 3 (10 Hours)

React Components: Pure Components, memo, Refs, Portals, Higher Order Components (HOC), Context, HTTP requests (POST & GET).

Learning Outcomes: Student will be able to

- Understand http request methods in handling end points. (L2)
- Implement components to handle react requests. (L3)
- Implement higher order components and refs in react. (L3)

Unit 4 (12 Hours)

React Hooks: Introduction to Hooks, useState, useEffect, Run Effects, Fetching Data, useContext, useReducer, useCallback, useMemo, useRef, Custom Hooks

Learning Outcomes: Student will be able to

- Understand react hooks. (L2)
- Apply hooks and custom methods for handling components. (L3)
- Implement context and callback methods in hooks. (L3)

Unit 5 (8 Hours)

React Render: Introduction to Rendering, useState, useReducer, State Immutability, Parent & Child, Memo, Context, useCallback.

Learning Outcomes: Student will be able to

- Understand the working react rendering. (L2)
- Implement userReducer and context for rendering react apps. (L3)

TEXT BOOKS:

1. React.js Book: Learning React JavaScript Library From Scratch by Greg Sidelnikov, Learning Curve.
2. React: Quickstart Step-By-Step Guide To Learning React Javascript Library (React.js, Reactjs, Learning React JS, React Javascript, React Programming) by Lionel Lopez

REFERENCE BOOKS:

- Full-Stack React Projects: Learn MERN stack development by building modern web apps using MongoDB, Express, React, and Node.js, 2nd Edition by Shama Hoque, Packt

Course Code	Subject Name	L	T	P	C
R23CSE-OE0015	Deep Learning	3	0	0	3

Course Objectives

1. Understand the fundamentals of machine learning algorithms and their challenges.
2. Learn the architecture and training of deep feedforward networks.
3. Master regularization techniques to improve deep learning model performance.
4. Explore optimization methods for training deep neural networks.
5. Gain comprehensive knowledge of convolutional neural networks and their applications.

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

1. Apply machine learning algorithms to solve practical problems, demonstrating understanding of overfitting and underfitting (Application).
2. Analyse and design deep feedforward networks using gradient-based learning techniques (Analysis).
3. Evaluate the effectiveness of various regularization techniques to enhance model performance and robustness (Evaluation).
4. Analyse advanced optimization strategies to efficiently train deep neural networks (Synthesis).
5. Understand the convolutional neural networks, explaining their significance in the context of deep learning history and neuroscientific principles.

Unit-I – Machine Learning Basics (8 Hours)

Learning Algorithms-Capacity,OverfittingandUnderfitting-HyperparametersandValidationSets-
Estimators,BiasandVariance -SupervisedLearningAlgorithms -UnsupervisedLearningAlgorithms -
ChallengesMotivatingDeepLearning.

Learning Outcomes: Student will be able to understand the fundamentals of machine learning.

Application:ML Algorithms can use in health care, NLP and computer vision applications.

Unit – II: DeepNetworks (8 Hours)

Deep Feed forward Networks: Example: Learning XOR - Gradient-Based Learning - Hidden Units - Architecture Design – BackPropagation and Other Differentiation Algorithms.

Learning Outcomes:Student will be able to analyse the fundamentals of deep learning.

Application:Deep Networks can use in NLP and finance applications for solving complex problems.

Unit – III: Regularization for Deep Learning (8 Hours)

Parameter Norm Penalties – Norm Penaltiesas Constrained Optimization- Regularization and Under Constrained Problems – DatasetAugmentation-NoiseRobustness- SemiSupervisedLearning- MultiTaskLearning- EarlyStopping - ParameterTyingandParameterSharing – SparseRepresentations -BaggingandOtherEnsembleMethods -Dropout.

Learning Outcomes: Student will be able to evaluate the regularization importance in deep neural networks.

Application: Regularization is used for improve the performance of network in various applications like computer vision and NLP etc.

Unit – IV: Optimization for Training Deep Models (8 Hours)

How Learning Differs from Pure Optimization- Challenges in Neural Network Optimization- Basic Algorithms – Parameter Initialization Strategies – Algorithms with Adaptive Learning Rates- Approximate Second Order Methods- Optimization Strategies and Meta-Algorithms.

Learning Outcomes: Student will be able to analyse the fundamentals of optimization techniques in deep learning.

Application: Optimization techniques are using in many applications like NLP, computer vision and finance sector.

Unit – V: Convolutional Networks (8 Hours)

The Convolution Operation- Motivation- Pooling – Convolution and Pooling as an Infinitely Strong Prior – Variants of the Basic Convolution Function- The Neuro scientific Basis for Convolutional Networks – Convolutional Networks and the History of Deep Learning.

Learning Outcomes: Student will be able to understand the purpose of CNN and its importance in deep learning.

Application: CNN used in the area of computer vision applications and many more like NLP, finance and manufacturing sectors.

Text Books: Ian Goodfellow and Yoshua Bengio and Aaron Courville,” Deep Learning” MIT Press, 2017.

References Books:

1. Shai Shalev-Shwartz, Shai Ben-David “Understanding Machine Learning: From Theory to Algorithms” , Cambridge Press
2. Peter Harington “ Machine Learning in Action”, , 2012, Cengage.

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1):

CO	PO1	PO2	P O3	P O4	P O5	P O6	P O7	P O8	P O9	PO 10	PO 11	PO 12	PS O1	PS O2	PSO 3
C01	3	2	1	1	1							1			1
C02	3	2	1	1	1							1			1
C03	3	2	1	1	1							1			1
C04	3	2	1	1	1							1			1
C05	3	2	1	1	1							1			1

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0016	DevOps	3	0	0	3

Course Objectives:

DevOps improves collaboration and productivity by automating infrastructure and workflows and continuously measuring applications performance.

(Need to write at least 5 objects for this course)

Course Outcomes:

At the end of the course, student will be able to

1. Enumerate the principles of continuous development and deployment, automation of configuration management, inter-team collaboration, and IT service agility
2. Understand different actions performed through Version control tools like Git.
3. Illustrate the types of version control systems, continuous integration tools, continuous monitoring tools, and cloud models
4. Ability to Perform Automated Continuous Deployment
5. Understand to leverage Cloud-based DevOps tools using Azure DevOps

Need to write what is the skill gained by student at the end of each unit and mention the blooms taxonomy levels in parenthesis for each course outcome

UNIT –I:

Introduction to Software Engineering: Phases of Software Development life cycle. Models ,Values and principles of agile software development.

Learning outcomes:

- Identify and describe the phases of the Software Development Life Cycle (SDLC) (Knowledge, Understanding). (L1 & L2)
- Compare and contrast different software development models (e.g., Waterfall, Agile) and their applications (L3)
- Apply the values and principles of agile software development in real-world scenarios (L3)

UNIT -II: Introduction To DevOps -Devops Essentials – Introduction To AWS, GCP, Azure – Version control systems: Git and Github.

Learning outcomes:

- Understand the essentials of DevOps and its importance in modern software development (L2)
- Demonstrate the use of version control systems(L3)
- Compare cloud platforms and their relevance to DevOps practices (L3)

UNIT –III:

DevOps adoption in projects: Technology aspects, Agiling capabilities, Tool stack implementation, People aspect, processes.

Learning outcomes:

- Analyze the technology aspects required for successful DevOps adoption (L4)
- Analyze the agile capabilities and tool stack implementation for DevOps in various projects (L4)
- Analyze the people and process aspects necessary for DevOps adoption and their impact on project success (L4)

UNIT -IV:

CONTINUOUS INTEGRATION USING JENKINS: Install & Configure Jenkins, Jenkins Architecture Overview, Creating a Jenkins Job, Configuring a Jenkins job, Introduction to Plugins, Adding Plugins to Jenkins, Commonly used plugins (Git Plugin, Parameter Plugin, HTML Publisher, Copy Artifact and Extended choice parameters). Configuring Jenkins to work with java, Git and Maven, Creating a Jenkins Build and Jenkins workspace.

Learning outcomes:

- Install and configure Jenkins for continuous integration (L3)
- implement Jenkins jobs and pipelines, including configuring jobs and adding plugins (L3)
- Understand Jenkins in continuous integration by creating and managing builds (L2)

UNIT-V: BUILDING DEVOPS PIPELINES USING AZURE :
Create Github Account, Create Repository, Create Azure Organization, Create a new pipeline, Build a sample code, Modify azure-pipelines.yaml file

Learning outcomes:

- Create and manage repositories on GitHub and integrate them with Azure DevOps (Application). (L3)
- Implement new pipeline in Azure DevOps and build sample code using azure-pipelines.yaml file(L3)
- Analyze the Modification and optimization Azure DevOps pipelines for continuous deployment (L4)

Text Books:

- Roberto Vormittag, “A Practical Guide to Git and GitHub for Windows Users: From Beginner to Expert in Easy Step-By-Step Exercises”, Second Edition, Kindle Edition, 2016.
- Jason Cannon, “Linux for Beginners: An Introduction to the Linux Operating System and Command Line”, Kindle Edition, 2014

Reference Books:

- Hands-On Azure Devops: Cidc Implementation For Mobile, Hybrid, And Web Applications Using Azure Devops And Microsoft Azure: CICD Implementation for ... DevOps and Microsoft Azure (English Edition) Paperback – 1 January 2020 by Mitesh Soni
- Jeff Geerling, “Ansible for DevOps: Server and configuration management for humans”, First Edition, 2015.
- David Johnson, “Ansible for DevOps: Everything You Need to Know to Use Ansible for DevOps”, Second Edition, 2016.
- MariotTsitoara, “Ansible 6. Beginning Git and GitHub: A Comprehensive Guide to Version Control, Project Management, and Teamwork for the New Developer”, Second Edition, 2019.

Web References :

- <https://www.jenkins.io/user-handbook.pdf>
- <https://maven.apache.org/guides/getting-started/>

COURSE OUTCOMES VS POs MAPPING (DETAILED: HIGH: 3, MEDIUM: 2, LOW: 1)

Cours e	CNO	PO 1	P O2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	P O 9	P O 10	P O 11	PO 12	PS O1	PS O2	PS O3
DevO ps		3	3	2	2					2			1	3	1	2
		3	3	2	2					2			1	3	1	2
		3	3	2		2				2			1	3	1	2
		3	3	2		2				2			1	3	1	2
		3	3	2		2				2			1	3	1	2
		3	3	2	2	2				2			1	3	1	2

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0017	Mobile Computing	3	0	0	3

Course Objective:

1. Understand the fundamental concepts, architecture, and paradigms of mobile computing and GSM.
2. Comprehend the motivation for specialized MAC techniques in wireless communications, addressing issues such as hidden and exposed terminals, near and far terminals and IEEE 802.11.
3. Analyze the IP and Mobile IP network layers, focusing on packet delivery, handover management, location management, registration, tunneling, encapsulation and DHCP.
4. Understand conventional TCP/IP protocols and specialized protocols like Indirect TCP, Snooping TCP, and Mobile TCP for mobile networks and database issues in mobile computing.
5. Introduce the concept, applications, and challenges of Mobile Ad hoc Networks (MANETs), and to explore various routing algorithms such as DSR, AODV, and DSDV.

Course Outcomes: Upon Successful completion of Course, the students will be able to

1. Understand the fundamental concepts, architecture, and paradigms of mobile computing and GSM.
2. Understand the need for specialized MAC techniques in wireless communications, addressing challenges like hidden and exposed terminals, near and far terminals and IEEE 802.11.
3. Understand the concept of the IP and Mobile IP network layers, focusing on packet delivery, handover management, location management, registration, tunnelling, encapsulation, route optimization, and DHCP.
4. Understand proficient in conventional TCP/IP protocols as well as specialized protocols like Indirect TCP, Snooping TCP, and Mobile TCP.
5. Understand the concept, applications, and challenges of Mobile Ad hoc Networks (MANETs).

UNIT I

Introduction: Mobile Communications, Mobile Computing – Paradigm, Promises/Novel Applications and Impediments and Architecture; Mobile and Handheld Devices, Limitations of Mobile and Handheld Devices.

GSM – Services, System Architecture, Radio Interfaces, Protocols, Localization and Calling, Handover, Security, New Data Services, GPRS.

Learning Outcome:

- 1) Student able to understand the basic concepts of mobile communications and GSM.

UNIT –II

(Wireless) Medium Access Control (MAC): Motivation for a specialized MAC (Hidden and exposed Terminals, Near and far terminals), SDMA, FDMA, TDMA, CDMA.

Learning Outcome:

- 1) Student able to differentiate the SDMA, FDMA, TDMA and CDMA.

UNIT –III

Mobile Network Layer: IP and Mobile IP Network Layers, Packet Delivery and Handover Management, Location Management, Registration, Tunnelling and Encapsulation, Route Optimization, DHCP.

Learning Outcome:

- 1) Student able to explain the Mobile IP in mobile networks.

UNIT –IV

Mobile Transport Layer: Conventional TCP/IP Protocols, Indirect TCP, Snooping TCP, Mobile TCP, Other Transport Layer Protocols for Mobile Networks.

Learning Outcome:

- 1) Student able to understand the issues of databases and Mobile TCP/IP in mobile networks.

UNIT V

Mobile Ad hoc Networks (MANETs): Introduction, Applications & Challenges of a MANET, Routing, Classification of Routing Algorithms, Algorithms such as DSR, AODV, DSDV, etc., Mobile Agents, Service Discovery. **Protocols and Platforms for Mobile Computing:** WAP, Bluetooth, XML, J2ME, Java Card, PalmOS, Windows CE, SymbianOS, Linux for Mobile Devices, Android.

Learning Outcomes:

- 1) Student able to identify the best routing protocol for mobile networks for data transmission.

Text Books:

1. Jochen Schiller, “Mobile Communications”, Addison-Wesley, Second Edition, 2009.
2. Raj Kamal, “Mobile Computing”, Oxford University Press, 2007, ISBN: 0195686772

Reference Book:

1. ASOKE K TALUKDER, HASAN AHMED, ROOPA R YAVAGAL, “Mobile Computing, Technology Applications and Service Creation” Second Edition, Mc Graw Hill.
2. UWE Hansmann, Lothar Merk, Martin S. Nocklous, Thomas Stober, “Principles of Mobile Computing,” Second Edition, Springer.

Course Code	Subject Name	L	T	P	C
R23CSE-OE0018	Java Full-Stack Development (Open Elective)	0	1	2	2

Course Objectives:

1. Understand the basics of full-stack web development and the software development life cycle.
2. Design simple and responsive web pages using HTML, CSS, and JavaScript.
3. Develop basic backend applications using Java Servlets, JSP, and connect to databases.
4. Learn how to use SQL for database management.
5. Build and deploy a simple full-stack project using basic tools.

Course Outcomes: After completing this course, students will be able to:

1. Understand the structure of a full-stack web application.
2. Design interactive and responsive web pages.
3. Write basic backend logic and connect to a database.
4. Apply simple SQL queries to manage data effectively.
5. Build and deploy a simple full-stack project.

Unit 1: Frontend Development

Introduction to Full-Stack Development

- What is Full-Stack Development?
- Frontend, Backend, and Databases overview

HTML & CSS Basics

- HTML5: Elements, Forms, Tables
- CSS3: Selectors, Flexbox, Grid
- Responsive design with media queries

JavaScript Basics

- Variables, Loops, Functions
- Simple DOM Manipulation and Event Handling

Unit 2: Backend Development

Java Servlets & JSP

- Servlet lifecycle
- Handling HTTP requests and responses
- Basic JSP: Scripting and Expressions

Introduction to Hibernate

- What is Hibernate?
- Basic setup and configuration
- Mapping simple Java classes to database tables

Unit 3: Database Development

SQL Basics

- SELECT, INSERT, UPDATE, DELETE
- Simple JOINS
- Basic database normalization

Hibernate Basics

- Using annotations for mapping
- Simple one-to-many relationships
- Basic queries with HQL

Unit 4: Introduction to Frameworks

Spring & Spring Boot

- What is Spring? IoC and Dependency Injection
- Introduction to Spring Boot: Starter packs, auto-configuration
- Simple Spring Boot application connecting to a database

Unit 5: REST APIs & Deployment

RESTful APIs

- Basic REST concepts: GET, POST, PUT, DELETE
- Building a simple REST API with Spring Boot

Deployment Basics

- Using Git/GitHub for version control
- Testing APIs with Postman
- Simple project deployment (local server)

Project & Capstone

Mini Projects:

- Online Book Store
- Student Portal or basic E-Commerce App

Tools:

- Git/GitHub for version control
- Maven/Gradle for builds
- Postman for testing

Project & Deployment Tools

- Git & GitHub – Version Control
- Maven/Gradle – Build Tools
- Postman – API Testing

Full-Stack Capstone Project

- Online Book Store / Student Portal
- E-Commerce App with Payment Gateway.

CONTEMPORARY TOPICS:

1. Micro services Architecture using Spring Boot and Spring Cloud
2. JWT-Based Authentication and Authorization in Web Applications
3. Containerization and Deployment using Docker and Kubernetes
4. Integration of No SQL Databases like MongoDB with Java Applications

APPLICATIONS:

1. Online Book Store

- Features: User registration/login, book catalog, shopping cart, order management, admin panel
- Tech Stack: Java Spring Boot , React/HTML-CSS-JS , MySQL

2. Student Information Portal

- Features: Student profiles, course registration, grade tracking, admin dashboard
- Tech Stack: Java Servlets + Hibernate, Bootstrap + JavaScript , PostgreSQL

3. Job Placement Management System

- Features: Company registration, student applications, interview tracking, placement stats
- Tech Stack: Spring Boot + JSP , HTML/CSS + JavaScript , MySQL

TEXT BOOKS:

1. "Learning Web Design" by Jennifer Niederst Robbins, 5th Edition, O'Reilly Media
2. "Beginning Hibernate: For Hibernate 5" by Joseph B. Ottinger, Jeff Linwood, Dave Minter, 4th Edition, Apress

REFERENCE BOOKS:

1. "Web Programming and Internet Technologies" by Uttam K. Roy, Published 2010, Oxford University Press.
2. "Java: The Complete Reference" By Herbert Schildt, Published 2023, McGraw Hill Education

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1)

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
117.1	3	2	2	1	3				1		1	1	2	3	3
117.2	3	2	2	1	3				1		1	1	2	3	3
117.3	3	3	3	2	3				1		1	2	3	3	3
117.4	3	3	3	2	3				1		1	2	3	3	3
117.5	2	2	2	2	2				1		1	1	2	2	2
117*	3	2	2	2	3				1		1	1	2	3	3

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0019	Human Computer Interface	3	0	0	3

Course Objectives:

1. Demonstrate an understanding of guidelines, principles, and theories influencing human Computer interaction.
2. Recognize how a computer system may be modified to include human diversity.
3. Select an effective style for a specific application.
4. Design mock ups and carry out user and expert evaluation of interfaces.
5. Carry out the steps of experimental design, usability and experimental testing, and evaluation of human computer interaction systems.
6. Use the information sources available, and be aware of the methodologies and technologies supporting advances in HCI.

Course Outcomes:

UNIT-I:

The User Interface: Introduction, Importance of the User Interface, Importance and benefits of Good Design History of Human Computer Interface. Characteristics of Graphical and Web User Interface: Graphical User Interface, popularity of graphics, concepts of Direct Manipulation, Graphical System advantage and disadvantage, Characteristics of GUI. Web User Interface, popularity of web, Characteristics of Web Interface, Merging of Graphical Business systems& the Web, Principles of User Interface Design.

UNIT-II:

The User Interface Design Process: Obstacles and Pitfall in the development Process, Usability, The Design Team, Human Interaction with Computers, Important Human Characteristics in Design, Human Consideration in Design, Human Interaction Speeds, Performance versus Preference, Methods for Gaining and Understanding of Users

UNIT-III:

Understanding Business Functions: Business Definitions & Requirement analysis, Determining Business Functions, Design standards or Style Guides, System Training and Documentation

UNIT-IV:

Principles of Good Screen Design: Human considerations in screen Design, interface design goals, test for a good design, screen meaning and purpose, Technological considerations in Interface Design System Menus and Navigation Schemes: Structure, Functions, Context, Formatting, Phrasing and Selecting, Navigating of Menus, Kinds of Graphical Menus Windows Interface: Windows characteristic, Components of Window, Windows Presentation Styles, Types of Windows, Window Management, Web systems.

UNIT-V:

Device and Screen-Based Control: Device based controls, Operable Controls, Text entry/read-Only Controls, Section Controls, Combining Entry/Selection Controls, Other Operable Controls and Presentation Controls, Selecting proper controls

Text Books:

1. Wilbert O. Galitz, "The Essential Guide to User Interface Design", Wiley India Edition
2. Prece, Rogers, "Sharps Interaction Design", Wiley India.
3. Ben Shneidermann, "Designing the user interfaces". 3rd Edition, Pearson Education Asia.

References Books:

1. Soren Lauesen, "User Interface Design", Pearson Education
2. Alan Cooper, Robert Riemann, David Cronin, "Essentials of Interaction Design", Wiley
3. Alan Dix, Janet Fincay, GreGoryd, Abowd, Russell, Bealg, "HumanComputer Interaction", Pearson Education

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0020	Cryptography and network security	3	0	0	3

Course Objectives:

- Understand the fundamentals of Information Security
- Acquire knowledge on Security Needs to provide confidentiality, integrity and authenticity.
- Understand the various key cryptography concepts
- Design security applications using security policies
- Understand the Security Issues in TCP/IP

Course Outcomes:

1. Analyze the vulnerabilities in any computing system and hence be able to design a security solution
2. Identify the security needs in the network
3. Explain the basic objectives of symmetric & Asymmetric key cryptography technique to secure the communication over the internet
4. Identify the security policies to provide strong authentication
5. Understand basic ecommerce security protocols.

Unit 1: Introduction.

The History of Information Security, Balancing Information Security and Access, Introduction and Security Trends, General Security Concepts and introduction to what is an “info sphere”, Operational Security and People’s Role in Information Security.

Learning outcomes: Student should be able to

1. Understand various types of Information Security concepts (L2)
2. Analyze the role of information security.(L4)

Unit 2: Security Needs.

The Need for Security, Business Needs, Needs to protect against Threats and Attacks, Security in Emails. Secure Software Development.

Learning outcomes: Student should be able to

1. Understand the need of security to deal with the threats and attacks.(L2)

Unit 3: Cryptography Concepts.

Concepts of Data encryption, Introduction, Plaintext & Cipher text, Substitution Techniques, Transposition Techniques, Encryption & Decryption, Symmetric& Asymmetric key Cryptography. Public Key Infrastructure (PKI), Different attacks on Cryptosystems

Network Security & Web Security.

Security Issues in TCP/IP – TCP, DNS, Routing (Topics such as basic problems of security in TCP/IP, IPsec, BGP Security, DNS Cache poisoning etc), Network Defense tools – Firewalls, Intrusion Detection, Filtering, DNSSec, NSec3, Distributed Firewalls

Learning outcomes: Student should be able to

1. Understand various Cryptography Concepts (L2)
2. Analyze the impact of Symmetric& Asymmetric key Cryptography in real time applications (L4)
3. Understand Security Issues in TCP/IP. (L2)
4. Identify the tools to provide the web and network security. (L2)

What is security policy, high and low level policy, user issues? Protocol problems, assumptions, Shared secret protocols, public key protocols, mutual authentication, reflection attacks, use of timestamps, nonce and sequence numbers, session keys, one-and two-way public key based authentication.

1. Understand various Security Policies for authentication (L2)
2. Identity various Security Handshake (L2)

1. Apply the concepts of the cryptography and security in case studies. (L4)

1. Michael E Whitman and Herbert J Mattord, “Principles of Information Security”, Vikas Publishing House, New Delhi.
- 2 Micki Krause, Harold F. Tipton, “ Handbook of Information Security Management”, CRC Press LLC
3. AtulKahate, Cryptography and Network Security, McGraw Hill
- 4 Kaufman, c., Perlman, R., and Speciner, M., Network Security, Private Communication in a public world, 2nd ed., Prentice Hall PTR., 2002
5. Stallings, W.,Cryptography and Network Security: Principles and Practice, 3rd ed., Prentice Hall PTR.,2003
6. Stallings, W. Network security Essentials: Applications and standards, Prentice Hall, 2000

[illegible]

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0021	QUANTUM COMPUTING	3	0	0	3

Course Objectives:

1. To understand the components of computing in a Quantum world
2. To gain knowledge on mathematical representation of quantum physics and operations.
3. To write computations in the real world (standard) in a Quantum computer and simulator.

Course Outcomes:

By the end of this course, the student is able to

1. Analyze the behavior of basic quantum algorithms
2. Implement simple quantum algorithms and information channels in the quantum circuit model
3. Simulate a simple quantum error-correcting code
4. Prove basic facts about quantum information channels
5. Know about Quantum Computing Models

UNIT –I:

Introduction: Quantum Measurements Density Matrices, Positive-Operator Valued Measure, Fragility of quantum information: Decoherence, Quantum Superposition and Entanglement, Quantum Gates and Circuits.

UNIT –II:

Quantum Basics and Principles: No cloning theorem & Quantum Teleportation, Bell's inequality and its implications, Quantum Algorithms & Circuits.

UNIT -III:

Algorithms: Deutsch and Deutsch–Jozsa algorithms, Grover's Search Algorithm, Quantum Fourier Transform, Shore's Factorization Algorithm.

UNIT –IV:

Performance, Security and Scalability: Quantum Error Correction: Fault tolerance; Quantum Cryptography, Implementing Quantum Computing: issues of fidelity; Scalability in quantum computing.

UNIT -V:

Quantum Computing Models: NMR Quantum Computing, Spintronics and QED MODEL, Linear Optical MODEL, Nonlinear Optical Approaches; Limits of all the discussed approaches, Future of Quantum computing.

Text Books:

1. Eric R. Johnston, Nic Harrigan, Mercedes and Gimeno-Segovia “Programming Quantum Computers: Essential Algorithms And Code Samples, SHROFF/O’Reilly.
2. Dr. Christine Corbett Moran, Mastering Quantum Computing with IBM QX: Explore the world of quantum computing using the Quantum Composer and Qiskit, Kindle Edition Packt

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0022	BIG DATA ANALYTICS	3	0	0	3

Course Objectives:

- Optimize business decisions and create a competitive advantage with Big Data analytics
- Introducing Hadoop concepts for developing solutions.
- Derive business benefits from unstructured data
- Imparting the architectural concepts of Hadoop and introducing map- reduce paradigm
- To introduce programming tools PIG & HIVE in the Hadoop ecosystem.

Course Outcomes:

1. Understands the basic concepts and challenges of handling Big Data.
2. Applying data modelling techniques of Big Data.
3. Analyze Hadoop components & its applications.
4. Analyze spark for optimized query execution and memory caching.
5. Understand the Big data frame work and its applications.

UNIT-I

Introduction: Introduction to Big data, Characteristics & Classification of Data, Challenges of conventional systems(storage), Intelligent data analysis, The Life cycle of Big Data Analytics, Types of Big Data Analytics, Analytic processes, and tools, Big Data Industry Applications, Analysis vs. Reporting.

Learning Outcomes: Students will be able to

- Understands the Basic concept of Big Data.
- Understands their challenges in the industry

UNIT-II

Working with Big Data: Google File System, Hadoop Distributed File System (HDFS) –Building blocks of Hadoop (Name node, Datanode, Secondary Name node, Job Tracker, Task Tracker), What is NoSQL, Why NoSQL, Use of No SQL in Industry, Comparison of SQL, No SQL, and New SQL, No SQL Business Drivers, No SQL Case Studies,

Learning Outcomes: Students will be able to

- Understand HDFS and its basic building blocks
- Understand No SQL for working with Data sets.

UNIT-III

Introduction to Hadoop: why Hadoop, RDBMS versus Hadoop, History of Hadoop, Components of Hadoop, Hadoop Distributed File System (HDFS), Processing Data with Hadoop, How Map Reduce Works, Anatomy of a Map Reduce Job run, Map Reduce Features Hadoop environment. Interacting with Hadoop Ecosystem.

Learning Outcomes: Students will be able to

- Understand and implement Hadoop Components.
- Understand the Concept of Interacting with the Hadoop Ecosystem.

UNIT-IV

SPARK: SPARK BASICS, Using the Spark Shell, RDD Data Types and RDD Creation, RDDs (Resilient Distributed Datasets) in Spark, General RDD Operations: Transformations & Actions, RDD Lineage, RDD Persistence, Overview, Distributed Persistence

Learning Outcomes: Student will be able to

- Understand Hadoop Architecture,
- Explain about Hadoop Ecosystem components.

UNIT-V

Frameworks and Applications: HIVE : Hive Shell, Hive Services, Hive Meta store, Comparison with Traditional Databases **Learning,** Frameworks: Applications on Big Data Using Pig and Hive, Data processing operators in Pig, Hive Architecture of Hive, Hive services, HiveQL, Querying Data in Hive, fundamentals of H Base and Zoo keeper.

Outcomes: Students will be able to

- Work with PIG and Hive Tech.
- Understand programming tools of HIVE in the Hadoop ecosystem.
- Applying a complete business data analytics solution.

Text Books :

1. Big Data Analytics 2nd Edition, Seema Acharya, Subhashini Chellappan, Wiley India Pvt. Ltd, Second Edition, 1 Jan 2019.
2. Min Chen, Shiwen Mao, Yin Zhang, Victor C.M. Leung, "Big Data: Related Technologies, Challenges and Future Prospects", Springer; 2014.
3. Big Java 4th Edition, Cay Horstman, Wiley John Wiley & Sons, INC, by Wiley India Pvt. Ltd, 2008.
4. Hadoop: The Definitive Guide by Tom White, 3rd Edition, O'Reilly, 12 June 2012.
5. Tom White, "Hadoop- The Definitive Guide", O'reilly, 4th Edition, April 2015.

Reference Books :

1. Hadoop in Practice by Alex Holmes, MANNING Publ, Second Edition, 5 Feb 2015.
2. Hadoop MapReduce Cookbook, Srinath Perera, Thilina Gunarathne, Ingram short title, 1 Jan 2013.
3. Hadoop for Dummies by Dirk deRoos, Paul C. Zikopoulos, Roman B. Melnyk, Bruce Brown, Rafael Coss, by For Dummies, First Edition, 7 May 2014.
4. Eric Sammer, "Hadoop Operations", O'Reilly, 2nd Edition., October 2012.

Software Links :

1. Hadoop: <http://hadoop.apache.org/>+
2. Hive: <https://cwiki.apache.org/confluence/display/Hive/Home>
3. Pig latin: <http://pig.apache.org/docs/r0.7.0/tutorial.html>
4. http://www.jbonneau.com/doc/2012-04-27-big_data_lecture_1.pdf
5. https://www.ibm.com/developerworks/community/blogs/SusanVisser/entry/flash_book_understanding_big_data_analytics_for_enterprise_class_hadoop_and_streaming_data?lang=en

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
x.1	1	2	2	3	1	2	1	1	1	-	2	1	1	2	1
x.2	2	1	3	3	3	-	-	-	1	-	-	1	2	3	1
x.3	1	2	1	3	3	3	-	-	1	-	1	1	3	3	1
x.4	2	2	3	3	3	1	1	-	-	-	1	1	3	3	3
x.5	2	2	3	3	3	1	1	-	-	-	1	1	3	3	3

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0023	BLOCK CHAIN TECHNOLOGIES	3	0	0	3

Course Objective:

1. To provide conceptual understanding of the function of Blockchain as a method of securing distributed ledgers.
2. To understand the structure of a Blockchain and why/when it is better than a simple distributed database
3. To make students understand the technological underpinnings of Blockchain operations as distributed data structures and decision making systems.

Course Outcomes:

Upon completion of the course, it is expected that student will be able to:

1. Define and explain the fundamentals of Blockchain.
2. Understand decentralization and the role of Blockchain in it.
3. Understand and analyze Bitcoin in Cryptocurrency and underlying Blockchain network.
4. Understand Ethereum currency and platform, and develop applications using Solidity.
5. Understand Hyper ledger project and its components; critically analyze the challenges and future opportunities in Block chain technology.

UNIT-I:

Introduction: History and basics, Types of Blockchain, Consensus, CAP Theorem.

Cryptographic Hash Functions: Properties of hash functions, Secure Hash Algorithm, Merkle trees, Patricia trees.

UNIT-II:

Decentralization: Decentralization using Blockchain, Methods of decentralization, decentralization framework, Blockchain and full ecosystem decentralization, Smart contracts, Decentralized Organizations, Platforms for decentralization.

UNIT-III:

Bitcoin: Introduction to Bitcoin, Digital keys and addresses, Transactions, Blockchain, The Bitcoin network, Bitcoin payments, Bitcoin Clients and APIs, Alternatives to Proof of Work, Bitcoin limitations.

UNIT-IV:

Ethereum: Smart Contracts, Introduction to Ethereum, The Ethereum network, Components of the Ethereum ecosystem, Blocks and Blockchain, Fee schedule, Ethereum Development Environment, Solidity.

UNIT-V:

Hyperledger: Introduction, Hyperledger Projects, Protocol, Architecture, Hyperledger Fabric, Sawtooth Lake, Corda.

Challenges and Opportunities: Scalability, Privacy, Blockchain for IoT, Emerging trends

Text Book:

1. Mastering Block chain, Imran Bashir, Second Edition, PacktPublishing.

References:

1. Mastering Bitcoin: Unlocking Digital Cryptocurrencies, 3rd Edition Andreas Antonopoulos,O'Reilly.
2. Blockchain Blueprint for a New Economy, Melanie Swan,O'Reilly.
3. Mastering Bitcoin: Programming the Open Blockchain, Antonopoulos, Andreas M. O'Reilly.
4. Blockchain Technology: Cryptocurrency and Applications, S. Shukla, M. Dhawan, S. Sharma, S. Venkatesan, Oxford University Press

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0024	MULTIMEDIA APPLICATION DEVELOPMENT	3	0	0	3

COURSE OBJECTIVES: To learn

1. To understand the definition of multimedia
2. To understand and differentiate text, image, video & audio.
3. To describe the ways in which multimedia information is captured, processed, and rendered
4. Introduce multimedia quality of service (QoS) and to compare subjective and objective methods of assessing user satisfaction and multicast protocols to provide QoS guarantees
5. Discuss privacy and copyright issues in the context of multimedia

COURSE OUTCOMES: Upon successful completion of the course, the student is able to

1. Describe different realizations of multimedia tools and the way in which they are used
2. Analyze the structure of the tools in the light of low-level constraints imposed by the adoption of various QoS schemes (i.e. bottom up approach)
3. Analyze the effects of scale and use on both presentation and lower-level requirements (i.e. top down approach)
4. State the properties of different media streams;
5. Compare and contrast different network protocols and to describe mechanisms for providing QoS guarantees in the network.

UNIT – I Classes: 12

Introduction: Definitions - Brief history of Multimedia; its market; content and copyright –public Domain, establishment of Copyright, fair use, multimedia copyright issues; resources for multimedia developers – Uses of multimedia - Making multimedia : Stages of a project

UNIT – II Classes: 14

Hardware Macintosh Versus Windows Platform – Connections – SCSI – IDE – EIDE – ULTRA – IDE – ATA – ULTRA - ATA - Memory and Storage Devices - Input Devices - Output Hardware – Communication Devices Basic Software Tools :Text Editing - Word Processing - OCR Software - Painting and Drawing Tools - 3D Modeling and Animation Tools - Image Editing - Sound Editing – Animation – Video - Digital Movie tools - Movie Editors - Compressing Movie Files MLR Institute of Technology B.Tech-IT Academic Regulations & Syllabi – MLR18

UNIT – III Classes: 14

Text : Fonts – Designing – Choosing -Menus for Navigation - Buttons for Interaction – Fields for Readings - HTML Documents - Symbols and Icons – Animating - Fonts Foundries – Managing Fonts - Character sets and Alphabets - Mapping Text – Fontographer - Hypermedia Structures – Hypertext tools Sound : Power of sound - Multimedia System Sound - MIDI Versus Digital Audio - Preparing Digital Audio Files - Making MIDI Audio - Audio File Formats - Sound for the World Wide Web – Adding Sound to Your Multimedia Project - Toward Professional Sound - The Red Book Standard – Space Considerations - Production Tips - Audio Recording -

Keeping Track of Your Sounds - Testing and Evaluation

UNIT – IV Classes: 12

Introduction: The Bandwidth Bottleneck - Internet Services - MIME-Types - World Wide Web and HTML – Dynamic Web Pages and XML - Multimedia on the Web. Tools for the World Wide Web: Web Servers - Web Browsers - Web Page Makers and Site Builders - Plug ins and Delivery Vehicles - Text – Images –Sound - Animation, Video and Presentation - Beyond HTML - 3D Worlds, designing for the World Wide Web..

UNIT – V Classes: 08

Multimedia File Handling: Compression & De compression - Data & file formats standards - Digital voice, Audio, video – Video image and Animation - Full motion video - storage and retrieval Technologies

Text Books:

1. Multimedia making it work Tay Vaughan Tata McGrawHill, Delhi
2. Multimedia – Technology and applications David Hillman Galgotia Publications, Delhi

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0025	MOBILE AD-HOC NETWORKS	3	0	0	3

Course Objectives:

- To understand the concepts of Ad Hoc Wireless Networks
- To understand the Data Transmission in MANETS
- To understand the MAC protocols for ad-hoc networks
- To understand and analyze the various routing protocols and model link cost
- Understanding cross layer design in Adhoc Networks

Course Outcomes:

1. Evaluate the principles and characteristics of mobile ad hoc networks (MANETs) and what distinguishes them from infrastructure-based networks
2. Discuss the challenges in designing MAC, routing, and transport protocols for wireless ad-hoc sensor networks
- 3.. Understand the MAC Protocols for Ad Hoc Wireless Networks
4. Illustrate the various Routing Protocols And Transport Layer In Ad Hoc Wireless
5. Demonstrate the issues and challenges in security provisioning and also familiar with the mechanisms for implementing security and trust mechanisms in MANETs and WSNs

UNIT - 1

INTRODUCTION: Introduction to ad-hoc networks – definition, characteristics features, applications. Characteristics of wireless channel, ad-hoc mobility models: indoor and outdoor models.

UNIT - 2

MEDIUM ACCESS PROTOCOLS: MAC Protocols: Design issues, goals and classification. Contention based protocols – with reservation, scheduling algorithms, protocols using directional antennas. IEEE standards: 802.11a, 802.11b, 802.11g, 802.15. HIPERLAN.

UNIT - 3

NETWORK PROTOCOLS: Routing Protocols: Design issues, goals and classification. Proactive Vs reactive routing, unicast routing algorithms, Multicast routing algorithms, hybrid routing algorithm, energy aware routing algorithm, hierarchical routing, QoS aware routing.

UNIT - 4

END – END DELIVERY AND SECURITY: Transport Layer: Issues in designing – Transport layer classification, adhoc transport protocols.

Security issues in adhoc networks: issues and challenges, network security attacks, secure routing protocols.

UNIT – 5

CROSS LAYER DESIGN:

Cross layer Design: Need for cross layer design, cross layer optimization, parameter optimization techniques, cross layer cautionary perspective. Integration of adhoc with Mobile IP networks.

TEXT BOOKS:

1. C. Siva Ram Murthy and B. S. Manoj, Ad hoc Wireless Networks Architecture and Protocols, 2nd edition, Pearson Edition, 2007.
2. Charles E. Perkins, Ad hoc Networking, Addison – Wesley, 2000.

REFERENCES:

1. Stefano Basagni, Marco Conti, Silvia Giordano and Ivan stojmenovic, Mobile ad-hoc networking, Wiley-IEEE press, 2004.
2. Mohammad Ilyas, The handbook of ad-hoc wireless networks, CRC press, 2002.
3. T. Camp, J. Boleng, and V. Davies “ A Survey of Mobility Models for Ad-hoc Network”
4. Research, “Wireless Commun, and Mobile Comp.. Special Issue on Mobile Ad-hoc Networking Research, Trends and Applications, Vol. 2, no. 5, 2002, pp. 483 – 502.
5. A survey of integrating IP mobility protocols and Mobile Ad-hoc networks, Fekri M.bduljalil and Shrikant K. Bodhe, IEEE communication Survey and tutorials, no: 12007.

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1):

[illegible]

Subject Code	Subject Name	L	T	P	C
R23CSS-OE0001	Operating Systems	3	0	0	3

Course Objectives:

- Provide knowledge about the services rendered by operating systems.
- Present detail discussion on processes, threads and scheduling algorithms.
- Expose the student with different techniques of handling deadlocks.
- Discuss various file-system implementation issues and memory management techniques.
- Learn the basics of Linux system and Android Software Platform.

Course Outcomes:

1. Understand the importance of operating systems and different types of system calls
2. Analyze process scheduling algorithms and various IPC mechanisms.
3. Understand the process synchronization, different ways for dead locks handling.
4. Analyze different page replacement methods, various File management techniques
5. Understand Linux and Android environment and behavior

Unit: 1: Operating Systems Overview: Introduction: What Operating systems Do, Types of Operating systems, Computer system Architecture, Computer system organization, Operating system functions, Operating systems operations, Protection and Security.

Virtualization: Types of Virtualizations, Benefits, and Challenges.

System structure: Operating System Services, User and Operating - System Interface, System calls, Types of System Calls, Operating system debugging, System Boot.

Learning Outcomes: Student will be able to

- Understand operating system structure and functions.
- Understand operating system services and system calls
- Comprehend the basics of virtualization

Unit: 2: Process Management: Process Concept, Process Scheduling, Operations on Processes, Inter process Communication.

Multithreaded Programming: Overview, Multithreading models, Threading Issues.

Process scheduling: Basic Concepts, Scheduling Criteria, Scheduling Algorithms.

Learning Outcomes: Student will be able to

- Identify various message sharing mechanisms used in IPC.
- Understand how to handling multiple threads.
- Differentiate between preemptive, non-preemptive and real time CPU scheduling

Unit: 3: Synchronization: Process Synchronization, The Critical-Section Problem, Synchronization Hardware, Semaphores, Classic Problems of Synchronization, Monitors, Synchronization examples Principles of deadlock – System Model, Deadlock Characterization, Deadlock Prevention, Detection and Avoidance, Recovery form Deadlock, Concurrency in Distributed Systems, Consistency, and Replication.

Learning Outcomes: Student will be able to

- Analyze various solutions for process synchronization.
- Analyze the reasons for deadlocks and proposed solutions to detect, avoid, recovery from deadlocks.
- Understand concurrency issues in distributed systems

Unit: 4: Memory Management:

Memory Management strategies: Swapping, Contiguous Memory Allocation, Segmentation, Paging, Structure of the Page Table.

Virtual Memory Management: Virtual Memory, Demand Paging, Page-Replacement Algorithms, Thrashing.

File system Interface and Introduction to Network Programming: - the concept of a file, Access Methods, OSI model, Unix standards, TCP and UDP & TCP connection establishment and Format, Buffer sizes and limitation, standard internet services, Protocol usage by common internet application.

Learning Outcomes: Student will be able to

- Demonstrate the ability to implement various memory management techniques
- Illustrate various demand paging techniques.
- Identify various file management and optimization techniques.

Unit: 5: Network Programming and OS Security:

Sockets: Address structures, value – result arguments, Byte ordering and manipulation function and related functions.

Elementary TCP sockets – Socket, connect, bind, listen, accept, fork and exec function, concurrent servers. Close function and related function.

Elementary UDP sockets: Introduction UDP Echo server function, lost datagram, summary of UDP example, Lack of flow control with UDP, determining outgoing interface with UDP.

OS Security - Security Policies, Intrusion Detection, and Prevention.

Learning Outcomes: Student will be able to

- Understand socket programming.
- Understand basics of UDP (L2), Comprehend OS security concepts

Text Books:

1. Silberschatz A, Galvin PB, and Gagne G, Operating System Concepts, 9th edition, Wiley, 2013
2. Tanenbaum AS, Modern Operating Systems, 3rd edition, Pearson Education, 2008. (for Inter process Communication and File systems).

References:

1. Tanenbaum AS, Woodhull AS, Operating Systems Design and Implementation, 3rd edition, PHI, 2006.
2. Dhamdhere D M, Operating Systems A Concept Based Approach, 3rd edition, Tata Mc Graw-Hill, 2012.
3. Stallings W, Operating Systems –Internals and Design Principles, 6th edition, Pearson Education, 2009
4. Nutt G, Operating Systems, 3rd edition, Pearson Education, 2004.

Subject Code	Subject Name	L	T	P	C
R23CSS-OE0002	Red Hat Linux	3	0	0	3

Course Objectives:

- Master essential command-line tools for file manipulation, system access, and documentation in a RHEL environment.
- Implement core system administration tasks, including booting, process control, service control (systemd), and managing user/group accounts.
- Configure and manage local storage using partitions, filesystems (XFS/Ext4), and Logical Volume Management (LVM).
- Secure the system by configuring the firewall (firewalld), managing file permissions, and enforcing SELinux policies.
- Perform network configuration, package management, and write basic Bash shell scripts for task automation.

Course Outcomes:

1. Navigate and operate a Red Hat Enterprise Linux system entirely from the command line.
2. Manage local security policies, including users, groups, and file permissions.
3. Diagnose and troubleshoot boot process failures and service issues.
4. Apply proper file system management techniques, including creating and extending LVM.
5. Automate routine administrative tasks using shell scripting and scheduled utilities.

Unit 1: Essentials and System Access

Introduction to RHEL: Command Line Interface (CLI), Shell basics, using grep and regular expressions.

Getting Help: Utilizing man pages and system documentation.

File Management: Standard commands (ls, cp, mv), hard and soft links.

Text Editing and Remote Access: Using vim/nano for configuration; Secure Shell (ssh) usage.

Unit 2: Running Systems and Management

System Boot and Processes: Boot procedure, run levels, interrupting boot for recovery.

Process Control: Identifying, managing, and adjusting process priority (top, kill, nice).

Service Control: Managing system services and daemons using systemctl (systemd).

Package Management: Installing, updating, and removing software using dnf / yum (RPM).

User and Group Administration: Creating, modifying, and managing local users, groups, and password policies.

Unit 3: Storage Administration

Disk Partitioning: Understanding MBR/GPT and creating partitions.

Filesystems: Creating, mounting and managing XFS/Ext4 filesystems, and configuring /etc/fstab.

Logical Volume Management (LVM): PVs, VGs, LVs, creating, resizing, and extending logical volumes.

Network Storage: Basics of mounting NFS and SMB/CIFS shares.

Unit 4: Networking and Security

Basic Networking Configuration: Configuring IPv4/IPv6 addresses and network interfaces.

Firewall Management: Configuring network access restrictions using firewalld.

Security Contexts: Managing Access Control Lists (ACLs) for granular permissions.

SELinux: Introduction to SELinux modes, contexts, and troubleshooting access issues.

System Logging: Locating and interpreting system logs using journalctl.

Unit 5: Automation and Advanced Topics

Archiving and Scheduling: Using tar and compression utilities; scheduling tasks with cron and at.

Bash Shell Scripting: Introduction, variables, conditional execution (if), loops, and processing script inputs/outputs.

Kernel and Updates: Managing kernel modules and performing system maintenance/updates.

Virtualization / Containers: Overview of enterprise virtualization and container concepts (e.g., Podman).

Text Books:

1. Red Hat RHCSA [RHEL Version] Cert Guide (Exam EX200), Sander van Vugt
2. UNIX and Linux System Administration Handbook, Evi Nemeth, Garth Snyder

Subject Code	Subject Name	L	T	P	C
R23CSS-OE0003	Cloud Computing	3	0	0	3

Course Objectives:

- To implement Virtualization
- To implement Task Scheduling algorithms
- Apply Map-Reduce concept to applications
- To build Private Cloud
- Broadly educate to know the impact of engineering on legal and societal issues involved

Course Outcomes: At the end of the course, student will be able to

1. Interpret the key dimensions of the challenge of Cloud Computing
2. Examine the economics, financial, and technological implications for selecting cloud computing for own organization
3. Assessing the financial, technological, and organizational capacity of employers for actively initiating and installing cloud-based applications
4. Evaluate own organizations. needs for capacity building and training in cloud computing-related IT areas
5. Illustrate Virtualization for Data-Center Automation

UNIT I

Introduction: Network centric computing, Network centric content, peer-to .peer systems, cloud computing delivery models and services, Ethical issues, Vulnerabilities, Major challenges for cloud computing. Parallel and Distributed Systems: introduction, architecture, distributed systems, communication protocols, logical clocks, message delivery rules, concurrency, and model concurrency with Petri Nets.

UNIT II

Cloud Infrastructure: At Amazon, The Google Perspective, Microsoft Windows Azure, Open Source Software Platforms, Cloud storage diversity, Inter cloud, energy use and ecological impact, responsibility sharing, user experience, Software licensing, Cloud Computing : Applications and Paradigms: Challenges for cloud, existing cloud applications and new opportunities, architectural styles, workflows, The Zookeeper, HPC on cloud.

UNIT III

Cloud Resource virtualization: Virtualization, layering and virtualization, virtual machine monitors, virtual machines, virtualization- full and para, performance and security isolation, hardware support for virtualization, Case Study: Xen, vBlades, Cloud Resource Management and Scheduling: Policies and Mechanisms, Applications of control theory to task scheduling, Stability of a two-level resource allocation architecture, feedback control based on dynamic thresholds, coordination, resource bundling, scheduling algorithms, fair queuing, start time fair queuing, cloud scheduling subject to deadlines, Scheduling Map Reduce applications, Resource management and dynamic application scaling.

UNIT IV

Storage Systems: Evolution of storage technology, storage models, file systems and database, distributed file systems, general parallel file systems. Google file system. Apache Hadoop, Big Table, Megastore (text book 1), Amazon Simple Storage Service(S3) (Text book 2), Cloud Security: Cloud security risks, security . a top concern for cloud users, privacy and

privacy impact assessment, trust, OS security, Virtual machine security, Security risks.

UNIT V

Cloud Application Development: Amazon Web Services : EC2 – instances, connecting clients, security rules, launching, usage of S3 in Java, Cloud based simulation of a Distributed trust algorithm, Cloud service for adaptive data streaming (Text Book 1), Google: Google App Engine, Google Web Toolkit (Text Book 2), Microsoft: Azure Services Platform, Windows live, Exchange Online, Share Point Services, Microsoft Dynamics CRM (Text Book 2)

Text Books:

1. Cloud Computing, Theory and Practice, 1st Edition, Dan C Marinescu, MK Elsevier publisher ,2013
2. Cloud Computing, A Practical Approach, 1st Edition, Anthony T Velte, Toby J Velte, Robert Elsenpeter, TMH,2017

Reference Books:

1. Mastering Cloud Computing, Foundations and Application Programming, 1st Edition, Raj Kumar Buyya, Christen vecctiola, S Tammaraiselvi, TMH,2013
2. Essential of Cloud Computing, 1st Edition, K Chandrasekharan, CRC Press, 2014.
3. Cloud Computing, A Hands on Approach, ArshdeepBahga, Vijay Madisetti, Universities Press, 2014.

Subject Code	Subject Name	L	T	P	C
R23CSS-OE0004	Distributed Operating Systems	3	0	0	3

Course Objectives:

- To study the concepts and design principles of Distributed Operating Systems,
- To understand clock synchronization protocols and distributed file system implementation,
- To gain knowledge on communication, synchronization, and consistency models in distributed systems.

Course Outcomes: On successful completion of the course, students will be able to:

- Explain the architecture and components of distributed systems,
- Understand various synchronization and coordination mechanisms,
- Analyze consistency and fault tolerance issues,
- Describe distributed file systems and object-based distributed environments,
- Apply concepts of distributed systems in real-time applications.

Detailed Syllabus:

Unit I – Fundamentals of Distributed Systems

Introduction to distributed systems, Goals of distributed systems, Hardware and software concepts, Design issues, Network operating systems, Comparison between time-sharing, multiprocessor, and true distributed systems, System architectures for distributed systems.

Unit II – Communication in Distributed Systems

Basics of communication systems, Layered protocols, ATM models, Client–Server model, Blocking and non-blocking primitives, Buffered and unbuffered communication, Reliable and unreliable primitives, Message passing, Remote Procedure Call (RPC).

Unit III – Synchronization and Processes

Clock synchronization, Mutual exclusion in distributed systems, Election algorithms, Atomic transactions, Deadlock handling, Processes and threads in distributed systems, System models, Processor allocation, Process scheduling in distributed systems.

Unit IV – Consistency, Replication, and Fault Tolerance

Data-centric and client-centric consistency models, Replica management, Consistency protocols, Fault tolerance in distributed systems, Process resilience, Distributed commit protocols, Reliable client–server communication.

Unit V – Distributed Object-Based Systems and File Systems

Distributed object-based systems, Object-oriented architecture, Processes and communication in object-based systems, Synchronization in object environments, Consistency and replication in object-based systems, Distributed file system design and implementation.

Reference Books:

- Andrew S. Tanenbaum, *Distributed Operating Systems*, Pearson Education, Reprint, 2011,
- Andrew S. Tanenbaum and Maarten Van Steen, *Distributed Systems – Principles and Paradigms*, 2nd Edition, PHI, 2007,
- Pradeep K. Sinha, *Distributed Operating Systems – Concepts and Design*, PHI, 2007.

Subject Code	Subject Name	L	T	P	C
R23CIT-OE0001	Basics of Computer Networks	3	0	0	3

Course Objectives:

1. understand the contemporary technologies in network protocols and network architecture
2. To acquire the knowledge on design principles of network infrastructure. the basics Physical layer and their functionality.
3. Understand the functionalities of the Data Link Layer and their protocols.
4. Understand the functionalities of the Network Link Layer and routing Algorithms.
5. Analyze different protocols in Application Layer

Course Outcomes:

1. Analyze different types of network topologies, various Reference models.[L2]
2. Analyze network performance metrics and data transmission Techniques.[L4]
3. Analyze different data link layer framing techniques and Link Layer Protocols.[L4]
4. Analyze the medium access techniques and different routing algorithms.[L4]
5. Understand various Application layer protocols.[L2]

Unit 1:

10-Hours

Introduction: Components of a Data Communication system, Dataflow , Network Topologies Categories of Networks: LAN, MAN,WAN. Reference models- The OSI Reference Model- the TCP/IP Reference Model, Networking and Internet working Devices.

Learning Outcomes: Student will be able to

- Understand the Basics of Computer Networks (L2).
- Understand the data flow in a Computer Network and the use of protocols.(L2)
- Analyze the importance of each layer in the reference models.(L4).

Applications:

Conceptual Framework of a Network, ATM, Online reservation systems, reservation systems.

Unit 2:

9-Hours

Physical Layer:

Transmission Media: Guided,Unguided.Bandwidth,throughput,Latency.

Multiplexing: frequency division multiplexing, wave length division multiplexing, synchronous time division multiplexing, statistical time division multiplexing, switching techniques.

Learning Outcomes: Studentwill be able to

- Understand the Basics of physical functionality .(L2).
- Analyze different types of Multiplexing Techniques. (L4).
- Analyze the Network performance Evaluation metrics . (L4).

Applications:

Identify the use of different devices in real time computer networks and data processing tasks.

Unit 3:**10- Hours**

Data Link Layer: Design issues, Framing, flow control, error control, error detection and correction, CRC.

Data Link Layer protocols: simplex protocol, Simplex stop and wait, Simplex protocol for Noisy Channel. Sliding window protocols. HDLC configuration and transfer modes, HDLC frame format, control field

Learning Outcomes: Student will be able to

- Understand DataLink Layer Services to the Network Layer. (L2)
- Understand Error Correction and Detection techniques. (L2)
- Apply Detecting Codes for sample data. (L3)

Applications: Error correction and detecting procedures on binary data.

Unit 4:**10- Hours**

Random Access: ALOHA protocols, Carrier sense multiple access (CSMA), CSMA with Collision Detection, CSMA with Collision Avoidance

Network Layer: Routing algorithm, shortest path routing, Flooding, distance vector routing, Link state routing Algorithms, IPv4 address, subnetting, Congestion Control Algorithms.

Learning Outcomes: Student will be able to

- Understand random access protocols in data link layer and their functions. (L2)
- Analyze the static and dynamic routing Algorithms. (L4)
- Analyze the IPv4 Addressing ,sub netting.(L4)

Applications: setting up the routes for data packets to take, checking to see if a server in another network is up and running, and addressing and receiving IP packets from other networks.

UNIT –5 :**09-Hours**

The Transport Layer: addressing, TCP establishing a connection, releasing connection, TCP Header format, End to end protocols: UDP,.

Application layer: File Transfer(FTP), WWW: architecture ,client / server ,uniform resource locator, cookies, web documents: static ,dynamic, active document, HTTP transaction: persistent, non-persistent, Proxy server, HTTP Generic Message Format, HTTP Request Message Format, HTTP Response Message Format, Domain Name System (DNS), SMTP (Simple Mail Transfer Protocol).

Learning Outcomes: Student will be able to

- Understand the functions of Transport Layer protocols.(L2)
- Analyze the various protocols in application layer .(L4)

Applications: Users can forward several emails and it also provides a storage facility, allows users to access, retrieve and manage files in a remote computer layer provides access to global information about various services.

Text Books:

1. Data Communications and Networking ,Behrouz A Forouzan,fifth Edition.
2. Tanenbaum and David J Wetherall, Computer Networks, 5th Edition, Pearson Edu, 2010

Reference Books:

1. Computer Networks, Mayank Dave, CENGAGE
2. Larry L. Peterson and Bruce S. Davie, “Computer Networks - A Systems Approach” (5th ed), Morgan Kaufmann/ Elsevier, 2011

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1):

SNO	PO 1	PO 2	P O3	P O4	P O5	P O6	P O7	P O8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3
Cxx.1	3	3	2	1	3				3			1		2	3
Cxx.2	3	3	2	1					3			1		2	3
Cxx.3	3	3	2	1					3					2	3
Cxx.4	3	3	2	1	3				3			1		2	3
Cxx.5	3	1	1	1	3				3			1		2	3
Cxx.*	3	3	2	1	3				3			1		2	3

** For Entire Course, PO & PSO Mapping*

Subject Code	Subject Name	L	T	P	C
R23CIT-OE0002	Cryptography & Network Security	3	0	0	3

Course Objectives:

- Classical systems, symmetric block ciphers (DES, AES, other contemporary symmetric ciphers) are Introduced.
- Introduction to Public- key cryptography (RSA, discrete logarithms) is provided.
- Algorithms for factoring and discrete logarithms, cryptographic protocols, hash functions, authentication, key management, key exchange, signature schemes are learnt.
- An overview of e-mail and web security is provided.
- An overview of viruses, firewalls and system security is provided.

Course Outcomes:

1. Understand the basics of Cryptography, the goals, services and mechanisms.
2. Analyze the Symmetric Encryption Algorithms.
3. Analyze the Asymmetric Cryptographic Algorithms.
4. Understand the Digital signature Schemes.
5. Understand the email security and system security.

UNIT- I

Basic Principles Security Goals, Cryptographic Attacks, Services and Mechanisms, Mathematics of Cryptography

Learning Outcomes: Student will be able to

- Understand what is meant by Cryptography.(L1)
- Understand the goals, mechanisms and services of Cryptography.(L1)

UNIT- II

Symmetric Encryption Mathematics of Symmetric Key Cryptography, Introduction to Modern Symmetric Key Ciphers, Data Encryption Standard, Advanced Encryption Standard.

Learning Outcomes: Student will be able to

- Understand symmetric key Cryptography (L2)
- Analyze the various algorithms of Symmetric key Cryptography (L3)

UNIT- III

Asymmetric Encryption Mathematics of Asymmetric Key Cryptography, Asymmetric Key Cryptography

Learning Outcomes: Student will be able to

- Understand symmetric key Cryptography (L1)
- Analyze the various algorithms of Asymmetric key Cryptography(L2)

UNIT- IV

Data Integrity, Digital Signature Schemes & Key Management Message Integrity and Message Authentication, Cryptographic Hash Functions, Digital Signature, KeyManagement.

Learning Outcomes: Student will be able to

- Understand about Digital Signature and the security schemes.(L1)
- Understand the Hash functions and its importance.(L2)

UNIT -V

Network Security: Security at application layer: PGP and S/MIME, Security at the Transport Layer: SSL and TLS, IPSec, System Security.

Learning Outcomes: Student will be able to

- Understand email-security.(L1)
- Understand the mechanisms of Transport Layer Security.(L1)
- Understand about system security.(L2)

Text Books:

1. Cryptography and Network Security, Behrouz A Forouzan, Debdeep Mukhopadhyay, (3e) McGraw Hill.
2. Cryptography and Network Security, William Stallings, (6e) Pearson.
3. Everyday Cryptography, Keith M. Martin, Oxford.

Reference Books:

4. Network Security and Cryptography, Bernard Meneges, Cengage Learning

COURSE OUTCOMES VS POs MAPPING (DETAILED: HIGH: 3, MEDIUM: 2, LOW: 1)

CO \ PO/PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	3	2	1	1	1	1	1	2	3	2	2
CO2	3	3	2	2	3	1	1	1	1	1	1	2	3	3	2
CO3	3	3	3	2	3	1	1	1	2	2	2	3	3	3	3
CO4	3	3	2	3	3	1	1	1	2	2	2	3	3	3	3
CO5	3	3	2	3	3	1	1	1	2	2	2	3	3	3	3
	3	3	3	3	3	1	1	1	2	2	2	3	3	3	3

**For Entire Course, PO & PSO Mapping*

Subject Code	Subject Name	L	T	P	C
R23CIT-OE0003	Mobile Computing	3	0	0	3

Course Objectives:

- To understand the fundamentals of mobile communication
- To understand the architecture of various Wireless Communication Networks
- To understand the significance of different layers in mobile system Course Contents
- To understand the mobility supported protocols
- To apply the mobility support in real time

Course Outcomes:

1. Understand the fundamentals of mobile Networks
2. Apply knowledge in MAC, Network, and Transport Layer protocols of Wireless Network
3. Comprehend, design, and develop a lightweight network stack
4. Analyze the Mobile Network Layer system working
5. Understand WAP Model

UNIT- I

Introduction to Wireless Networks: Applications, History, Simplified Reference Model, Wireless transmission, Frequencies, Signals, Antennas, Signal propagation, Multiplexing, Modulation, Spread spectrum, Cellular Systems: Frequency Management and Channel Assignment, types of hand-off and their characteristics.

Learning Outcomes: Student will be able to

1. Understand the basic concepts of wireless networks (L2)
2. Understand the fundamentals of cellular system(L2)

UNIT-II

MAC – Motivation, SDMA, FDMA, TDMA, CDMA, Telecommunication Systems, GSM: Architecture Location tracking and call setup, Mobility management, Handover, Security, GSM, SMS, International roaming for GSM, call recording functions, subscriber and service data management, DECT, TETRA, UMTS, IMT-2000.

Learning Outcomes: Student will be able to

1. Understand the MAC layer functionalities (L2)
2. apply the strategy of subscriber and service data management(L3)

UNIT-III

Wireless LAN: Infrared vs. Radio transmission, Infrastructure, Adhoc Network, IEEE 802.11 WLAN Standards, Architecture, Services, HIPERLAN, Bluetooth Architecture & protocols.

Learning Outcomes: Student will be able to

1. Understand the wireless LAN functionalities(L2)
2. Understand the the various protocols in WLAN(L2)

UNIT-IV

Mobile Network Layer: Mobile IP, Dynamic Host Configuration Protocol, Mobile Transport Layer, Traditional TCP, Indirect TCP, Snooping TCP, Mobile TCP, Fast retransmit/Fast recovery, Transmission/Time-out freezing, Selective retransmission, Transaction Oriented TCP.

Learning Outcomes: Student will be able to

1. Understand the working of mobile network layer (L2)
2. Understand the concepts of mobile transport layer(L2)

UNIT-V

Support for Mobility: Wireless Application Protocol: Architecture, Wireless Datagram Protocol, Wireless Transport Layer Security, Wireless Transaction Protocol, Wireless Session Protocol, Wireless Application Environment, Wireless Markup Language, WML Scripts, Wireless Telephone Application.

Learning Outcomes: Student will be able to

1. Understand the working functionality of wireless protocols(L2)
2. Apply the wireless markup language in real time (L3)

Text Books:

1. Jochen Schiller, "Mobile Communication", Second Edition, Pearson Education, 2008.
2. "Mobile Computing: Principles and Practices" by Asoke K. Talukder, Roopa R. Yavagal

Reference Books:

1. William Stallings, "Wireless Communications and Networks", Second Edition, Pearson Education, 2004.
2. C. Siva Ram Murthy, B. S. Manoj, "Adhoc Wireless Networks: Architectures and Protocols", Second Edition, Pearson Education, 2008.

COURSE OUTCOMES VS POs MAPPING (DETAILED: HIGH: 3, MEDIUM: 2, LOW: 1)

COs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	2	2	2				1		1	2	3	1	2
CO2	3	3	2	2	2				1			2	3	1	2
CO3	3	3	2		2			1			1	2	3	1	2
CO4	3	3	2		2			1	1			2	3	1	2
CO5	3	3	2		2			1	1		1	2	3	1	2
CO*	3	3	2	2	2				1			2	3	1	2

**For Entire Course, PO & PSO Mapping*

Subject Code	Subject Name	L	T	P	C
R23CIT-OE0004	Wireless Sensor Networks	3	0	0	3

Course Objectives:

- Define WSN and Dynamic modulation scaling.
- Explore working of the MAC protocols
- Demonstrate Routing and Data gathering protocols
- Illustrate working of Embedded OS.
- Explore a wide range of WSN applications in different sectors

Course Outcomes:

1. Understand the basics, characteristics and challenges of Wireless Sensor Network
2. Apply the knowledge to identify appropriate physical and MAC layer protocol
3. Apply the knowledge to identify the suitable routing algorithm based on the network and user requirement
4. Analysis of OS used in Wireless Sensor Networks and build basic modules
5. Analyze specific WSN application using a case study approach

Unit-I – CHARACTERISTICS OF WSN (8 Hours)

Characteristic requirements for WSN – Challenges for WSNs – WSN vs Adhoc Networks – Sensor node architecture – Commercially available sensor nodes – Imote, IRIS, Mica Mote, EYES nodes, BTnodes, TelosB, Sunspot -Physical layer and transceiver design considerations in WSNs, Energy usage profile, Choice of modulation scheme, Dynamic modulation scaling, Antenna considerations.

Learning Outcomes:

- Identify and explain the key characteristics
- Differentiate between Wireless Sensor Networks (WSNs) and Ad-hoc Networks
- Understand the role and functionalities of each component within the sensor node.

Unit – II: MEDIUM ACCESS CONTROL PROTOCOLS (10 Hours)

Fundamentals of MAC protocols – Low duty cycle protocols and wakeup concepts – Contention based protocols – Schedule-based protocols – SMAC – BMAC – Traffic adaptive medium access protocol (TRAMA) – The IEEE 802.15.4 MAC protocol.

Learning Outcomes:

- Describe the main challenges of MAC protocols in wireless sensor networks (WSNs)
- Understand the concept of low duty cycle operation and its importance
- Evaluate the performance characteristics of contention-based protocols, including throughput, latency, and energy efficiency

Unit – III: ROUTING AND DATA GATHERING PROTOCOLS (10 Hours)

Routing Challenges and Design Issues in Wireless Sensor Networks, Flooding and gossiping – Data centric Routing – SPIN – Directed Diffusion – Energy aware routing – Gradient-based routing –Rumor Routing – COUGAR – ACQUIRE – Hierarchical Routing – LEACH, PEGASIS – Location Based Routing – GF, GAF, GEAR, GPSR – Real Time routing Protocols – TEEN, APTEEN, SPEED, RAP – Data aggregation - data aggregation operations – Aggregate Queries in Sensor Networks – Aggregation Techniques – TAG, Tiny DB.

Learning Outcomes:

- Identify the key routing challenges in WSNs compared to traditional wired networks
- Analyze popular hierarchical routing protocols
- Analyze location-based routing protocols, Real-Time Routing Protocols

Unit – IV: EMBEDDED OPERATING SYSTEMS (10 Hours)

Operating Systems for Wireless Sensor Networks – Introduction – Operating System Design Issues – Examples of Operating Systems – TinyOS – Mate – MagnetOS – MANTIS – OSPM – EYES OS – SenOS – EMERALDS – PicOS – Introduction to Tiny OS – NesC – Interfaces and Modules – Configurations and Wiring – Generic Components – Programming in Tiny OS using NesC, Emulator TOSSIM.

Learning Outcomes:

- Understand the role and importance of operating systems in managing the resources and functionalities of Wireless Sensor Networks.
- Compare and contrast prominent WSN operating systems like TinyOS, Mate, MagnetOS, MANTIS, OSPM, EYES OS, SenOS, EMERALDS, and PicOS.
- Understand the strengths and weaknesses of each operating system in terms of features, resource management, and suitability.

Unit – V: APPLICATIONS OF WSN (10 Hours)

WSN Applications – Home Control – Building Automation – Industrial Automation – Medical Applications – Reconfigurable Sensor Networks – Highway Monitoring – Military Applications – Civil and Environmental Engineering Applications – Wildfire Instrumentation – Habitat Monitoring – Nanoscopic Sensor Applications – Case Study: IEEE 802.15.4 LR-WPANs Standard – Target detection and tracking – Contour/edge detection – Field sampling

Learning Outcomes:

- Identify the key characteristics of Wireless Sensor Networks (WSNs) that make them suitable for various applications.
- Analyze a specific WSN application through a Case Study
- Develop a basic understanding of common data analysis techniques used with WSN data

Text Books:

1. Wireless Sensor Networks Technology, Protocols, and Applications, KazemSohraby, Daniel Minoli and TaiebZnati, John Wiley & Sons, 2007
2. Protocols and Architectures for Wireless Sensor Network, Holger Karl and Andreas Willig John Wiley & Sons, Ltd ,2005

References Books:

1. A survey of routing protocols in wireless sensor networks , K. Akkaya and M. Younis, Elsevier
2. Ad Hoc Network Journal, Vol. 3, no. 3, pp. 325--349
3. TinyOS Programming , Philip Levis
4. Wireless Sensor Network Designs , Anna Ha'c , John Wiley & Sons Ltd

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1) :

[illegible]

Course Code	Subject Name	L	T	P	C
R23CSM-OE0001	An Introduction to Artificial Intelligence	3	0	0	3

Prerequisites:

- Basic knowledge of programming, linear algebra, and probability & statistics.

Course Objectives:

- To focus is made on definition, scope, foundations, historical development, applications of AI, and core concepts such as the Turing Test and intelligent agents.
- To work on uninformed and informed search techniques, including heuristic and game-based approaches, to solve AI problems effectively.
- To differentiate between various knowledge representation techniques such as logic-based, semantic networks, frames, scripts, and conceptual dependency
- To introduce students to fundamental reasoning and learning techniques in Artificial Intelligence
- To analyse the impact of AI technologies on society, identify ethical challenges, and discuss current trends in AI research, robotics, and perception.

Course Outcomes:

- Understand the Fundamentals and Scope of AI
- Develop Problem-Solving and Search Strategy Skills
- Acquire Knowledge Representation Techniques
- Apply reasoning techniques and learning methods to solve problems under uncertainty
- Explore Emerging AI Topics and Ethical Considerations

Unit-1:

Introduction to Artificial Intelligence- Definition and scope of AI- AI Applications- Foundations of AI- History and Philosophy of AI- Turing Test and Intelligent Agents.

Unit-2:

Problem Solving and Search- Problem formulation- Uninformed search: BFS, DFS- Heuristic search: Hill Climbing, Best-First, A*- Game playing: Minimax, Alpha-Beta pruning.

Unit-3:

Knowledge Representation- Declarative vs Procedural Knowledge- Logic-Based Representations- Semantic networks, Frames, Scripts- Conceptual Dependency.

Unit-4:

Reasoning and Learning- Rule-based systems and Expert Systems, Fuzzy Sets and Fuzzy Logic, Machine Learning -Types of learning – Learning by analogy- explanation based learning.

Unit-5:

Emerging Topics and AI Ethics- Robotics and Perception- AI in society: Ethics, Bias, Safety- Current trends in AI research.

Text Book:

1. *Elaine Rich, Kevin Knight, and Shivashankar B. Nair , Artificial Intelligence, Tata McGraw-Hill Education*
2. *Stuart Russell and Peter Norvig – Artificial Intelligence: A Modern Approach, 3rd Edition, Pearson*
3. George F. Luger - Artificial Intelligence Principles and Practice (2025) -Springer

Reference Text Books:

4. N.P. Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press
5. *Nick Bostrom, Superintelligence: Paths, Dangers, Strategies*
6. *Cathy O'Neil, Weapons of Math Destruction*

Course Code	Subject Name	L	T	P	C
R23CSM-OE0002	Introduction to Machine Learning Using Python	3	0	0	3

Prerequisites:

- Basic knowledge of mathematics (linear algebra, probability, and statistics) and fundamental programming concepts.

Course Objectives:

- To introduce the fundamental concepts, types, and real-world applications of machine learning, and to familiarize students with essential tools such as Python, Jupyter Notebooks, and scikit-learn.
- To enable students to understand and perform essential data pre processing techniques including data cleaning, transformation, and visualization for machine learning tasks.
- To provide a solid foundation in implementing and evaluating supervised learning algorithms such as linear regression, logistic regression, decision trees, and k-nearest neighbours.
- To familiarize students with unsupervised learning methods including clustering and dimensionality reduction techniques, and their application to engineering problems.
- To develop students' ability to validate and tune machine learning models using appropriate techniques and apply their knowledge through case studies relevant to engineering domains.

Course Outcomes:

- Describe the fundamental concepts of machine learning and its types.
- Pre process and represent data effectively using Python libraries
- Implement basic supervised learning algorithms and evaluate their performance.
- Apply unsupervised learning techniques for data grouping and dimensionality reduction
- Perform model validation, avoid over fitting, and analyze real-world ML case studies.

Unit-1:

Introduction to Machine Learning -What is Machine Learning? - Types of Machine Learning: Supervised, Unsupervised, Reinforcement- ML in real-world engineering applications, Introduction to Python, scikit-learn, and Jupyter Notebooks, ML pipeline overview.

Unit-2:

Data Representation and Pre-Processing - Data types: numerical, categorical, Feature extraction and representation, handling missing values, scaling, normalization, encoding categorical variables, splitting data: train-test split, validation set, Visualization using Matplotlib.

Unit-3:

Supervised Learning Algorithms - Linear Regression, Logistic Regression, Decision Trees, K-Nearest Neighbours, Model evaluation: accuracy, confusion matrix, Bias-variance trade-off.

Unit-4:

Unsupervised Learning Algorithm and Dimensionality Reduction- Clustering: K-Means, Hierarchical clustering, Evaluation of clustering, Principal Component Analysis (PCA).

Unit-5:

Model Validation and Applications - Cross-validation, Over fitting and under fitting. Case Studies - Predictive maintenance, Demand Forecasting, Simple Recommendation Systems.

Text Book:

1. Andreas C. Müller & Sarah Guido – Introduction to Machine Learning with Python (O'Reilly, 2016)
2. Tom M. Mitchell – Machine Learning (McGraw-Hill, 1997) – for foundational concepts
3. Zhen _Leo_ Liu - Artificial Intelligence for Engineers_ Basics and Implementations (AI) (2025)-Springer

Reference Text Books:

4. Aurélien Géron – Hands-On Machine Learning with Scikit-Learn, Keras, and Tensor Flow (O'Reilly) – for optional deeper reading/projects

Course Code	Subject Name	L	T	P	C
R23CSM-OE0003	Foundation of Deep Learning for Engineering Applications	3	0	0	3

Prerequisites:

- Basic knowledge on python programming and overview on AI and Machine Learning

Course Objectives:

- To introduce the fundamentals of artificial and deep neural networks.
- To familiarize students with the working of popular deep learning architectures.
- To train students to implement and apply deep learning models using Python-based tools.
- To expose students to practical applications of deep learning across various engineering domains.
- To highlight the ethical and responsible use of deep learning technologies.

Course Outcomes:

- Describe the basic concepts and architecture of neural networks and their relevance to engineering applications.
- Explain the training process of neural networks and optimization techniques.
- Implement and evaluate convolutional and recurrent neural networks for solving problems in image and time-series.
- Apply deep learning techniques to domain-specific case studies.
- Analyse the ethical implications, limitations, and emerging trends in deep learning.

Unit-1:

Introduction to Neural Networks- Introduction to Artificial Neural Networks (ANN)- Biological inspiration, Perceptron, Activation functions, Neural network architecture: Input, Hidden, Output layers, Applications of deep learning in various engineering fields

Unit-2:

Training Neural Networks- Forward and backward propagation, Loss functions and optimization, Gradient descent and learning rate, Overfitting and underfitting. Introduction to TensorFlow and Keras frameworks

Unit-3:

Deep Architectures – CNN and RNN- Convolutional Neural Networks (CNN): Basics, layers, and applications, CNN for image classification and object detection, Recurrent Neural Networks (RNN): Basics, vanishing gradients

Unit-4:

Applications and Case Studies- Image processing -Defect detection, Biomedical imaging- Predictive maintenance in mechanical systems- Speech and signal recognition- Forecasting in energy and climate models

Unit-5:

Ethics, Challenges & Future Trends- Interpretability and explainability in deep learning, Bias and fairness in deep learning systems, Deep fakes and misuse of AI, Green AI and energy-efficient training. Future trends: Generative AI, Edge AI, TinyML

Text Book:

1. François Chollet – *Deep Learning with Python* – Manning Publications
2. Ian Good fellow, Yoshua Bengio, Aaron Courville – *Deep Learning* – MIT Press
3. Michael Nielsen – *Neural Networks and Deep Learning* – Online book

Reference Text Books:

4. Melanie Mitchell – *Artificial Intelligence: A Guide for Thinking Humans*-Farrar, Straus and Giroux

Course Code	Subject Name	L	T	P	C
R23CSM-OE0004	Natural Language Processing– Frontiers Approach	3	0	0	3

Prerequisites:

- A foundational understanding of programming, basic linguistics, and probability/statistics is essential.

Course Objectives:

- To learn the fundamentals of natural language processing
- To understand the use of CFG and PCFG in NLP
- To understand the role of semantics of sentences and Pragmatics
- To gain knowledge in automated natural language generation and machine translation
- To understand language modeling

Course Outcomes:

- Understand the fundamentals of basic language features
- Analyse the words involved in NLP
- Analyse the syntactic analysis involved in NLP
- Apply semantic Analysis for NLP
- Compare different statistical approaches of NLP applications.

Unit-1:

Introduction: Origins and challenges of NLP, Language Modeling: Grammar-based LM, Statistical LM – Regular Expressions, Finite-State Automata – English Morphology, Transducers for lexicon and rules, Tokenization, Detecting and Correcting Spelling errors.

Unit-2:

Word level analysis: Unsmoothed N-grams, Evaluating N-grams, Smoothing, Interpolation and Backoff – Word Classes, Part-of-Speech Tagging, Rule-based, Stochastic and Transformation-based tagging, Issues in Po Tagging –Hidden Markov and Maximum Entropy models.

Unit-3:

Syntactic analysis: Context-Free Grammars, Grammar rules for English, Normal Forms for grammar – Dependency Grammar – Syntactic Parsing, Ambiguity, Dynamic Programming parsing – Probabilistic CFG, Probabilistic CYK, Probabilistic Lexicalized CFGs – Feature structures, Unification of feature structures.

Unit-4:

Semantics Analysis: Requirements for representation, First-Order Logic, Description Logics –Syntax- Driven Semantic analysis, Semantic attachments– Word Senses, Relations between Senses, Thematic Roles, selection restrictions – Word Sense Disambiguation

Unit-5:

Discourse Analysis and Lexical Resources: Discourse segmentation, Coherence–Reference Phenomena, Anaphora Resolution using Hobbs and Centering Algorithm–Coreference Resolution – Resources: Porter Stemmer, Lemmatizer, Penn Treebank, Brill's Tagger, Word Net, Prop Bank, Frame Net, Brown Corpus, British National Corpus (BNC).

Text Book:

1. Daniel Jurafsky, James H. Martin — Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech, Pearson Publication, 2014.
2. Steven Bird, Ewan Klein and Edward Loper, —Natural Language Processing with Python, First Edition, O'Reilly Media, 2009.

Reference Text Books:

3. Breck Baldwin, — Language Processing with Java and Ling Pipe Cook book, Atlantic Publisher, 2015.
4. Richard M Reese, —Natural Language Processing with Java, O'Reilly Media, 2015.
5. Nitin Indurkha and Fred J. Damerau, —Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010.
6. Tanveer Siddiqui, U.S. Tiwary, Natural Language Processing and Information Retrieval, Oxford University Press, 2008.