KUVEMPU UNIVERSITY
Department of Studies & Research in Electronics
SCHOOL OF PHYSICAL SCIENCES
Jnanasahyadri, Shankaraghatta- 577 451

Scheme of M.Sc., Electronics Syllabus (NEW) 2025-26

Preamble

The **Master of Science (M.Sc.) in Electronics** is a dynamic and interdisciplinary postgraduate programme aimed at fostering advanced learning and research in the field of electronics. In response to the rapid technological advancements and growing demand for skilled professionals in electronics, embedded systems, robotics, artificial intelligence, and communication technologies, this curriculum has been carefully structured to provide both theoretical depth and practical expertise.

The programme emphasizes hands-on experience through laboratory courses, industrial internships, project work, and the integration of modern tools such as microcontrollers, IoT platforms, machine learning frameworks, and simulation environments like ROS and MATLAB. The inclusion of soft core electives enables students to tailor their learning to specific interests such as mechatronics, control systems, drone technology, and VLSI design.

Aligned with current academic and industry needs, the M.Sc. Electronics programme equips graduates with the technical proficiency, analytical thinking, and innovative mindset required to thrive in research institutions, technology-driven companies, and entrepreneurial ventures. It also lays a strong foundation for those pursuing doctoral studies and academic careers in electronics and allied disciplines.

Objectives of the M.Sc. Electronics Programme

1. To provide a strong foundation in core areas of electronics including circuit design, microcontrollers, communication systems, and signal processing.
2. To enable students to design and implement real-time embedded and robotic systems.
3. To integrate modern computing technologies such as artificial intelligence, machine learning, IoT, and ROS into electronic applications.
4. To encourage research, critical thinking, and innovation through project-based learning and industrial internships.
5. To prepare students for employment in the electronics, automation, AI, and related industries, or for further academic research.

Programme Outcomes (POs)

Upon successful completion of the M.Sc. Electronics programme, students will be able to:

- **PO1:** Demonstrate in-depth knowledge of electronic systems, including analog/digital design, embedded platforms, and control systems.
- **PO2:** Apply appropriate tools and modern techniques to solve complex engineering problems in signal processing, communication, and automation.
- **PO3:** Design and simulate intelligent systems using AI, machine learning, and IoT frameworks.
- **PO4:** Implement robotic systems using platforms like Arduino, ESP32, and Robot Operating System (ROS).
- **PO5:** Exhibit research aptitude through mini-projects, industrial internships, and dissertation work in contemporary areas of electronics.
- **PO6:** Communicate effectively, work in interdisciplinary teams, and adapt to emerging technological challenges in electronics and allied domains.

I Semester:

SUBJECT CODE	SUBJECT	TH/PR IA	IA	CREDITS	TOTAL
ELH - 1.1	Applied Electronics & Circuit Design	75	25	4	100
ELH - 1.2	ARM and AVR Microcontroller	75	25	4	100
ELH - 1.3	Artificial Intelligence in Robotics	75	25	4	100
ELH - 1.4	Programming in C++ and Python	75	25	4	100
ELP - 1.5	Applied Electronics & Circuit Design Lab	50	-	2	50
ELP - 1.6	ARM and AVR Microcontroller Lab	50	-	2	50
ELP - 1.7	Programming in C++ and Python Lab	50	-	2	50
			TOTAL	**22**	**550**

II Semester:

SUBJECT CODE	SUBJECT	TH/PR IA	IA	CREDITS	TOTAL
ELH - 2.1	Digital Signal Processing	75	25	4	100
ELH - 2.2	Digital Communication	75	25	4	100
ELH - 2.3	Robotic Systems: Design, Control, and Applications	75	25	4	100
ELS – 2.4	**Soft Core Subjects:** ELS –2.4.1 Control Systems ELS –2.4.2 Fundamentals of Mechatronics ELS -2.4.3 Microwave Devices & Antennas	75	25	4	100
ELE - 2.5	Basic Electronics (Ele)	40	10	2	50
ELP - 2.6	Digital Signal Processing Lab	50	-	2	50
ELP - 2.7	Advanced Digital Communication Lab	50	-	2	50
ELP - 2.8	Robotics Programming and Control Lab	50	-	2	50
			TOTAL	**24**	**600**

III Semester:

SUBJECT CODE	SUBJECT	TH/PR IA	IA	CREDITS	TOTAL
ELH - 3.1	Pattern Recognition	75	25	4	100
ELH - 3.2	Robot Modeling and Simulation	75	25	4	100
ELH - 3.3	Image Processing	75	25	4	100
ELS – 3.4	**Soft Core Subjects:** ELS -3.4.1 Embedded Systems and RTOS ELS -3.4.2 Electric Vehicles ELS -3.4.3 Optoelectronics and Optical Fiber Communication	75	25	4	100
ELE - 3.5	Fundamentals of Digital Electronics (Ele)	40	10	2	50
ELP - 3.6	Pattern Recognition Lab	50	-	2	50
ELP - 3.7	Robot Modeling and Simulation Lab	50	-	2	50
ELP - 3.8	Image Processing Lab	50	-	2	50
ELR - 3.9	Industrial Internship	50	-	2	50
			TOTAL	**26**	**650**

IV Semester:

SUBJECT CODE	SUBJECT	TH/PR IA	IA	CREDITS	TOTAL
ELH - 4.1	Machine Learning	75	25	4	100
ELH - 4.2	Internet of Things (IoT)	75	25	4	100
ELH - 4.3	Robot Operating System (ROS)	75	25	4	100
ELS – 4.4	**Soft Core Subjects:** ELS – 4.4.1 Information theory & coding (ITC) ELS – 4.4.2 Fundamentals of Drone technology ELS – 4.4.3 CMOS and Low Power VLSI Design	75	25	4	100
ELP - 4.5	Machine Learning Lab	50	-	2	50
ELP - 4.6	IoT and ROS Lab	50	-	2	50
ELP - 4.7	Project Work	75		4	100
			TOTAL	**24**	**600**

TOTAL MARKS AND CREDITS:

SL.NO	SEMESTER	CREDITS	MARKS
1	FIRST	22	550
2	SECOND	24	600
3	THIRD	26	650
4	FOURTH	24	600
GRAND TOTAL		96	2400

Course Title: APPLIED ELECTRONICS & CIRCUIT DESIGN

Course Code: ELH 1.1

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the fundamentals of electronic components, power systems, and signal behavior used in embedded systems, robotics, and IoT applications.
2. Learn how to interface a variety of sensors and actuators with suitable driver circuits for intelligent systems.
3. Acquire practical skills in designing, prototyping, and testing electronic circuits for robotics, automation, and IoT sub-systems
4. Develop hands-on expertise in circuit simulation, PCB layout, and real-world hardware troubleshooting relevant to robotics and IoT projects.

Course Outcomes (COs):

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

CO1: Identify and explain the roles of fundamental electronic components, power systems, and their relevance in circuits used for Robotics and IoT.

CO2: Design and implement interfacing circuits for a wide range of sensors and actuators in robotic and IoT-based systems.

CO3: Construct, prototype, and validate electronic sub-systems using breadboards, stripboards, and PCBs for embedded and intelligent devices.

CO4: Use simulation tools and practical techniques to develop and troubleshoot electronics for real-time Robotics and IoT applications.

Contents	60Hrs
Unit I: Electronic Components and Power Systems	**20 Hrs**

Basic Electronic Components: Classification of electronic components, Resistors, capacitors, inductors, Diodes: PN, Zener, Light Emitting Diode (LED), Transistors: BJT, MOSFET (as switch & amplifier).

Power Supply Design: Battery technologies: Li-Ion, Li-Po, NiMH, Lead Acid – selection criteria for IoT/robotic platforms, Voltage regulation: 7805, LM317, buck/boost converters, SMPS basics, Power management: Power distribution, heat dissipation, protection circuits. **Signal Concepts:** Analog vs. Digital signals, current, voltage, resistance, impedance, Filtering and decoupling capacitors, Noise sources and EMI handling in embedded/robotic circuits	
Unit II: Sensors and Actuators – Construction, Working & Interfacing	**20 Hrs**
Sensors – Construction, Operation & Interfacing: Proximity & Distance Sensors: IR sensor (reflective), Ultrasonic sensor (HC-SR04): Echo-pulse principle, Light & Motion Detection: LDR: Light sensitivity and voltage divider principle, PIR sensor: Pyroelectric effect and human motion detection. Environmental Sensors: LM35 (Temperature), DHT11 (Temp + Humidity), MQ gas sensors, Position & Orientation: Hall Effect sensor: Magnetic field detection, Accelerometer (ADXL345): 3-axis motion sensing, Sensor Interfacing: Pull-up/down resistors, signal conditioning, ADC basics, debounce circuits **Actuators – Types, Construction & Drivers:** DC motors: Working, speed control using PWM, Servo motors: Feedback control and pulse width control, Stepper motors: Construction, unipolar/bipolar control, Solenoids and Relays: Solenoids and Relays. **Driver Circuits**: Motor driver ICs: L298N, ULN2003, H-bridge using discrete MOSFETs, Flyback diodes, opto-isolation, and transistor switch interface.	
Unit III: Circuit Design, Prototyping & PCB Development	**20 Hrs**
Prototyping Techniques: Breadboarding, stripboard, soldering techniques, Wiring and grounding best practices. **PCB Design and Simulation:** Schematic design using tools: Fritzing, EasyEDA, KiCad, PCB layout rules: trace width, clearance, ground plane, via usage, ntroduction to multi-layer boards and EMI/EMC design considerations. **Project Design and Debugging:** Design of basic sub-systems: sensor modules, actuator driver modules, Integration and validation of complete embedded/robotic circuits, Fault detection using multimeter, continuity checks, and logic probes, Simulation and testing using software before hardware implementation.	

Reference Books	
1	**Paul Scherz, Simon Monk**, *Practical Electronics for Inventors*, 4th Edition, McGraw Hill Education, 2016.
2	**Thomas L. Floyd**, *Electronic Devices*, 10th Edition, Pearson Education, 2017.
3	**Sedra & Smith**, *Microelectronic Circuits*, 7th Edition, Oxford University Press, 2015.
4	**R. S. Sedha**, *A Textbook of Applied Electronics*, 3rd Edition, S. Chand Publishing, 2008.
5	**Muhammad H. Rashid**, *Power Electronics: Circuits, Devices and Applications*, 4th Edition, Pearson, 2013.
6	**Michael Margolis**, *Arduino Cookbook*, 2nd Edition, O'Reilly Media, 2011.
7	**Ramon Pallas-Areny & John G. Webster**, *Sensors and Signal Conditioning*, 2nd Edition, Wiley, 2000.

Course Title: ARM AND AVR MICROCONTROLLER

Course Code: ELH 1.2

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the architecture and instruction sets of ARM and AVR microcontrollers.
2. Gain hands-on experience in writing and executing programs using Keil and Arduino IDE.
3. Learn peripheral interfacing and embedded system design techniques.
4. Develop real-time embedded applications using ATmega328P and ARM Cortex-based systems.

Course Outcomes (COs):

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

CO1: Demonstrate an understanding of ARM and AVR microcontroller architectures and features.

CO2: Develop and execute assembly and C programs for ARM and AVR microcontrollers using Keil and Arduino IDE.

CO3: Interface sensors, actuators, and peripherals with microcontrollers using digital, analog, and serial communication techniques.

CO4: Design and implement simple embedded systems and real-world applications using ATmega328P and ARM platforms.

Contents	**60Hrs**
UNIT I: ARM Architecture, Programming Model, and Instruction Set	**20 Hrs**

Introduction to Microcontroller: Microcontroller vs. microprocessor, types of microcontrollers, memory types, core features, clocking, I/O pins, interrupts, timers, peripherals.

ARM Architecture and Design Philosophy: ARM Design Philosophy, ARM Processor Families and Their Features, Architecture of ARM Cortex-M Series (with focus on Cortex-M3), AMBA Bus Technology: AHB, ASB and APB Overview.

Programming Model and Processor Fundamentals: ARM Core Data Flow Model, Processor Modes: User, FIQ, IRQ, Supervisor, Abort, Undefined, System, Register Organization: General-Purpose and Special-Purpose Registers, Current Program Status Register (CPSR) and its Role, Memory Organization: Little Endian and Big Endian Concepts, Memory Map of ARM Cortex-M3, Exception Handling and Vector Table. **ARM Instruction Set and Execution:** Data processing instructions, load/store operations, software interrupts, program status register manipulation, constant loading techniques, conditional execution, and ARM instruction set extensions.	
UNIT II:AVR Architecture and Programming.	**20 Hrs**
AVR Architecture and Programming: Overview of AVR microcontroller family and features of ATmega328P; functional block diagram and CPU architecture; general-purpose and special-function registers; memory organization – Flash, SRAM, EEPROM, memory map, and stack operation; I/O port structure and configuration; digital input/output operations. **Timers, PWM, and ADC Modules:** Timer/counter modules – modes of operation, control registers, generation of time delays, and pulse-width modulation (PWM); analog-to-digital converter – ADC channels, resolution, control registers, and programming. **Interrupts and Serial Communication Interfaces:** Interrupt structure – external and internal interrupts, interrupt vector table, and interrupt service routines; USART serial communication – data transmission and reception, baud rate settings, and register-level configuration; introduction to synchronous serial communication – I^2C and SPI protocols, configuration and data transfer mechanisms.	
UNIT III: Interfacing and Embedded System Design	**20 Hrs**
Embedded System Overview: Definition, characteristics, and components of embedded systems, role of microcontrollers in embedded applications, real-time embedded control concepts. **Device Interfacing and Control Techniques:** Digital I/O interfacing – LEDs, switches, buzzers, and relay driver circuits; Keypad and display interfacing – 4x4 matrix keypad scanning, 16x2 LCD interfacing in 4-bit/8-bit modes, display multiplexing, 7-segment display (common cathode/anode); Motor interfacing – DC motor with PWM speed control, H-Bridge for	

bidirectional control, stepper motor logic and sequencing, servo motor pulse-width control; Sensor interfacing – analog and digital sensors (LM35, DHT11, LDR, IR, ultrasonic).

System Integration and Application Prototyping: Real-time control fundamentals; system-level integration of sensors and I/O devices; design and implementation of embedded applications – automated lighting system, smart temperature monitoring, security alarm, ultrasonic-based obstacle detection.

Reference Books	
1	Microprocessors and Microcontrollers by Kani A. Nagoor
2	ARM System Developer's Guide: Designing and Optimizing System Software by Andrew Sloss , Chris Wright , Dominic Symes.
3	Joseph Yiu, "The Definitive Guide to the ARM Cortex-M3", 2nd Edition, Newnes, (Elsevier), 2010.
4	The AVR Microcontroller and Embedded Systems Using Assembly and C By Muhammad Ali Mazidi, SarmadNaimi, &SepehrNaimi - Pearson Education
5	Programming and Interfacing with Arduino: Learning by Doing & quot; by YogeshMisra, AnshulParmar.
6	AVR Programming: Learning to Write Software for Hardware & quot; by Elliot Williams.

Course Title: **ARTIFICIAL INTELLIGENCE IN ROBOTICS**

Course Code: ELH -1.3

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the foundational concepts and techniques of Artificial Intelligence (AI) used in robotics.
2. Learn problem-solving techniques using search algorithms, reasoning, and decision-making.
3. Explore AI approaches for robotic perception, motion planning, and navigation.
4. Apply AI algorithms in robot control, learning, and intelligent behavior modeling.

Course Outcomes (COs):

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

CO1: Describe key concepts and architectures of AI systems used in robotics.

CO2: Apply search and reasoning algorithms for robot decision-making.

CO3: Implement AI techniques in perception, motion planning, and control.

CO4: Design and simulate intelligent robotic behaviors using AI tools and frameworks.

Contents	60Hrs
UNIT I: Introduction to AI and Problem Solving in Robotics	**20 Hrs**

Introduction to Artificial Intelligence: Definition, History, Applications in Robotics,Intelligent Agents, Rationality, Environment Types.

AI in Robotics: Role of AI in modern robots, Sensing, Perception, and Decision-making Loop.

Problem Solving and Search: State-space Representation, Problem Formulation, Uninformed Search: BFS, DFS, Depth-Limited, Iterative Deepening, Informed Search: Best-First, A*, Heuristic Design.

Introduction to Rule-Based Systems: Inference rules and simple expert systems

UNIT II: Knowledge Representation, Planning, and Learning	**20 Hrs**

Knowledge Representation: Propositional and First-Order Logic, Semantic Networks, Frames, Ontologies. **Planning in Robotics:** Planning with STRIPS, Forward and Backward Planning, Goal Stack Planning, Partial Order Planning. **Introduction to Machine Learning for Robotics:** Supervised and Reinforcement Learning Basics, Concept of Reward and Policy in Robot Learning. **Fuzzy Logic in Robotics:** Fuzzy sets, membership functions, Fuzzy rule-based control for obstacle avoidance and path following	
UNIT III: Perception, Motion Planning, and AI Applications in Robotics	**20 Hrs**
Robotic Perception: AI for Sensor Data Interpretation (vision, ultrasonic, LIDAR), Introduction to Object Detection and Image Segmentation. **Path Planning:** Grid-based methods, Potential Fields, Dijkstra's Algorithm**,** Probabilistic Roadmaps (PRM), RRT (Rapidly-Exploring Random Trees) **Localization and Mapping:**Kalman Filter, Particle Filter ,Basics of SLAM (Simultaneous Localization and Mapping) **AI Applications:** Human-Robot Interaction,Speech Recognition for Command Input,Case Study: ROS-based AI control using Python or OpenCV,Ethical Considerations in AI Robotics.	

Reference Books	
1	**Stuart Russell & Peter Norvig**, *Artificial Intelligence: A Modern Approach*, Pearson
2	**Robin R. Murphy**, *Introduction to AI Robotics*, MIT Press
3	**Joseph L. Jones et al.**, *Mobile Robots: Inspiration to Implementation,* A K Peters
4	**Roland Siegwart et al.**, *Introduction to Autonomous Mobile Robots*, MIT Press
5	Selected research papers and online tutorials (e.g., OpenAI Gym, ROS, OpenCV)

Course Title: PROGRAMMING IN C++ AND PYTHON

Course Code: ELH - 1.4

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the fundamentals of object-oriented programming using C++, including data types, control structures, functions, and classes.
2. Learn core data structures and file handling concepts in C++ for structured programming and efficient data organization.
3. Acquire the basics of Python programming, including object-oriented features and exception handling.
4. Gain exposure to Python libraries and tools used for data manipulation, visualization, and building simple AI/ML models.

Course Outcomes (COs):

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

CO1: Apply object-oriented principles in C++ to develop programs involving control structures, functions, and class-based design.

CO2: Implement common data structures such as arrays, stacks, queues, and linked lists, and perform file operations using C++.

CO3: Develop Python programs using control flow, functions, and object-oriented programming for general-purpose applications.

CO4: Use Python libraries such as NumPy, Pandas, Matplotlib, and Scikit-learn to build basic AI and machine learning models.

Contents	60Hrs
UNIT I: Fundamentals of C++ Programming and Control Structures	**20 Hrs**
Introduction: Object oriented programming, characteristics of an object-oriented language.	

C++ programming language: Tokens, keywords, identifier and constants, basic data types, user defined data types, derived data types, arithmetic operators, relational operators, logical operators, assignment operators, increment and decrement operators. **Decision making, branching and looping:** if, if-else, else-if, switch statement, break, continue and go to statement, for loop, while loop and do loop. **Functions:** Function definition, function arguments and passing, returning values from functions, referencing arguments, function overloading, virtual functions, library functions, local, static and global variables.	
UNIT II: Data Structures, OOP, and File Handling in C++	**20 Hrs**
Data Structures: Arrays, pointers, storage classes dynamic memory allocation, introduction to stacks, queues, linked list and trees. **Classes and objects:** Classes and objects, member functions, class constructors and destructors, array of objects, operator overloading. **Class inheritance:** Derived class and base class, multiple inheritance, polymorphism. **Managing Console I/O Operation:** C++ streams, C++ stream classes, unformatted I/O operations, formatted console I/O operations, managing output with manipulators. Working with files: Classes for file stream operations, opening and closing a file, detecting end-of file, file modes, file pointers and their manipulations, updating a file, error handling during file operations, command-line arguments.	
UNIT III: Python Programming for AI and Machine Learning	**20 Hrs**
Python Basics: Introduction to Python programming language, Variables, data types, and operators, Control flow: if-else statements, loops, Functions and modules, File handling in Python. **Advanced Python Programming:** Object-oriented programming (OOP) concepts in Python, Classes and objects, Inheritance and polymorphism, Exception handling, Introduction to Python standard library. **Python for AI and ML:** Introduction to Numbly and pandas for data manipulation, Introduction to matplotlib and seaborne for data visualization, Introduction to scikit-learn for machine learning algorithms, Building simple AI and ML models using Python**.**	

Reference Books	
1	Object- oriented programming with C++: Balagurusamy E, TMH, 2005
2	The Waite group's object oriented programming in Turbo C++: Robert Lafore, Galgotia Publication. Pvt. Ltd, 2005.
3	Automate the Boring Stuff with Python by Al Sweigart
4	Python for Data Analysis by Wes McKinney
5	Python Crash Course by Eric Matthes
6	Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlowby AurélienGéron

Course Title: DIGITAL SIGNAL PROCESSING

Course Code: ELH - 2.1

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Provide a fundamental understanding of discrete-time signals and systems in the frequency domain.
2. Introduce students to DFT, FFT algorithms, and their efficient computations.
3. Equip students with knowledge of digital filter structures and design methodologies.
4. Familiarize students with analog and digital filter design and their implementations.

Course Outcomes (COs):

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

CO1: Analyze and interpret discrete-time signals in the frequency domain using DTFT and DFT.

CO2: Implement and compute the DFT efficiently using FFT algorithms.

CO3: Design and realize analog and digital filters (IIR and FIR) for various signal processing applications.

CO4: Evaluate and compare different filter structures and design methods for DSP systems.

Contents	60Hrs
UNIT 1	**20 Hrs**

Discrete Time Signals In Frequency domain: Discrete Time Fourier Transform (DTFT) **Discrete Fourier transform (DFT):** Introduction, **Definition of DFT:** Linearity, Circular shift of a sequence, Symmetry properties, Circular convolution, Linear convolution using DFT. Computation DFT: Introduction to FFT, Decimation-in-time FFT algorithm and in-place computations, and Decimation-in-frequency FFT algorithm and in-place computations, LTI DTS in Frequency domain, transfer function, frequency response.

UNIT 2	**20 Hrs**

Digital Filters: simple digital filters, All pass functions, complimentary transfer functions, digital two pairs, Sampling and reconstruction. **Analog Filter Design:** The filter problem, maximally flat low-pass filter approximation, Chebyshev Filter approximation, Frequency transformation. Digital Filter Structures: Direct, parallel, cascade, ladder and lattice for IIR, Possible realizations for FIR, including pollyphase, all pass structures, tunable filters.	
UNIT 3	**20 Hrs**
Digital Filter Design: IIR Filter Design: using Impulse invariance and Bi Linear transformations, Spectral transformations, FIR Filter Design using winnowing, frequency sampling and computer aids. Difference between IIR and FIR.	

Reference Books	
1	“Digital Signal Processing”, Rabiner and Gold, Prentice Hall of India Ltd.
2	“Network Analysis and Synthesis”, F.F. Kuo, John Wiley & Sons, 7th Edition
3	“Digital Signal Processing”, Proakis, Prentice Hall of India Ltd.
4	“Digital Signal Processing”, Sanjit. K. Mitra, Tata-McGraw Hill.

Course Title: DIGITAL COMMUNICATION

Course Code: ELS -2.2

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the principles and performance of digital modulation techniques.
2. Learn the fundamentals and decoding of convolutional and turbo codes.
3. Gain knowledge of spread spectrum techniques and their applications in digital communication.
4. Analyze performance metrics such as BER and coding gain in practical systems.
5. To provide an introductory understanding of modern wireless communication technologies, especially 5G and 6G systems and their key enabling technologies.

Course Outcomes (COs):

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

CO1: Explain and evaluate digital modulation schemes including binary and M-ary techniques.

CO2: Apply convolutional and turbo coding techniques for error detection and correction.

CO3: Analyze the performance of coded communication systems using BER and coding gain.

CO4: Describe and compare spread spectrum techniques like DSSS, FHSS, and CDMA.

CO4: Understand the basics of 5G and 6G wireless communication, including key features, architecture, and evolution from legacy systems.

Contents	**60Hrs**
UNIT I: Digital Modulation Techniques	**20 Hrs**

Introduction to Communication Systems: Basics of communication, need for modulation, analog vs digital communication, block diagrams of analog and digital communication systems. **Overview of Digital Communication:** Structure of a digital communication system, roles of source coding, channel coding, modulation, demodulation, noise impact, bandwidth and power efficiency.

Performance Measures of Digital Modulation: E_b/N_0, spectral and bandwidth efficiency, Bit Error Rate (BER), and modulation scheme selection criteria. **Binary Modulation Techniques:** ASK, FSK, PSK, DPSK – modulation and demodulation methods, time-domain waveforms, coherent vs non-coherent detection, BER derivation under AWGN. **M-ary Modulation Techniques:** QPSK, QAM, MFSK – concept, need, modulator and demodulator designs, constellation diagrams, waveform illustrations, bandwidth/power efficiency, BER analysis. **Effect of Inter Symbol Interference (ISI):** Causes and effects of ISI, eye diagrams, mitigation using pulse shaping and matched filtering.	
UNIT II : Coding Techniques	**20 Hrs**
Convolutional Encoding and Structures: Introduction to convolutional codes, shift register implementation, generator polynomials, state diagrams, trellis representation, code rate, constraint length. **Convolutional Decoding Problem Formulation:** Trellis-based decoding, maximum likelihood decoding, metric calculations, Hamming and Euclidean distances. **Properties of Convolutional Codes:** Free distance, error detection/correction capability, catastrophic error propagation, systematic vs non-systematic codes. **Performance Bounds and Coding Gain:** BER bounds, union bound estimation, coding gain concepts, trade-offs in decoding complexity, delay, and performance. **Convolutional Decoding Algorithms:** Viterbi algorithm – hard/soft decision decoding, traceback, path memory; Sequential decoding – Fano and Stack algorithms; feedback decoding techniques. **Turbo Codes:** Parallel concatenated convolutional codes, interleaving, iterative decoding using SISO decoders, near-Shannon limit performance.	
UNIT III:Spread Spectrum and Introduction to 5G Communications	**20 Hrs**
Spread Spectrum Principles and Applications: Need for spreading, jamming/interference resistance, signal security, bandwidth expansion, system modeling. **Direct Sequence Spread Spectrum (DSSS):** PN sequence generation, chip rate, processing gain, spreading with BPSK, correlation and spectrum characteristics.	

Frequency Hopping Spread Spectrum (FHSS): Slow and fast hopping, frequency synthesizers, hop sequence generation, synchronization and error resilience.
Time Hopping Spread Spectrum (THSS): Pulse position modulation, pseudorandom slot allocation, interference reduction, multiple access in time-domain.
Code Division Multiple Access (CDMA): Spreading sequences (Walsh, Gold), multi-user communication, near-far problem, RAKE receiver concept.
Synchronization in SS Systems: Acquisition and tracking, correlator-based synchronization, delay-locked loops, matched filters, multipath and fading effects.
Introduction to 5G Communications: Key 5G features – eMBB, URLLC, mMTC; architecture overview, OFDM waveform design, NOMA schemes, beamforming, mmWave and massive MIMO.
Introduction to 6G Communications: Vision and goals of 6G, integration of AI and machine learning, THz communication, ultra-low latency and ultra-high capacity design principles, challenges and research directions.

Reference Books	
1	**Simon Haykin**, *"Communication Systems"*, Wiley, 4th Edition, 2000.
2	**John G. Proakis**, *"Digital Communications"*, McGraw Hill, 5th Edition, 2008.
3	**Bernard Sklar**, *"Digital Communications: Fundamentals and Applications"*, Pearson Education, 2nd Edition, 2001.
4	**Theodore S. Rappaport**, *"Wireless Communications: Principles and Practice"*, Pearson Education, 2nd Edition, 2010.
5	**Jonathan Rodriguez**, *"Fundamentals of 5G Mobile Networks"*, Wiley, 1st Edition, 2015.
6	**Christopher Cox**, *"An Introduction to 5G"*, Wiley, 1st Edition, 2020.

Course Title: ROBOTIC SYSTEMS: DESIGN, CONTROL, AND APPLICATIONS

Course Code: 2.3

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the mechanical structure, types, and basic anatomy of robotic systems.
2. Analyze and model the kinematics and dynamics of robotic manipulators.
3. Explore control techniques and trajectory planning strategies used in robot motion.
4. Examine real-world robotic applications across industrial, medical, and service domains, including modern trends like collaborative robots and AI integration.

Course Outcomes (COs):

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

CO1: Describe the structural components and configurations of various robotic systems.

CO2: Apply forward and inverse kinematic models to analyze and solve robotic motion problems.

CO3: Design and evaluate robot motion control strategies including PID and trajectory planning.

CO4: Identify and assess practical applications of robotics in different domains and interpret current trends such as SLAM, cobots, and AI-enhanced robots.

Contents	60Hrs
UNIT I: Robot Design and Kinematics	20 Hrs

Introduction to Robotics: Definition, evolution, components, and classification of robots.

Robot Structure: Links, joints, degrees of freedom (DOF), robot configurations – Cartesian, SCARA, articulated, cylindrical, spherical.

Forward Kinematics: Transformation matrices, Denavit-Hartenberg (DH) parameters, examples for 2-DOF and 3-DOF manipulators.

Inverse Kinematics: Analytical solutions for simple manipulators, geometric and algebraic approaches, multiple solutions and redundancy.

Robot Workspace: Joint space vs task space, reachability analysis.

Homogeneous Transformation Matrix: Composition of transformations, rotation and translation.

Robot Anatomy Design Considerations: Payload, accuracy, repeatability, and stiffness (introductory design perspectives).

UNIT II: Dynamics and Control of Robotic Systems	20 Hrs

Introduction to Robot Dynamics: Kinetic and potential energy, Newton-Euler and Lagrangian formulations (conceptual overview).

Equations of Motion: Degrees of freedom and motion constraints (no derivation), torque requirements.

Control Architectures: Open loop vs closed loop control, joint-level and task-space control, centralized and decentralized control strategies.

PID Control: Tuning and application in robotic joint control.

Trajectory Planning: Path vs trajectory, velocity and acceleration profiles, time parameterization (linear, trapezoidal, and cubic interpolation).

Force and Impedance Control (Conceptual): Basic principles, use in interaction with environment, hybrid position/force control.

Singularity and Redundancy: Types of singularities, impact on control, redundancy handling strategies.

UNIT III: Robotic Applications and Future Trends	20 Hrs

Industrial Robotics: Pick-and-place, assembly, painting, welding—task-specific robot selection.

Medical and Service Robotics: Surgical and rehabilitation robots, service robots in logistics, cleaning, and assistance.

Mobile Robotics: Ground and aerial robots – types, structure, basic motion types, and navigation.

Navigation and Mapping Concepts: Basics of SLAM (Simultaneous Localization and Mapping), applications in autonomous robotics.

Collaborative Robots (Cobots): Safety standards, human-robot interaction, real-time responsiveness.

Artificial Intelligence in Robotics: Overview of AI integration for perception and decision-making.

Case Studies: Real-world robotic systems from manufacturing, healthcare, space, military, and consumer applications.

Reference Books	
1	**Saeed B**. Niku, *Introduction to Robotics: Analysis, Control, Applications*, Wiley.
2	**John J**. Craig, *Introduction to Robotics: Mechanics and Control*, Pearson.
3	**Mikell P. Groover**, *Industrial Robotics: Technology, Programming, and Applications*, McGraw-Hill.
4	**K.S. Fu, R.C. Gonzalez, C.S.G. Lee**, *Robotics: Control, Sensing, Vision and Intelligence*, McGraw-Hill.
5	**Richard D. Klafter**, *Robotic Engineering: An Integrated Approach*, Prentice-Hall.
6	**Siegwart, Nourbakhsh, Scaramuzza**, *Introduction to Autonomous Mobile Robots*, MIT Press.

Course Title: CONTROL SYSTEMS

Course Code: ELS –2.4.1

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the modeling of physical systems and derive transfer functions using block diagrams and signal flow graphs.
2. Analyze the time-domain and frequency-domain behavior of linear control systems to evaluate their performance.
3. Apply stability analysis techniques including Routh and Nyquist criteria to assess system stability.
4. Explore digital control systems and state-space modeling approaches for both continuous and discrete systems.
5. Design compensators and controllers (PID, lead, lag, and lead-lag) for desired system behavior.

Course Outcomes (COs):

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

CO1: Develop mathematical models of mechanical and electrical systems and derive their transfer functions using block diagrams and signal flow graphs.

CO2: Analyze the time-domain response of first and second-order systems and compute steady-state errors using error constants.

CO3: Evaluate system stability using Routh-Hurwitz and Nyquist stability criteria and interpret frequency response using Bode and Polar plots.

CO4: Explain the principles of digital control systems, state-space representation, and design suitable compensators and controllers for performance enhancement.

Contents	60Hrs
UNIT I:Modeling of Systems	**20 Hrs**

The control system, Mathematical models of physical systems –Introduction, Differential equations of physical systems – Mechanical systems, Friction, Translational systems (Mechanical accelerometer, Levered systems excluded), Rotational systems, Electrical systems, Analogous systems. Block diagrams and signal flow graphs: Transfer functions, Block diagram algebra, Signal Flow graphs (State variable formulation excluded), Time Response of feedback control systems: Standard test signals, Unit step response of First and second order systems, Time response specifications, Time response specifications of second order systems, steady – state errors and error constants.	
UNIT II: Stability Analysis	**20 Hrs**
Concepts of stability, Necessary conditions for Stability, Routh- stability criterion, Relative stability analysis; More on the Routh stability criterion. Frequency domain analysis and stability: Correlation between time and frequency response, Bode Plots, Experimental determination of transfer function. Introduction to Polar Plots, (Inverse Polar Plots excluded) Mathematical preliminaries, Nyquist Stability criterion, (Systems with transportation lag excluded) Introduction to lead, lag and lead-lag compensating networks.	
UNIT III:Modern Digital Control System	**20 Hrs**
Introduction, Spectrum Analysis of Sampling process, Signal reconstruction, Difference equations. Introduction to State variable analysis: Introduction, Concept of State, State variables & State model, State model for Linear Continuous & Discrete time systems, Diagonalization. Design of Control Systems: Introduction, Design with the PD Controller, Design with the PI Controller, Design with the PID Controller, Design with Phase- Lead Controller, Design with Phase - Lag Controller, Design with Lead-Lag Controller.	

Reference Books	
1	J. Nagarath and M. Gopal, “Control Systems Engineering”, New Age International (P) Limited, Publishers, Fourth edition – 2005
2	A Nagoor Kani “Control Systems”, CBS Publishers & Distributors Pvt Ltd, Fifth Edition.
3	“Modern Control Engineering “, K. Ogata, Pearson Education Asia/ PHI, 4th Edition, 2002.
4	“Control Systems – Principles and Design”, M. Gopal, TMH, 1999

Course Title: FUNDAMENTALS OF MECHATRONICS

Course Code: ELS –2.4.2

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

6. Grasp the integration of mechanical, electronic, and computer systems into intelligent automated products.
7. Model systems using Newtonian mechanics, Lagrangian formalism, and bond graphs.
8. Learn types, selection criteria, and integration techniques of mechanical sensors and electromechanical/pneumatic/hydraulic actuators.

Course Outcomes (COs):

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

CO1: Understand the fundamentals of Mechatronic systems.

CO2: Analyze sensors and transducers used in Mechatronic systems.

CO3: Apply knowledge of microcontrollers/microprocessors for automation.

CO4: Design simple Mechatronic systems for real-world applications.

Contents	**60Hrs**
UNIT 1	**20 Hrs**

Introduction to Mechatronics: Design concept, Intermigrations of Mechanical, Electrical and System design, Types of Mechatronics systems, Basics of Robotic Manipulator, block diagram of robotic manipulator, Robotic manipulator mechanisms, basics of computer controlled robotic manipulator, embedded computer controlled robotic systems.

Types of motions – Linear, Circular, Simple harmonic motion, Quick return mechanism. Conversion of motion.

UNIT 2	**20 Hrs**

Mechanical components: Pulley, Gears, Levers, Linkages, Screw, Fasteners, Hand tools, Gear train, measurement instruments (Vernier calliper, micrometer, sine bar).

Automobile- Two/four stroke I C engine, Power cycle, Hydraulic and pneumatics – Cylinder, Motor, Direction control valve, Circuit diagram. Degree of freedom and controls. Type of joining – Screwing, Riveting, Welding, Press fitting, Latches.	
UNIT 3	**20 Hrs**
Revision of three phase, single phase supply Conversion of A.C. to D.C and Vice versa. Various types of motors: A/C motors Single phase, Three phase, Variable frequency drives, D/C motor, BLDC, Stepper motor, servo motor. Sensors – Positional sensor, Pressure sensor, Level sensor, Rotary sensor, Infra red sensor, Measurements. Vernier calliper, micrometer screw gauge, sine bar.	

Reference Books	
1	Mechatronics with experiments: Sabri Cetinkunt. Wiley Publications.
2	Mechatronics-Integrated Mechanical Electronic Systems; K. P. Ramchandran, G. K. Vijayaraghavan, Wiley India Editions; ISBN 978-81-265-1837-1.
3	Mechatronics - A Multidisciplinary approach, Bolton, 4th Edition, Prentice Hall, 2009.

Course Title: MICROWAVE DEVICES AND ANTENNAS

Course Code: ELS -2.4.3

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the operation of microwave tubes, passive devices, and transmission line theory relevant to high-frequency systems.
2. Analyze multi-port microwave networks using Z, Y, and S-parameter representations.
3. Learn the fundamental principles of antenna operation including field regions, patterns, gain, and radiation mechanisms.
4. Study the performance, design, and characteristics of various antennas such as loop, horn, helical, Yagi-Uda, and parabolic types.
5. Explore smart antennas, metamaterial-based antennas, and antenna innovations relevant to modern communication systems like 5G and MIMO.

Course Outcomes (COs):

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

CO1: Explain the working principles of microwave tubes, waveguide components, and transmission lines used in RF systems.

CO2: Analyze and solve problems involving impedance matching, reflection coefficient, and standing wave using Smith Chart.

CO3: Describe the fundamental parameters and radiation characteristics of various basic antennas and antenna arrays.

CO4: Evaluate the design, working principles, and applications of modern antennas including smart, reconfigurable, and phased array antennas used in advanced wireless systems.

Contents	**60Hrs**
UNIT I: Microwave Tubes, Network Theory, and Transmission Lines	**20 Hrs**

Microwave Tubes: Introduction, Reflex Klystron Oscillator, Mechanism of Oscillations, Modes of Oscillations, Mode Curve

Microwave Network theory: Symmetrical Z and Y-Parameters for Reciprocal Networks, S matrix representation of Multiport Networks. **Microwave Passive Devices:** Coaxial Connectors and Adapters, Attenuators, Phase Shifters, Waveguide Tees, Magic tees. **Microwave Transmission Lines:** Microwave Frequencies, Microwave devices, Microwave Systems, Transmission Line equations and solutions, Reflection Coefficient and Transmission Coefficient, Standing Wave and Standing Wave Ratio, Smith Chart, Single Stub matching.	
UNIT II: Antenna Fundamentals and Radiation Mechanisms	**20 Hrs**
Antenna Basics: Introduction, Basic Antenna Parameters, Patterns, Beam Area, Radiation Intensity, Beam Efficiency, Directivity and Gain, Antenna Apertures, Effective Height, Bandwidth, Radio Communication Link, Antenna Field Zones & Polarization **Electric Dipoles:** Introduction, Short Electric Dipole, Fields of a Short Dipole (General and Far Field Analyses), Radiation Resistance of a Short Dipole, Thin Linear Antenna (Field Analyses), Radiation Resistances of Lambda/2 Antenna. **Point Sources and Arrays:** Introduction, Point Sources, Power Patterns, Power Theorem, Radiation Intensity, Field Patterns, Phase Patterns, Arrays of Two Isotropic Point Sources, Pattern Multiplication, Linear Arrays of n Isotropic Point Sources of equal Amplitude and Spacing.	
UNIT III: Advanced Antenna Types and Emerging Technologies	**20 Hrs**
Antenna Types Loop and Horn Antenna: Introduction, Small loop, Comparison of Far fields of Small Loop and Short Dipole, The Loop Antenna General Case, Far field Patterns of Circular Loop Antenna with Uniform Current, Radiation Resistance of Loops, Directivity of Circular Loop Antennas with Uniform Current, Horn antennas Rectangular Horn Antennas. Helical Antenna, Helical Geometry, Practical Design Considerations of Helical Antenna, Yagi-Uda array, Parabola General Properties, Log Periodic Antenna. **Smart Antennas:** Introduction to Smart Antennas: Need for Smart Antennas, Overview, Smart Antenna Configurations, Space Division Multiple Access, Architecture of Smart Antenna System, Benefits, Drawbacks, Basic Principles, Mutual Coupling Effects. **Next generation Antennas**: Metamaterial Antennas Metamaterial Antennas Based on NRI	

Concepts, High Gain Antennas Utilizing EBG Defect Modes, Reconfigurable Antennas: Introduction, Analysis, Overview of Reconfiguration Mechanisms for Antennas, UWB planar antennas, Phased array antennas for 5G communications, MIMO antennas

Reference Books	
1	"Microwave Devices and circuits"- Liao, Pearson Education.
2	"Antennas and Wave Propagation"- John D. Krauss, Ronald J Marhefka and Ahmad S Khan, 4th Special Indian Edition , McGraw- Hill Education Pvt. Ltd., 2010.
3	"Electromagnetic Waves and Radiating systems" – A CJordan and K G Balmin, Prenticehall.
4	"Microwave Engineering"-Sushrut Das, Oxford Higher Education, 2ndEdn, 2015.

Course Title: BASIC ELECTRONICS (ELE)

Course Code: ELE - 2.5

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. To help students understand how amplifiers and oscillators work and where they are used in electronic circuits.
2. To introduce operational amplifiers (OPAMPs) and show how they can be used for different tasks like adding, subtracting, and changing signals.
3. To explain basic communication systems**,** including how signals are sent and received using different types of modulation like AM and FM.
4. To give an idea about transducers and measuring tools**,** and to help students learn the basics of flip-flops and how microcontrollers are used in simple control systems.

Course Outcomes (COs):

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

CO1: Understand the working principles and qualitative behaviour of amplifiers and oscillators, including negative feedback and different types of oscillator circuits (RC phase shift, Hartley, Colpitts, crystal).

CO2: Analyze the basic configuration, properties, and applications of operational amplifiers in analog circuits such as voltage follower, adder, subtractor, integrator, and differentiator.

CO3: Demonstrate conceptual understanding of analog communication systems, including the processes of amplitude, frequency, and phase modulation and demodulation.

CO4: Describe the working of various electrical transducers, measuring instruments, flip-flops, and microcontroller-based control systems using block diagram representations.

Contents	**60Hrs**
UNIT 1	**20 Hrs**

Amplifiers & oscillators: Decibels and Half power points, Single Stage CE Amplifier and Capacitor coupled two stage CE amplifier(Qualitative discussions only), Series voltage negative feedback and

Additional effects of Negative feed back (Qualitative discussions only), The Barkhausen Criterion for Oscillations, BJT RC phase shift oscillator, Hartley ,Colpitts and crystal oscillator (Qualitative discussions only). **Introduction to operational amplifiers:** Ideal OPAMP, Saturable property of an OP AMP inverting and non inverting OPAMP circuits, need for OPAMP, Characteristics and applications - voltage follower, addition, subtraction, integration, differentiation. **Communication Systems**: Introduction, Elements of Communication Systems, Modulation: Amplitude Modulation, Spectrum Power, AM Detection (Demodulation), Frequency and Phase Modulation. Amplitude and Frequency Modulation

UNIT 2	**20 Hrs**
Transducers: Introduction, Passive Electrical Transducers, Resistive Transducers, Resistance Thermometers, Thermistor. Linear Variable Differential Transformer (LVDT). Active Electrical Transducers, Piezoelectric Transducer, Photoelectric Transducer. Voltmeter, Ammeter, Multimeter, Oscilloscope. **Flip-Flops**: Introduction to Flip-Flops, NAND Gate Latch/ NOR Gate Latch, RS Flip-Flop, Microcontrollers: Introduction to Microcontrollers, 8051 Microcontroller Architecture and an example of Microcontroller based stepper motor control system (only Block Diagram approach)	

Reference Books	
1	Integrated Electronics: Millman and Halkias
2	Electronic Instrumentation – H. S Kalsi
3	Basic electronics – D. P. Kothari and I J Nagrath
4	Digital Electronics – Morris Mano
5	Basic Electronics – Punagin.

Course Title: PATTERN RECOGNITION

Course Code: ELH - 3.1

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the fundamentals of pattern recognition systems and their applications.
2. Learn statistical and non-statistical methods for classification and parameter estimation.
3. Gain knowledge of feature extraction, dimensionality reduction, and machine learning models.
4. Explore supervised and unsupervised learning techniques including decision trees, neural networks, and clustering.

Course Outcomes (COs):

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

CO1: Describe the components and life cycle of a pattern recognition system and apply statistical methods for classification

CO2: Apply feature extraction and dimensionality reduction techniques for effective pattern representation.

CO3: Implement and evaluate classification algorithms such as decision trees, SVMs, and neural networks.

CO4: Analyze unsupervised learning methods and ensemble techniques for clustering and pattern discovery.

Contents	**60Hrs**
UNIT I:Fundamentals of Pattern Recognition and Statistical Approaches	**20 Hrs**

Introduction to PR: Basics of pattern recognition system, various applications, Machine Perception, classification of pattern recognition systems Design of Pattern recognition system, Pattern recognition Life Cycle Statistical Pattern Recognition: Review of probability theory, Gaussian distribution, Bayes decision theory and Classifiers, Optimal solutions for minimum error and minimum risk criteria, Normal density and discriminant functions, Decision surfaces

Parameter estimation methods: Maximum-Likelihood estimation, Expectation-maximization method, Bayesian parameter estimation	
UNIT II:Feature Extraction, Dimensionality Reduction, and Non-Parametric Methods	**20 Hrs**
Feature Extraction and Dimensionality: Concept of feature extraction and dimensionality, Curse of dimensionality, Dimension reduction methods -Fisher discriminant analysis, Principal component analysis Hidden Markov Models (HMM) basic concepts, Gaussian mixture models. **Non-Parameter methods:** Non-parametric techniques for density estimation -Parzen-window method, K-Nearest Neighbour method. Non-metric methods for pattern classification: Non-numeric data or 15% nominal data	
UNIT III:Classification Algorithms and Unsupervised Learning	**20 Hrs**
Decision trees and ANN: Concept of construction, splitting of nodes, choosing of attributes, over fitting, pruning. **Linear Discriminant based algorithm:** Perceptron, Support Vector. Machines Multilayer perceptron, Backpropagation algorithm, Artificial. Neural networks Classifier Ensembles: Bagging, Boosting / Ada Boost Unsupervised learning: Clustering - Criterion functions for clustering, Algorithms for clustering: K-means and Hierarchical methods, Cluster validation	

Reference Books	
1	C M Bishop, Pattern Recognition and Machine Learning, Springer
2	R O Duda, P.E. Hart and D.G. Stork, Pattern Classification and scene analysis, John Wiley
3	Morton Nadier and Eric Smith P., Pattern Recognition Engineering, John Wiley & Sons, New York,1993.
4	Robert J. Schalkoff, Pattern Recognition : Statistical, Structural and Neural Approaches, John Wiley &Sons Inc., New York, 2007.

Course Title: ROBOT MODELING AND SIMULATION

Course Code: ELH - 3.2

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the mathematical foundations of robot modeling including kinematics, dynamics, and trajectory planning.
2. Gain knowledge of simulation tools and techniques for testing robotic systems.
3. Analyze robot behavior in virtual environments using control, planning, and sensor feedback.
4. Develop the ability to model and simulate robotic systems for industrial, mobile, and collaborative applications.

Course Outcomes (COs):

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

CO1: Apply kinematic and dynamic modeling techniques to various robot manipulators.

CO2: Develop simulation models using URDF, RViz, and Gazebo for robot visualization.

CO3: Design and evaluate motion planning and control algorithms in simulation.

CO4: Analyze the behavior of mobile robots and manipulators under varying operating conditions.

Contents	**60Hrs**
UNIT I: Mathematical Modeling and Kinematics of Robots	**20 Hrs**
Introduction to Robot Modeling: Configuration space, State space, Workspace,Classification of Robotic Manipulators: Structure, Degrees of Freedom,Symbolic Representation of Robot Arms, Homogeneous Transformation Matrices, Forward and Inverse Kinematics,Differential Kinematics, Jacobian Matrix, Kinematic Singularities,Robot Statics: Force/Torque relationship, Tools for Modeling: MATLAB Robotics Toolbox, Python Robotics Libraries	
UNIT II: Dynamics, Trajectory Planning, and Control	**20 Hrs**
Dynamics of Robot Manipulators using Lagrange and Newton-Euler Formulations,	

Dynamic Model Properties: Linearity, Symmetry, Energy Conservation,Trajectory Planning: Joint Space vs Task Space, Cubic and Quintic Polynomials,Dynamic Parameter Identification, Joint Space and Operational Space Control,Computed Torque Control, Feedback Linearization, Introduction to Force Control: Impedance and Admittance Control,Modeling in Simulink / MATLAB	
UNIT III: Simulation Tools, Mobile Robots and Applications	**20 Hrs**
URDF and Xacro: Building Robot Models,Simulation Environments: RViz, Gazebo, Integrating Sensors (IMU, LIDAR, Cameras) in Simulation,Mobile Robot Kinematics: Differential drive, Nonholonomic constraints,Path and Motion Planning Techniques: Dijkstra, A*, RRT,SLAM and Localization Overview (conceptual),Simulating Robot Tasks: Pick and Place, Navigation, Obstacle Avoidance,Project-Based Simulation Assignments using ROS/Gazebo	

Reference Books	
1	Siciliano B., Sciavicco L., Villani L., Oriolo G., *Robotics: Modelling, Planning and Control*, Springer
2	Spong M. W., Hutchinson S., Vidyasagar M., *Robot Modeling and Control*, Wiley
3	Craig J. J., *Introduction to Robotics: Mechanics and Control*, Pearson
4	Peter Corke, *Robotics, Vision and Control: Fundamental Algorithms*, Springer
5	Choset H. et al., *Principles of Robot Motion: Theory, Algorithms, and Implementation*, MIT Press

Course Title: IMAGE PROCESSING

Course Code: ELH - 3.3

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Develop an overview of the field of image processing.
2. Understand the fundamental algorithms and how to implement them.
3. Prepare to read the current image processing research literature.
4. Gain experience in applying image processing algorithms to real problems.

Course Outcomes (COs):

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

CO1: Understand the fundamental concepts of digital image processing

CO2: Apply image enhancement techniques in spatial and frequency domains

CO3: Analyze various image segmentation and feature extraction methods

CO4: Develop algorithms for image restoration and compression

Contents	**60Hrs**
UNIT I:Digital Image Fundamentals and Spatial Domain Techniques	**20 Hrs**

Introduction and Digital Image fundamentals: Introduction to Digital Image Processing, Elements of Visual Perception, Light and the Electromagnetic Spectrum, Image Sensing and Acquisition, Image Sampling and Quantization, Some Basic Relationships Between Pixels, Mathematical tools used in DIP.

Intensity Transformations and Spatial Filtering: Some basic intensity Transformation Functions, Histogram Processing, Fundamentals of Spatial Filtering, Smoothing Spatial Filters, Sharpening Spatial Filters, Combining Spatial Enhancement Methods.

UNIT II: Frequency Domain Processing and Image Restoration	**20 Hrs**

Filtering in Frequency Domain: Preliminary concepts, Sampling, Fourier Transform of sampled Functions, DFT of two variables, Properties of 2D DFT, Basics of Filtering in the

Frequency Domain, Image Smoothing using Frequency-Domain Filters, Image Sharpening using Frequency Domain Filters, Selective Filtering. Image Restoration and **Reconstruction:** Model of the Image Degradation/Restoration Process, Noise Models, Restoration in the Presence of Noise Only Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear Position-Invariant.	
UNIT III:Morphological Processing, Segmentation, and Color Image Techniques	**20 Hrs**
Morphological Image Processing: Preliminaries, Erosion and Dilation, Opening and Closing, the Hit or Miss Transformation, Basic Morphological Algorithms, Gray Scale Morphology. **Image Segmentation:** Fundamentals, Point, Line and Edge Detection, Thresholding, Region-Based Segmentation. **Color Image Processing:** Color Fundamentals, Color Models, Pseudo-color Image Processing, Full-Color Image Processing, Color Transformations, Smoothing and Sharpening.	

Reference Books	
1	"Digital Image Processing", Rafael Gonzalez and Richard Woods, PHI.2nd Edition.
2	"Fundamentals of Digital Image Processing", A. K. Jain, Prentice Hall of India, 1989.
3	"Digital Image Processing", W. K. Pratt, Prentice Hall, 1989.

Course Title: EMBEDDED SYSTEM AND RTOS

Course Code: ELS -3.4.1

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the architecture, design metrics, and development challenges of embedded systems.
2. Analyze and design custom single-purpose processors using hardware and software approaches.
3. Apply system-level modeling techniques with hardware/software co-design and partitioning.
4. Explore real-time operating system (RTOS) concepts and design embedded applications using RTOS principles.
5. Develop optimized and power-aware embedded solutions through co-design and real-time integration.

Course Outcomes (COs):

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

CO1: Describe the fundamental concepts of embedded systems, including design constraints, processor types, and interrupt mechanisms.

CO2: Analyze and apply hardware/software co-design techniques and partitioning models for embedded system development.

CO3: Evaluate and design embedded systems using hardware/software co-synthesis, scheduling, and optimization methods.

CO4: Implement real-time embedded applications using RTOS features such as tasks, semaphores, queues, timers, and memory management.

Contents	60Hrs
UNIT I:Embedded System Fundamentals and Processor Architectures	**20 Hrs**

Introduction to Embedded Systems: Overview of embedded systems, embedded system design challenges, common design metrics and optimizing them. Survey of different embedded

system design technologies, trade-offs. Custom Single-Purpose Processors, Design of custom single purpose processors. **Single Purpose Processors:** Hardware, Combinational Logic, Sequential Logic, RT level Combinational and Sequential Components, Optimizing single-purpose processors. Single-Purpose Processors: Software, Basic Architecture, Operation, Programmer's View, Development Environment, ASIPS. **Interrupts:** Basics - Shared Data Problem - Interrupt latency. Survey of Software Architecture, Round Robin, Round Robin with Interrupts - Function Queues - scheduling - RTOS architecture.	
UNIT II:Hardware/Software Co-Design and System Modeling	**20 Hrs**
System modelling with Hardware/Software Partitioning: Hardware/ Software Co-Design, Co-Design for system specification and modeling. Single-processor Architecture & Multi-Processor Architecture, comparison of Co-design Approaches, Models of Computation, Requirements of Embedded system Specification. Hardware/ Software partitioning problem. Hardware/ Software cost estimation, Generation of partitioning by graphical modeling, Formulation of the HW/SW scheduling, optimization.	
UNIT III:Real-Time Operating Systems and Embedded System Integration	**20 Hrs**
Introduction to RTOS: Tasks - states - Data - Semaphores and shared data. More operating systems services - Massage Queues - Mail Boxes -Timers – Events - Memory Management. **Basic Design Using RTOS, Principles:** Basic Design Using RTOS, Principles- An example, Encapsulating semaphores and Queues. Hard real-time scheduling considerations – Saving Memory space and power. Hardware software co-design aspects in embedded systems. **Hardware/ Software Co-synthesis:** The Co-synthesis problem, State-Transition Graph, Refinement and controller generation, Distributed system Co-synthesis	

Reference Books	
1	Introduction to Embedded Systems - Shibu K.V, Mc Graw Hill.
2	Embedded Systems - Raj Kamal, TMH.
3	Embedded System Design - Frank Vahid, Tony Givargis, John Wiley.
4	Embedded Systems – Lyla, Pearson, 2013
5	An Embedded Software Primer - David E. Simon, Pearson Education.

Course Title: ELECTRIC VEHICLES

Course Code: ELS-3.4.2

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand devices like diodes, BJTs, MOSFETs, IGBTs.
2. Design rectifiers, inverters, DC–DC converters (buck, boost, buck–boost) for EV use
3. Build motor controllers, Battery Management Systems (BMS), and electronic control units.
4. Integrate microcontrollers to manage power and performance.

Course Outcomes (COs):

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

CO1: Understand the fundamentals of power electronics and electronic control systems used in electric vehicle (EV) applications.

CO2: Analyze the operation and characteristics of power semiconductor devices (like IGBT, MOSFET) and their role in electric traction systems.

CO3: Design basic power conversion systems (DC-DC converters, inverters, battery chargers) suitable for EVs using appropriate control techniques.

CO4: Evaluate various motor drive technologies (e.g., BLDC, PMSM, induction motors) and their electronic control strategies in EVs.

Contents	**60Hrs**
UNIT I: Electric Vehicle Architecture and Performance Parameters	**20 Hrs**

EV System Architecture: Motivation for hybrid and electric vehicles, Hybrid-Electric Vehicle Power trains, Vehicle Energy Storage System Design Motors & motive power splitting concepts, and interface within power train system, Vehicle Development Process Overview, and System test considerations.

Performance Parameters of EV: Efficiency, vehicle range, safety, reliability, life, size, weight, power dissipation, power density etc.	
UNIT II: Devices, Packaging, and Energy Storage Systems for EVs	**20 Hrs**
Devices and Components used in EVs: Silicon Carbide MOSFETs, Silicon IGBT, DC-link capacitor, boost inductor, EMI filter, Integrated IGBT modules, Integrated chip-level temperature & current sensors. Packaging of the devices used for EVs: surface-mount devices (SMD) DPAK or D2PAK. **Basics of Energy storage elements:** Ragone Chart, Theory of Ragone Plots, Ragone Plot of a Battery, Battery characterisation and testing systems & Battery life cycle, Modular battery packs, packaging, thermal control and legislative implications. Supercapacitors: Materials and Construction, Basic Model, Series and Parallel Connections.	
UNIT III: Motor Control and Power Electronics in Electric Vehicles	**20 Hrs**
Control Electronics: Basic Concepts of DC–AC Inverters, Single-Phase DC–AC Inverter, Three-Phase DC–AC Inverter, BLDC Motor and Control, Operation of BLDC Motor, Torque and Rotating Field Production, BLDC Motor Control, BLDC Motor Torque–Speed Characteristics, Sensor-less BLDC Motor Control, AC Induction Motor and Control. Basic Configuration of PHEV /BEV Battery Charger, Concept of Onboard Chargers (OBC) Power Factor and Correcting Techniques, Controls of Plug-In Charger.	

Reference Books	
1	Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, Third Edition, New Delhi, 2011.
2	Chang Liang Xia," Permanent Magnet Brushless Dc Motor Drives and Controls" Wiley 2012.
3	Electric Vehicle Engineering, PerEnge, Nick Enge, Stephen Zoepf, McGraw Hill, 2021.

Course Title: OPTOELECTRONICS AND OPTICAL FIBER COMMUNICATION

Course Code: ELH-3.4.3

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. To provide students with fundamental knowledge of optoelectronic devices and optical fiber communication systems, enabling them to understand the principles, design, and applications of modern optical communication technologies.

Course Outcomes (COs):

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

CO1: Understand the fundamentals of optoelectronic devices

CO2: Analyze semiconductor lasers and Photodetectors

CO3: Comprehend optical fiber properties and light propagation

CO4: Design and evaluate optical fiber communication systems

Contents	**60Hrs**
UNIT 1	**20 Hrs**
Lamps and illumination systems, LEDs – working principle and applications, LED lighting, Display devices, indicators, numeric, alphanumeric and special function displays, Liquid Crystal Display elements, Plasma Displays, Multimedia projectors. Semiconductor lasers, - Fabry-Perot lasers, Distributed Feedback, (DFB) lasers, Distributed Bragg Reflection (DBR) lasers Photodetectors types and applications, PN and PIN Photodiodes, Avalanche Photodiodes (APD) Optocouplers, Opto interrupters, LASCR. used in safety interlocks, power isolators, rotary and linear encoders and remote control. Intrinsic and Extrinsic Fiber optic sensors.	
UNIT 2	**20 Hrs**
Optical Fiber Theory, Parameters of Optical Fibers, Types of Optical Fibers-Single Mode and Multi-Mode Fibers, Step Index & Graded Index Fibers. Modal Properties-Waveguide Parameter (V Number), Cut-off wavelength, Dispersion-Intermodal and Intramodal dispersion Loss	

Mechanism in Optical Fibers-Adsorption and Scattering, Fresnel Reflection, Micro bending & Macro bending, Connector types and Splices, Misalignment and Mismatch losses.	
UNIT 3	**20 Hrs**
Fiber-Optic transmitters and receivers, Direct Modulators, External Modulators-Electro-Optic Modulators, Electro-Absorption Modulators, Noise in detection process, Noise Equivalent Power (NEP). Single Channel System Design, Power budgeting, Transmission Capacity Budgeting, Dispersion Compensation, Nonlinear effects in optical fibers-Stimulated Brillouin Scattering (SBS), Self-Phase Modulation (SPM), Cross-Phase Modulation (XPM), Four-Wave Mixing (FWM).	

Reference Books	
1	Optical Engineering Fundamentals B.H. Walker, PHI
2	Electro-Optical Instrumentation Sensing and Measuring with Lasers: Silvano Donati, Pearson
3	Fiber optics and Optoelectronics: R.P. Khare, Oxford Press.
4	Optical Fiber Communication Principles and Systems A. Selvarajan, S.Kar and Srinivas, TMH
5	Optical Fiber Communications G. Keiser, TMH

Course Title: FUNDAMENTALS OF DIGITAL ELECTRONICS

Course Code: ELE 3.5

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the fundamentals of number systems, binary arithmetic, logic gates, and Boolean algebra.
2. Apply Boolean simplification techniques to design efficient combinational logic circuits.
3. Analyze, design, and implement basic combinational and sequential digital systems.
4. Learn the functioning and applications of flip-flops, registers, and counters in digital design.

Course Outcomes (COs):

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

CO1: Convert between different number systems and perform binary arithmetic and coding operations used in digital systems.

CO2: Simplify Boolean expressions using Karnaugh maps and tabulation methods, and design logic circuits using universal gates.

CO3: Design and implement combinational logic circuits such as adders, subtractors, decoders, and multiplexers.

CO4: Analyze and construct sequential circuits using flip-flops, counters, and shift registers for basic digital applications.

Contents	60Hrs
UNIT I: Number Systems, Boolean Algebra, and Logic Simplification	**20 Hrs**

Binary Systems: Digital Computers and Digital Systems, binary numbers, number based conversion, Octal and Hexa decimal Numbers, complements, binary codes, binary storage and registers, binary logic, integrated circuits

Boolean Algebra and Logic Gates: Basic definitions, Axiomatic definition of Boolean algebra, basic theorems and properties of Boolean algebra, Boolean functions, canonical and standard forms, the map method of simplification of Boolean functions. Two-Three-Four-Five-Six variable maps, product of Sum simplification, NAND and NOR implementation, don't care conditions, The Tabulation Method, determination and selection of prime implicants

UNIT II:Design of Combinational and Sequential Logic Circuits	**20 Hrs**
Combinational logic: Introduction, design procedure, adders, binary parallel adder, decimal adder, Subtractor, Code conversion, magnitude Comparators, decoders and multiplexers. **Sequential Logic:** Introduction, Flip Flops, Types-SR, JK, D & T, Triggering of Flip Flops, Analysis of Clocked sequential circuits, State reduction and assignment, Flip flop excitation tables, design procedure, shift registers and counters	

Reference Books	
1	M. Morris Mono, Digital Logic and Computer Design, PHI, 2002
2	Floyd T L "Digital Fundamentals", 7th edn. (Pearson Education Asia), 2002
3	A P Malvino and D P Leach, Digital Principles and Applications, TaTa McGraw Hill, 4th edition, 1998

Course Title: MACHINE LEARNING

Course Code: ELH - 4.1

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand foundational concepts and algorithms in machine learning, including concept learning and decision trees.
2. Gain knowledge of artificial neural networks and Bayesian methods for learning from data.
3. Learn to evaluate and compare learning hypotheses and algorithms.
4. Explore advanced learning methods like instance-based and reinforcement learning.

Course Outcomes (COs):

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

CO1: Explain key concepts in concept learning, decision tree learning, and their algorithmic implementations.

CO2: Apply neural networks and Bayesian learning approaches for classification and prediction tasks.

CO3: Evaluate and compare learning hypotheses using statistical methods and error estimation techniques.

CO4: Implement instance-based learning and reinforcement learning techniques for solving practical problems.

Contents	60Hrs
UNIT I: Foundations of Machine Learning and Decision Tree Methods	**20 Hrs**

Introduction to ML: Well posed learning problems, Designing a Learning system, Perspective and Issues in Machine Learning. Concept Learning: Concept learning task, Concept learning as search, Find-S algorithm, Version space, Candidate Elimination algorithm, Inductive Bias. Decision Tree Learning: Decision tree representation, Appropriate problems for decision tree

learning, Basic decision tree learning algorithm, hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning.	
UNIT II: Neural Networks and Probabilistic Learning Approaches	**20 Hrs**
Artificial Neural Networks: Introduction, Neural Network representation, Appropriate problems, Perceptrons, Backpropagation algorithm. Bayesian Learning: Introduction, Bayes theorem, Bayes theorem and concept learning, ML and LS error hypothesis, ML for predicting probabilities, MDL principle, Naïve Bayes classifier, Bayesian belief networks, EM algorithm.	
UNIT III: Hypothesis Evaluation, Instance-Based, and Reinforcement Learning	**20 Hrs**
Evaluating Hypothesis: Motivation, estimating hypothesis accuracy, Basics of sampling theorem, General approach for deriving confidence intervals, Difference in error of two hypotheses, Comparing learning algorithms. Instance Based Learning: Introduction, k-nearest neighbor learning, locally weighted regression, radial basis function, cased-based reasoning, Reinforcement Learning: Introduction, Learning Task, QLearning.	

Reference Books	
1	Tom M. Mitchell, Machine Learning, India Edition 2013, McGraw Hill Education.
2	Trevor Hastie, Robert Tibshirani, Jerome Friedman, h The Elements of Statistical Learning, 2nd edition, springer series in statistics.
3	EthemAlpaydın, Introduction to machine learning, second edition, MIT press.

Course Title: INTERNETS OF THINGS(IoT)

Course Code: ELH - 4.2

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the foundational principles, architecture, and core components of IoT systems.
2. Gain practical knowledge in building, deploying, and securing IoT applications.
3. Analyze communication technologies and protocols across the IoT stack.
4. Explore advanced IoT applications and the role of next-generation networks like 5G and 6G.

Course Outcomes (COs):

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

CO1: Explain the architecture and essential elements of IoT ecosystems.

CO2: Design and develop IoT-based applications for various domains.

CO3: Evaluate and apply communication protocols and edge-to-cloud integration models.

CO4: Analyze the impact of emerging technologies such as 5G/6G in future IoT applications.

Contents	60Hrs
UNIT I: IoT Foundations and Communication Protocols	**20 Hrs**
Introduction to IoT: Definition, scope, and relevance in modern systems, **IoT Reference Architecture:** Perception, network, and application layers, **IoT Components:** Actuators, gateways, embedded systems, cloud and edge platforms, **IoT Protocols:** MQTT, CoAP, HTTP/HTTPS, AMQP, LoRaWAN, NB-IoT, **IoT Applications:** Smart cities, smart homes, connected health, industrial automation	
UNIT II: IoT System Design and Security	**20 Hrs**
IoT Architecture Design: Embedded device selection, integration, and configuration. **Edge and Fog Computing in IoT:** Concepts, benefits, and deployment strategies, **Cloud Integration:** Device-to-cloud data flow and analytics overview. **IoT Device Management:**	

Provisioning, OTA updates, diagnostics. **IoT Security:** Authentication, data encryption, secure communication, privacy concerns, **Case Studies:** Real-world IoT system implementation challenges and solutions	
UNIT III: Advanced IoT Applications and Emerging Trends	**20 Hrs**
Industrial IoT (IIoT): Smart manufacturing, predictive maintenance, digital twins **IoT in Agriculture and Environment:** Precision farming, climate monitoring **IoT in Healthcare:** Remote patient monitoring, AI-enabled diagnostics **Role of 5G and 6G in IoT:** Ultra-reliable low-latency communication (URLLC), massive machine-type communication (mMTC), energy-efficient connectivity Integration with AI, Blockchain, and Cloud for intelligent and scalable IoT **Future Trends:** IoT standardization, interoperability, green IoT, and ethical concerns	

Reference Books	
1	**Arshdeep Bahga & Vijay Madisetti**, *Internet of Things: A Hands-on Approach*, Universities Press
2	**Adrian McEwen & Hakim Cassimally**, *Designing the Internet of Things*, Wiley
3	**Jan Holler et al.**, *From Machine-to-Machine to the Internet of Things*, Academic Press
4	**William Stallings**, *Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud*, Pearson
5	**Klaus Schwab**, *Shaping the Future of the Fourth Industrial Revolution*, World Economic Forum

Course Title: Robot Operating System (ROS)

Course Code: ELH - 4.3

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the architecture, core concepts, and communication mechanisms of ROS.
2. Learn to develop and integrate robotic software using ROS nodes, topics, services, and actions.
3. Gain hands-on experience in robot simulation using Gazebo and visualization using RViz.
4. Interface sensors and actuators using ROS and deploy control and navigation algorithms on robotic platforms.

Course Outcomes (COs):

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

CO1: Describe the architecture and key components of ROS.

CO2: Develop, configure, and debug ROS nodes and communication interfaces (topics, services, actions).

CO3: Simulate and visualize robotic applications using ROS tools like RViz and Gazebo.

CO4: Interface sensors and actuators with ROS and implement basic control/navigation strategies.

Contents	**60Hrs**
UNIT II: Introduction to ROS and Communication Infrastructure	**20 Hrs**

Introduction to ROS: History, Architecture, Distributions (ROS1, ROS2), ROS Filesystem Level Concepts: Packages, Nodes, Topics, Services, Actions, Master Node, roscore, rosrun, ros launch, ROS Communication: Publisher-Subscriber Model, Service-Client Model, Writing ROS Nodes in Python (rospy) and C++ (roscpp),ROS Parameters and Dynamic Reconfiguration, Catkin Build System and Workspace Management, Debugging and Visualization Tools: rqt_graph, rosnode, rostopic, rosparam

UNIT II: Simulation and Visualization with RViz and Gazebo	20 Hrs
Introduction to RViz: Visualization of Sensors, Transforms, Robot State, URDF (Unified Robot Description Format) and Xacro: Creating Robot Models,Launch Files and Multi-node Execution,Introduction to Gazebo Simulator: World, Model, and Robot Simulation,Integrating Gazebo with ROS,Simulating Sensors (Laser, IMU, Camera) in Gazebo,Joint State Publisher, Robot State Publisher,Controlling Robot Models in Simulation: Velocity and Position Control	
UNIT III: Sensor Integration, Control, and Navigation in ROS	**20 Hrs**
Interfacing Real Sensors (Ultrasonic, IMU, LIDAR) with ROS, Working with Serial and USB Interfaces in ROS, Using ROS Bags for Data Logging and Playback, ROS Control Framework and Controllers,Navigation Stack Overview: Mapping, Localization, Path Planning, SLAM using gmapping/hector_slam/cartographer, Localization using AMCL, Path Planning using move_base, Case Study: Autonomous Mobile Robot using ROS	

Reference Books	
1	Morgan Quigley, Brian Gerkey, and William D. Smart, *Programming Robots with ROS*, O’Reilly Media.
2	Wyatt Newman, *A Systematic Approach to Learning Robot Programming with ROS*, CRC Press.
3	Anis Koubaa (Ed.), Robot Operating System (ROS): The Complete Reference (Volume 1–5), Springer.

Course Title: INFORMATION THEORY & CODING

Course Code: ELS -4.4.1

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. Understand the fundamentals of information theory, entropy, and coding for efficient and reliable communication.
2. Learn the principles and methods of source and channel coding including lossless compression techniques.
3. Analyze and design error control coding schemes such as block codes, cyclic codes, and convolutional codes.
4. Apply mathematical tools to evaluate the performance of various coding methods in terms of error detection, correction, and channel capacity.

Course Outcomes (COs):

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

CO1: Describe and compute information measures such as entropy, information rate, and mutual information for different sources and channels.

CO2: Apply source coding algorithms like Shannon and Huffman coding for data compression and transmission efficiency.

CO3: Design and analyze linear block codes, Hamming codes, and cyclic redundancy codes for error detection and correction.

CO4: Implement and evaluate advanced coding techniques such as BCH, Reed-Solomon, and convolutional codes for noise-resilient communication systems.

Contents	60Hrs
UNIT I: Information Theory and Source Coding	**20 Hrs**

Information Theory – Measure of information, Average information content of symbols in long independent sequences, Average information content of symbols in long dependent

sequences. Mark-off statistical model for information source, entropy and information rate of mark-off source, **Source Coding** - Encoding of source output, Shannon's encoding algorithm, Communication channels, Source coding theorem, Huffman coding, Discretememoryless channels, Mutual information, channel capacity. Channel coding theorem, Differential entropy and mutual information for continuous ensembles, Channel capacity theorem.	
UNIT II: Error Control Coding and Linear Block Codes	**20 Hrs**
Error Control Coding: BLOCK Codes – Introduction, Types of errors, examples, Types of codes, Definitions and Principles: Hamming weight, hamming distance, Minimum distance decoding - Single parity codes, Hamming codes, Repetition codes - Linear block codes, Matrix description, error detection and correction, standard arrays and table lookup for decoding.	
UNIT III: Cyclic, BCH, RS, and Convolutional Codes	**20 Hrs**
Binary cyclic codes, Algebraic structures of cyclic codes, Encoding using an (n-k) bit shift register, Syndrome calculation, BCH codes. RS codes, Goley Codes, shortened cyclic codes, burst error correcting codes, Burst and Random error correcting codes. Convolution Codes, Time domain approach, Transform domain Approximation.	

Reference Books	
1	Digital and Analog Communication systems, K Sam Shanmugam
2	Information theory and coding, Giridhar
3	ITC and Cryptography, Ranjan Bose, TMH, II edition, 2007
4	Digital Communications – Glover and Granti 2nd Edition, 2008
5	Information theory & Coding – J S Chitode, Technical publications 2009.

Course Title: FUNDAMENTALS OF DRONE TECHNOLOGY

Course Code: ELS-4.4.2

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. To provide foundational knowledge of drone technology, including structure, components, regulations, and control systems.
2. To develop skills in drone programming, operation, and applications with an emphasis on safety, sensors, and future trends.

Course Outcomes (COs):

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

CO1: Understand the basics of drone technology

CO2: Comprehend drone flight principles

CO3: Identify various drone systems and subsystems

CO4: Develop skills in drone operation and control

Contents	**60Hrs**
UNIT 1	**20 Hrs**

Introduction: Introduction to drones and their applications, Key features of drone regulations for civil use, operational and procedural requirements, no drone zones, operations through digital platform, enforcement actions, relevant sections of aircraft act-1934, Structural classification of drones, classifications of drone structures and their suitability, applications and uses of drone frame materials, classifications and applicability of propeller motors, drone propeller materials, design parameters for propellers, composition and structuring of electronic speed controller, flight control board, characteristics of FCB and their structure.

UNIT 2	**20 Hrs**

Drone Battery and Management: Introduction of Battery, Description of Li-Po Battery, Charging / Discharging of Battery. Back up, Ratings, Shelf Life, Maintenance and safety of

Battery. Selection criteria of Battery for Drone application, Selection criterion of motor for drone application. Working and application of BLDC motor. **Sensors for UAV and Drones:** Wi-Fi devices, RADAR and range finder, GPS receiver, Gyro sensor, Speed and Distance sensor, Image sensor, TOF sensor, Chemical sensor. Cameras in drones and selection criteria of camera for different range. Barometers, Accelerometer, Magnetometer, remote control for drone.	
UNIT 3	**20 Hrs**
Radio Control System: Introduction of radio control system, Controllers, Transmitter and Receiver, Flight Controllers, Electronic Speed Controller, Battery Eliminator Circuit, Universal Battery Eliminator Circuit, Connections and Interfaces of Devices in Drones. **Introduction to Drone Programming:** Introduction to programming language used in drone: C and Python. Installation of cards. Auto Pilot software i.e. Ardupilot, Open pilot. Drone flying and operation, Drone accessories and maintenance. Drone Applications, Case studies, Future of drones.	

Reference Books	
1	Robert L. Boylestad / Louis Nashelsky“Electronic Devices and Circuit Theory”, Latest Edition, Pearson Education.
2	D. P. Kothari and I. J. Nagrath, “Basic Electrical Engineering”, Tata McGraw Hill.
3	H S Kalsi, “Electronic Instrumentation”, Latest Edition, TMH Publication.
4	Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost (Green Energy and Technology) by Gianfranco Pistoia, BoryannLiaw , Springer.
5	Wireless Communications | Second Edition | By Pearson: Principles and Practice.
6	Drone Technology in Architecture, Engineering and Construction (, Tal Daniel).

Course Title: CMOS AND LOW POWER VLSI DESIGN

Course Code: ELS – 4.4.3

Credits: 4

Duration: 60 Hours

Course Objectives:

Upon completing the syllabus contents of the course, the student will:

1. To impart foundational knowledge of MOS transistor theory
2. To familiarize students with CMOS fabrication technologies
3. To develop the ability to analyse and design basic digital CMOS logic circuits
4. To introduce various low-power VLSI design techniques
5. To build competence in estimating and optimizing delay and power in digital CMOS circuits

Course Outcomes (COs):

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

CO1: Analyze MOS Transistor Behavior and Low Power Fundamentals

CO2: Apply CMOS Fabrication Processes and Layout Techniques

CO3: Evaluate CMOS Inverter Characteristics and Low Power Design Approaches

CO4: Design and Analyze Combinational CMOS Logic Circuits

CO5: Design and Implement Sequential and Dynamic Logic Circuits

Contents	60Hrs
UNIT 1	**20 Hrs**
MOS Transistor Theory & low power VLSI fundamentals: n MOS / p MOS transistor, threshold voltage equation, body effect, MOS device design equation, small signal AC Characteristics, Short Channel Effects –Drain Induced Barrier Lowering and Punch Through, Velocity Saturation, Impact Ionization, Hot Electron Effect. Channel length modulation. Mobility variation, Tunnelling. Need for Low Power Circuit Design, Sources of Power Dissipation – Switching Power Dissipation, Short Circuit Power Dissipation, Leakage Power Dissipation, Glitching Power Dissipation	
UNIT 2	**20 Hrs**

CMOS Process Technology: Semiconductor Technology overview, basic CMOS technology, p well / n well, twin well process, SOI, stick diagram, design rules and layout, symbolic diagram. **CMOS Inverter Design:** Introduction to CMOS Inverter, Static CMOS Inverter: Structure, DC Transfer Characteristics (VTC), noise margins. Power Dissipation in CMOS Inverter, static load MOS inverters, differential inverter, tristate inverter, BiCMOS inverter. scaling of MOS circuits. **Low-Power Design Approaches:** Low-Power Design through Voltage Scaling – VTCMOS circuits, MTCMOS circuits,

UNIT 3	**20 Hrs**
Basics of Digital CMOS Design: Combinational MOS Logic Circuits-Introduction, CMOS logic circuits with a MOS load, CMOS logic circuits, complex logic circuits, CMOS full adder, Transmission Gate. Sequential MOS logic Circuits – Introduction, Behavior of bi-stable elements, SR latch Circuit, clocked latch and Flip Flop Circuits, CMOS D latch and edge triggered Flip Flop. **Dynamic Logic Circuits** – Introduction, principles of pass transistor circuits, Voltage boot strapping synchronous dynamic circuits techniques, Dynamic CMOS circuit techniques Sheet resistance & standard unit capacitance concepts, delay unit time, inverter delays, driving capacitive loads, propagate delays.	

Reference Books	
1	Neil Weste and K. Eshragian, “Principles of CMOS VLSI Design: A System Perspective”, Pearson Education (Asia) Pvt. Ltd., 2nd Edition ,2000.
2	Wayne Wolf, “Modern VLSI design: System on Silicon” Pearson Education, Second Edition, 1998
3	Douglas A Pucknell & Kamran Eshragian, “Basic VLSI Design” PHI 3rd Edition (original Edition – 1994)
4	Sung Mo Kang & Yosuf Leblebici, “CMOS Digital Integrated Circuits: Analysis and Design”, McGraw- Hill, 3rd Edison, 2003.
5	Low Power CMOS VLSI Circuit Design – Kaushik Roy, Sharat C. Prasad, John Wiley & Sons, 2000.