COURSE STRUCTURE (R23)
AND
DETAILED SYLLABUS
(IV YEAR)

For
B.Tech. Four 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)
Jonnada (Village), Denkada (Mandal), Vizianagaram Dist – 535 005
Phone No. 08922-241111, 241112
E-Mail:lendi_2008@yahoo.com Website:www.lendi.edu.in

B.Tech. – IV Year I Semester

S.No.	Code	Category	Title	L	T	P	Credits
1	R23ECE-PC4101	PCC	Digital Image and Video Processing	3	0	0	3
2	R23ECE-HS4101	HSMC	Management Science	2	0	0	2
3	R23ECE-PE4101	PE - IV	1. 5G Communications. 2. VLSI Physical design 3. Drone Technology 4. AI in signal Processing 5. Radar Engineering.	3	0	0	3
4	R23ECE-PE4102	PE-V	1. Introduction to Quantum Communications 2. Design Verification and Test of VLSI Circuits. 3. Digital Twin and IOT. 4. Speech Processing. 5. Advanced Microwave Networks.	3	0	0	3
5	R23ECE-OE4101	OE- III	Pool selection	3	0	0	3
6	R23ECE-OE4102	OE-IV	Pool Selection	3	0	0	3
7	R23ECE-SC4101	SEC	Industrial IoT & Automation	1	0	2	2
8	R23ECE-MC4101	MC	Entrepreneurship & Incubation (E&I)	2	0	0	0
9	R23ECE-SI4101	Internship	Evaluation of Industry Internship	-	-	-	2
		Total		**20**	**0**	**02**	**21**

B.Tech. – IV Year II Semester

S.No.	Code	Category	Title	L	T	P	Credits
1	R23ECE-PR4201	PR	Project and Industrial Internship	0	0	24	12
Total				0	0	24	12

Subject Code	Subject Name	L	T	P	C
R23ECE-PC4101	Digital Image and Video Processing	3	0	0	3

Course Objectives:

• To introduce fundamentals of Image Processing.
• To expose various intensity transformations in spatial and frequency domains.
• To impart concepts of wavelets and various coding techniques for image compression.
• To dissimilate various segmentation techniques for images.
• To teach various color models and to introduce the concepts of color image segmentation.

Course Outcomes:

1. Analyze various types of images mathematically
2. Compare image enhancement methods in spatial and frequency domains
3. Demonstrate various segmentation algorithms for given image and describe various color models for color image processing
4. Justify DCT and wave let transform techniques for image compression
5. Demonstrate the basics of video processing

Unit-1

Digital Image Fundamentals-Elements of visual perception, image sensing and acquisition, image sampling and quantization, basic relationships between pixels – neighborhood, adjacency, connectivity, distance measures.

Contemporary Issues

- AI-enhanced image acquisition and perception modeling for intelligent vision systems.
- High-resolution image sampling and quantization challenges in real-time imaging applications.

Learning outcomes:

• Explain mathematical models of various types of images(L2)
• Define image processing parameters such as adjacency and distance measures(L1)

Unit-2

Image Enhancements and Filtering- Gray level transformations, histogram equalization and specifications, pixel-domain smoothing filters – linear and order statistics, pixel-domain sharpening filters – first and second derivative, two-dimensional DFT and its inverse, frequency domain filters – low-pass and high-pass.

Contemporary Issues

- AI-powered image enhancement and denoising for low-light and degraded images.
- Real-time frequency-domain filtering for high-resolution imaging and video analytics.

Learning outcomes:

• Compare image enhancement methods in spatial and frequency domains(L3)
• Apply frequency Domain filtering techniques for image enhancement (L2)

Unit-3

Image Segmentation, Detection of discontinuities, edge linking and boundary detection, thresholding – global and adaptive, region-based segmentation.

Color Image Processing-Color models–RGB, YUV, HSI; Color transformations–formulation, color complements, color slicing, tone and color corrections; Color image smoothing and sharpening; Color Segmentation.

Contemporary Issues

- Deep learning-based image segmentation for autonomous vehicles and medical diagnostics.
- Advanced color correction and segmentation techniques for HDR and multimedia imaging applications.

Learning outcomes:

• Describe various Image segmentation techniques(L2)
• Illustrate detection of discontinuities in an image(L2)
• Describe various color models for color image processing(L2)
• Apply various techniques for color image smoothing, sharpening and segmentation (L3)

Unit-4

Wavelets and Multi-resolution image processing- Image Pyramids, Sub band Coding, The Haar Transform. Wavelet functions. Wavelet Transforms in Two Dimensions

Image Compression- Coding Redundancy, Spatial Redundancy; compression Methods-Huffman Coding, Arithmetic Coding, Bit Plane Coding, Block Transform Coding, Predictive Coding. Still image compression standards JPEG and JPEG-2000

Contemporary Issues

- AI-driven image compression techniques for efficient storage and transmission of high-resolution images.
- Wavelet-based processing for medical imaging and next-generation multimedia applications.

Learning outcomes:

• Describe various transform techniques for lossy compression(L2)
• Apply various coding techniques for lossless compression(L3)

Unit-5

Basic Steps of Video Processing: Analog video, Digital Video, 2-D Motion Estimation: Optical flow, pixel-based motion estimation, Block matching algorithm, Application of motion estimation in video coding, Video Segmentation.

Contemporary Issues

- AI-based motion estimation and video segmentation for autonomous and surveillance systems.
- Real-time high-efficiency video coding for 4K/8K streaming and low-latency applications.

Learning outcomes:

• Describe various steps of video processing and image formation models(L2)
• Apply various techniques for motion estimation and video segmentation (L3)

Text Books:

1. R.C. Gonzalez and R.E. Woods, Digital Image Processing, Second Edition, Pearson Education, 2008.
2. Yao wang, Joem Ostermann and Ya–quin Zhang," Video processing and communication ", 1st edition, PHI, 2001.

References:

1. Rafae lC. Gonzalez, Richard E woods and Steven L. Eddins, "Digital Image

processing using MATLAB", Tata McGraw Hill, 2010.
2. Anil Kumar Jain, Fundamentals of Digital Image Processing, Prentice Hall of India, 2nd edition 2004.
3. S Jayaraman, SE sakkirajan, T Veerakumar, "Digital Image processing", Tata McGraw Hill.

Subject Code	Subject Name	L	T	P	C
R23ECE-HM4101	Managerial Skills for Engineers	2	0	0	2

COURSE OBJECTIVES:

- To provide fundamental knowledge on Management, Administration, Organization & its concepts
- To equip with the knowledge of Production/Materials/Purchases/Stores/Inventory/Marketing Management and Quality control.
- To make the students know the role of human relations in the management of operations and to identify Strategic Management areas
- To Study the PERT/CPM for better Project Management and to nurture the students with the contemporary practices of management.

COURSE OUTCOMES:

1. To apply the concepts & principles of management & designs of organization in a practical world. (L3)
2. To apply Work-study principles, Quality Control techniques in real life industry & knowledge of Inventory control.(L3)
3. To appraise the functional management challenges with levels of changes in the organization. and identify the importance of marketing in emerging world.(L5)
4. To develop PERT/CPM Charts for projects of an enterprise and estimate time & cost of project.(L6)
5. Develop vision and management skills both at strategic level and interpersonal level to analyse the business through SWOT(L6)
6. Aware of the latest and contemporary issues of Management(L1)

UNIT I

INTRODUCTION TO MANAGEMENT: Management-Concept -Nature-Functions-Taylor‘s Scientific Theory-Henry Fayol‘s principles -Motivational theories- Organizational Structure and Design: Features of Organizational Structure & Departmentation-Line organization-Line & Staff Organization-Functional Organization-Matrix Organization-Project Organization-Committee form of Organization Leadership styles.

Learning Outcomes:

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

- To apply the concepts & principles of management & designs of organization in a practical world (L3)
- Evaluate management aspects and its implementation in aim of achieving organizational goals (L5)

Applications: Each student collects the information related to interrelations, roles and responsibilities and prepare the structure of the organization..

UNIT II

OPERATIONS MANAGEMENT: Principles and Types of Plant Layout-Work Study-Statistical Quality Control: X-bar chart, R chart, C chart and P chart, (simple Problems)

Deming's contribution to Quality. Material Management: Objectives-Inventory-Functions, Types, Inventory Techniques-EOQ-ABC Analysis-Inventory analysis (HML, SDE, VED, FSN Analysis)

Learning Outcomes:

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

- To equip with the concepts of operations & their technical relationships (L2)
- Knowledge of relationships between input, output and inventory control(L1)

Applications: Calculation of techniques and preparation of control charts related to quality control.

2. Interpret and calculate ordering cost and carrying cost for estimation of number of orders required to hold Inventory level.

UNIT III

HUMAN RESOURCES MANAGEMENT& MARKETING MANAGEMENT: HRM-Definition and Meaning – Nature-Managerial and Operative functions-Wage and Salary Administration-(simple Problems)-Job Evaluation and Merit rating.

Marketing Management: Concept-Meaning - Nature-Functions of Marketing- Marketing Mix-Channels of Distribution - Marketing Strategies based on Product Life Cycle.

Learning Outcomes:

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

- To understand the importance of human resources power in the main functional areas (L2)
- Awareness about marketing mix and strategies (L1)

Applications:

1. Role plays about the job description, job specification, job enrichment and job evaluation.
2. Compare and contrast a product between different companies which are in similar features.

UNIT IV

PROJECT MANAGEMENT: Project planning and control- Project life cycle- Development of network-Difference between Program Evaluation Review Technique and Critical Path Method- Identifying critical path- probability of completing the project within the given time, cost analysis, - project crashing(simple numerical problems).

Learning Outcomes:

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

- Project handling and controlling techniques for optimum utilization of resources(L2)
- Develop PERT/CPM networks for projects of an enterprise and estimate time & cost of project(L6)

Application: Analyze various parameters of the project like critical path, crashing etc. for best cost decisions according to probability of the project.

UNIT V

STRATEGIC MANAGEMENT: Definition& Meaning-Setting of Vision- Mission- Goals-Corporate Planning Process- Environmental Scanning-Steps in Strategy Formulation and Implementation-SWOT Analysis. Global strategies and theories of Multinational Companies.

Learning Outcomes:

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

- Analyse the organization through SWOT analysis(L4)
- Describes the concept and practical issues relating to strategic management and its role in longterm decision making(L2)

Application: Student has to make his self analysis and prepare a report consists of vision, mission, objective, goal and SWOT (Strengths, Weakness, Opportunities and Threats)

UNIT VI

CONTEMPORARY PRACTICES IN MANAGEMENT: Concept of Management Information System(MIS)- Just In Time(JIT)- Customer Relations Management(CRM)-Digital Quality Management (DQM)-Total Quality Management (TQM)- Six Sigma Concept-Supply Chain Management(SCM)- Enterprise Resource Planning (ERP)- Capability Maturity Model (CMM)-Business Process Outsourcing (BPO), Bench Marking and Balanced Score Card-Single Window System.(SWS).

Learning Outcomes:

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

- Apply modern management techniques to meet global challenges in effective manner(L3)
- Describe the required aspects according to real time scenario(L2)

Applications: Adopt new trends in techno managerial practices according to current scenario.

Text Books:

1. Management Science by Aryasri; Publisher: Tata McGraw Hill, 2009

2. Management by James Arthur, Finch Stoner, R. Edward Freeman, and Daniel R. Gilbert 6th Ed; Publisher: Pearson Education/Prentice Hall.

References Books:

1. Principles of Marketing: A South Asian Perspective by Kotler Philip, Gary Armstrong, Prafulla Y. Agnihotri, and EshanulHaque , 2010, 13th Edition, Publisher: Pearson Education/ Prentice Hall of India.

2. A Handbook of Human Resource Management Practice by Michael Armstrong, 2010; Publisher: Kogan Page Publishers.

3. Quantitative Techniques in Management by N.D. Vohra, 4th edition, 2010; Publisher: Tata McGraw Hill.

Subject Code	Subject Name	L	T	P	C
R23ECE-PE4101.1	5G COMMUNICATIONS	3	0	0	3

COURSES OBJECTIVES:

- To understand the evolution, requirements, architecture, and key performance indicators of 5G communication systems.
- To analyze the transmission techniques, waveforms, numerology, and multiple access schemes used in 5G New Radio.
- To examine the principles of massive MIMO, beamforming techniques, and millimeter wave propagation for high-capacity 5G communication.
- To explain the 5G network architecture, protocol stack, network slicing, and enabling technologies such as SDN and NFV.
- To explore emerging applications of 5G including IoT, edge computing, AI-driven networks, and future trends toward 6G.

COURSE OUTCOMES:

1. Explain the evolution of mobile communication systems and interpret the requirements, architecture, and key performance indicators of 5G networks.
2. Analyze various 5G transmission techniques including OFDM-based NR, advanced waveforms, and multiple access schemes used in next-generation wireless systems.
3. Evaluate the principles of massive MIMO, beamforming strategies, and millimeter wave communication for high-data-rate wireless systems.
4. Illustrate and examine the 5G network architecture, protocol stack, network slicing, SDN, and NFV for efficient network management.
5. A**ssess** the role of 5G technologies in IoT, smart cities, Industry 4.0, healthcare, and interpret future research directions toward 6G communication systems.

UNIT - I

Introduction to 5G Networks: Evolution from 1G to 5G, Need and vision for 5G, 3GPP and ITU-T contributions to 5G standardization, 5G spectrum bands (sub-6 GHz and mm-Wave),Use cases and application scenarios: Enhanced Mobile Broadband (Embb), Ultra-Reliable Low Latency Communications (URLLC), Massive Machine-Type Communications (mMTC); performance targets and KPIs of 5G. 5G architecture overview (Core network and Access network).

Contemporary Issues

- 5G Security Risks in IoT Networks.
- Spectrum Scarcity and Interference Management.

Learning outcomes:

- Explain the evolution of mobile networks from 1G to 5G and describe the basic concepts of 5G architecture, spectrum, and standards. (L2)
- Identify the main 5G use cases (eMBB, URLLC, and mMTC) and their applications in modern communication systems. (L2)

UNIT –II

5G New Radio and Waveforms (OR)**Transmission and Design Techniques for 5G:**

5G New Radio (NR) – Overview, Orthogonal Frequency Division Multiplexing (OFDM) based transmission, alternative waveforms: filter bank multi-carriers (FBMC), universal filtered multi-carrier (UFMC), Generalized frequency division multiplexing (GFDM), 5G NR frame structure and numerology in 5G.

Multiple Accesses Techniques – orthogonal frequency division multiple accesses (OFDMA), generalized frequency division multiple accesses (GFDMA), non-orthogonal multiple accesses (NOMA); spectrum sharing, dynamic spectrum access (DSA), physical layer design aspects.

Contemporary Issues

- Integration of AI-driven dynamic spectrum access for efficient 5G resource allocation.
- Reducing interference and complexity in NOMA-based massive user connectivity.

Learning outcomes:

- Explain the architecture, frame structure, numerology, and waveform technologies (OFDM, FBMC, UFMC, GFDM) used in 5G New Radio (NR). (L2)
- Analyze and compare multiple access techniques (OFDMA, GFDMA, NOMA) and spectrum access methods for efficient 5G physical layer design. (L4)

UNIT III

Massive MIMO and Millimeter Wave Communications: Introduction to MIMO systems, massive MIMO principles, beamforming techniques, hybrid beamforming, millimeter wave propagation characteristics, channel models, advantages and challenges of mm-Wave communications

Contemporary Issues

- AI-assisted beamforming optimization for Massive MIMO networks.
- Overcoming blockage and coverage limitations in mm-Wave communications.

Learning outcomes:

- Explain massive MIMO and beamforming techniques in 5G systems. (L2)
- Analyze mmWave propagation characteristics and communication challenges. (L4)

UNIT –IV

5G Network Architecture and Protocols

5G system architecture, Basics about 5G Radio Access Network (RAN) architecture, ORAN,Service-Based Architecture (SBA) in 5G Core; Network Slicing: Concept, implementation and use cases;Software Defined Networking (SDN) and Network Function Virtualization (NFV), Mobility Management in 5G. Protocol stack (RRC, PDCP, RLC, MAC, PHY), Dual Connectivity and Carrier Aggregation

Contemporary Issues

- Security challenges in virtualized 5G networks using SDN, NFV, and network slicing.
- Efficient management of multi-vendor interoperability in Open RAN (O-RAN) deployments.

Learning outcomes:

- Explain 5G architecture, RAN, ORAN, SBA, and network slicing concepts. (L2)
- Analyze 5G protocols, mobility management, dual connectivity, and carrier aggregation. (L4)

UNIT V

Applications and Future Trends : Internet of Things (IoT) in 5G, Edge and fog computing, Device-to-Device (D2D) Communication, AI/ML in network optimization,security challenges in 5G, 5G NR deployment strategies (Standalone and Non-Standalone),Case studies on 5G in Smart Cities, Industry 4.0, and Healthcare, vision towards 6G.

Contemporary Issues

- Integration of AI-driven autonomous network management for 5G and beyond.
- Ensuring security and privacy in large-scale IoT and edge computing deployments.

Learning outcomes:

- Explain 5G applications in IoT, edge computing, D2D communication, and smart systems. (L2)
- Analyze AI/ML-based optimization, security challenges, deployment strategies, and future 6G trends. (L4)

TEXT BOOKS:

1. Fundamentals of 5G Communications: Connectivity for Enhanced Mobile Broadband and Beyond, 1st Edition. Mc Graw Hill, 2021
2. Afif Osseiran, Jose F Monserrat, Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016
3. Harri Holma, Antti Toskala, Takehiro Nakamura, "5G Technology 3GPP NEW RADIO", John Wiley & Sons First Edition,2020
4. Theodore S. Rappaport, Robert W. Heath Jr., Robert C. Daniels, and James N. Murdock, Millimeter Wave Wireless Communications, 1st Edition, Pearson Education, 2014.

REFERENCE BOOKS:

1. Erik Dahlman, Stefan Parkvall, Johan Skold"5G NR: The Next Generation Wireless Access Technology" Academic Press (Elsevier), 2nd Edition, 2020
2. Srinivas R. Kota, Krishna Sivalingam "5G Networks: Fundamental Requirements, Enabling Technologies, and Operations Management" Springer, 1st Edition, 2020
3. Ying Zhang, "Network Function Virtualization Concepts and Applicability in 5G Networks", John Wiley & Sons, 2018.
4. Jonathan Rodriguez – Fundamentals of 5G Mobile Networks,1st Edition, Wiley, 2015.
5. Sassan Ahmadi – 5G NR: Architecture, Technology, Implementation, and Operation of 3GPP New Radio, Academic Press 2019.

Course code	Subject Name	L	T	P	C
R23ECE-PE4101.2	VLSI Physical Design	3	0	0	3

Course Objectives

- To introduce students to the VLSI design methodology and RTL to GDSII physical design flow used in modern semiconductor chip development.
- Learn the basics of standard cell libraries and technology nodes.
- Understand floor planning and power planning in chip design.
- Study placement and clock tree synthesis techniques.
- Learn routing, timing analysis, and physical verification before chip fabrication.

Course Outcomes

1. List the stages involved in the RTL to GDSII physical design flow. (L1)
2. Identify the standard cells, technology nodes, and design rules used in VLSI physical design. (L1)
3. Explain the concepts of floor planning and power planning in chip design. (L2)
4. Explain the basic concepts of placement and clock tree synthesis. (L2)
5. Apply the basic steps of routing and physical verification in VLSI design flow. (L3)

Unit-1

Introduction to VLSI Design and Physical Design Flow: Overview of VLSI Design Methodology, Moore’s Law and semiconductor technology trends, ASIC vs FPGA design approaches, Front-end vs Back-end design flow, Introduction to RTL to GDSII flow, Role of Physical Design in chip implementation, Introduction to EDA tools used in industry (Cadence, Synopsys, Mentor).

Contemporary Issues

- AI-assisted EDA tools for accelerating RTL-to-GDSII chip design flow.
- Challenges in sustaining Moore’s Law with advanced nanometer semiconductor technologies.

Learning Outcomes

- Explain VLSI design methodology, RTL-to-GDSII flow, and design approaches. (L2)
- Analyze physical design stages and the role of EDA tools in chip implementation. (L4)

Unit-2

Technology Nodes, Standard Cells and Library Basics: Semiconductor technology nodes (180nm, 65nm, 28nm, 7nm etc.), Introduction to standard cells, Standard cell architecture, Cell libraries and LEF/DEF formats, Basic CMOS layout concepts, Design rules and layout constraints, Power rails and cell rows, Introduction to PVT (Process, Voltage, Temperature) variations.

Contemporary Issues

- Challenges of PVT variability and reliability in advanced technology nodes (7nm and below).
- Adoption of FinFET/GAAFET technologies for improved power and performance scaling.

Learning Outcomes

- Explain technology nodes, standard cells, cell libraries, and CMOS layout concepts. (L2)
- Analyze design rules, layout constraints, and PVT variations in VLSI design. (L4)

Unit-3

Floor planning and Power Planning: Importance of floor planning, Die size estimation, Core utilization and aspect ratio, Macro placement (Memories, IP blocks), Power planning, Power rings, Power stripes, Power grid, Pin placement, Basic congestion awareness, Introduction to IR drop and electro migration

Contemporary Issues

- Managing IR drop and electro migration challenges in advanced nanometer VLSI technologies.
- AI-driven floor planning and congestion optimization for high-performance SoC designs.

Learning Outcomes

- Explain floor planning, macro placement, and power planning in VLSI physical design. (L2)
- Analyze congestion, IR drop, electro migration, and power distribution networks. (L4)

Unit-4

Placement and Clock Tree Synthesis: Introduction to cell placement, Types of placement, Global placement, Detailed placement, Placement optimization, Timing-driven placement, Introduction to Clock Tree Synthesis (CTS), Clock skew and clock latency, Clock buffers and clock routing, Basic concepts of timing closure

Contemporary Issues

- AI-driven placement and CTS optimization for advanced VLSI nodes.
- Managing clock skew and timing closure challenges in high-performance SoC designs.

Learning Outcomes

- Explain cell placement techniques and Clock Tree Synthesis (CTS) in VLSI physical design. (L2)
- Analyze clock skew, clock latency, and timing closure optimization techniques. (L4)

Unit-5

Routing, Physical Verification and Sign-off: Introduction to routing, Global routing and detailed routing, Routing layers and vias, Congestion handling, Design Rule Check (DRC), Layout vs Schematic (LVS), Parasitic extraction, Static Timing Analysis (STA), Final GDSII generation and tape-out process, Overview of manufacturing and yield considerations.

Contemporary Issues

- AI-assisted routing and sign-off verification for advanced semiconductor nodes.
- Managing parasitic effects and yield challenges in sub-5nm VLSI technologies.

Learning Outcomes

- Explain routing, physical verification, STA, and the tape-out process in VLSI design. (L2)
- Analyze congestion, parasitic effects, timing violations, and yield considerations. (L4)

TEXT BOOKS

1. Naveed A. Sherwani, *Algorithms for VLSI Physical Design Automation*, Kluwer Academic Publishers, 1999.
2. VLSI Physical Design: From Graph Partitioning to Timing Closure Andrew B. Kahng, Jens Lienig, Igor L. Markov, Jin Hu, *VLSI Physical Design: From Graph Partitioning to Timing Closure*, Springer, 2011.
3. Physical Design Essentials Khosrow Golshan, *Physical Design Essentials: An ASIC Design Implementation Perspective*, Springer, 2007.
4. CMOS VLSI Design: A Circuits and Systems Perspective Neil H. E. Weste, David Harris, *CMOS VLSI Design: A Circuits and Systems Perspective*, Pearson, 2011.

REFERENCE BOOKS

1. Neil H. E. Weste and David Harris, *CMOS VLSI Design: A Circuits and Systems Perspective*, 4th Edition, Pearson, 2010.
2. Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic, *Digital Integrated Circuits: A Design Perspective*, 2nd Edition, Pearson, 2003.
3. Wayne Wolf, *Modern VLSI Design: IP-Based Design*, 4th Edition, Pearson, 2008.

Subject Code	Subject Name	L	T	P	C
R23ECE-PE4101.3	DRONE TECHNOLOGY	3	0	0	3

Course Objectives

- Understand the basic concepts, history, and types of drones (UAVs).
- Learn the key components and working systems of drones.
- Gain knowledge of drone control systems, software, and communication technologies.
- Develop practical skills in drone operation, safety procedures, and regulations.
- Explore real-world applications of drones and perform basic hands-on projects.

Course Outcomes (COs)

- Explain the fundamentals of drones, including types, applications, and principles of flight (lift, thrust, drag, and weight).
- Describe the components and systems of a drone, including frame, motors, ESC, sensors, and power systems.
- Understand and analyze drone control mechanisms, communication systems, and basic autopilot software.
- Demonstrate safe drone operation practices and interpret relevant regulations and ethical considerations.
- Apply drone technology in practical scenarios such as aerial photography, mapping, or agriculture through a mini project.

Unit 1

Introduction & Fundamentals: Introduction to drone (UAV), History and evolution of drones, Types of drones -multirotor, fixed-wing, hybrid, Basic applications-agriculture, surveillance, delivery, photography, Principles of flight (lift, thrust, drag, weight)

Contemporary Issues

- AI-enabled autonomous drones for smart applications.
- Battery limitations affecting drone endurance and range.

Learning Outcomes

- Explain the history, evolution, types, and applications of drones (UAVs)(L2)

Unit 2

Drone Components & Systems

Drone structure/frame, Motors and propellers, Electronic Speed Controller (ESC), Flight controller, Batteries and power systems, Sensors (GPS, gyroscope, accelerometer)

Contemporary Issues

- Development of lightweight, high-energy-density batteries.
- Advanced sensor integration for precise navigation and obstacle avoidance.

Learning Outcomes

- Identify the functions of major drone components such as motors, ESCs, flight controllers, and sensors.(L1)
- Analyze the role of power systems and sensors in drone performance and stability.(L4)

Unit 3

Control, Software & Communication

Basics of flight control systems, Remote controllers and transmitters, Communication systems (radio signals, GPS), Introduction to autopilot systems, Mobile apps and ground control stations

Contemporary Issues

- Secure drone communication against cyberattacks and signal spoofing.
- AI-based autonomous navigation and intelligent flight planning.

Learning Outcomes

- Explain flight control systems, communication methods, and autopilot concepts.(L2)
- Demonstrate the use of remote controllers, mobile applications, and ground control stations.(L3)

Unit 4

Drone Operation, Safety & Regulations

Pre-flight checks and calibration, Basic flying skills (takeoff, landing, hovering), Manual vs autonomous flight, Safety procedures and risk management, Drone laws and regulations (DGCA or relevant authority), Ethical and privacy considerations

Contemporary Issues

- Regulatory challenges in integrating drones into urban airspace.
- Privacy and ethical concerns in drone surveillance applications.

Learning Outcomes

- Apply safe operating procedures for drone flights including pre-flight checks and risk management.(L3)
- Evaluate legal, ethical, and regulatory aspects governing drone operations.(L5)

Unit 5

Applications & Practical Project

Applications: Agriculture (crop monitoring, spraying), Mapping and surveying, Photography & videography, Disaster management

Hands-on: Basic drone assembly or kit, Simulation or real flight practice

Mini project: Example: aerial survey / photography task

Contemporary Issues

- AI and IoT-enabled drones for precision agriculture and smart cities.
- Drone swarm technologies for disaster response and monitoring.

Learning Outcomes

- Apply drone technology to agriculture, mapping, surveying, photography, and disaster management applications.(L3)
- Develop and execute a basic drone-based project for data collection and analysis.(L6)

Text books

- Fahlstrom, P. G., Gleason, T. J., and Sadraey, M. H., *Introduction to UAV Systems*, **5th Edition**, Wiley, 2022.
- Beard, R. W., and McLain, T. W., *Small Unmanned Aircraft: Theory and Practice*, **1st Edition**, Princeton University Press, 2012.
- McGriffy, D., *Make: Drones – Teach an Arduino to Fly*, **1st Edition**, Maker Media, 2016.
- Kumar, P., *Quadcopter and Drone Mechanics*, **1st Edition**, 2018.

Reference Books

- **Reg Austin**, *Unmanned Aircraft Systems: UAVs Design, Development and Deployment*, **1st Edition**, **John Wiley & Sons Ltd., 2010**.
- **Ian Cinnamon, Romi Kadri, and Fitz Tepper**, *DIY Drones for the Evil Genius: Design, Build, and Customize Your Own Drones*, **1st Edition**, **McGraw-Hill Education, 2016**.

Subject Code	Subject Name	L	T	P	C
R23ECE-PE4101.4	AI for Signal Processing	3	0	0	3

Course Objectives

- To provide understanding of preprocessing techniques for real-world signals such as audio, speech, and biomedical signals.
- To enable students to extract and represent meaningful features from signal data.
- To apply machine learning techniques for classification and clustering of signal patterns.
- To introduce dimensionality reduction techniques such as SVD and PCA and apply decision-based models for efficient signal representation and classification.
- To develop knowledge of deep learning models for signal classification, denoising, and sequence modeling.

Course Outcomes

- Apply signal preprocessing techniques to analyze and prepare audio, speech, and biomedical signals.
- Extract and represent meaningful features from signal data using time-domain, frequency-domain, and cepstral methods.
- Apply machine learning techniques to classify and cluster signal data and evaluate model performance.
- Analyze high-dimensional signal data using dimensionality reduction techniques and decision-based models for classification.
- Apply deep learning models for classification, denoising, and sequence modeling of signal data.

UNIT–1

Fundamentals of Signals and Preprocessing:

Types of signals: Audio, speech, biomedical (EEG, ECG), Noise in signals and sources of noise, Signal preprocessing techniques: Normalization, Noise removal (basic filtering concepts), Smoothing and filtering (moving average, low-pass filter), Introduction to time-frequency representation.

Learning Outcomes:

- Explain the characteristics of audio, speech, and biomedical signals and identify various noise sources affecting signal quality. (L2)
- Apply normalization, filtering, smoothing, and time-frequency representation techniques for signal preprocessing.(L3)

Contemporary Issues:

1. AI-based adaptive noise suppression in real-time communication systems.
2. Wearable sensor signal enhancement for healthcare monitoring.

UNIT–2

Feature Extraction from Signals:

Time-domain features: Mean, variance, RMS energy, Zero Crossing Rate (ZCR), Frequency-domain analysis using Fourier Transform, Cepstral features: Mel-Frequency Cepstral Coefficients (MFCC), Statistical feature representation, Feature vector formation, Feature scaling and normalization.

Learning Outcomes:

- Compute time-domain and frequency-domain features from audio, speech, and biomedical signals. (L3)
- Extract MFCC and statistical features and construct normalized feature vectors for machine learning applications.(L3)

Contemporary Issues:

1. Self-supervised feature learning for speech and audio analytics.
2. Robust feature extraction from noisy biomedical signals using deep learning.

UNIT–3

Machine Learning for Signal Classification:

k-Nearest Neighbors (k-NN) algorithm for signal classification of audio, speech, and biomedical signals, Training and testing of models using signal datasets, Performance evaluation metrics: Accuracy, precision, recall, F1-score, Clustering of signal patterns of audio, speech, and biomedical signals using K-means algorithm without labeled data, DBSCAN and hierarchical clustering for pattern discovery.

Learning Outcomes:

- Implement k-NN-based classification models for audio, speech, and biomedical signal datasets.(L3)
- Analyze clustering results using K-means, DBSCAN, and hierarchical clustering for pattern discovery.(L4)

Contemporary Issues:

1. Explainable AI for biomedical signal classification.
2. Federated learning for privacy-preserving signal analytics.

UNIT–4

Dimensionality Reduction and Decision Models:

Need for dimensionality reduction in signal data, Singular Value Decomposition (SVD) and its role in data representation, Principal Component Analysis (PCA) using variance maximization, Relationship between SVD and PCA, Projection of high-dimensional signal data onto lower-dimensional subspace, Reduction of signal feature dimensionality using PCA, Decision-based models: Decision Trees, Rule-based classification, Applications to biomedical signal analysis.

Learning Outcomes:

- Analyze high-dimensional signal data using SVD and PCA techniques for efficient representation. (L4)
- Apply PCA and decision-tree-based models for signal classification and biomedical data analysis.(L3)

Contemporary Issues:

1. Dimensionality reduction for large-scale multimodal healthcare datasets.
2. Interpretable decision models for clinical signal analysis.

UNIT–5

Deep Learning for Signal Processing:

Introduction to deep learning for signal processing, Feedforward neural networks for signal classification, Application of neural networks to audio, speech, and biomedical signals, Autoencoders for signal denoising and feature learning, Recurrent Neural Networks (RNN) for modeling time-series signals, Classification of sequence data such as speech and ECG signals, Model validation techniques: Cross-validation, Overfitting, Regularization.

Learning Outcomes:

- Implement neural network, autoencoder, and RNN models for signal classification and denoising tasks. (L3)

- Evaluate deep learning models using validation techniques and regularization methods for sequence signal analysis.(L5)

Contemporary Issues:

1. Edge AI deployment for real-time ECG, EEG, and speech processing.
2. Transformer-based architectures for speech and biomedical signal understanding.

Textbooks

1. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, 1st Edition, Springer, 2006.
2. Ian Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, 1st Edition, MIT Press, 2016.
3. Ben Gold, Nelson Morgan and Dan Ellis, *Speech and Audio Signal Processing: Processing and Perception of Speech and Music*, 2nd Edition, Wiley, 2011.

References:

1. Christopher M. Bishop, Pattern Recognition and Machine Learning, 2nd Ed., Springer (2011)
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press (2016)
3. B. Gold, N. Morgan, D. Ellis, Speech and Audio Signal Processing, Wiley (2011)
4. Soumya D. Sen et al., Audio Processing and Speech Recognition, Springer (2019)
5. R.C. Gonzalez, R.E. Woods, Digital Image Processing, 3rd Ed., Prentice Hall (2008)
6. L.R. Rabiner & B.-H. Juang, Fundamentals of Speech Recognition, Prentice Hall (1993)

Subject Code	Subject Name	L	T	P	C
R23ECE-PE4101.5	RADAR ENGINEERING	3	0	0	3

Course Objectives:

- To understand the basic principles of radar systems, including radar equation, radar block diagram, receiver noise, system losses, radar frequencies, and range performance analysis.
- To explain the working principles and applications of Continuous Wave (CW) and Frequency Modulated CW (FM-CW) radars, including Doppler effect, range and velocity measurement techniques.
- To analyze the operation of MTI and Pulse Doppler radar systems, including delay line cancellers, blind speeds, staggered PRFs, and performance limitations.
- To study radar tracking techniques and signal detection in noise, including monopulse tracking, matched filter receivers, detection criteria, and CFAR receivers.
- To understand phased array antenna systems and radar-based navigational aids**,** including beam steering, radiation patterns, and systems such as VOR, ILS, and LORAN.

Course Outcomes

- Understand the basic principles of radar systems and analyze radar performance using radar range equation, receiver noise, system losses, and radar displays.
- Explain the operation of CW and FM-CW radar systems and analyze Doppler effect, range measurement, and velocity measurement techniques.
- Analyze the working of MTI and Pulse Doppler radar systems, including delay line cancellers, blind speeds, staggered PRFs, and system limitations.
- Evaluate tracking radar techniques and radar signal detection in noise, including monopulse tracking, matched filter receivers, and CFAR detection methods.
- Understand the principles of phased array antennas and radar navigational aids such as Direction Finder, VOR, ILS, and LORAN.

UNIT I

Basics of Radar: Introduction, Maximum Unambiguous Range, Simple form of Radar Equation, Radar Block Diagram and Operation, Radar Frequencies and Applications, Prediction of Range Performance, Minimum Detectable Signal, Receiver Noise, Modified Radar Range Equation, Illustrative Problems. Radar Equation: SNR, Envelope Detector, False Alarm Time and Probability, Integration of Radar Pulses, Radar Cross Section of Targets (simple targets -sphere, conesphere), Transmitter Power, PRF and Range Ambiguities, System Losses (qualitative treatment), Displays – types, Illustrative Problems.

Learning Outcomes:

- Explain radar fundamentals, radar equations, receiver characteristics, and range performance parameters.(L2)
- Apply radar range equations and SNR concepts to determine target detection capability and system(L3) performance.

Contemporary Issues:

1AI-assisted radar signal processing for enhanced target detection in cluttered environments.

2 Low Probability of Intercept (LPI) radar systems for modern defense applications.

UNIT II

CW and Frequency Modulated Radar: Doppler Effect, CW Radar – Block Diagram, Isolation between Transmitter and Receiver, Non-zero IF Receiver, Receiver Bandwidth Requirements, Applications of CW radar, Illustrative Problems.FM-CW Radar, Range and Doppler Measurement, Block Diagram and Characteristics (Approaching/ Receding Targets), FM-CW altimeter, Multiple Frequency CW Radar.

Learning Outcomes:

- Describe the principles of CW, Doppler, and FM-CW radar systems and their operational characteristics.(L2)
- Analyze range and velocity measurements using CW and FM-CW radar techniques.(L3)

Contemporary Issue:

- Automotive FMCW radar for autonomous and advanced driver-assistance systems (ADAS).
- Millimeter-wave radar sensors for smart mobility and industrial automation.

UNIT III

MTI and Pulse Doppler Radar: Introduction, Principle, MTI Radar with - Power Amplifier Transmitter and Power Oscillator Transmitter, Delay Line Cancellers – Filter Characteristics, Blind Speeds, Double Cancellation, And Staggered PRFs. Range Gated Doppler Filters, MTI Radar Parameters, Limitations to MTI Performance, MTI versus Pulse Doppler radar.

Learning Outcomes:

- Explain MTI and Pulse Doppler radar principles, blind speeds, and delay line canceller characteristics.(L2)
- Analyze clutter suppression and moving target detection using MTI and Pulse Doppler radar techniques.(L4)

Contemporary Issue:

- Cognitive radar for adaptive clutter mitigation and target tracking.
- Integration of Pulse Doppler radar with unmanned aerial vehicle (UAV) surveillance systems.

UNIT IV

Tracking Radar: Tracking with Radar, Sequential Lobing, Conical Scan, Mono pulse Tracking Radar – Amplitude Comparison Mono pulse (one- and two-coordinates), Phase Comparison Mono pulse, Tracking in Range, Acquisition and Scanning Patterns, Comparison of Trackers. Detection of Radar Signals in Noise: Introduction, Noise Figure and Noise Temperature, Matched Filter Receiver – Response Characteristics and Derivation, Correlation detection, Detection criteria, Detector Characteristics, Automatic Detection, Constant False Alarm Rate Receiver.

Learning Outcomes:

- Apply tracking radar techniques such as sequential lobing, conical scan, and monopulse tracking for target localization.(L3)
- Analyze radar signal detection performance in noise using matched filters and CFAR receivers.(L4)

Contemporary Issue:

- AI-enabled multi-target tracking in dense airspace environments.
- Advanced CFAR algorithms for radar operation in complex electromagnetic environments.

UNIT V

Phased Array Antennas and Navigational Aids: Introduction to Phased Array Antennas- Basic Concepts, Electronically Steered Phased Array Antennas, Phase Shifters, Frequency – scan Arrays, Radiation for Phased Array, Architecture for Phased Arrays. Radiation Pattern. Beam Steering and Beam Width changes. Navigational Aids: Direction Finder, VOR, ILS and Loran

Learning Outcomes:

- Explain phased array antenna architectures, beam steering mechanisms, and navigational aid systems. (L2)
- Apply phased array concepts to analyze radiation patterns, beam steering, and navigation system performance. (L3)

Contemporary Issue

- Active Electronically Scanned Array (AESA) radar for next-generation defense and aerospace systems.
- Integration of phased array antennas with 5G/6G communication and satellite navigation systems.

Textbooks:

1. Merrill I. Skolnik, "Introduction to Radar Systems", 2nd Edition, TMH Special Indian Edition, 2012.
2. Byron Edde, "Radar Principals, Technology, Applications", Pearson Education, 2000.
3. Hai Deng and Zhe Geng**,** "Radar Networks", 1st Edition, CRC Press, Taylor & Francis Group, Boca Raton, 2021.
4. Francesco Fioranelli, Hugh Griffiths, Matthew Ritchie and Alessio Balleri, "Micro-Doppler Radar and Its Applications", Institution of Engineering and Technology (IET), London, 2020

References:

1. F.E. Terman, Radio Engineering, Mc Graw Hill Book Co. (for Chapter 7 only), Fourth Edition 2000
2. Simon Kingsley & Shaun Quegan, Understanding RADAR Systems, McGraw Hill Book Co., 2010
3. David K. Barton and Sergey A. Leonov**,** "Modern Radar Systems", 2nd Edition, Artech House, Norwood, Massachusetts, 2021.
4. Bassem R. Mahafza, "Radar Systems Analysis and Design Using MATLAB", 4th Edition, Chapman and Hall/CRC Press, Taylor & Francis Group, Boca Raton, 2022.

Subject Code	Subject Name	L	T	P	C
R23ECE-PE4102.1	Introduction to Quantum Communications	3	0	0	3

Course Objectives

1. Understand the principles of quantum communication systems.
2. Study quantum states, qubits and quantum measurement.
3. Learn quantum cryptography and quantum key distribution protocols.
4. Analyze quantum channels and quantum communication networks.
5. Explore practical implementations of quantum communication systems.

Course Outcomes

1. Explain the principles of quantum communication systems.
2. Describe quantum states, qubits and measurement processes.
3. Analyze quantum communication protocols.
4. Evaluate quantum channel behavior and noise effects.
5. Design basic quantum communication systems.

UNIT I

Fundamentals of Quantum Information

Quantum states, Qubits and quantum superposition, Dirac notation, Quantum measurement, Bloch sphere representation of qubits, Composite quantum systems, Tensor products, Quantum entanglement.

Contemporary Issue

- Scalable fault-tolerant quantum computing using advanced qubit error correction and noise mitigation techniques.
- Development of quantum internet technologies for secure communication through entanglement and quantum key distribution (QKD).

Learning Outcomes

1. Explain the representation of quantum states and qubits.
2. Analyze quantum measurement and entanglement.

UNIT II

Quantum Gates and Quantum Circuits

Single qubit gates, Pauli gates, Hadamard gate, Phase gate, Controlled quantum gates, CNOT gate, Quantum circuit representation, Universal quantum gate sets, Quantum circuit implementation.

Contemporary Issue:

- Optimization of quantum gate fidelity and error-resilient quantum circuit design for noisy intermediate-scale quantum (NISQ) devices.
- Development of scalable quantum processors using universal gate sets for practical quantum computing applications.

Learning Outcomes

1. Analyze the operation of quantum gates and circuits.
2. Design simple quantum circuits for information processing.

UNIT III

Quantum Communication Protocols

Quantum teleportation, Super dense coding, Quantum key distribution concepts, BB84 protocol, E91 protocol, Security of quantum communication protocols, Entanglement based communication systems.

Contemporary Issue:

- Development of long-distance quantum communication networks using quantum repeaters and entanglement distribution techniques.
- Implementation of satellite-based Quantum Key Distribution (QKD) for globally secure communication systems.

Learning Outcomes

1. Explain major quantum communication protocols.
2. Evaluate security mechanisms in quantum key distribution.

UNIT IV

Quantum Channels and Noise

Quantum channel models, Density matrices, Mixed quantum states, Decoherence in quantum systems, Quantum noise models, Quantum error correction concepts, Quantum repeaters.

Contemporary Issue:

- Mitigation of decoherence and quantum noise to improve the reliability of large-scale quantum computing systems.
- Development of advanced quantum error correction and quantum repeater technologies for scalable quantum networks.

Learning Outcomes

1. Analyze the effects of noise and decoherence in quantum channels.
2. Apply error correction techniques in quantum communication systems.

UNIT V

Practical Quantum Communication Systems

Quantum communication using optical fibers, Free space quantum communication, Satellite based quantum communication, Quantum network architecture, Quantum internet concepts, Experimental quantum communication systems.

Contemporary Issue:

- Deployment of satellite-based quantum communication networks for global-scale secure information exchange.
- Development of quantum internet architectures integrating fiber-optic, free-space, and quantum repeater technologies.

Learning Outcomes

1. Analyze practical quantum communication implementations.
2. Design basic quantum communication network architectures.

Textbooks

- Michael A. Nielsen and Isaac L. Chuang, *Quantum Computation and Quantum Information*, 10th Anniversary Edition, Cambridge University Press, 2010.
- Mark M. Wilde, *Quantum Information Theory*, 2nd Edition, Cambridge University Press, 2017.

Reference Books

- Michael A. Nielsen & Isaac L. Chuang — *Quantum Computation and Quantum Information*, Cambridge University Press.
- Mark M. Wilde — *Quantum Information Theory*, Cambridge University Press.
- Rodney Van Meter — *Quantum Networking*, Wiley.

S.No	Course code	Subject	L	T	P	C
1	R23ECE-PE4102.2	Design Verification and Test of VLSI Circuits	3	0	0	3

Course Objectives

1. To introduce the importance of testing and verification in the VLSI design process.
2. To provide knowledge of fault models and automatic test pattern generation techniques.
3. To explain the concepts of Design for Testability (DFT) and scan-based testing methods.
4. To familiarize students with Built-In Self-Test (BIST) and memory testing techniques.
5. To understand verification methodologies used for validating VLSI systems.

Course Outcomes

- List the basic concepts of VLSI testing, verification, and fault modeling.
- Identify different fault models and ATPG techniques used in digital circuits.
- Explain the concepts of Design for Testability (DFT) and scan design techniques.
- Explain the principles of Built-In Self-Test (BIST) and memory testing methods.
- Explain the basic simulation and formal verification techniques used in VLSI systems.

UNIT–I

Introduction to Testing and Verification: Scope of testing and verification in VLSI design process, pre-silicon and post-silicon validation, Issues in testing complex chips, embedded cores and System-on-Chip (SoC) designs, Fundamentals of VLSI testing, structural and functional testing, basic fault modeling concepts.

Learning Outcomes

- Explain the role of testing and verification in the VLSI design flow, including pre-silicon and post-silicon validation.(L2)
- Apply structural and functional testing concepts to identify faults in VLSI and SoC designs.(L3)

Contemporary Issue

- AI-driven post-silicon validation for complex heterogeneous SoC architectures.
- Testing challenges in advanced-node chips with 3D IC and chiplet-based integration.

UNIT–II

Fault Modelling and Automatic Test Pattern Generation: Fault models: stuck-at, bridging, open, transition, delay and IDDQ faults, fault simulation techniques. Automatic Test Pattern Generation (ATPG), D-Algorithm, PODEM, ATPG for combinational and sequential circuits, Fault coverage evaluation and test pattern compaction.

Learning Outcomes

- Apply fault models and simulation techniques for detecting defects in combinational and sequential circuits.(L3)

- Analyze ATPG algorithms and evaluate fault coverage and test pattern efficiency.(L4)

Contemporary Issue

- Machine learning-assisted ATPG for reducing test generation time and improving fault coverage.
- Detection of reliability and aging-induced faults in nanoscale VLSI circuits.

UNIT–III

Design for Testability and Scan Design Design for Testability (DFT) concepts, controllability and observability measures, Scan design techniques: full scan, partial scan and scan chain architecture, Boundary scan and test interface based on IEEE 1149.1; SoC testing approaches.

Learning Outcomes

- Explain DFT concepts, controllability, observability, and scan-based testing methodologies.(L2)
- Implement scan-chain and boundary-scan techniques for efficient testing of VLSI and SoC designs.(L3)

Contemporary Issue

- Secure scan architectures to prevent hardware attacks and intellectual property theft.
- DFT optimization for heterogeneous multi-core and chiplet-based systems.

UNIT–IV

Built-In Self-Test and Memory Testing: Built-In Self-Test (BIST) for logic circuits, LFSR, MISR and signature analysis, Memory fault models, March tests, Memory BIST (MBIST), delay fault testing, Test automation, fault coverage analysis and test data compression.

Learning Outcomes

- Apply BIST and MBIST techniques for automated testing of logic and memory circuits.(L3)
- Analyze memory fault models, March tests, and test compression techniques for fault diagnosis.(L4)

Contemporary Issue :

- AI-assisted memory fault diagnosis in high-density semiconductor memories.
- BIST solutions for emerging memories such as MRAM, ReRAM, and 3D NAND devices.

UNIT–V

Design Verification Techniques: Simulation-based verification; functional verification; timing verification using static timing analysis. Formal verification techniques: equivalence checking and model checking. Hardware emulation and advanced verification methodologies for large VLSI systems.

Learning Outcomes

Apply simulation-based, timing, and functional verification techniques for VLSI system validation.(L3)

Analyze formal verification methods, hardware emulation, and advanced verification methodologies.(L4)

Contemporary Issues:

- AI-powered verification and bug prediction for large-scale semiconductor designs.
- Verification challenges in hardware accelerators for AI and machine learning applications.

Text Books

- **Naveed A. Sherwani**, *Algorithms for VLSI Physical Design Automation*, **3rd Edition**, **Kluwer Academic Publishers**, **1999**.

Reference Books

- Andrew B. Kahng, Jens Lienig, Igor L. Markov and Jin Hu, *VLSI Physical Design: From Graph Partitioning to Timing Closure*, **1st Edition**, Springer, **2011**.
- Khosrow Golshan, *Physical Design Essentials: An ASIC Design Implementation Perspective*, **1st Edition**, Springer, **2007**.
- Neil H. E. Weste and David Harris, *CMOS VLSI Design: A Circuits and Systems Perspective*, **4th Edition**, Pearson, **2011**.

S.No	Course code	Subject	L	T	P	C
1	R23ECE-4102.3	Digital Twin and IoT	3	0	0	3

Course Objectives

1. Understand Digital Twin architecture and lifecycle.
2. Study IoT-based interfacing for Digital Twin systems.
3. Learn modeling and synchronization between physical and virtual systems.
4. Implement real-time Digital Twin monitoring systems.
5. Explore industrial Digital Twin applications.

Course Outcomes

- Explain Digital Twin architecture and lifecycle.
- Interface IoT devices with Digital Twin platforms.
- Develop Digital Twin models for physical systems.
- Implement real-time monitoring and analytics.
- Design Digital Twin applications for engineering systems.

UNIT I

Digital Twin Concepts and Architecture

Concept and definition of Digital Twin, Evolution of Digital Twin technology, Role of IoT in Digital Twin systems, Digital Twin architecture, Components of Digital Twin, Physical entity, Virtual entity, Data connection, Service layer, Digital Twin lifecycle, Designing Digital Twin architecture for engineering systems.

Contemporary Issues:

- Integration of AI-driven Digital Twins for real-time predictive maintenance and autonomous decision-making in smart industries.
- Cybersecurity and data privacy challenges in IoT-enabled Digital Twin ecosystems for critical infrastructure and manufacturing systems.

Learning Outcomes

1. Explain the concept, architecture and lifecycle of Digital Twin systems.
2. Design a conceptual Digital Twin architecture for engineering systems.

UNIT II

IoT Interfacing for Digital Twin Systems

Physical system integration with Digital Twin, Interfacing IoT sensors with Digital Twin platforms, Data acquisition from IoT devices, Device-to-cloud communication for Digital Twin systems, Real-time data streaming for Digital Twin, Synchronization between IoT devices and Digital Twin models, Digital Twin data pipeline architecture, Implementation workflow for IoT-enabled Digital Twin systems.

Contemporary Issues:

- Edge AI-enabled Digital Twin systems for real-time monitoring and predictive analytics using IoT sensor networks.
- Interoperability and cybersecurity challenges in large-scale IoT-to-cloud Digital Twin deployments across smart industries.

Learning Outcomes

1. Interface IoT devices and sensors with Digital Twin platforms.
2. Implement real-time data communication between physical systems and Digital Twins.

UNIT III

Digital Twin Modeling and Simulation: Digital Twin modeling concepts, Physical system modeling for Digital Twin, Data-driven Digital Twin models, Hybrid Digital Twin modeling approaches, Simulation of Digital Twin systems, Model validation using IoT sensor data, Dynamic updating of Digital Twin models, Digital Twin simulation tools and visualization.

Contemporary Issues:

- AI-driven hybrid Digital Twin models combining physics-based simulations and machine learning for real-time system optimization.
- High-fidelity Digital Twin simulation and visualization for smart manufacturing, autonomous systems, and Industry 4.0 applications.

Learning Outcomes

1. Develop simulation models representing physical systems using Digital Twin concepts.
2. Validate and update Digital Twin models using real-time sensor data.

UNIT IV

Digital Twin Implementation Framework: Digital Twin implementation architecture, Data acquisition and processing for Digital Twin, Cloud platforms for Digital Twin deployment, Edge computing in Digital Twin systems, Real-time synchronization of physical and virtual systems, Monitoring and control using Digital Twin models, Optimization of system performance using Digital Twin.

Contemporary Issues:

- Integration of edge-cloud Digital Twin frameworks for low-latency monitoring and autonomous control of industrial systems.
- Scalable real-time Digital Twin deployment using AI-driven analytics and distributed computing architectures for smart infrastructure.

Learning Outcomes

1. Implement Digital Twin systems using cloud and edge computing frameworks.
2. Apply Digital Twin architecture for system monitoring and optimization.

UNIT V

Applications of Digital Twin Systems

Digital Twin in smart manufacturing systems, Digital Twin for production monitoring and optimization, Digital Twin for predictive maintenance, Digital Twin in energy systems and smart grids, Digital Twin in healthcare monitoring systems, Digital Twin in smart agriculture and smart cities, Future trends and research directions in Digital Twin technology.

Contemporary Issues:

- Generative AI-enabled Digital Twins for autonomous optimization and decision-making in smart manufacturing, healthcare, and energy systems.
- Development of sustainable and scalable Digital Twin ecosystems for smart cities, Industry 5.0, and climate-resilient infrastructure management.

Learning Outcomes

1. Analyze the role of Digital Twin technology in industrial applications.
2. Design Digital Twin solutions for real-world engineering systems.

Text Books

- Fei Tao and Qi Qi, *Digital Twin Driven Smart Manufacturing*, **1st Edition**, Academic Press (Elsevier), **2019**.
- Fei Tao and Ang Liu, *Digital Twin in Industry: Smart Manufacturing and Industry 4.0 Applications*, **1st Edition**, Springer, **2020**.

References

- Michael Grieves, *Digital Twin: Manufacturing Excellence through Virtual Factory Replication*, **1st Edition**, **2014**.
- John Vickers and Michael Grieves, *Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems*, **1st Edition**, Springer, **2017**.

S.No	Course code	Subject	L	T	P	C
1	R23ECE-4102.4	Speech Processing	3	0	0	3

Course Objectives

1. Understand the fundamentals of speech production and perception.
2. Learn techniques for speech signal analysis and feature extraction.
3. Study speech coding and compression methods.
4. Analyze speech recognition and synthesis techniques.
5. Explore modern applications of speech processing.

Course Outcomes

- Explain speech production and perception mechanisms.
- Apply signal processing techniques for speech analysis.
- Develop feature extraction methods for speech signals.
- Analyze speech recognition and synthesis systems.
- Design basic speech processing applications.

UNIT I

Speech Production and Perception: Speech production mechanism, Human vocal tract model, Voiced and unvoiced sounds, Phonetics and phonology, Speech perception, Auditory system, Characteristics of speech signals, Time-domain representation of speech.

Learning Outcomes

1. Explain the human speech production mechanism.
2. Analyze the characteristics of speech signals.

Contemporary Issues:

- Advances in AI-generated speech and methods for detecting synthetic voices.
- Application of deep neural networks to mimic human auditory perception.

UNIT II

Speech Signal Analysis: Speech signal preprocessing, Framing and windowing, Short-time energy and zero-crossing rate, Autocorrelation function, Pitch detection methods, Linear predictive analysis, Spectral analysis of speech signals.

Learning Outcomes

1. Apply preprocessing techniques to speech signals.
2. Analyze speech signals using time and frequency domain methods.

Contemporary Issues:

- AI-based noise reduction for robust speech communication.
- Integration of speech with facial and lip movement information for improved analysis.

UNIT III

Feature Extraction Techniques: Cepstral analysis, Mel-frequency cepstral coefficients (MFCC), Linear predictive cepstral coefficients (LPCC), Formant analysis, Feature normalization techniques, Feature selection methods, Spectrogram analysis.

Learning Outcomes

1. Extract meaningful features from speech signals.
2. Evaluate different feature extraction techniques.

Contemporary Issues:

- **Self-Supervised Speech Feature Learning** – Learning speech representations without labeled data using transformer models.
- **Emotion-Aware Speech Feature Extraction** – Advanced features for speech emotion recognition and affective computing.

UNIT IV

Speech Coding and Compression: Speech coding fundamentals, Waveform coding techniques, Predictive coding, Linear predictive coding (LPC), Code excited linear prediction (CELP), Quantization methods, Speech compression standards.

Learning Outcomes

1. Analyze speech coding techniques for efficient transmission.
2. Implement basic speech compression methods.

Contemporary Issues:

- Deep learning techniques achieving ultra-low bitrate speech compression.
- Efficient coding methods for next-generation wireless communication systems.

UNIT V

Speech Recognition and Synthesis

Automatic speech recognition (ASR) fundamentals, Hidden Markov models (HMM), Acoustic and language models, Speech synthesis techniques, Text-to-speech systems, Deep learning approaches for speech processing, Applications of speech processing.

Learning Outcomes

1. Explain speech recognition and synthesis systems.
2. Design basic speech-based applications.

Contemporary Issues:

- Integration of LLMs with ASR for improved contextual understanding.
- Neural TTS models capable of generating speech in multiple languages with minimal training data.

Textbook

- Speech and Language Processing Daniel Jurafsky, James H. Martin, *Speech and Language Processing*, Pearson, 2009.

Reference Books

1. Lawrence Rabiner, Ronald Schafer, *Digital Processing of Speech Signals*, Prentice Hall, **1978**.
2. Thomas F. Quatieri, *Discrete-Time Speech Signal Processing*, Pearson, **2002**.
3. Ben Gold, Nelson Morgan, Dan Ellis, *Speech and Audio Signal Processing*, Wiley, 2011.

Subject Code	Subject Name	L	T	P	C
R23ECE-PE4102.5	**Advanced Microwave Networks**	3	0	0	3

Course Objectives

1. To understand the theoretical principles underlying microwave devices and networks.
2. To design microwave components such as hybrid junctions, microwave filters, ferrite devices, and single-stage microwave transistor amplifiers.
3. To summarize the basic operating principles of various Microwave solid state devices.
4. To understand the basic knowledge on Radar range equation and various components of Radar.
5. To quantify the various tracking radars, direction finders of microwave systems such as communication networks, radars, and antennas related in this design process.

Course Outcomes

1. Understand the basics of Microwaves, Waveguides, and other Microwave devices (L2).
2. Analyze the performance analysis of various Microwave Components and their measurements (L4).
3. Understand the operating principles of different Microwave Solid State Devices (L2).
4. Identify the performance and functionality of different types radars (L3)
5. Compare the performance analysis of Direction finders (L4).

UNIT-I

Microwave Network Analysis: Impedance and Equivalent Voltages and Currents, Impedance and Admittance Matrices, The Scattering Matrix: Reciprocal Networks and Lossless Networks, A Shift in Reference Planes, Power Waves and Generalized Scattering Parameters, The Transmission (ABCD) Matrix: Relation to Impedance Matrix, Equivalent Circuits for Two-Port Networks, Signal Flow Graphs, Discontinuities and Modal Analysis: Modal Analysis of an H-Plane Step in Rectangular Waveguide, Excitation of Waveguides—Electric and Magnetic Currents, Excitation of Waveguides—Aperture Coupling.

Learning Outcomes

- Analyze microwave networks using S-parameters, impedance/admittance matrices, and ABCD parameters.
- Evaluate waveguide discontinuities, modal behavior, and excitation mechanisms in microwave structures.

Contemporary Issues

- AI-assisted electromagnetic modeling and optimization of complex microwave networks.
- Advanced waveguide and meta surface-based components for 6G and terahertz communication systems.

UNIT-II

Impedance Matching and Tuning: Matching with Lumped Elements (L Networks), Analytic Solutions, Smith Chart Solutions, Single-Stub Tuning, Shunt Stubs, Series Stubs, Double-Stub Tuning, Smith Chart Solution, Analytic Solution, The Quarter-Wave Transformer, The Theory of Small Reflections, Single-Section Transformer 250 Multisection Transformer, Binomial Multisection Matching Transformers, Chebyshev Multisection Matching Transformers, Chebyshev Polynomials, Design of Chebyshev Transformers, Tapered Lines, Exponential Taper, Triangular Taper, Klopfenstein Taper, The Bode–Fano Criterion.

Learning Outcomes

- Design impedance matching networks using Smith charts, stubs, and transformer techniques.
- Analyze broadband matching methods and optimize microwave circuit performance.

Contemporary Issues

- Reconfigurable impedance matching networks for adaptive RF and 6G communication systems.
- Machine learning-based automated microwave matching and tuning techniques.

UNIT-III

Power Dividers and Directional Couplers: Basic Properties of Dividers and Couplers, Three-Port Networks (T-Junctions), Four-Port Networks (Directional Couplers), The T-Junction Power Divider, Lossless Divider, Resistive Divider, The Wilkinson Power Divider, Even-Odd Mode Analysis, Unequal Power Division and N-Way Wilkinson Dividers, Waveguide Directional Couplers, Bethe Hole Coupler 334 Design of Multihole Couplers, The Quadrature (90◦) Hybrid, Even-Odd Mode Analysis, Coupled Line Directional Couplers, Coupled Line Theory 347 Design of Coupled Line Couplers, Design of Multisection Coupled Line Couplers, The Lange Coupler, The 180◦ Hybrid, Even-Odd Mode Analysis of the Ring Hybrid, Even-Odd Mode Analysis of the Tapered Coupled Line Hybrid.

Learning Outcomes

- Analyze the operation and characteristics of microwave power dividers and directional couplers.
- Design Wilkinson dividers, hybrid couplers, and coupled-line microwave components.

Contemporary Issues

- Compact coupler and divider designs for massive MIMO and phased-array antenna systems.
- Integrated microwave passive components using advanced RFIC and MMIC technologies.

UNIT-IV

Microwave Filters: Periodic Structures: Analysis of Infinite Periodic Structures, Terminated Periodic Structures, k-β Diagrams and Wave Velocities, Filter Design by the Image Parameter Method, Image Impedances and Transfer Functions for Two-Port Networks, Constant-k Filter Sections 390 m-Derived, Filter Sections, Composite Filters, Filter Design by the Insertion Loss Method, Characterization by Power Loss Ratio, Maximally Flat Low-Pass Filter Prototype, Equal-Ripple Low-Pass Filter Prototype, Linear Phase Low-Pass Filter Prototypes, Filter Transformations: Impedance and Frequency Scaling Bandpass and Bandstop Transformations.

Learning Outcomes

- Design microwave filters using image parameter and insertion loss methods.
- Analyze filter responses and implement frequency transformation techniques for practical applications.

Contemporary Issues

- Tunable and reconfigurable microwave filters for cognitive radio and 6G networks.

- High-selectivity SIW and metamaterial-based filters for next-generation wireless systems.

UNIT-V

Microwave Resonators: Principles of microwave resonators, loaded, unloaded and external Q, open and shorted TEM lines as resonators, microstrip resonators, dielectric resonators.

Learning Outcomes

- Analyze the operating principles and quality factors (loaded, unloaded, and external Q) of microwave resonators.
- Design and evaluate TEM-line, microstrip, and dielectric resonators for microwave applications.

Contemporary Issues

- High-Q dielectric and superconducting resonators for 6G, quantum communication, and sensing applications.
- Miniaturized and tunable microwave resonators using metamaterials and MEMS technologies.

Textbooks

1. Collin, R.E., "Foundations for Microwave Engineering", 2nd Ed., John Wiley & Sons. 2000
2. Pozar, D.M., "Microwave Engineering", 3rd Ed., John Wiley & Sons. 2004
3. Edwards, T.C. and Steer M.B., "Foundations for Interconnects and Microstrip Design", 3rd Ed., John Wiley & Sons. 2001

Reference Books

1. Ludwig, R. and Bretchko, P., "RF Circuit Design", Pearson Education. 2000
2. Hunter, I., "Theory and Design of Microwave Filters", IEE Press. 2001
3. Misra, D.K., "Radio-frequency and Microwave Communication Circuits", John Wiley & Sons.

Subject Code	Subject Name	L	T	P	C
R23BSH- MC4102	ENTREPRENEURSHIP AND INCUBATION	2	0	0	0

Course Objectives:

- Outline an environment to inculcate entrepreneurial skills.
- Develop innovative products, services,processes and techniques.
- Plan to prepare financial proposals and start-ups.
- Analyse the ideas to collaborate entrepreneur skills in establishment of start-ups.
- Explain the financial resources existing in government and private sectors.

Course outcomes:

- Explain the knowledge of Entrepreneurial behavior and skill development.(L2)
- Choose business ideas that have value in the end-market.(L2)
- Identify the validity of idea and its unique selling proportion.(L3)
- Comprehend opportunity and challenges of-start up (L3)
- Analyze various Government and non-Government financial resources.(L2)

Unit I:

Fundamentals of Entrepreneurship: Entrepreneurship-Concept, Importance, Characteristics – Myths and Traits of Entrepreneurship -Entrepreneurial Ecosystem– Manager Vs Entrepreneur-Social and Ethical Perspectives of Entrepreneurship-Women Entrepreneurship. Application: Case lets: Business cases of young entrepreneurs.

Learning Outcomes:

- Interpret the concepts of entrepreneurship and the characteristics of an entrepreneur.(L2)
- Explain the significance of entrepreneurship in the economic development of a nation.(L2)

Unit II:

Ideation and Evaluation of Business Ideas

Opportunity identification – Ideation process - Sources of business ideas – Role of creativity – Sources of Innovation –Technological Innovation and Entrepreneurship - Product/ Service design–Design Thinking-Entrepreneurs Eco-system-Networking

Caselets: Business cases of OYO.

Activity: Collection of novel business ideas.

Learning Outcomes:

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

- Choose the right business ideas.(L2)
- Evaluate the business idea. (L3)

Unit III

Feasibility Analysis and Business plan

Thrust areas of entrepreneurship- Techno-economic feasibility assessment-Financial feasibility Market feasibility– Legal Feasibility, Environmental analysis and regulations. Preparation of Business plan–Lean Startup Methodologies-Business canvas &Lean canvas.

Activity:

Preparation of business plan(draft)

Analysis on TEDx program Talks

Learning Outcomes:

- Evaluate technical feasibility.(L3)
- Develop Business and Lean canvas. (L2)

Unit IV

Business Incubation and startups
Fundamentalsofbusinessincubation-Servicesofincubators-Start-ups-meaning, significance-startup strategy-Present scenario of startups. Role of startups in Indian economy-MSME- Idea Registration process -Pitching

Activity:
Evaluating newstart-ups in India
Analysis on Shark Tank India program
Learning Outcomes:
- Describe the process of business incubation/incubators(L2)
- Select a suitable incubator and build a feasible business model.(L3)

Unit V

Financial resources: Sources of finance–Bootstrapping-Government Support– M S ME s - Crowd Funding–Venture Capitalists &Angel0Investors - Schemes for women entrepreneurs Activity: Identify different financial sources available for Funding
Learning Outcomes:
- Knowledge about various sources of finance for entrepreneurship. (L2)
- AnalyzetheopportunitiesSeedcapital/Angelfinanciersandunderstandoperation.(L2)

Text Books:
- T.VRao,Donald F.Kuratko, Entrepreneurship, ASouth-AsianPerspective,CengageLearning,2012
- Datsy Davies, IndianStartups,AmazonAsia-PacificHoldingsPrivateLimited,2016

Reference Books:
- P.N.Rath, Sarjue Pandita, Entrepreneurship: Startup India& tandupIndia,LexiconPublishingHouse,2018
- Madhurima Lall, Shikha Sahai, Entrepreneurship, Excel Books(P)Ltd.2008
- RajeevRoy,Entrepreneurship,OxfordHigherEducation.2011
- H.Nandan, Fundamentals of Entrepreneurship, PHI Learning(P)Ltd,2013

Subject Code	Subject Name	L	T	P	C
R23ECE-SC4101	Industrial IoT & Automation	3	0	0	3

COURSE OUTCOMES

1. Know the various IoT sensors and understand the functionality
2. Design and analyze IoT experiments and transfer the data to IoT Clouds.
3. Design the IoT systems for real time applications
4. Understand Drones and Perform Internet of Drones Experiments
5. Apply the real time algorithms for Industrial environment.

LIST OF EXPERIMENTS

1. Controlling actuators through Serial Monitor. Creating different led patterns and controlling them using push button switches. Controlling servo motor with the help of joystick.
2. Calculate the distance to an object with the help of an ultrasonic sensor and display it on an LCD
3. a) Controlling relay state based on ambient light levels using LDR sensor. (b)Basic Burglar alarm security system with the help of PIR sensor and buzzer. (c)Displaying humidity and temperature values on LCD
4. a) Controlling relay state based on input from IR sensors (b)Interfacing stepper motor with R-Pi (c)Advanced burglar alarm security system with the help of PIR sensor, buzzer and keypad. (Alarm gets disabled if correct keypad password is entered) (d)Automated LED light control based on input from PIR (to detect if people are present) and LDR (ambient light level)
5. Upload humidity & temperature data to Thing Speak, periodically logging ambient light level to Thing Speak
6. Controlling LEDs, relay & buzzer using Blynk app
7. Introduction to HTTP. Hosting a basic server from the ESP32 to control various digital based actuators (led, buzzer, relay) from a simple web page
8. Displaying various sensor readings on a simple web page hosted on the ESP32
9. Controlling LEDs/Motors from an Android/Web app, Controlling AC Appliances from an android/web app with the help of relay.
10. Displaying humidity and temperature data on a web-based application.