S. No	Category	Course Code	Course Title	L	T	P	C
Theory							
1	PC	RA23501	Additive Manufacturing	3	0	0	3
2	PC	RA23502	Mobile Robotics	3	0	0	3
3	PC	RA23503	Embedded Systems	3	0	0	3
4	PC	RA23504	Industrial Automation	3	0	0	3
5	PC	RA23505	Design of Robot Elements	3	0	0	3
6	PE	RA2325*	Professional Elective-I	3	0	0	3
Practical							
7	PC	RA23506	Embedded Systems Laboratory	0	0	2	1
8	PC	RA23507	Industrial Automation Laboratory	0	0	2	1
9	PC	RA23508	Industrial Training	0	0	2	1
10	EE	GE23501	Professional Development III	0	0	2	1
			Total	**18**	**0**	**8**	**22**
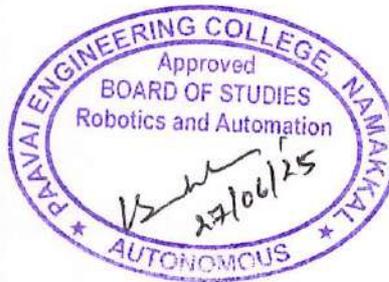
PROFESSIONAL ELECTIVE COURSES (PE) - VERTICALS

VERTICAL I - APPLICATION OF ROBOTICS

S. No	Category	Course Code	Course Title	L	T	P	C
1	PE	RA23151	Medical Robots	3	0	0	3
2	PE	RA23152	Humanoid Robots	3	0	0	3
3	PE	RA23153	Machine Learning and Cognitive Robotics	3	0	0	3
4	PE	RA23154	Drone Technologies	3	0	0	3
5	PE	RA23155	Micro Robotics	3	0	0	3
6	PE	RA23156	Robot Operating Systems	3	0	0	3
7	PE	RA23157	UAV and Underwater Robotics	3	0	0	3

VERTICAL II - ADVANCED MANUFACTURING TECCHNOLOGIES

S. No	Category	Course Code	Course Title	L	T	P	C
1	PE	RA23251	Advanced Metrology and Sensing Systems	3	0	0	3
2	PE	RA23252	Advanced Manufacturing Systems	3	0	0	3
3	PE	RA23253	CNC Machine Tools and Programming	3	0	0	3
4	PE	RA23254	Electronics Manufacturing Technology	3	0	0	3
5	PE	RA23255	Intelligent Manufacturing Systems	3	0	0	3
6	PE	RA23256	Smart Manufacturing	3	0	0	3
7	PE	RA23257	Design For X	3	0	0	3

VERTICAL III - INTELLENGENCE SYSTEM

S. No	Category	Course Code	Course Title	L	T	P	C
1	PE	RA23351	Cloud Computing	3	0	0	3
2	PE	RA23352	Condition Monitoring and Fault Diagnostics	3	0	0	3
3	PE	RA23353	Wearable Devices	3	0	0	3
4	PE	RA23354	Smart Mobility and Advanced Intelligent Vehicles	3	0	0	3
5	PE	RA23355	Vision Guided Robotics	3	0	0	3
6	PE	RA23356	Cyber Security	3	0	0	3
7	PE	RA23357	Wireless Sensor Networks for Robotics	3	0	0	3

VERTICAL IV – ADVANCED ROBOT TCHNOLOGIES

S. No	Category	Course Code	Course Title	L	T	P	C
1	PE	RA23451	Advanced Robotics and Analysis	3	0	0	3
2	PE	RA23452	Computer Vision and Image Processing	3	0	0	3
3	PE	RA23453	Field and Service Robotics	3	0	0	3
4	PE	RA23454	Advanced Materials for Robotics	3	0	0	3
5	PE	RA23455	Intelligent Control of Robotic System	3	0	0	3
6	PE	RA23456	Immersive Technologies and Haptics	3	0	0	3
7	PE	RA23457	Optimization for Robot Modelling	3	0	0	3

VERTICAL V - AUTOMATION

S. No	Category	Course Code	Course Title	L	T	P	C
1	PE	RA23551	Robotics and Automation in the Food Industry	3	0	0	3
2	PE	RA23552	Industrial Robotics and Material Handling Systems	3	0	0	3
3	PE	RA23553	Agricultural Robotics and Automation	3	0	0	3
4	PE	RA23554	Motion Control System	3	0	0	3
5	PE	RA23555	Robot Safety and Maintenance	3	0	0	3
6	PE	RA23556	Sustainability for Automation	3	0	0	3
7	PE	RA23557	Industrial IoT and Automation	3	0	0	3

VERTICAL VI - EMERGING TECHNOLOGIES

S. No	Category	Course Code	Course Title	L	T	P	C
1	PE	RA23651	Generative AI in Human Collaborative Interaction	3	0	0	3
2	PE	RA23652	Micro Electro Mechanical Systems	3	0	0	3
3	PE	RA23653	Signal Processing in Robotics	3	0	0	3
4	PE	RA23654	Smart Sensors for Robotics	3	0	0	3
5	PE	RA23655	Soft robotics	3	0	0	3
6	PE	RA23656	Digital Twins	3	0	0	3
7	PE	RA23657	Industrial Networking	3	0	0	3

RA23501	ADDITIVE MANUFACTURING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce the development of Additive Manufacturing (AM), various business opportunities
2	familiarize various software tools, processes and techniques to create physical objects that satisfy product development
3	be acquainted with vat polymerization and direct energy deposition processes
4	be familiar with powder bed fusion and material extrusion processes
5	gain knowledge on applications of binder jetting, material jetting and sheet lamination processes

UNIT I	INTRODUCTION	9

Overview, Need - Development of Additive Manufacturing (AM) Technology: Rapid Prototyping- Rapid Tooling - Rapid Manufacturing, Additive Manufacturing Process Chain- ASTM/ISO 52900 Classification - Benefits. Applications: Building Printing - Bio Printing - Food Printing- Electronics Printing. Business Opportunities and Future Directions – Case studies: Automobile, Aerospace, Healthcare.

UNIT II	DESIGN FOR ADDITIVE MANUFACTURING (DFAM)	9

Concepts and Objectives – AM Unique Capabilities – Part Consolidation – Topology Optimization – Generative Design – Lattice Structures – Multi-Material Parts and Graded Materials – Data Processing: CAD Model Preparation – AM File Formats: STL – Problems with STL – AMF – Design for Part Quality Improvement: Part Orientation, Support Structure, Slicing, Tool Path Generation – Design Rules for Extrusion-Based AM.

UNIT III	VAT POLYMERIZATION AND DIRECTED ENERGY DEPOSITION	9

Photopolymerization: Stereolithography Apparatus (SLA) – Materials, Process – Top-Down and Bottom-Up Approach – Advantages, Limitations, Applications. Digital Light Processing (DLP) – Process, Advantages, Applications. Continuous Liquid Interface Production (CLIP) Technology. Directed Energy Deposition: Laser Engineered Net Shaping (LENS) – Process, Material Delivery, Materials, Benefits, Applications.

UNIT IV	POWDER BED FUSION AND MATERIAL EXTRUSION	9

Powder Bed Fusion: Selective Laser Sintering (SLS) – Process, Powder Fusion Mechanism, Materials and Application. Selective Laser Melting (SLM), Electron Beam Melting (EBM) – Materials, Process, Advantages and Applications. Material Extrusion: Fused Deposition Modeling (FDM) – Process, Materials.

UNIT V	OTHER ADDITIVE MANUFACTURING PROCESSES	9

Binder Jetting: Three-Dimensional Printing – Materials, Process, Benefits, Limitations. Material Jetting: Multijet Modeling – Materials, Process, Benefits, Applications. Sheet Lamination: Laminated Object Manufacturing (LOM) – Basic Principle, Mechanism: Gluing or Adhesive Bonding, Thermal Bonding.

TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED (Highest Level)
At the end of the course, the students will be able to		
CO1	recognize the evolution of Additive Manufacturing (AM) technologies, including its classification, process chain, applications, and emerging business opportunities	Understanding (K2)
CO2	demonstrate the design principles of Design for Additive Manufacturing (DfAM), including part consolidation, topology optimization, and data preparation techniques	Applying (K3)
CO3	illustrate the working principles and industrial applications of vat polymerization and direct energy deposition processes.	Applying (K3)
CO4	describe the working mechanisms, materials, and applications of Powder Bed Fusion and Material Extrusion technologies.	Understanding (K2)
CO5	apply the knowledge of binder jetting, material jetting, and sheet lamination techniques to identify their benefits,	Applying (K3)

TEXT BOOKS

1. Ian Gibson, David Rosen, Brent Stucker, Mahyar Khorasani "Additive manufacturing technologies". 3rd edition Springer Cham, Switzerland. (2021). ISBN: 978-3-030-56126-0

2. Andreas Gebhardt and Jan-Steffen Hotter "Additive manufacturing" 3D Printing for Prototyping and Manufacturing", Hanser publications United States, 2015.
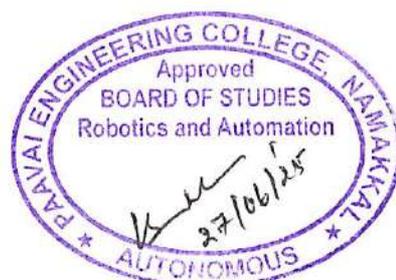
REFERENCES

1. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing", Hanser Gardner Publication, Cincinnati., Ohio, 2011

2. Milan Brandt, "Laser Additive Manufacturing: Materials, Design, Technologies, and Applications", Woodhead Publishing., United Kingdom, 2016, ISBN: 9780081004333

3. Amit Bandyopadhyay and Susmita Bose, "Additive manufacturing ", 1st Edition, CRC Press., United states, 2015, ISBN-13: 978-1482223590.

4. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer., United States,2006,

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	-	-	-	1	2	1	2	2	2
CO2	3	3	2	2	2	-	-	-	2	1	2	1	3	2
CO3	3	3	2	1	1	-	-	-	1	2	1	2	2	2
CO4	3	3	2	2	1	-	-	-	1	2	1	2	2	2
CO5	3	3	2	1	2	-	-	-	1	1	2	2	1	2

RA23502	MOBILE ROBOTICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce mobile robotic technology and its types in detail
2	learn the kinematics of wheeled and legged robot.
3	familiarize the intelligence into the mobile robots using various sensors
4	acquaint the localization strategies and mapping technique for mobile robot
5	aware the collaborative mobile robotics in task planning, navigation and intelligence.

UNIT I	INTRODUCTION TO MOBILE ROBOTICS	9

Introduction – Locomotion of the Robots – Key Issues on Locomotion – Legged Mobile Robots – Configurations and Stability – Wheeled Mobile Robots – Design Space and Mobility Issues – Unmanned Aerial and Underwater Vehicles – Teleportation and Control.

UNIT II	KINEMATICS	9

Kinematic Models – Representation of Robot – Forward Kinematics – Wheel and Robot Constraints – Degree of Mobility and Steerability – Manoeuvrability – Workspace – Degrees of Freedom – Path and Trajectory Considerations – Motion Controls – Holonomic Robots – Open-Loop and Feedback Motion Control – Humanoid Robot – Kinematics Overview.

UNIT III	PERCEPTION	9

Sensors for Mobile Robots – Classification and Performance Characterization – Wheel/Motor Sensors – Heading Sensors – Ground-Based Beacons – Active Ranging – Motion/Speed Sensors – Vision-Based Sensors – Uncertainty – Statistical Representation – Error Propagation – Feature Extraction Based on Range Data (Laser, Ultrasonic, Vision-Based Ranging) – Visual Appearance-Based Feature Extraction.

UNIT IV	LOCALIZATION	9

The Challenge of Localization – Sensor Noise and Aliasing – Effector Noise – Localization-Based Navigation versus Programmed Solutions – Belief Representation – Single-Hypothesis Belief and Multiple-Hypothesis Belief – Map Representation – Continuous Representations – Decomposition Strategies – Current Challenges in Map Representation – Probabilistic Map-Based Localization – Markov Localization – Kalman Filter Localization – Landmark-Based Navigation – Globally Unique Localization – Positioning Beacon Systems – Route-Based Localization – Autonomous Map Building – Stochastic Map Technique – Other Mapping Techniques – Simultaneous Localization and Mapping (SLAM).

UNIT V	PLANNING, NAVIGATION AND COLLABORATIVE ROBOTS	9

Introduction – Competences for Navigation: Planning and Reacting – Path Planning – Obstacle Avoidance – Navigation Architectures – Modularity for Code Reuse and Sharing – Control Localization – Techniques for Decomposition – Case Studies – Collaborative Robots – Swarm Robots.

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest Level)
CO1	identify suitable mobile robots based on application needs and locomotion types	Understanding (K2)
CO2	understand different sensors used in mobile robots to enhance perception and intelligence.	Understanding (K2)
CO3	inspect the kinematic models and motion control strategies for legged and wheeled robots	Analysing (K2)
CO4	apply localization and mapping techniques like SLAM and Kalman filter for robot navigation	Applying (K3)
CO5	describe collaborative and swarm robot systems used for navigation and planning tasks	Understanding (K2)

TEXT BOOKS

1. Roland Siegwart and IllahR.Nourbakish, "Introduction to Autonomous Mobile Robots" MIT Press, Cambridge, 2004.

2. Dragomir N. Nenchev, Atsushi Konno, TeppeiTsujita, "Humanoid Robots: Modelling and Control", Butterworth-Heinemann, 2018
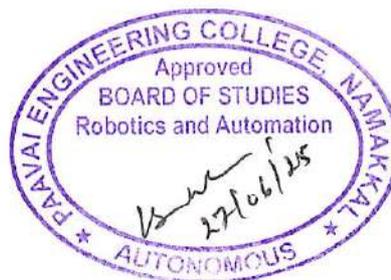
REFERENCES

1. MohantaJagadish Chandra, "Introduction to Mobile Robots Navigation", LAP Lambert Academic Publishing, 2015.

2. Peter Corke, "Robotics, Vision and Control", Springer, 2017.

3. Alonzo Kelly, Mobile Robotics: Mathematics, Models, and Methods, Cambridge University Press, 2013

4. Xiao Qi Chen, Y.Q. Chen and J.G. Chase, "Mobile Robots - State of the Art in Land, Sea, Air, and Collaborative Missions", Intec Press, 2009.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	-	-	-	1	1	2	2	2	2
CO2	3	3	3	2	2	-	-	-	1	1	2	2	3	2
CO3	3	2	3	2	2	-	-	-	2	2	1	2	2	3
CO4	3	3	2	3	2	-	-	-	1	2	1	3	3	2
CO5	3	3	3	2	3	-	-	-	2	2	2	3	3	3

RA23503	EMBEDDED SYSTEMS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce the foundational concepts, key components, and development challenges of embedded systems and firmware.
2	explore the core hardware components of embedded systems including CPU, memory, and I/O subsystems.
3	analyze the structure of real-time systems with focus on multitasking, scheduling, and operating
4	understand synchronization mechanisms and effective inter-task communication in real-time systems.
5	examine synchronization techniques and inter-task communication to assess their effectiveness in real-time embedded applications.

UNIT I	INTRODUCTION	9

Functional Building Blocks – Characteristics – Challenges in Embedded System Design – Embedded System Design Processes – Embedded Firmware Design and Development – Assembly, Linking and Loading, Basic Compilation Techniques – Quality Assurance.

UNIT II	EMBEDDED SYSTEM COMPONENTS	9

CPUs – Bus-Based Computer Systems: CPU Bus – Memory Management: Dynamic Memory Allocation and Fixed-Size Memory Allocation – I/O Subsystems – Exceptions and Interrupts.

UNIT III	REAL-TIME SYSTEM CONCEPTS	9

Processes – Threads and Tasks – Task States – Multi-Tasking – Context Switch – Kernel – Scheduler – Pre-emptive RTOS – Priority-Based Scheduling – Power Management and Optimization for Processes – Program Optimization – Introduction to Vx Works, RT Linux.

UNIT IV	RESOURCE MANAGEMENT AND INTER-TASK COMMUNICATION	9

Critical Sections – Semaphores: Binary, Counting and MUTEX – Common Design Problems: Premature Task Deletion and Deadlocks – Inter-task Communication: Shared Memory Technique, Mailbox and Message Queues.

UNIT V	APPLICATIONS	9

Real-Time Embedded Systems in Healthcare: Health Monitoring Gadgets – Automotive: Adaptive Cruise Control System – Automation: Smart Elevator System – Consumer Electronics: Digital Camera.

TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest Level)
CO1	understand the design flow, firmware development process, and compilation techniques for embedded systems.	Understanding (K2)
CO2	analyze the internal architecture and functionality of bus systems, memory allocation, and I/O handling.	Understanding (K2)

CO3	gain knowledge on task management, real-time scheduling, and power optimization in embedded environments.	Applying (K3)
CO4	implement semaphores and communication techniques to handle concurrency and prevent deadlocks.	Analyzing (K4)
CO5	apply embedded system concepts to design and analyze domain-specific real-time applications.	Applying (K3)

TEXT BOOKS

1. Wayne Wolf, "Computers as Components: Principles of Embedded Computer Systems Design", Morgan Kaufmann.

2. Jean J Labrosse, "Embedded Systems Building Blocks", 2nd Edition, R & D Books, 2000.

REFERENCES

1. Giorgio C. Buttazzo, "Hard Real-Time Computing Systems", Springer, New York, 2011

2. Brian Amos, "Hands-On RTOS with Microcontrollers", Packt Publishing, 2020.

3. Sam Siewert, John Pratt, "Real Time Embedded Components and Systems with Linux and RTOS", Mercury Learning and Information, New Delhi, 2016

4. Raj Kamal, "Embedded Systems Architecture, Programming and Design", Tata McGraw Hill Education Private Ltd., 2011.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	-	-	-	1	1	1	2	3	3
CO2	3	3	3	2	3	-	-	-	2	2	2	2	3	3
CO3	3	3	3	2	3	-	-	-	2	1	2	2	3	3
CO4	3	2	3	2	2	-	-	-	1	2	2	3	2	3
CO5	3	3	3	2	3	-	-	-	2	2	2	3	3	3

RA23504	INDUSTRIAL AUTOMATION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the design of signal conditioning circuits for various applications.
2	apply knowledge of signal transmission techniques to infer effective circuit designs.
3	understand the of components used in data acquisition systems interface techniques
4	interpret the components used in distributed control systems
5	introduce the communication buses used in automation industries

UNIT I	INTRODUCTION	9

Automation overview – Requirement of automation systems – Architecture of industrial automation system – Introduction to PLC and Supervisory Control and Data Acquisition (SCADA) – Industrial bus systems: Modbus and Profibus.

UNIT II	AUTOMATION COMPONENTS	9

Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity, and pH measurement – Actuators – Process control valves – Power electronic devices: DIAC, TRIAC, power MOSFET, and IGBT – Introduction to DC and AC servo drives for motion control.

UNIT III	COMPUTER AIDED MEASUREMENT AND CONTROL SYSTEMS	9

Role of computers in measurement and control – Elements of computer-aided measurement and control – Man-machine interface – Computer-aided process control hardware – Process-related interfaces – Communication and networking – Industrial communication systems – Data transfer techniques – Computer-aided process control software – Computer-based data acquisition system – Internet of Things (IoT) for plant automation.

UNIT IV	PROGRAMMABLE LOGIC CONTROLLERS	9

Programmable controllers – Programmable Logic Controllers – Analog and digital input/output modules – PLC programming – Ladder diagram – Sequential flow chart – PLC communication and networking – PLC selection – PLC installation – Advantages of using PLC for industrial automation – Applications of PLC in process control industries.

UNIT V	DISTRIBUTED CONTROL SYSTEM	9

Overview of DCS – DCS software configuration – DCS communication – DCS supervisory computer tasks – DCS integration with PLC and computers – Features of DCS – Advantages of DCS.

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED (Highest Level)
At the end of the course, the students will be able to	
CO1	describe signal conditioning circuits for various applications.	Understanding (K2)
CO2	illustrate the data acquisition system interface and DCS system in detail.	Understanding (K2)

CO3	explain the basics and importance of communication buses in applied automation engineering.	Understanding (K2)
CO4	apply timer/counter, arithmetic, and logic instructions to design PLC programs using ladder logic.	Applying (K3)
CO5	develop PLC logic for real-world industrial applications.	Applying (K3)

TEXT BOOKS

1. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw-Hill, New York, 2016.

2. S.K.Singh, "Industrial Instrumentation", Tata Mcgraw Hill, 2nd edition companies, 2003.

REFERENCES

1. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003

2. Krishna Kant, "Computer - Based Industrial Control", 2nd Edition, Prentice Hall, New Delhi, 2011.

3. Gary Dunning, Thomson Delmar, "Programmable Logic Controller", Ceneage Learning, 3rd Edition, 2005.

4. C D Johnson, "Process Control Instrumentation Technology", Prentice Hall India, 8th Edition, 2006.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	-	-	-	1	1	1	2	2	2
CO2	3	3	3	2	3	-	-	-	2	1	2	2	3	2
CO3	3	2	3	2	3	-	-	-	2	2	2	2	3	3
CO4	3	3	3	2	3	-	-	-	2	2	2	3	3	3
CO5	3	2	2	3	2	-	-	-	1	2	2	3	2	3

RA23505	DESIGN OF ROBOT ELEMENTS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the fundamentals of machine design and material selection to solve basic design problems.
2	derive essential parameters for modelling links and joints in robotic systems.
3	explore the core principles of computer graphics and geometric transformations used in CAD environments.
4	identify appropriate motion control components for automation systems based on application needs.
5	apply design concepts to develop effective robotic gripper mechanisms.

UNIT I	FUNDAMENTALS OF MECHANICAL DESIGN	9

Fundamentals of Machine Design – Engineering Design, Phases of Design, Design Considerations – Standards and Codes – Design against Static and Dynamic Load – Modes of Failure, Factor of Safety, Principal Stresses, Theories of Failure – Stress Concentration, Stress Concentration Factors, Variable Stress, Fatigue Failure, Endurance Limit, Design for Finite and Infinite Life, Soderberg and Goodman Criteria.

UNIT II	DESIGN OF LINKS AND JOINTS	9

Loads and Forces on Links and Joints – Design of Solid and Hollow Shafts – Rigid and Flexible Couplings – Threaded Fasteners – Rolling Contact Bearings – Links Design: Path and Motion Synthesis – Cognate Linkages – Design of Spherical Joints – Design of Fixtures for Simple Applications.

UNIT III	FUNDAMENTALS OF COMPUTER GRAPHICS	9

Product cycle- Design process - Computer Aided Design – Computer graphics – co-ordinate systems- 2D and 3D transformations- homogeneous coordinates - graphic primitives (point, line, circle drawing algorithms) - Clipping- viewing transformation- Representation of curves - Hermite cubic spline curve, Bezier curve, B-spline curves.

UNIT IV	MOTION COMPONENTS	9

Selection of Servomotor for Automation System – Inertia Force Calculation – LM Guideways – Selection of LM Guideways for Specific Applications – Ball Screws – Selection of Ball Screws for Specific Applications.

UNIT V	DESIGN OF GRIPPERS	9

Grippers – Types of Grippers Mechanisms – Gripping Methods – Gripping Force analysis – Gripper Design – Two Finger gripper – Three Finger Gripper – Magnetic Gripper Design – Vacuum Gripper Design – Hooks – Scoops – Spools – Miscellaneous Grippers

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED (Highest Level)
At the end of the course, the students will be able to	
CO1 identify the design parameters for developing various components of a	Understanding (K2)

	robot.	
CO2	analyze shaft, keys, keyway, flange, and coupling design for specific applications.	Analyzing (K4)
CO3	apply 2D/3D transformations, curve representations, and implement basic drawing and clipping	Applying (K3)
CO4	analyze and select appropriate servomotors, linear motion guideways, and ball screws for various	Analyzing (K4)
CO5	design a robot gripper model for specific mechanical tasks.	Analyzing (K4)

TEXT BOOKS

1. Bhandari V B, "Design of Machine Elements", 5th Edition , Tata McGraw-Hill Book Co, 2020

2. Joseph Shigley, Richard G. Budynas and J. Keith Nisbett "Mechanical Engineering Design", 10th Edition, Tata McGraw-Hill , 2015.

REFERENCES

1. Sundararajamoorthy T. V. and Shanmugam .N, "Machine Design", Anuradha Publications, Chennai, 2021.

2. Robert L.Norton , "Machine design –An Intergrated Approach", Prentice Hall International Edition, 2020

3. Sharma. C.S. and Kamlesh Purohit, "Design of Machine Elements", Prentice Hall of India Private Limited, 2003

4. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.
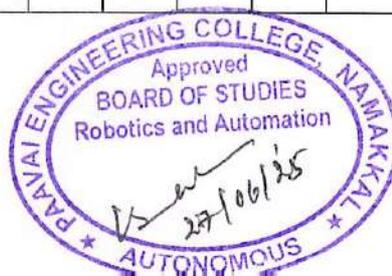
CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	-	-	-	1	1	1	2	2	2
CO2	3	3	3	2	2	-	-	-	1	1	2	2	3	2
CO3	3	3	3	2	2	-	-	-	2	1	2	2	3	2
CO4	3	2	3	2	2	-	-	-	1	2	2	3	2	3
CO5	3	3	3	3	3	-	-	-	2	2	2	3	3	3

RA23506	EMBEDDED SYSTEMS LABORATORY	0	0	2	1

COURSE OBJECTIVES

To enable the students to

1	understand and implement arithmetic and logical operations using 8051 assembly language
2	familiarize students with the process of integrating external input devices to a microcontroller
3	provide students with practical skills to drive various output devices through microcontroller signals
4	integrate multiple devices to design and simulate a real-time embedded system

LIST OF EXPERIMENTS

1. Programming using Arithmetic instruction of 8051.(Addition subtraction)
2. Programming using Arithmetic instruction of 8051.(Multiplication division)
3. Programming using logical instructions of 8051(Ascending , Descending)
4. Program for reading and writing of a file
5. Interfacing of keyboard
6. Interfacing of ADC and DAC
7. Interfacing of. 7 segment displays
8. Interfacing of Temperature sensor
9. Interfacing of Stepper motor
10. Interfacing of Traffic light control

TOTAL PERIODS : 30

COURSE OUTCOMES

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

		BT MAPPED (Highest Level)
CO1	apply arithmetic and logical instruction operations in embedded programs to solve real-time problems using the 8051 microcontroller.	Applying (K3)
CO2	analyze and configure a matrix keyboard to detect and process key inputs.	Analyzing (K4)
CO3	apply output device interfacing techniques to display numbers and characters, and generate signals.	Applying (K3)
CO4	design and implement a microcontroller-based traffic light control system	Applying (K3)

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	-	2	-
CO2	3	2	2	-	-	-	-	-	-	-	-	-	2	-
CO3	3	2	2	-	-	-	-	-	2	-	-	-	3	2
CO4	3	2	2	-	-	-	-	-	2	-	-	-	3	2

RA23507	INDUSTRIAL AUTOMATION LABORATORY	0	0	2	1

COURSE OBJECTIVES

To enable the students to

1	familiar and exercise the design procedure of various types of pneumatic and hydraulic fluid power circuits.
2	practice the fundamentals of Programmable Logic Controller
3	design and verify electro-pneumatic and sequencing circuits experimentally
4	understand and analyze basic pneumatic and hydraulic control circuits

LIST OF EXPERIMENTS

1. Experimental Verification of Speed Control Circuits in Pneumatic and Hydraulic Trainer.
2. Experimental Verification of Single and Double Acting Cylinder Circuits Using Different Directional Control Values
3. Experimental Verification of Electro-Pneumatic Circuits
4. Experimental Verification of Pneumatic Sequencing Circuits
5. Experimental Verification of Logic, Metre-in and Metre-out Pneumatic Circuits
6. Experimental Verification of Electro Pneumatic Sequencing Circuits.
7. Sequential operation of Pneumatic cylinder using PLC
8. Hydraulic motor with Timer using PLC
9. Automate the tank water level control using PLC
10. Automatic bottle filling process using PLC

	TOTAL PERIODS :30

COURSE OUTCOMES	BT MAPPED (Highest Level)
At the end of the course, the students will be able to	
CO1	analyze and demonstrate speed control and cylinder actuation using pneumatic and hydraulic systems.	Analyzing (K4)
CO2	construct and verify electro-pneumatic and sequencing circuits using appropriate control valves.	Applying (K3)
CO3	develop PLC-based automation for industrial applications like water level and motor control.	Analyzing (K4)
CO4	design and simulate automated industrial processes like bottle filling using PLC and actuators.	Analyzing (K4)

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COS	Programme Outcomes(POs)													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	1	-	-	1	2	-	1	3	2
CO2	3	3	2	2	3	1	-	-	1	2	-	2	3	2
CO3	2	2	3	2	3	1	-	-	2	3	1	2	2	3
CO4	2	2	3	2	3	2	-	-	3	3	1	2	3	3

RA23508	INDUSTRIAL TRAINING	0	0	2	1

COURSE OBJECTIVES

To enable the students to

1	know Automation experience and knowledge which is required in industry, where these are not taught in the lecture rooms.
2	apply the Robotics knowledge taught in the lecture rooms in real industrial situations and get a feel of the work environment.
3	know the Robotics safety responsibilities and ethics.
4	identify the concept of Robotics Automation towards the Industry.

DESCRIPTION

Industrial Training provides work experience relevant to their field of specialization, before graduation, and it is an essential component for the development of practical and professional skills required for an engineering graduate and supports for prospective employment.

At the end of the industrial training, students should be able to improve their knowledge and skills relevant to their areas of specialization where they have been trained. The students should also be able to relate, apply, and adapt the relevant knowledge, concepts, and theories within an industrial organization, and also to practice the general workplace behavior and interpersonal skills.

The student (either in group or single) should undergo industrial training for a minimum period of two weeks during the summer vacation after the completion of fourth semester as specified in the curriculum in any research organization/university/industry of State/National and International level industry relevant to their branch of specialization, after getting proper approval from the Head of the Institution.

On the completion of the industrial training for the specified period, the student has to submit the industrial training report (at least 25-30 pages) containing the following details, along with the certificate obtained from the industry for the period of training undergone.

1. Introduction of the industry.

2. Industry layout and its various operations with its infrastructure facilities.

3. Formulation of practical problems, data required to formulate the problems and its analysis.

4. Suggestions and recommendations for the above problems

During the period of training, the student has to abide the rules and regulations enforced by the organization and to ensure FULL attendance during the period of industrial training and uphold the discipline and decorum of the institution.

On the completion of the industrial training, the End Semester Examinations shall be conducted by the Office of the Controller of Examinations at the end of the fifth semester. A three-member committee constituted by the Head of the Institution, consisting of (1) a senior faculty member at the Professor level, (2) senior faculty member at the Associate Professor and (3) faculty member from outside the department, will evaluate the industrial training undergone by the student. The evaluation shall be made based on the report submitted along with the presentation and a Viva voce Examination.

		TOTAL PERIODS :30
COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest level)
CO1	analyse practical problems encountered during industrial training by identifying relevant data, examining possible cause's solutions.	Analysing (K2)
CO2	explain the structure, layout, operations, and infrastructure facilities of the industry/organization where training is undertaken.	Understanding (K2)
CO3	apply theoretical knowledge and concepts of the area of specialization to analyse industrial problems and suggest feasible solutions.	Applying (K3)
CO4	interpret workplace practices, organizational rules, and professional ethics required in an industrial environment.	Understanding (K2)

CO - PO MAPPING
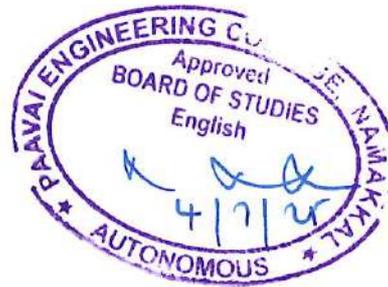
Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	-	-	-	-	-	-	2	1	3
CO2	1	-	-	-	-	-	-	-	-	-	-	2	1	3
CO3	2	2	-	-	-	-	-	-	-	-	-	3	2	3
CO4	3	2	2	2	2	-	-	-	-	-	-	3	3	3

GE23501	PROFESSIONAL DEVELOPMENT III	0	0	2	1

COURSE OBJECTIVES

To enable students to

1.	enhance their Resume writing skills and improving corporate vocabularies to survive in the corporate world.
2.	evaluate their interview skills and improve their interview presentation.
3.	solve the quantitative aptitude problems and improve their mental ability.
4.	improve critical thinking and reasoning skills.

UNIT I	RESUME WRITING SKILLS	6

Updated Resume Building III – Self Introduction III – Dressing Etiquette – JAM V – Corporate Vocabulary.

UNIT II	INTERVIEW SKILLS	6

Interview skills – General guidelines - Work Ethics – Group Discussion III – JAM VI – Presentation Competence – Mock Interview.

UNIT III	QUANTITATIVE APTITUDE	9

Cube Root and Square Root - Time and Work - Ages - Permutation and Combination - Probability – Calendar.

UNIT IV	LOGICAL REASONING	9

Series Completion - Blood Relations - Coding and Decoding - Data Sufficiency - Statements and Assumptions.

	TOTAL PERIODS:	30

COURSE OUTCOMES Upon completion of the course, the students will be able to	BT MAPPED (Highest Level)
CO1 excel in drafting Resumes and speaking.	Applying (K3)
CO2 demonstrate the participative skills in group discussions and Interviews.	Applying (K3)
CO3 solve problems based on quantitative aptitude.	Applying (K3)
CO4 enhance their logical and verbal reasoning.	Analyzing (K4)

TEXTBOOKS

1. Aggarwal, R. S. A Modern Approach to Verbal & Non-Verbal Reasoning. Revised ed., 2024–25, S. Chand & Company Ltd., 2024.

2. Aggarwal, R. S. Objective General English: Fully Revised Video Edition. S. Chand & Company Ltd., 2022.

REFERENCES

1. Abhijit Guha, "Quantitative Aptitude ", Tata-Mcgraw Hill.2015.

2. Word Power Made Easy By Norman Lewis, Wr.Goyal Publications.2016.

3. Johnson, D.W. Reaching out — Interpersonal Effectiveness and self- actualisation. Boston: Allyn and Bacon.2019.

4. Infosys Campus Connect Program — students' guide for soft skills.2015.

CO/PO MAPPING:

Mapping of Course Outcome (CO's) with Programme Outcomes (PO's)
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	Programme Outcomes (PO's)													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
CO1	3	2	2	3	3	1	-	-	-	-	-	-	3	2
CO2	-	2	3	-	2	-	2	-	-	-	-	-	3	2
CO3	3	2	2	2	-	-	1	-	-	-	-	-	2	3
CO4	3	2	2	-	-	1	-	-	-	-	2	-	2	3

RA23151		MEDICAL ROBOTS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce the fundamental concepts of medical robotics
2	explain different robotic tracking technologies and their working principles.
3	inculcate the diverse applications of robotics in surgery
4	emphasize the importance of robotics in Rehabilitation and medical care
5	familiarize the methodologies for design of medical robots

UNIT I	INTRODUCTION	9

Types of Medical Robots: Navigation, Motion Replication, Imaging, Rehabilitation, and Prosthetics – State of the Art of Robotics in the Field of Healthcare – Localization and Tracking: Position Sensor Requirements.

UNIT II	ROBOTIC TRACKING METHODS	9

Tracking: Mechanical Linkages, Optical, Sound-Based, Electromagnetic, Impedance-Based, In-Bore MRI Tracking, Video Matching, Fiber Optic Tracking Systems, Hybrid Systems.

UNIT III	APPLICATIONS OF SURGICAL ROBOTICS	9

Applications of Surgical Robotics: Radiosurgery, Orthopedic Surgery, Urologic Surgery and Robotic Imaging, Cardiac Surgery, Neurosurgery, ENT Surgery.

UNIT IV	ROBOTS IN REHABILITATION	9

Robots in Rehabilitation: Rehabilitation for Limbs, Brain-Machine Interfaces, Steerable Needles.

Robots in Medical Care: Assistive Robots – Types of Assistive Robots – Case Studies.

UNIT V	DESIGN OF MEDICAL ROBOTS	9

Design of Medical Robots: Characterization of Gestures to the Design of Robots – Design Methodologies – Technological Choices – Security – Case Studies.

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	understand the sensor requirements for accurate position tracking in medical robots.	Understanding (K2)
CO2	select specialized tracking systems such as in-bore MRI and fiber-optic systems.	Understanding (K2)
CO3	describe different methods of surgical robots and their applications.	Understanding (K2)
CO4	review the methodologies for implementing medical robots using case studies.	Applying (K3)
CO5	design robots for rehabilitation and medical care applications.	Analysing (K4)

TEXT BOOKS

1. Achim Schweikard and Floris Ernst, Medical Robotics, Springer, 2015.

2. Paula Gomes, Medical robotics: Minimally invasive surgery, Woodhead Publishing Limited, 2012.

REFERENCES

1. Roberto Colombo and Vittorio Sanguineti, Rehabilitation Robotics: Technology and Application, Academic Press, 2018.

2. Pedro Encarnação and Albert M. Cook, Robotic Assistive Technologies: Principles and Practice, CRC Press, 2017.

3. Jocelyne Troccaz, Medical Robotics, John Wiley & Sons, 2012

4. Introduction to Medical Robotics, Nadine Sarter Publisher: Cambridge University Press

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	-	-	-	-	-	1	2	2
CO2	3	2	1	2	-	-	-	-	-	-	-	1	2	2
CO3	3	3	1	2	-	-	-	-	-	-	-	1	2	2
CO4	3	3	3	3	-	-	-	-	-	-	-	1	2	2
CO5	3	3	3	3	-	-	-	-	-	-	-	1	2	2

Approved
BOARD OF STUDIES
Robotics and Automation
27/06/25

RA23152	HUMANOID ROBOTS	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	learn the knowledge of the kinematics and dynamics of Humanoid Robots.
2	familiarize the generation of biped walking patterns and control.
3	impart the design of different methods for generation of Whole-Body Motion Patterns.
4	inculcate the methods for simulating humanoid robot dynamics.
5	understand the principles and mathematical models governing the dynamics of rigid bodies

UNIT I	INTRODUCTION	9

Introduction – Kinematics: Coordinate Transformations, Characteristics of Rotational Motion, Velocity in Three-Dimensional Space – Robot Data Structure and Programming – Kinematics of a Humanoid Robot.

UNIT II	HUMANOID ROBOT DYNAMICS	9

Zero Moment Point (ZMP) and Dynamics: ZMP and Ground Reaction Forces, Measurement of ZMP, Dynamics of Humanoid Robots, Calculation of ZMP from Robot's Motion.

UNIT III	BIPEDAL WALKING PATTERN GENERATION AND CONTROL	9

Biped Walking: How to Realize Biped Walking – Two-Dimensional Walking Pattern Generation – 3D Walking Pattern Generation – ZMP-Based Walking Pattern Generation – Stabilizer – Pioneers of Dynamic Biped Walking Technology – Additional Methods for Biped Control.

UNIT IV	STABILITY IN HUMANOID ROBOTS	9

Generation of Whole-Body Motion Patterns: How to Generate Whole-Body Motion – Converting Whole-Body Motion Patterns to Dynamically Stable Motion – Remote Operation of Humanoid Robots with Whole-Body Motion Generation – Reducing the Impact of a Humanoid Robot Falling Backwards.

UNIT V	DYNAMIC SIMULATION	9

Dynamic Simulation: Dynamics of Rotating Rigid Body, Spatial Velocity, Dynamics of Rigid Body – Dynamics of Link System: Forward and Inverse Dynamics – Featherstone's Method.

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	understand the kinematics and dynamics of Humanoid Robots	Understanding (K2)
CO2	describe the design principles for generating biped walking patterns and control.	Understanding (K2)
CO3	infer whole-body motion patterns for humanoid robots.	Applying (K3)
CO4	review different methods for simulating humanoid robot dynamics.	Applying (K3)
CO5	apply forward and inverse dynamics formulations to multi-link robotic mechanisms	Applying (K3)

TEXT BOOKS

1. Dragomir N. Nenchev, Atsushi Konno, Teppei Tsujita, Humanoid Robots: Modelling and Control, Butterworth-Heinemann,2019

2. Shuuji Kajita, Hirohisa Hirukawa, Kensuke Harada and Kazuhito Yokoi, Introduction to Humanoid Robotics, Springer, 2014.

REFERENCES

1. Ben Choi, Humanoid Robots, In-Tech, 2019.

2. Matthias Hackel, Humanoid Robots: Human-like Machines, I-Tech Education and Publishing, 2007.

3. Roy Featherstone, Rigid Body Dynamics Algorithms, Springer, 2008

4. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Robot Modeling and Control, Wiley, 2006

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	-	-	-	-	-	-	-	1	2	2
CO2	3	3	2	2	-	-	-	-	-	-	-	1	2	2
CO3	3	3	2	2	1	-	-	-	-	-	-	1	2	2
CO4	3	3	2	2	2	-	-	-	-	-	-	1	2	2
CO5	3	3	2	2	2	-	-	-	-	-	-	1	2	2

RA23153	MACHINE LEARNING AND COGNITIVE ROBOTICS	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	introduce the fundamentals of machine learning and its integration into cognitive robotics, focusing on robotic perception and decision-making.
2	explore supervised and unsupervised learning techniques and their applications in robotics tasks such as object recognition and mapping.
3	study reinforcement learning algorithms and their implementation in robotic control and decision-making in dynamic environments.
4	examine cognitive architectures, memory integration, and human-robot interaction for enhancing collaborative and social capabilities in robots.
5	delve into advanced topics such as deep learning, transfer learning, ethics, and emerging trends in cognitive robotics.

UNIT I	INTRODUCTION TO MACHINE LEARNING AND ROBOTICS	9

Overview of Machine Learning (ML): Fundamentals of ML, types of learning (supervised, unsupervised, and reinforcement learning), and key algorithms. Introduction to Cognitive Robotics: Definition, scope, and differences between cognitive and traditional robotics. Role of ML in Robotics: Applications of ML in robotic perception, navigation, and decision-making. Basics of Robotics Perception: Sensor data processing, feature extraction, and pattern recognition.

UNIT II	SUPERVISED AND UNSUPERVISED LEARNING IN ROBOTICS	9

Supervised Learning: Algorithms like linear regression, decision trees, support vector machines, and neural networks, with a focus on their applications in robotic tasks. Unsupervised Learning: Clustering techniques, principal component analysis (PCA), and their use in data-driven robotic perception and exploration. Application in Robotics: Use cases for supervised and unsupervised learning in object recognition, localization, and mapping.

UNIT III	REINFORCEMENT LEARNING FOR ROBOTIC CONTROL	9

Fundamentals of Reinforcement Learning (RL): Concepts of rewards, states, actions, and policies. RL Algorithms: Q-learning, deep Q-networks (DQNs), and policy gradient methods. Applications in Robotics: Implementing RL for robotic control, adaptive behaviors, and decision-making in dynamic environments. Case Studies: Examples of RL in robotic applications such as robotic arm manipulation, autonomous driving, and mobile robot navigation.

UNIT IV	COGNITIVE ARCHITECTURES AND LEARNING SYSTEMS	9

Cognitive Architectures for Robotics: SOAR, ACT-R, and other architectures for cognitive computing in robotics. Memory and Learning: Integration of short-term and long-term memory models, episodic memory, and learning from experience. Human-Robot Interaction (HRI): Techniques for natural interaction, understanding intent, and collaborative tasks. Social and Emotional Intelligence in Robots: Basics of affective computing and its role in developing socially aware robots.

Deep Learning in Robotics: Convolutional neural networks (CNNs) for image processing, recurrent neural networks (RNNs) for sequence learning, and their applications in robotics. Transfer Learning and Domain Adaptation: Enabling robots to adapt learned behaviors to new tasks or environments. Ethics and Safety in Cognitive Robotics: Addressing ethical considerations, human safety, and responsible AI use in cognitive robotics. Future Trends and Challenges: Emerging research areas such as explainable AI, continual learning, and brain-inspired computing for cognitive robotics.

	TOTAL PERIODS:45

COURSE OUTCOMES	**BT MAPPED**
At the end of the course, the students will be able to	(Highest level)

CO1	categorize the role of machine learning in cognitive robotics and infer basic robotic perception techniques for data processing and decision-making.	Analysing (K4)
CO2	utilize supervised and unsupervised learning techniques for robotic tasks such as object recognition, localization, and mapping.	Understanding (K2)
CO3	apply reinforcement learning algorithms for robotic control and adaptive behaviors in dynamic environments.	Applying (K3)
CO4	understand cognitive architectures for robotics, incorporating memory systems and enabling effective human-robot interaction.	Understanding (K2)
CO5	analyze advanced learning techniques such as deep learning and transfer learning in robotics while addressing ethical and safety concerns.	Analysing (K4)

TEXT BOOKS

1. Bishop, C. M, Pattern Recognition and Machine Learning. Springer, 2016

2. Sutton, R. S., & Barto, A. G, Reinforcement Learning: An Introduction, MIT Press, 2018.

REFERENCES

1. Goodfellow, I., Bengio, Y., & Courville, A., Deep Learning, MIT Press, 2016.

2. Russell, S., & Norvig, P., Artificial Intelligence: A Modern Approach, 4th Edition, Pearson, 2020.

3. Murphy, K. P., Machine Learning: A Probabilistic Perspective, MIT Press, 2012.

4. Siegwart, R., Nourbakhsh, I., & Scaramuzza, D., Introduction to Autonomous Mobile Robots, MIT Press, 2011.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	3	-	-	-	1	2	-	2	2	1
CO2	3	3	3	2	3	-	-	-	2	2	-	2	3	3
CO3	3	3	3	3	3	2	-	-	2	3	-	3	3	3
CO4	3	3	3	3	3	-	-	-	2	2	-	2	3	3
CO5	3	3	3	3	3	2	-	-	3	3	2	2	3	3

RA23154	DRONE TECHNOLOGIES	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the basics of drone concepts
2	learn and understand the fundaments of design, fabrication and programming of drone
3	impart the knowledge of an flying and operation of drone
4	know about the various applications of drone
5	understand the safety risks and guidelines of fly safely

UNIT I	INTRODUCTION	9

Drone Concept – Vocabulary Terminology – History of Drones – Types of Current Generation of Drones Based on Their Method of Propulsion – Drone Technology Impact on Businesses – Drone Business Through Entrepreneurship – Opportunities/Applications for Entrepreneurship and Employability.

UNIT II	DRONE DESIGN, FABRICATION AND PROGRAMMING	9

Classifications of UAV – Overview of the Main Drone Parts – Technical Characteristics of the Parts – Function of the Component Parts – Assembling a Drone – The Energy Sources – Level of Autonomy – Drone Configurations – Methods of Programming Drones – Download Program – Install Program on Computer – Running Programs – Multi-Rotor Stabilization – Flight Modes – Wi-Fi Connection.

UNIT III	DRONE FLYING AND OPERATION	9

Concept of Operation for Drones – Flight Modes – AI-Driven Visual Servoing and Target Tracking – Operate a Small Drone in a Controlled Environment – Drone Controls – Flight Operations – Management Tools – Sensors – Onboard Storage Capacity – Removable Storage Devices – Linked Mobile Devices and Applications.

UNIT IV	DRONE COMMERCIAL APPLICATION	9

Choosing a Drone Based on the Application – Drones in the Insurance Sector – Drones in Delivering Mail, Parcels, and Other Cargo – Drones in Agriculture – Drones in Inspection of Transmission Lines and Power Distribution – Drones in Filming and Panoramic Picturing.

UNIT V	FUTURE DRONES AND SAFETY	9

The Safety Risks – Guidelines to Fly Safely – Specific Aviation Regulations and Standardization – Drone License – Miniaturization of Drones – Increasing Autonomy of Drones – The Use of Drones in Swarms.

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	understand various types of drone technologies, including fabrication and programming techniques.	Understanding (K2)
CO2	describe suitable operating procedures for the functioning of a drone.	Understanding (K2)

CO3	select appropriate sensors and actuators for drone applications.	Applying (K3)
CO4	implement the development of a drone mechanism for specific applications.	Applying (K3)
CO5	analyze and create programs for various types of drones.	Analysing (K4)

TEXT BOOKS

1. Daniel Tal and John Altschuld, "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation", 2021 John Wiley & Sons, Inc.

2. Terry Kilby and Belinda Kilby, "Make:Getting Started with Drones ", Maker Media, Inc, 2016
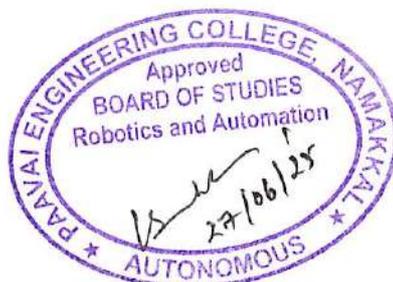
REFERENCES

1. John Baichtal, "Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs", Que Publishing, 2016

2. Zavrsnik, "Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance", Springer, 2018.

3. R. Beard, and T. W. McLain, "Small Unmanned Aircraft: Theory and Practice", Princeton University Press, 2012

4. Terry Kilby and Belinda Kilby" Make: Getting Started with Drones" Published by Maker Media

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	3	1	3	2	-	-	-	-	-	1	2	1
CO2	1	2	3	1	3	2	-	-	-	-	-	1	2	1
CO3	1	2	3	1	3	2	-	-	-	-	-	1	2	1
CO4	1	2	3	1	3	2	-	-	-	-	-	1	2	1
CO5	1	2	3	1	3	2	-	-	-	-	-	1	2	1

RA23155	MICRO ROBOTICS	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	understand micro systems and scaling laws for MEMS
2	acquaint actuators and sensors used for micro robots
3	understand and gain knowledge about microrobots
4	apply the knowledge gained about micro robots in the real time application
5	integrate micro fabrications and micro assembly into micro robots

UNIT I	SCALING LAWS AND MATERIALS FOR MEMS	9

MST (Micro System Technology) – Micromachining – Working Principles of Microsystems – Applications. Introduction – Scaling Laws – Scaling Effect on Physical and Electrical Properties – Scaling Effect on Physical Forces – Silicon-Compatible Material Systems – Shape Memory Alloys – Material Properties: Piezo-Resistivity, Piezoelectricity, and Thermoelectricity.

UNIT II	FLEXURES, ACTUATORS AND SENSORS	9

Elemental Flexures – Flexure Systems – Mathematical Formalism for Flexures – Electrostatic Actuators – Piezoelectric Actuators – Magnetostrictive Actuators – Electromagnetic Sensors – Optical-Based Displacement Sensors – Motion Tracking with Microscopes.

UNIT III	MICROROBOTICS	9

Introduction – Task-Specific Definition of Micro-Robots – Size and Fabrication Technology-Based Definition of Micro-Robots – Mobility and Functional-Based Definition of Micro-Robots – Applications for MEMS-Based Micro-Robots.

UNIT IV	IMPLEMENTATION OF MICROROBOTS	9

Arrayed Actuator Principles for Micro-Robotic Applications – Micro-Robotic Actuators – Design of Locomotive Micro-Robot Devices Based on Arrayed Actuators – Micro-Robotics Devices – Micro-Grippers and Other Micro-Tools – Micro-Conveyors – Walking MEMS Micro-Robots.

UNIT V	MICROFABRICATION AND MICROASSEMBLY	9

Multi-Robot System: Micro-Robot Powering, Micro-Robot Communication – Micro-Fabrication Principles – Design Selection Criteria for Micromachining – Packaging and Integration Aspects – Micro-Assembly Platforms and Manipulators.

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	understand the basic concepts and working principles of microrobots.	Understanding (K2)
CO2	interpret the sensors and actuators used in basic microrobot mechanisms.	Understanding (K2)

CO3	develop knowledge of fabrication techniques used for microrobots.	Applying (K3)
CO4	demonstrate the real-time applications of microrobots.	Understanding (K2)
CO5	analyze the process of fabrication and assembly of microrobots.	Analysing (K4)

TEXT BOOKS

1. Yves Bellouard, "Microrobotics Methods and Applications", CRC Press, Massachusetts, 2019.

2. Mohamed Gad-el-Hak , "The MEMS Handbook", CRC Press, New York, 2019.

REFERENCES

1. Nadim Maluf and Kirt Williams, "An Introduction to Microelectromechanical systems Engineering", Artech House, 2002

2. Metin Sitti, "Mobile Microrobotics", MIT Press, 2017

3. Nicolas Chaillet, Stephane Regnier, "Microrobotics for Micromanipulation", John Wiley & Sons, 2013.

4. Microsystem Design, Stephen D. Senturia Publisher: Springer Science & Business Media / Kluwer Academic Publishers

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	2	-	-	-	-	-	-	1	2	2
CO2	3	2	1	1	2	-	-	-	-	-	-	1	2	2
CO3	3	2	1	1	2	-	-	-	-	-	-	1	2	2
CO4	3	2	1	1	2	-	-	-	-	-	-	1	2	2
CO5	3	2	1	1	2	-	-	-	-	-	-	1	2	2

RA23156	ROBOT OPERATING SYSTEMS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	apply the principles and concepts of ROS in robotic systems
2	select and create robot environments using CAD tools and ROS packages
3	relate robots using Gazebo and integrate ROS controllers for joint movement
4	use V-REP as a multi-platform simulator for robotic arm and wheeled robot simulation.
5	implement mapping, navigation, and motion planning using ROS.

UNIT I	ROS ESSENTIALS	9

Introduction to ROS – Advantages and Disadvantages of ROS – ROS Framework – ROS Package (C++, Python) – ROS Computation Graph: Nodes, Messages, Topics, Services, Bags, ROS Master – ROS Community – Basic Programming and Syntax Overview in C++ and Python – Start with ROS Programming – Creating Environment – Services, Actions, and Nodes – Simple Interaction with the Simulation Environment.

UNIT II	BUILD YOUR OWN ROBOT ENVIRONMENT	9

CAD Tools for Robot Modelling – ROS Packages for Robot Modelling – Unified Robot Description Format (URDF) and Tags – Kinematics and Dynamics Library – Create URDF Model – Robot Modelling Using URDF – ROS Parameter Server and Adding Real-World Object Representations to the Simulation Environment – Create Robot Description Using 7 DOF: Joint Number, Name, Type, and Angle Limits – Xacro – Rviz – Viewing of 7 DOF Arm – Creation of Wheeled Robot.

UNIT III	SIMULATION ROBOTS IN ROS WITH GAZEBO	9

Robot Simulation – Gazebo – Create Simulation Model in Gazebo – Adding Colors, Textures, Transmission Tags, 3D Vision Sensor to Gazebo – Moving Robot Joints Using ROS Controllers – ROS Controller Interaction with Gazebo – Interfacing State Controller – Simulation of Moving the Robot Joints – Simulation of Differential Wheeled Robot in Gazebo.

UNIT IV	ROS WITH VREP	9

V-REP as a Multi-Platform Robotic Simulator – Simulating the Robotic Arm Using V-REP – Adding the ROS Interface to V-REP Joint – Simulating a Differential Wheeled Robot – Adding a Laser Sensor, 3D Vision Sensor.

UNIT V	MAPPING, NAVIGATION AND MOTION PLANNINGROS WITH MOVEIT	9

MoveIt Installation – Generating the Self-Collision Matrix, Virtual Joints, Planning Groups, Robot Poses, Robot End Effector – MoveIt Architecture Diagram – Trajectory from RViz GUI Executed in Gazebo – Planning Scene Overview Diagram – Collision Checking – Motion Planning – Pick and Place Behaviors Using Industrial Robots with ROS MoveIt – ROS with MATLAB – ROS with Industrial.

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED (Highest level)
At the end of the course, the students will be able to		
CO1	understand the application of ROS principles and concepts in practical robotic systems.	Understanding (K2)
CO2	describe the design and development of robot environments using CAD tools and ROS packages.	Understanding (K2)
CO3	apply Gazebo simulation to robot models and incorporate ROS controllers for joint manipulation.	Applying (K3)
CO4	illustrate the use of V-REP as a multi-platform simulator for realistic robot simulation scenarios.	Understanding (K2)
CO5	analyze mapping, navigation, and motion planning using ROS MoveIt for efficient robot motion.	Analysing (K4)

TEXT BOOKS

1. Lentin Joseph, Jonathan Cacace, "Mastering ROS for Robotics Programming", Second Edition, Packt Publishing, 2018

2. Programming Robots with ROS: A Practical Introduction to the Robot Operating System Morgan Quigley, Brian Gerkey, William D. Smart 2015
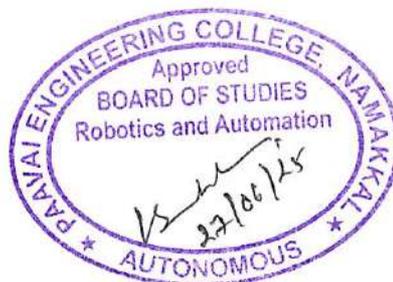
REFERENCES

1. Learning ROS for Robotics Programming, Aaron Martinez, Enrique Fernández

2. Effective Robotics Programming with ROS Anil Mahtani, Luis Sanchez, Enrique Fernandez, Aaron Martinez Publisher: Packt Publishing

3. A Systematic Approach to Learning Robot Programming with ROS Wyatt Newman Publisher: CRC Press 2017

4. ROS Robotics By Example , Carol Fairchild, Dr. Thomas L. Harman Publisher: Packt Publishing

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	-	-	-	-	-	-	-	1	1	2	1
CO2	2	1	2	-	-	-	-	-	-	-	1	1	2	1
CO3	2	1	2	-	-	-	-	-	-	-	1	1	2	1
CO4	2	1	2	-	-	-	-	-	-	-	1	1	2	1
CO5	2	1	2	-	-	-	-	-	-	-	1	1	2	1

RA23157		UAV AND UNDERWATER ROBOTICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	recognize the role of unmanned aerial vehicles (UAVs) in past, present, and future society.
2	comprehend the various components of UAVs.
3	describe the basics of flight and flight control systems.
4	describe the basic concepts of underwater robots.
5	understand the working of hydraulic systems in underwater vehicles.

UNIT I	INTRODUCTION	9

Definitions – History of UAVs – Classifications of UAVs – Scale – Lift Generation Method – Contemporary Applications: Military, Government, Civil – Societal Impact and Future Outlook – Operational Considerations – Liability / Legal Issues – Insurance – Ethical Implications – Human Factors – LOS / BLOS.

UNIT II	PAYLOAD FOR UAV	9

Introduction – Types – Non-Dispensable Payloads – Electro-Optic Payload Systems – Electro-Optic Systems Integration – Radar Imaging Payloads – Other Non-Dispensable Payloads – Dispensable Payloads – Payload Development.

UNIT III	UNMANNED AERIAL SYSTEM (UAS) COMPONENTS	9

Platforms – Configurations – Characteristics – Applications – Propulsion: Internal Combustion – On-board Flight Control – Payloads – Sensing / Surveillance – Weaponized – Delivery – Communications – Command / Control – Telemetry – Launch / Recovery Systems – Ground Control Stations.

UNIT IV	UNDERWATER ROBOTICS	9

Robotics in Water – Basic Representation of Underwater Robots – Types and Classification of Underwater Robotics – Differentiating Aerial and Underwater Robotics – Overview of Environmental Factors Affecting Objects in Water.

UNIT V	CONTROL SYSTEM AND MANIPULATOR	9

Control System and Types of Control Systems in Underwater Robotics – Sensors Connected with Underwater Robotics – Introduction to Underwater Manipulators – Introduction to Hydraulics on Underwater Vehicles – Applications of Underwater Vehicles. Autonomous Underwater Systems: Introduction to AUVs – Development of AUVs, ROVs in Market – Case Study on AUV Control System Basics – Case Study on Subsea Manipulator – Case Study on Technologies Used.

TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	analyze UAV applications in military, civil, and government sectors.	Analysing (K4)

CO2	understand the importance of payload systems in UAV performance.	Understanding (K2)
CO3	apply knowledge of communication, telemetry, and command/control systems in UAS.	Applying (K3)
CO4	describe the impact of underwater environmental conditions on robot performance.	Understanding (K2)
CO5	infer real-world case studies involving AUV control, manipulators, and commercial technologies.	Analysing (K4)

TEXT BOOKS

1. Roland Siegwant & Illah R. Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press, 2004.

2. Austin, Unmanned Aircraft Systems: UAVS Design, Development and Deployment. Wiley,

REFERENCES

1. Baichtal, Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs. Que Publishing, 2016.

2. Beard & McLain, Small Unmanned Aircraft: Theory and Practice. Princeton University Press, 2012.

3. Cares & Dickmann, Operations Research for Unmanned Systems. Wiley, 2016.

4. Gianluca Antonelli, - Underwater Robots‖, Springer, 2014.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	-	-	-	-	-	-	-	1	2	2
CO2	3	3	2	2	-	-	-	-	-	-	-	1	2	2
CO3	3	3	2	2	1	-	-	-	-	-	-	1	2	2
CO4	3	3	2	2	2	-	-	-	-	-	-	1	2	2
CO5	3	3	2	2	2	-	-	-	-	-	-	1	2	2

RA23251	ADVANCED METROLOGY AND SENSING SYSTEMS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce the principles of high-precision measurements and software-driven inspection methods including AFM and Talysurf instruments.
2	provide knowledge on laser-based metrology tools and in-process measurement systems for dimensional accuracy and surface evaluation.
3	develop understanding of CMMs, their applications, CNC integration, and non-contact measurement technologies.
4	study machine vision techniques, image processing, and automated quality control applications in manufacturing.
5	introduce nano-dimension measurement tools and microscopy techniques including XRD and its applications in material analysis.

UNIT I	COMPUTER-AIDED INSPECTION AND METROLOGY FUNDAMENTALS	9

High-precision measurements – Interfacing – Software metrology – Automated visual inspection in manufacturing – Contact and non-contact type inspection methods – Electrical field techniques – Radiation techniques – Ultrasonic inspection – Atomic Force Microscopes (AFM) – Talysurf instruments.

UNIT II	LASER METROLOGY AND IN-PROCESS MEASUREMENT SYSTEMS	9

Laser interferometer – Alignment telescope – Laser scanners – On-line and in-process measurements – Diameter measurement – Surface roughness – Micro hole inspection – Surface topography measurements – Straightness and flatness measurement – Speckle measurement techniques.

UNIT III	COORDINATE MEASURING MACHINES (CMM)	9

Types of CMMs – Applications – Non-contact CMMs using electro-optical sensors for dimensional metrology – Non-contact sensors for surface finish measurement – Measurement and programming with CNC CMMs – Performance evaluation – Measurement integration systems.

UNIT IV	MACHINE VISION AND QUALITY CONTROL SYSTEMS	9

Image acquisition and processing – Binary and gray level images – Image segmentation and labelling – Color representation – Edge detection techniques – Normalization – Grey scale correlation – Surface roughness and texture characterization – Reflectance maps – Photogrammetry – Machine vision applications in inspection – Measurement of length, diameter, and surface roughness – Automated visual inspection – 3D feature extraction – Online quality control with feedback systems for lot and batch production.

UNIT V	NANO METROLOGY	9

Importance of nano-dimensions – Classification of nanostructures – Applications – Introduction to nano metrology – Introduction to microscopy: Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Scanning Tunneling Microscope (STM) – X-ray Diffraction System (XRD) – Principles of XRD – Bragg's Law – Two-dimensional XRD systems – Applications of XRD.

TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	distinguish contact and non-contact inspection techniques for quality analysis in manufacturing.	Applying (K3)
CO2	describe laser metrology and on-line measurement techniques for process control.	Understanding (K2)
CO3	implement appropriate CMM systems and evaluate their performance in dimensional metrology.	Applying (K3)
CO4	describe image-based inspection techniques and implement automated visual quality control in batch and continuous production.	Understanding (K2)
CO5	analyze the classification of nanostructures and apply advanced microscopy and diffraction techniques in nano-scale metrology.	Analysing (K4)

TEXT BOOKS

1. Bechwith-Marangoni-Lienhard, "Mechanical Measurements", Pearson Education Asia, Sixth Edition, 2009

2. Marshall A. D. and Martin R. R. - 'Computer Vision, Models and Inspection' - World Scientific – 1998.

REFERENCES

1. NelloZuech - 'Understanding and Applying Machine Vision' - Marcel Dekker - 2000 - 2nd Edition

2. John A. Bosch, Giddings, and Lewis Dayton - 'Coordinate Measuring Machines and Systems' - Marcel Dekker – 1999

3. ASTE - 'Handbook on Industrial Metrology' - Prentice Hall – 1992.

4. Connie Dotson, et al., "Fundamentals of Dimensional Metrology", Thomas Asia, Singapore, 2006

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes (POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	-	-	-	-	-	-	2	3	2
CO2	3	2	3	2	3	-	-	-	-	-	-	2	3	3
CO3	3	2	3	2	2	-	-	-	-	1	-	2	3	3
CO4	3	3	3	2	3	-	-	-	-	1	-	2	3	3
CO5	3	2	3	2	3	-	-	-	-	-	-	2	3	2

Approved
BOARD OF STUDIES
Robotics and Automation
27/06/25

RA23252	ADVANCED MANUFACTURING SYSTEMS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	teach the lean tools to attain optimum level in quality.
2	enhance the ability to make decisions for new product development.
3	develop the skills to conserve energy and natural resources with minimal environmental
4	introduce advanced information process techniques.
5	learn various smart manufacturing techniques and their applications.

UNIT I	INTRODUCTION TO LEAN MANUFACTURING	9

Objectives of lean manufacturing – Key principles and implications of lean manufacturing – Traditional vs. Lean manufacturing – Flow – Continuous improvement (Kaizen) – Worker involvement – 5S principles – Elements of JIT – Uniform production rate – Kanban system – Lean implementation – Reconciling lean with other systems – Lean Six Sigma – Lean and ERP – Lean with ISO 9001:2000.

UNIT II	AGILE MANUFACTURING	9

Agile manufacturing vs. Mass manufacturing – Agile practices for product development – Manufacturing agile practices – Implementing new technology – Technology application checklist – Technology applications that enhance agility – Agile technology make-or-buy decisions – Costing for agile manufacturing practices.

UNIT III	SUSTAINABLE MANUFACTURING	9

Concepts of competitive strategy and manufacturing strategies – Development of a strategic improvement programme – Manufacturing strategy in business success – Strategy formation and formulation – Structured strategy formulation – Sustainable manufacturing system design options – Approaches to strategy formulation – Realization of new strategies/system designs.

UNIT IV	INTELLIGENT MANUFACTURING	9

Introduction to intelligent manufacturing – Fundamentals of Artificial Intelligence – AI in manufacturing processes – Introduction to fuzzy logic – Applications of fuzzy logic in manufacturing – Integrating AI and fuzzy logic in production planning – Real-time decision making – Case studies and practical applications – Emerging trends and future directions.

UNIT V	SMART MANUFACTURING	9

Introduction to various smart manufacturing techniques – Supply chain management – Blockchain in inventory management – Plant digitization – Predictive maintenance – Supply chain visibility – Warehouse automation – Cost reduction – Waste management – Automated systems – Applications.

	TOTAL PERIODS:45
COURSE OUTCOMES	**BT MAPPED**
At the end of the course, the students will be able to	(Highest level)
CO1	analyze the basic principles and practices of lean manufacturing.	Analysing (K4)

CO2	understanding the fundamentals and integration of agile manufacturing.	Understanding (K2)
CO3	formulate strategies for sustainable manufacturing.	Applying (K3)
CO4	describe the application of artificial intelligence (AI) and fuzzy techniques to improve manufacturing system efficiency.	Understanding (K2)
CO5	analyze smart manufacturing and its various techniques.	Analysing (K4)

TEXT BOOKS

1. Lonnie Wilson, "How to Implement Lean manufacturing", McGraw-Hill Professional; 2nd edition, 2015.

2. Ibrahim Garbie, "Sustainability in Manufacturing Enterprises Concepts, Analyses and Assessments for Industry 4.0", Springer International Publishing., United States, 2016, ISBN-13: 978-3319293042.

REFERENCES

1. Black .J.T. and Kohser R.A, "DeGarmo's Materials and Processes in Manufacturing", Published by Wiley, 11th edition, 2011

2. Seliger G., "Sustainable Manufacturing: Shaping Global Value Creation", Springer, United States, 2012, ISBN 978-3-642-27289-9.

3. Rao R. V, "Advanced Modeling and Optimization of Manufacturing Processes", 2nd edition, 2006.

4. Ronald G. Askin and Jeffrey B. Goldberg, "Design and Analysis of Lean Production Systems", John Wiley and Sons, 2003

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	2	-	-	2	2	2	-	1	1	2	2	2
CO2	3	-	-	-	-	2	2	-	-	1	1	2	1	2
CO3	3	-	-	-	-	2	2	3	-	1	1	2	1	2
CO4	3	-	3	-	-	2	2	-	1	1	2	2	2	3
CO5	3	-	3	-	-	2	2	2	-	1	1	2	2	2

RA23253	CNC MACHINE TOOLS AND PROGRAMMING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	describe the mechanics of metal cutting and the factors affecting machinability.
2	illustrate the working of basic and advanced turning machines.
3	teach the basics of machine tools with reciprocating and rotating motions and abrasive finishing processes.
4	outline the constructional features of CNC machine tools.
5	demonstrate the basics of CNC programming and the machine tools through planning, writing codes, and setting up CNC machine tools.

UNIT I	MECHANICS OF METAL CUTTING	9

Mechanics of chip formation, forces in machining, types of chip, cutting tools – Single point cutting tool nomenclature, orthogonal and oblique metal cutting, thermal aspects, cutting tool materials, tool wear, tool life, surface finish, cutting fluids and Machinability

UNIT II	TURNING MACHINES	9

Centre lathe, constructional features, specification, operations – taper turning methods, thread cutting methods, special attachments, surface roughness in turning, machining time and power estimation. Special lathes - Capstan and turret lathes - tool layout – automatic lathes: semi-automatic – single spindle: Swiss type, automatic screw type – multi spindle

UNIT III	RECIPROCATING MACHINE TOOLS	9

Reciprocating machine tools: shaper, planer, slotter: Types and operations- Hole making: Drilling, reaming, boring, tapping, type of milling operations-attachments- types of milling cutters– machining time calculation - Gear cutting, gear hobbing and gear shaping – gear finishing methods Abrasive processes: grinding wheel – specifications and selection, types of grinding process – cylindrical grinding, surface grinding, centreless grinding, internal grinding - micro finishing methods

UNIT IV	CNC MACHINES	9

Computer Numerical Control (CNC) machine tools, constructional details, special features – Drives, Recirculating ball screws, tool changers; CNC Control systems – Open/closed, point-to-point/continuous - Turning and machining centers - Work holding methods in Turning and machining centers, Coolant systems, Safety features.

UNIT V	PROGRAMMING OF CNC MACHINE TOOLS	9

Coordinates, axis and motion, Absolute vs Incremental, Interpolators, Polar coordinates, Program planning, G and M codes, Manual part programming for CNC machining centers and Turning centers – Fixed cycles, Loops and subroutines, Setting up a CNC machine for machining

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	analyze the mechanics of the metal cutting process and identify factors involved in improving machinability.	Analysing (K4)
CO2	understand the constructional features and working principles of basic and advanced turning machines.	Understanding (K2)
CO3	select and apply suitable machining operation to manufacture a given component	Applying (K3)
CO4	understand the constructional features and working principles of CNC machine tools	Understanding (K2)
CO5	analyze CNC programming by planning, writing codes, and setting up CNC machine tools to manufacture a given component.	Analysing (K4)

TEXT BOOKS

1. Kalpakjian. S, "Manufacturing Engineering and Technology", Pearson Education 8th Edition, 2022.

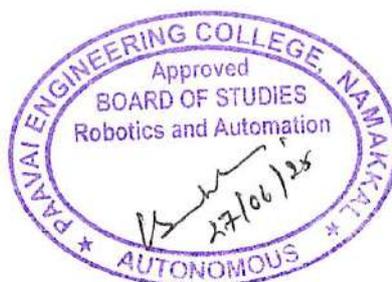2. Michael Fitzpatrick, "Machining and CNC Technology", McGraw-Hill Education;4th edition, 2019.

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1. Roy. A. Lindberg, "Processes and materials of manufacture", Pearson India Education Services Pvt. Ltd, 4th edition, 2015

2. Geofrey Boothroyd, "Fundamentals of Metal Machining and Machine Tools", McGraw Hill,

3. Rao. P.N, "Manufacturing Technology Volume 2, Metal Cutting and Machine Tools", McGraw-Hill, New Delhi, 3rd edition, 2013.

4. Fundamentals of Modern Manufacturing: Materials, Processes, and Systems Mikell P. Groover Publisher: Wiley

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	-	-	-	-	-	1	1	1	2
CO2	2	2	1	1	-	-	-	-	-	-	1	1	1	2
CO3	2	2	1	1	-	-	-	-	-	-	1	1	1	2
CO4	2	2	1	1	-	-	-	-	-	-	1	1	1	2
CO5	2	2	1	1	-	-	-	-	-	-	1	1	1	2

RA23254	ELECTRONICS MANUFACTURING TECHNOLOGY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	impart knowledge on wafer preparation and PCB fabrication.
2	introduce Through Hole Technology (THT) and Surface Mount Technology (SMT) with various types of electronic components.
3	elaborate various steps in Surface Mount Technology (SMT).
4	acquaint with various testing and inspection methods of populated PCBs.
5	outline repair, rework, and quality aspects of electronic assemblies.

UNIT I	INTRODUCTION TO ELECTRONICS MANUFACTURING	9

History, definition, wafer preparation by growing, machining, and polishing, diffusion, microlithography, etching and cleaning, Printed circuit board –fabrication, types, single sided, double sided, multi-layer and flexible printed circuit board

UNIT II	COMPONENTS AND PACKAGING	9

Introduction to packaging, types - Through hole technology (THT) and Surface mount technology (SMT), Through hole components – axial, radial, multi leaded, odd form Surface-mount components - active, passive. Interconnections - chip to lead interconnection, die bonding, wire bonding, TAB, flip chip, chip on board, multi chip module, direct chip array module, leaded, leadless, area array and embedded packaging, miniaturization and trends

UNIT III	SURFACE MOUNT TECHNOLOGY	9

SMT Process, SMT equipment and material handling systems, handling of components and assemblies - moisture sensitivity and ESD, safety and precautions needed, IPC and other standards, stencil printing process - solder paste material, storage and handling, stencils and squeegees, process parameters, quality control

UNIT IV	INSPECTION AND TESTING	9

Inspection techniques, equipment and principle - AOI, X-ray. Defects and Corrective action - stencil printing process, component placement process, reflow soldering process, electrical testing of PCB assemblies - In circuit test, functional testing, fixtures and jigs

UNIT V	REPAIR, REWORK, QUALITY AND RELIABILITY OF ELECTRONICS ASSEMBLIES	9

Repair and rework of PCB - Coating removal, base board repair, conductor repair, thermo-mechanical effects and thermal management, Reliability fundamentals, reliability testing, failure analysis, design for manufacturability, assembly, reworkability, testing, reliability, and environment

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	understand the processes involved in wafer preparation and PCB fabrication.	Understanding (K2)
CO2	identify the importance of Through Hole Technology (THT) and Surface Mount Technology (SMT).	Understanding (K2)
CO3	demonstrate the various steps involved in Surface Mount Technology (SMT).	Applying (K3)
CO4	apply the different testing and inspection methods used for populated PCBs.	Applying (K3)
CO5	analyze techniques used in repair, rework, and assessment of quality and reliability in electronic assemblies.	Analysing (K4)

TEXT BOOKS

1. Prasad R., "Surface Mount Technology – Principles and practice", 2nd Edition, Chapman and Hall., New York, 1997, ISBN 0-41-12921-3.

2. Tummala R.R., "Fundamentals of microsystem packaging", Tata McGraw Hill Co. Ltd., New Delhi, 2001, ISBN 00-71-37169-9.
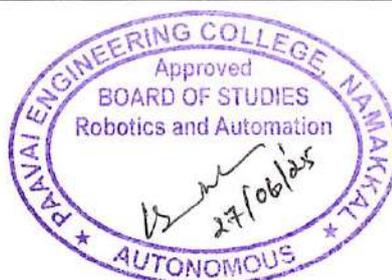
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1. Lee N.C., "Reflow Soldering Process and Trouble Shooting SMT, BGA, CSP and Flip Chip Technologies", Elsevier Science. United Kingdom, 2001.

2. Totta P., Puttlitz K. and Stalter K., "Area Array Interconnection Handbook", Kluwer Academic Publishers, Norwell, MA, United States, 2001, ISBN 0-7923-7919-5.

3. Zarrow P. and Kopp D., "Surface Mount Technology Terms and Concepts", Elsevier, 1997

4. Dr. Jerome T. Lyman Handbook of Electronic Assembly and A Guide to SMTA Certification, 2014

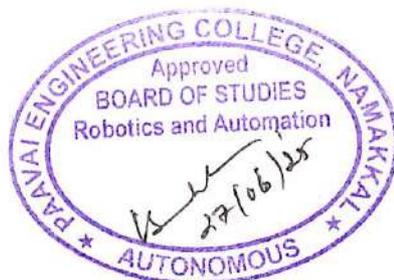**CO - PO MAPPING**

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-			-	-	1	-	-	-	-	1	-	2
CO2	2	-			-	-	1	-	-	-	-	1	-	2
CO3	2	-	1		1	-	-	-	-	-	-	1	-	2
CO4	2	-	1		1	-	-	-	-	-	-	1	-	2
CO5	2	-	1		1	-	1	-	-	-	-	1	-	2

RA23255	INTELLIGENT MANUFACTURING SYSTEMS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	provide fundamental concepts of Intelligent Manufacturing Systems (IMS) for flexible, smart, reconfigurable manufacturing.
2	examine real-time implementation challenges, diagnostics, and deployment of IMS.
3	enable integration of AI/ML and automation for intelligent decision-making in manufacturing.
4	familiarize students with supporting technologies required to implement IMS.
5	analyze practical approaches for overcoming real-time IMS deployment challenges.

UNIT I	INTRODUCTION TO MANUFACTURING SYSTEMS AND SUBSYSTEMS	9

Introduction to manufacturing systems, various subsystems in manufacturing systems including procurement, design, manufacturing, inspections, assembly, prototyping, material handling, and storage systems. Additional concepts include types of manufacturing systems such as job shop, batch, and continuous production; integration of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM); and the role of Enterprise Resource Planning (ERP) systems in coordinating subsystems.

UNIT II	CONCEPT OF INTELLIGENT MANUFACTURING	9

Concept of Intelligent Manufacturing, Internet of Things (IoT) enabled manufacturing, and cloud manufacturing. Additional topics include digital transformation in manufacturing, role of edge computing in real-time process control, and smart sensors for data acquisition and system optimization.

UNIT III	CHARACTERISTICS AND TECHNOLOGIES OF IMS	9

Characteristics of intelligent manufacturing systems, intelligent decision-making, application of Artificial Intelligence and Machine Learning in developing intelligent manufacturing systems. Components of intelligent manufacturing technologies, development of intelligent systems for design, process planning, controls, scheduling, quality management, maintenance, and diagnostics.

UNIT IV	SUPPORTING TECHNOLOGIES	9

Supporting technologies for intelligent manufacturing systems including Industry Internet of Things (IIoT), Cyber-Physical Systems (CPS), cloud computing, RFID technologies, data analytics, and other Information and Communication Technologies (ICT).

UNIT V	IMPLEMENTATION ISSUES IN IMS	9

Framework for intelligent manufacturing including smart design, smart machines, smart control, smart scheduling, human-machine collaboration, collaborative robots, enabling technologies such as Augmented Reality (AR) and Virtual Reality (VR), data-driven intelligent manufacturing models, autonomous intelligent manufacturing units. Applications and case studies in intelligent manufacturing systems implementation, limitations of technologies, and other real-time issues in implementation of IMS.

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	understand IMS concepts and manufacturing subsystems.	Understanding (K2)
CO2	describe and select subsystems and technologies to implement IMS.	Understanding (K2)
CO3	develop intelligent systems using AI/ML across manufacturing functions.	Applying (K3)
CO4	illustrate and troubleshoot technologies for IMS deployment.	Applying (K3)
CO5	analyze real-world cases, identify limitations, and apply IMS solutions.	Analysing (K4)

TEXT BOOKS

1. Andrew Kusiak, Intelligent Manufacturing Systems,Prentice Hall, ISBN 978-0134722344

2. Ibrahim Zeid and R Sivasubramanian, CAD/CAM Theory and Practice, Tata McGraw Hill, 2010

REFERENCES

1. Jagadeesha T, Non-Traditional Machining Processes, I K International Publishing House 2016

2. V. K. Jain, Introduction to Micromachining, Second Edition, Narosa Publishing House 2019

3. Benedict. G.F. Nontraditional Manufacturing Processes, Marcel Dekker Inc., New York,2018

4. Kaushik Kumar et al., Digital Manufacturing & Assembly Systems in Industry 4.0 CRC Press, 2019

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	2	1	0	0	0	0	0	0	0	2	1
CO2	3	1	2	2	1	0	0	0	0	0	0	0	2	1
CO3	3	1	2	2	1	0	0	0	0	0	0	0	2	1
CO4	3	1	2	2	1	0	0	0	0	0	0	0	2	1
CO5	3	1	2	2	1	0	0	0	0	0	0	0	2	1

RA23256	SMART MANUFACTURING	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	introduce the fundamentals of smart manufacturing systems, technologies, and infrastructure.
2	introduce the fundamentals of smart manufacturing systems, technologies, and infrastructure.
3	provide insights into smart manufacturing applications through real-world industrial case studies.
4	apply cybersecurity, standards, and system interoperability in smart manufacturing environments.
5	explore human-machine collaboration, digital skills, and emerging trends in smart manufacturing.

UNIT I	FOUNDATIONS OF SMART MANUFACTURING	9

Introduction to Smart Manufacturing, Smart Sensors and Smart Tooling, Smart Machines and Intelligent Machining, Digital and Smart Factories, Implementing Smart Manufacturing Across an Industrial Organization, Cyberinfrastructure for the Democratization of Smart Manufacturing, The Role of Hardware and Software in Smart Manufacturing Infrastructure Changes, Reinvigorating the Manufacturing Workforce, Benefits of Smart Manufacturing to the Value Chain.

UNIT II	DATA-DRIVEN SMART MANUFACTURING AND SYSTEM MODELING	9

Measuring, Managing, and Transforming Data for Operational Insights, The Role of Advanced Process Modelling in Smart Manufacturing, Industrial AI and Predictive Analytics for Smart Manufacturing Systems, A Systems Engineering-Driven Decomposition Approach for Large-Scale Industrial Decision-Making Processes, Model-Predictive Safety: A New Evolution in Functional Safety, Inferential Modelling and Soft Sensors, A Decision Support Framework for Sustainable and Smart Manufacturing.

UNIT III	INDUSTRY-SPECIFIC APPLICATIONS AND CASE STUDIES	9

Smart Manufacturing in the Food Industry, Advancing Smart Manufacturing in the Pharmaceutical Industry, Smart Reservoir Management in the Oil and Gas Industry, Smart Manufacturing in the Paints and Coatings Industry, Smart Manufacturing in Additive Manufacturing, Smart Manufacturing in Industrial Gas Production: A Digital Transformation, Smart Manufacturing: Machine Learning-Based Economic MPC and Preventive Maintenance.

UNIT IV	CYBERSECURITY, STANDARDS, AND INTEROPERABILITY IN SMART MANUFACTURING	9

Cybersecurity in Smart Manufacturing Systems, Industrial IoT Security Frameworks, Data Integrity and Secure Communication, Standards and Protocols for Interoperability (OPC UA, ISA-95, ISO 23247), Edge and Cloud Computing Integration, Blockchain Applications for Traceability, Digital Twin Security, Regulatory Compliance and Risk Management in Smart Factories.

UNIT V	HUMAN-MACHINE COLLABORATION, DIGITAL SKILLS, AND FUTURE TRENDS	9

Human-Machine Collaboration in Smart Manufacturing, Role of Collaborative Robots (Cobots), Human-in-

the-Loop Systems, Digital Literacy and Workforce Upskilling, Augmented Reality (AR) and Virtual Reality (VR) for Operator Assistance, Emerging Technologies in Smart Manufacturing (Quantum Computing, Bio-Integrated Manufacturing), Future Trends and Innovation in Autonomous Manufacturing Systems.

		TOTAL PERIODS:45
COURSE OUTCOMES		**BT MAPPED**
At the end of the course, the students will be able to		(Highest level)
CO1	discuss the core principles of smart manufacturing including digitalization, intelligent machines, and infrastructure evolution.	Understanding (K2)
CO2	describe data-driven decision-making techniques using advanced modeling, AI, and predictive analytics.	Understanding (K2)
CO3	evaluate industry-specific implementations of smart manufacturing using case study approaches.	Applying (K3)
CO4	illustrate cybersecurity frameworks, interoperability standards, and digital infrastructure in modern manufacturing systems.	Understanding (K2)
CO5	analyze human-machine collaboration, digital skills, and emerging trends shaping the future of manufacturing.	Analysing (K4)

TEXT BOOKS

1. "Smart Manufacturing: Concepts and Methods" by Masoud Soroush, Springer, 2020.

2. "Smart Manufacturing: The Lean Six Sigma Way" by Anthony Tarantino, Wiley, 2023.

REFERENCES

1. "Design Principles for Industry 4.0: Concepts, Technologies and Applications" by G. Schuh et al., Springer,

2. "Smart Manufacturing: Integrating Transformational Technologies for Competitiveness and Sustainability" by V. Jayaraman and Kee-hung Lai, Springer, 2022.

3. "Artificial Intelligence for the Internet of Everything" by William Lawless, Ranjeev Mittu, Elsevier, 2021.

4. Handbook of Smart Manufacturing :A. Singh, H. Singh, P. Kumar, B. AlMangour, CRC / Taylor & Francis, 2023

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	1	-	-	-	-	1	-	2
CO2	3	2	-	2	-	-	1	-	-	-	-	1	-	2
CO3	3	2	1	2	-	-	-	-	-	-	-	1	-	2
CO4	3	2	1	2	-	-	-	-	-	-	-	1	-	2
CO5	3	2	1	2	-	-	1	-	-	-	-	1	-	2

RA23257	DESIGN FOR X	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	introduce the economic process selection principles and general design principles for manufacturability
2	understood the design consideration principles of forming in the design of extruded, stamped, and forged products
3	analyze the design considerations for machining in the design of turned, drilled, milled, planed, shaped, slotted, and ground products.
4	explore design consideration principles of welding in the design of welded products.
5	examine design consideration principles in additive manufacturing

UNIT I	INTRODUCTION	9

General design principles for manufacturability - strength and mechanical factors, mechanisms selection, evaluation method, Process capability - Feature tolerances Geometric Tolerances - Assembly limits - Datum features - Tolerance stacks. Design to minimize material usage – Design for disassembly – Design for recyclability – Design for manufacture – Design for energy efficiency – Design to regulations and standards.

UNIT II	FACTORS INFLUENCING FORM DESIGN	9

Working principle, Material, Manufacture, Design - Possible solutions - Materials choice – Influence of materials on form design - form design of welded members, forgings and castings.

UNIT III	COMPONENT DESIGN - MACHINING CONSIDERATION	9

Design features to facilitate machining - drills - milling cutters - keyways - Doweling procedures, counter sunk screws - Reduction of machined area - simplification by separation - simplification by amalgamation - Design for machinability - Design for economy - Design for clampability – Design for accessibility - Design for assembly – Product design for manual assembly - Product design for automatic assembly – Robotic assembly.

UNIT IV	COMPONENT DESIGN – CASTING CONSIDERATION	9

Redesign of castings based on Parting line considerations - Minimizing core requirements, machined holes, redesign of cast members to obviate cores. Identification of uneconomical design - Modifying the design - group technology - Computer Applications for DFMA.

UNIT V	DESIGN FOR ADDITIVE MANUFACTURING	9

Introduction to AM, DFMA concepts and objectives, AM unique capabilities, exploring design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers. Introduction to AI-assisted design tools.

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	analyze the design principles for manufacturability.	Analysing (K4)
CO2	discuss the factors influencing form design.	Understanding (K2)
CO3	apply the component design features of various machines.	Applying (K3)
CO4	implement the design consideration principles of welding in the design of welded products.	Analysing (K4)
CO5	analyze the design consideration principles of additive manufacturing.	Analysing (K4)

TEXT BOOKS

1. James G. Bralla, "Design for Manufacturability Handbook", McGraw Hill Professional, 1998.

2. O. Molloy, E.A. Warman, S. Tilley, Design for Manufacturing and Assembly: Concepts, Architectures and Implementation, Springer, 1998.

REFERENCES

1. CorradoPoli, Design for Manufacturing: A Structured Approach, Elsevier, 2001

2. David M. Anderson, Design for Manufacturability & Concurrent Engineering: How to Design for Low Cost, Design in High Quality, Design for Lean Manufacture, and Design Quickly for Fast Production, CIM Press, 2004.

3. Erik Tempelman, Hugh Shercliff, Bruno Ninaber van Eyben, Manufacturing and Design: Understanding the Principles of How Things Are Made, Elsevier, 2014.

4. Graedel T. Allen By. B, Design for the Environment Angle Wood Cliff, Prentice Hall. Reason Pub., 1996.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	1	1	-	-	-	1	-	-	1	2	3
CO2	2	2	3	1	1	-	-	-	1	-	-	1	2	3
CO3	2	2	3	1	1	-	-	-	1	-	-	1	2	3
CO4	2	2	3	1	1	-	-	-	1	-	-	1	2	3
CO5	2	2	3	1	1	-	-	-	1	-	-	1	2	3

RA23351	CLOUD COMPUTING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand distributed and cloud computing paradigms.
2	analyze cloud use cases, market trends, and security challenges.
3	develop cloud-native applications and architect effective solutions.
4	explore virtualization, containerization, and orchestration technologies.
5	design secure, scalable, and automated cloud systems using modern tools.

UNIT I	DISTRIBUTED & CLOUD COMPUTING PARADIGMS	9

Distributed Computing Taxonomy – Cluster, Grid, P2P, Utility, Cloud, Edge, Fog computing paradigms; Introduction to Cloud Computing – Cloud delivery models (XaaS), Cloud deployment models (Private, Public, Hybrid); Characteristics of Cloud.

UNIT II	CLOUD USE CASES, MARKET & SECURITY	9

Major use cases of Cloud; Administrative and technical disadvantages and best practices; Major public cloud players; Security issues and challenges; AI as a Service (AIaaS), big-data analytics, support for real-time IoT and edge-cloud integration, serverless computing, and multi cloud/hybrid cloud strategies.

UNIT III	CLOUD-NATIVE APPLICATION DEVELOPMENT	9

Cloud Native application development – Introduction to JavaScript Cloud native application development; Public Cloud – Using public cloud for infrastructure management (compute and storage services), Web application deployment using public cloud services, and Deploying container images in public cloud; Overview of cognitive services; Case study on architecting cloud-based solutions for a chosen scenario.

UNIT IV	VIRTUALIZATION & CONTAINERIZATION	9

Virtualization – Basics, Cloud vs Virtualization, Types of virtualization, Hypervisor types; Containers – Introduction to Dockers and containers, containerization vs virtualization, docker architecture, Use cases; Learn how to build container images, operations on container images.

UNIT V	CONTAINER ORCHESTRATION & KUBERNETES	9

Kubernetes – Need for orchestration, container orchestration methods, Introduction to Kubernetes, Kubernetes architecture, using YAML files, running Kubernetes via Minikube container networking and service mesh (e.g., Cilium), cluster security and network policies, multi-cluster federation, and CI/CD pipelines for Kubernetes-based deployments.

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	understand distributed systems models and cloud computing fundamentals.	Understanding (K2)

CO2	implement cloud-native solutions using containers, compute, storage, and cognitive services.	Understanding (K2)
CO3	implement cloud-native solutions using containers, compute, storage, and cognitive services.	Applying (K3)
CO4	compare virtualization and containerization, and illustrate building container images for cloud deployment.	Understanding (K2)
CO5	analyze the deployment and management of containerized applications using Kubernetes and CI/CD pipelines.	Analysing (K4)

TEXT BOOKS

1. Rajkumar Buyya et.al. Mastering cloud computing, McGraw Hill Education; 2013.

2. Matthias K, Kane SP. Docker: Up & Running: Shipping Reliable Containers in Production. "O'Reilly Media, Inc."; 2018

REFERENCES

1. Kocher PS. Microservices and Containers. Addison-Wesley Professional; 2018.

2. Sarkar A, Shah A. Learning AWS: Design, build, and deploy responsive applications using AWS Cloud components. Packt Publishing Ltd; 2018

3. Menga J. Docker on Amazon Web Services: Build, deploy, and manage your container applications at scale. Packt Publishing Ltd; 2018

4. Distributed and Cloud Computing: From Parallel Processing to the Internet of Things Kai Hwang, Jack, Dongarra & Geoffrey C. Fox Morgan Kaufmann / Elsevier, 3rd Edition, 2018

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	0	-	-	-	-	-	-	0	2	1
CO2	3	2	2	2	2	-	-	-	-	-	-	0	2	2
CO3	3	2	2	2	2	-	-	-	-	-	-	0	2	1
CO4	3	2	2	2	2	-	-	-	-	-	-	0	2	1
CO5	3	2	2	2	2	-	-	-	-	-	-	0	2	1

RA23352	CONDITION MONITORING AND FAULT DIAGNOSTICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the basics of various condition monitoring methods
2	identify the selection of condition monitoring sensors for various applications
3	study various signal processing for condition monitoring applications.
4	explore failure analysis, maintenance strategies, and the role of machine learning.
5	provide a basic understanding with case studies on different fault diagnosis method

UNIT I	INTRODUCTION	9

Condition Monitoring in manufacturing industries; Noise monitoring, Wear and debris Analysis, Thermography, Cracks monitoring, Ultrasonic techniques - Case studies. Vibration, Acoustic emission and vibro-acoustics signal analysis; intelligent fault detection system, Case studies.

UNIT II	SENSORS FOR FAULT DIAGNOSTICS	9

Introduction - Contaminant monitoring sensors - Corrosion monitoring sensors - Force monitoring sensors - Gas leakage monitoring sensors - Air pollution monitoring sensors - Liquid contamination monitoring sensors - Non-destructive testing techniques - Optical examination - Temperature sensing.

UNIT III	SIGNAL PROCESSING AND ANALYSIS	9

Study of periodic and random signals, probability distribution, statistical properties, auto and cross correlation and power spectral density functions. Time domain and Frequency domain and Time-frequency domain analysis.

UNIT IV	FAILURE ANALYSIS, MAINTENANCE AND MACHINE LEARNING	9

Maintenance Principles, Failure mode analysis - Equipment down time analysis – Breakdown analysis - condition based maintenance, Vibration, Acoustic emission and vibrio-acoustics signal analysis; intelligent fault detection system, Case studies.

UNIT V	MONITORING SYSTEMS CASE STUDEIS	9

Introduction - Marine monitoring systems - Marine turbine monitoring systems - Shipboard vibration monitoring - Monitoring integrity verification - Aircraft condition monitoring - Condition monitoring - generating plant - Automotive diagnostic equipment - Systematic fault monitor selection.

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	understand the basics of various condition monitoring	Understanding (K2)
CO2	identify suitable condition monitoring sensors for various applications.	Understanding (K2)
CO3	apply signal processing techniques for condition monitoring applications.	Applying (K3)

CO4	classify various failure analysis methods, maintenance strategies, and machine learning approaches.	Analysing (K4)
CO5	analyze different fault diagnosis methods for various	Analysing (K4)

TEXT BOOKS

1. Mechanical Fault Diagnosis and condition monitoring" by R. A. Collacott, Chapman and Hall London A Halstead Press Book John Wiley & Sons, New York

2. Chiang, L.H., Russell, E.L. and Braatz, R.D., 2012. Fault detection and diagnosis in industrial systems. Springer Science & Business Media.

REFERENCES

1. "Condition Monitoring and Assessment of Power Transformers Using Computational Intelligence", W.H. Tang, Q.H. Wu, Springer-Verlag London

2. Nandi, S., Toliyat, H.A. and Li, X., 2005. Condition monitoring and fault diagnosis of electrical motors—A review. IEEE transactions on energy conversion, 20(4), pp.719-729.

3. Mohanty, A.R., 2014. Machinery condition monitoring: Principles and practices. CRC Press.

4. Amiya Ranjan Mohanty, Machinery Condition Monitoring: Principles and Practices, CRC Press / Taylor & Francis, 2017

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	1	-	-	-	-	-	-	1	3	2
CO2	3	2	1	2	1	-	-	-	-	-	-	1	3	2
CO3	3	2	1	2	1	-	-	-	-	-	-	1	3	2
CO4	3	2	1	2	1	-	-	-	-	-	-	1	3	2
CO5	3	2	1	2	1	-	-	-	-	-	-	1	3	2

RA23353	WEARABLE DEVICES	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	define the concepts and components of wearable systems and sensors.
2	describe the concepts and components of wearable systems and sensors.
3	evaluate different types of sensors used in wearable systems.
4	apply signal processing techniques for data acquisition and energy harvesting in wearables.
5	assess the applications and benefits of wearable systems in healthcare.

UNIT I	INTRODUCTION TO WEARABLE SYSTEMS AND SENSORS	9

Wearable Systems – Introduction, Need for Wearable Systems, Drawbacks of Conventional Systems for Wearable Monitoring, Applications of Wearable Systems, Types of Wearable Systems, Components of Wearable Systems. Sensors for wearable systems – Inertia movement sensors, Respiration activity sensor, Impedance plethysmography, Wearable ground reaction force sensor.

UNIT II	SIGNAL PROCESSING AND ENERGY HARVESTING FOR WEARABLE DEVICES	9

Wearability issues – Physical shape and placement of sensor. Technical challenges – Sensor design, signal acquisition, sampling frequency for reduced energy consumption, rejection of irrelevant information. Power requirements – Solar cell, vibration based, thermal based, human body as a heat source for power generation, hybrid thermoelectric photovoltaic energy harvests, thermopiles – SAR.

UNIT III	WIRELESS HEALTH SYSTEMS	9

Need for wireless monitoring, Definition of Body Area Network, BAN and healthcare. Technical challenges – System security and reliability. BAN Architecture – Introduction, Wireless communication techniques.

UNIT IV	SMART TEXTILE	9

Introduction to smart textile – Passive smart textile, active smart textile. Fabrication techniques – Conductive fibres, treated conductive fibres, conductive fabrics, conductive inks, Case study – Smart fabric for monitoring biological parameters – ECG, respiration.

UNIT V	APPLICATIONS OF WEARABLE SYSTEMS	9

Medical diagnostics, medical monitoring – Patients with chronic disease, hospital patients, elderly patients, neural recording, gait analysis, sports medicine, smart bag.

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	describe the key features and components of wearable systems and sensors.	Understanding (K2)

CO2	discuss the limitations and advantages of conventional and wearable monitoring systems.	Understanding (K2)
CO3	select and justify appropriate sensors for specific wearable applications.	Applying (K3)
CO4	implement signal processing and energy harvesting techniques in wearable devices.	Applying (K3)
CO5	apply wearable systems for medical diagnostics, health monitoring, and other healthcare applications.	Applying (K3)

TEXT BOOKS

1. Zhang and Yuan-Ting, "Wearable Medical Sensors and Systems", Springer, 2023

2. Annalisa Bonfiglio and Danilo De Rossi, "Wearable Monitoring Systems", Springer, 2011

REFERENCES

1. Sandeep K.S, Gupta, Tridib Mukherjee and Krishna Kumar Venkatasubramanian, "Body Area Networks Safety, Security, and Sustainability", Cambridge University Press, 2013.

2. Guang-Zhong Yang, "Body Sensor Networks", Springer, 2nd Edition, 2016

3. Edward Sazonov and Micheal R Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications", Elsevier, 2015

4. Mehmet R. Yuce and JamilY.Khan, "Wireless Body Area Networks Technology, Implementation applications",Pan Stanford Publishing Pte.Ltd, Singapore, 2012

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	2	-	-	-	-	-	-	-	2	2	2
CO2	3	2	-	2	-	-	-	-	-	-	-	2	2	2
CO3	3	2	-	2	2	-	-	-	-	-	-	2	2	2
CO4	3	2	2	2	-	-	-	-	-	-	-	2	2	2
CO5	3	2	2	3	-	-	-	-	-	-	-	2	2	2

RA23354	SMART MOBILITY AND ADVANCED INTELLIGENT VEHICLES	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce students to the various technologies and systems used to implement smart mobility and intelligent vehicles.
2	understand the basics of radar technology, ultrasonic sonar systems, LIDAR sensor technology, and other sensors used in automobile vision systems.
3	apply basic control system theory to autonomous vehicle systems.
4	explore the impact of automation on driving functions and the integration of external information sources to support driving tasks.
5	enable autonomous vehicles to make intelligent decisions that impact occupant safety through connected car technologies.

UNIT I	INTRODUCTION TO INTELLIGENT VEHICLES	9

Concept of Automotive Electronics, Electronics Overview, History & Evolution, Infotainment, Body, Chassis, and Powertrain Electronics, Introduction to Automated, Connected, and Intelligent Vehicles. Case studies: Automated, Connected, and Intelligent Vehicles.

UNIT II	SENSOR TECHNOLOGY AND VEHICLE PERCEPTION SYSTEMS	9

Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Other Sensors; Introduction to Perception Architectures in Autonomous Vehicles, Environment Modeling and Object Tracking; Use of Sensor Data Fusion; Integration of Sensor Data with On-Board Control Systems.

UNIT III	CONNECTED AUTONOMOUS VEHICLE	9

Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical System Theory and Autonomous Vehicles, Role of Surroundings Sensing Systems and Autonomy, Role of Wireless Data Networks and Autonomy.

UNIT IV	VEHICLE WIRELESS TECHNOLOGY & NETWORKING	9

Wireless System Block Diagram and Overview of Components, Transmission Systems – Modulation/Encoding, Receiver System Concepts – Demodulation/Decoding, Wireless Networking and Applications to Vehicle Autonomy, Basics of Computer Networking – the Internet of Things, Wireless Networking Fundamentals, Integration of Wireless Networking and On-Board Vehicle Networks.

UNIT V	ADVANCED CONNECTIVITY AND AUTONOMY IN VEHICLE	9

Connectivity Fundamentals, Navigation and Other Applications, Vehicle-to-Vehicle (V2V) Technology and Applications, Vehicle-to-Infrastructure (V2I) Applications, Edge and Cloud Computing in Connected Vehicles, Over-the-Air (OTA) Software Updates, Autonomous Vehicles – Driverless Car Technology, Moral, Legal, Roadblock Issues, Technical Issues, Security Issues.

	TOTAL PERIODS:45

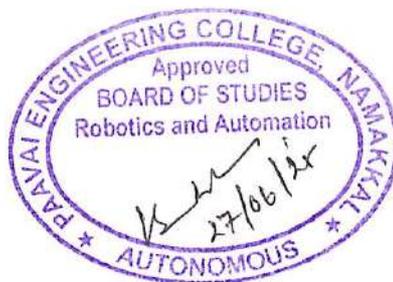| COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	understand the fundamental concepts related to cyber-physical systems and their significance.	Understanding (K2)
CO2	understand the principles of remote sensing and identify suitable sensor technologies.	Understanding (K2)
CO3	apply core concepts to design or analyze fully autonomous vehicle systems.	Applying (K3)
CO4	demonstrate an understanding of wireless communication and data networking basics.	Understanding (K2)
CO5	analyze the connected vehicle ecosystem and assess its role in automation..	Analysing (K4)

TEXT BOOKS

1. "Intelligent Transportation Systems and Connected and Automated Vehicles", 2016, Transportation Research Board

2. Radovan Miucic, "Connected Vehicles: Intelligent Transportation Systems", 2019, Springer

REFERENCES

1. Tom Denton, "Automobile Electrical and Electronic systems, Roult edge", Taylor & Francis Group, 5th Edition, 2018.

2. Autonomous Driving: Technical, Legal and Social Aspects Markus Maurer, J. Christian Gerdes, Barbara Lenz, Hermann Winner

3. Connected and Autonomous Vehicles: The Basics, A. B. Pritchard ,Publisher: Routledge

4. Automotive Embedded Systems Handbook, Nicolas Navet, Francoise Simonot-Lion, Publisher: CRC Press

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	1	-	-	-	-	-	1	2	1
CO2	3	2	1	1	-	1	-	-	-	-	-	1	2	1
CO3	3	2	1	1	-	1	-	-	-	-	-	1	2	1
CO4	3	2	1	1	-	1	-	-	-	-	-	1	2	1
CO5	3	2	1	1	-	1	-	-	-	-	-	1	2	1

RA23355	VISION GUIDED ROBOTICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce foundational concepts of robot vision, including modeling rigid-body motion, camera configurations, triangulation, and pose estimation.
2	develop a mathematical understanding of visual servoing architectures such as IBVS and PBVS, including interaction matrix derivation, stability analysis, and calibration methods.
3	explore visual perception techniques for mobile robotics using VSLAM and visual odometry, with comparisons of methods and real-world applications.
4	analyze motion fields via optical flow, address the aperture problem, and apply Kalman filtering for robust target tracking.
5	investigate advanced visual control schemes—including hybrid/partitioned serving, coordinated eye-hand visual systems, segmentation, and structure-from-motion techniques.

UNIT I	**INTRODUCTION**	9

Vision for robot manipulation and Navigation – Motivation. Modeling velocity of a rigid object – Camera configurations in vision-guided Robots – Triangulation – Vision-based pose estimation.

UNIT II	**VISUAL SERVOIN**	9

Mathematical formulation of visual servo problem – Classification of visual servoing architectures – Image-Based Visual Servoing (IBVS), interaction matrix derivation – Geometrical interpretation of IBVS, stability analysis – Case study: IBVS with stereo vision system – IBVS with other geometrical features, direct estimation – Position-Based Visual Servoing: Point feature-based motion, pose-based motion – Calibration for visual servoing systems.

UNIT III	**VISION FOR MOBILE ROBOTS**	9

Introduction to Simultaneous Localization and Mapping, Visual SLAM (VSLAM) – VSLAM Approaches – Introduction to Visual Odometry (VO). VO: Motion from image feature correspondences, motion from 3D structure. Comparison between VSLAM and VO calibration techniques – Case study of VSLAM and VO application.

UNIT IV	**MOTION ANALYSIS**	9

Formulation of the motion analysis – Motion field of rigid objects, Aperture Problem – Optical flow and motion field, brightness constancy equation and validity – Estimating motion field: Differential techniques, feature-based techniques. Target tracking: Challenges and solutions, Kalman filtering basics – Kalman tracking.

UNIT V	**INTRODUCTION ADVANCED TOPICS**	9

Hybrid visual servoing, partitioned visual servoing, switching schemes in visual servoing. Joint space control of eye-in-hand and eye-to-hand systems – Motion-based segmentation – Structure from Motion (SFM), multi-view SFM – 3D structure and motion from motion field.

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	understand the foundations of the field of computer vision required for Robot vision	Understanding (K2)
CO2	identify the mathematical concepts and implementation methods of vision guidance for manipulators.	Understanding (K2)
CO3	formulate approaches to apply computer vision techniques in mobile robotics.	Applying (K3)
CO4	develop algorithms for Motion analysis.	Applying (K3)
CO5	apply computer vision algorithms to practical scenarios involving manipulators and mobile robots.	Applying (K3)

TEXT BOOKS

1. Emanuele Trucco, Alessandro Verri, "Introductory Techniques for 3D Computer Vision", Prentice Hall of India, April 11-13, 2018.

2. D. Scaramuzza and F. Fraundorfer, "Visual Odometry [Tutorial]", IEEE Robotics & Automation, Magazine, vol. 18, no. 4, pp. 80-92, December, 2011

REFERENCES

1. F. Fraundorfer and D. Scaramuzza, "Visual Odometry: Part II: Matching, Robustness, Optimization, 1 EE Robotics & Automation Magazine, Vol 18, Issue 4, 2011.

2. Revisiting Visual Odometry for Real-Time Performance, Gaurav Singh, Meiqing Wu, S. Lam, Published 27 May 2019

3. Bruno Siciliano, Oussama Khatib, "Springer Handbook of Robotics", Springer, 2008

4. Visual Servoing: Real-Time Control of Robot Manipulators Based on Visual Sensory Feedback Author: Koichi Hashimoto 1998

CO - PO MAPPING

	Mapping of Course Outcomes with Programme Outcomes: (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak													
COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	-	-	-	-	-	-	1	2	1
CO2	3	2	2	2	2	-	-	-	-	-	-	1	2	2
CO3	3	2	3	2	3	-	-	-	-	-	-	1	2	1
CO4	3	2	2	2	2	-	-	-	-	-	-	1	2	1
CO5	3	2	3	2	3	-	-	-	-	-	-	1	2	1

RA23356	CYBER SECURITY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand concepts of computer security, cryptography, digital money, secure protocols, threat detection, and other security techniques.
2	understand essential techniques for protecting information systems and IT infrastructure.
3	analyze and monitor potential threats and attacks, and implement appropriate security architecture and solutions.
4	gain a broader perspective on information security from both technological and legal standpoints, including national security implications.
5	acquire foundational knowledge and practical skills for securing modern digital platforms.

UNIT I	**CYBER SECURITY CONCEPTS**	9

Essential Terminologies: CIA, Risks, Breaches, Threats, Attacks, Exploits. Information Gathering (Social Engineering, Foot Printing & Scanning). Open Source/ Free/ Trial Tools: nmap, zenmap, Port Scanners, Network scanners. Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls - Types of Firewalls, User Management, VPN Security.

UNIT II	**SECURITY PROTOCOLS**	9

Security Protocols: - Security at the Application Layer - PGP and S/MIME, Security at Transport Layer - SSL and TLS, Security at Network Layer – IP Sec. Introduction to Networks, Network Packet Sniffing, Network Design Simulation. DOS/ DDOS attacks. Asset Management and Audits, Vulnerabilities and Attacks. Intrusion Detection and Prevention Techniques, Host-based Intrusion Prevention Systems.

UNIT III	**VULNERABILITIES& SAFE GUARDS**	9

Cyber Security Vulnerabilities & Safeguards: Internet Security, Cloud Computing & Security, Social Network Sites Security, Cyber Security Vulnerabilities - Overview, vulnerabilities in software, System Administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Authorization, Unprotected Broadband Communications, Poor Cyber Security Awareness. Cyber Security Safeguards - Overview, Access Control, IT Audit, Authentication.

UNIT IV	**MALWARE AND SYSTEM HARDENING**	9

Malware: Explanation of Malware, Types of Malware: Virus, Worms, Trojans, Rootkits, Robots, Adwares, Spywares, Ransomwares, Zombies etc. OS Hardening (Process Management, Memory Management, Task Management, Windows Registry/Services and Other Configuration), Malware Analysis. Open Source/ Free/ Trial Tools: Antivirus Protection, Anti Spywares, System Tuning Tools, Anti Phishing.

UNIT V	**SECURITY IN EVOLVING TECHNOLOGY**	9

Biometrics, Mobile Computing and Hardening on Android and iOS, IoT Security, Web Server Configuration and Security. Introduction, Basic Security for HTTP Applications and Services, Basic Security for Web

Services like SOAP, REST etc., Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges.

	TOTAL PERIODS:45

COURSE OUTCOMES

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

CO1	understand foundational cybersecurity concepts, threats, and cryptographic techniques for securing digital environments.	Understanding (K2)
CO2	analyze and apply various security protocols across application, transport, and network layers to protect data transmission.	Understanding (K2)
CO3	identify and implement appropriate safeguards for common cybersecurity vulnerabilities in systems, networks, and cloud platforms.	Applying (K3)
CO4	recognize and apply system hardening and malware analysis techniques for secure system configuration.	Analysing (K4)
CO5	evaluate and implement cybersecurity measures in emerging technologies such as IoT, mobile platforms, and web services.	Analysing (K4)

TEXT BOOKS

1. William Stallings, "Cryptography and Network Security", Pearson Education/PHI, 2006
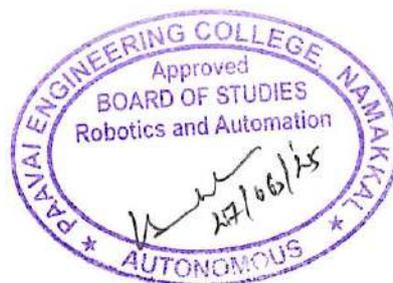2. V.K. Jain, "Cryptography and Network Security", Khanna Publishing House

REFERENCES

1. Gupta Sarika, "Information and Cyber Security", Khanna Publishing House, Delhi
2. Atul Kahate, "Cryptography and Network Security", McGraw Hill
3. V.K. Pachghare, "Cryptography and Information Security", PHI Learning
4. Mayank Bhushan, Rajkumar Singh Rathore & Aatif Jamshed ,Fundamentals of Cyber Security: Principles, Theory & Practices, BPB Publications, 2018

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	-	-	3	1	1	-	1	-	2
CO2	3	2	2	2	2	-	-	3	1	1	-	1	-	2
CO3	3	2	2	2	2	-	-	3	1	1	-	1	-	2
CO4	3	2	2	2	2	-	-	3	1	1	-	1	-	2
CO5	3	2	2	2	2	-	-	3	1	1	-	1	-	2

RA23357	WIRELESS SENSOR NETWORKS FOR ROBOTICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the basic concepts of wireless sensor networks.
2	explain the fundamentals of wireless architecture.
3	impart knowledge in sensor-based networking techniques.
4	explore various techniques used in wireless networking.
5	identify tools and technologies used in network implementation.

UNIT I	OVERVIEW OF WIRELESS SENSOR NETWORKS	9

Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks – Energy Constraints, Scalability and Maintenance, Harsh Environmental Conditions, Security Vulnerabilities.

UNIT II	ARCHITECTURES	9

Single-Node Architecture – Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments. Network Architecture – Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts.

UNIT III	NETWORKING SENSORS	9

Physical Layer and Transceiver Design Considerations, MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols and Wakeup Concepts – S-MAC, The Mediation Device Protocol, Wakeup Radio Concepts. Address and Name Management, Assignment of MAC Addresses. Routing Protocols – Energy-Efficient Routing, Geographic Routing.

UNIT IV	INFRASTRUCTURE ESTABLISHMENT	9

Techniques include adjusting transmission ranges, creating communication backbones, and utilizing algorithms like Gabriel Graph and Relative Neighborhood Graph. These methods help in reducing interference and extending network lifetime.

UNIT V	SENSOR NETWORK PLATFORMS AND TOOLS	9

Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level Software Platforms, Node-level Simulators, State-Centric Programming.

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	understand the challenges, enabling technologies, and limitations of wireless sensor networks in real-world environments.	Understanding (K2)
CO2	discuss the hardware components, energy consumption aspects, and system architecture of sensor nodes and networks.	Understanding (K2)
CO3	apply communication protocols and address management strategies for	Applying (K3)

	efficient data transmission in sensor networks.	
CO4	implement topology control techniques to optimize communication and prolong network lifetime.	Applying (K3)
CO5	demonstrate practical skills in sensor hardware, programming platforms, and simulation tools used in wireless sensor networks.	Applying (K3)

TEXT BOOKS

1. Holger Karl & Andreas Willig, "Protocols And Architectures for Wireless Sensor Networks", John Wiley, 2005.

2. Feng Zhao & Leonidas J. Guibas, "Wireless Sensor Networks- An Information Processing Approach", Elsevier, 2007.
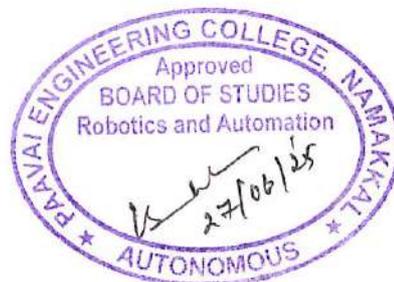
REFERENCES

1. KazemSohraby, Daniel Minoli, &TaiebZnati, "Wireless Technology, Protocols, And Applications", John Wiley, 2007.

2. Anna Hac, "Wireless Sensor Network Designs", John Wiley, 2003.

3. Wireless Sensor Networks: Principles and Practice,Authors: Fei Hu and Xiaojun Cao
   Publisher: CRC Press

4. Wireless Sensor Networks, Ian F. Akyildiz and Mehmet Can Vuran Publisher: Wiley-VCH

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	-	-	-	-	-	-	2	3	3
CO2	3	3	3	3	2	-	-	-	-	-	-	2	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	2	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	2	3	3
CO5	3	3	3	3	3	-	-	-	-	-	-	2	3	3

RA23451	ADVANCED ROBOTICS AND ANALYSIS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the fundamentals of robotic manipulators and develop analytical and numerical skills in solving kinematic problems.
2	analyze redundancy in robotic systems and apply advanced techniques for redundancy resolution and hyper-redundant manipulator control.
3	derive and simulate dynamic models for complex robotic systems using different dynamic formulations.
4	study and implement control strategies for position, motion, and force control in robotic manipulators.
5	explore the modeling, analysis, and real-time control of flexible and deployable robotic systems.

UNIT I	FUNDAMENTALS OF ROBOTIC MANIPULATORS AND KINEMATICS	9

Review of serial and parallel robot manipulators - Denavit-Hartenberg (D-H) convention - Forward and inverse kinematics - Robot workspace; Analytical and numerical solutions of kinematics - Jacobian matrix and its applications - Manipulability analysis; Vibration isolation in robotic systems;

UNIT II	REDUNDANCY AND RESOLUTION TECHNIQUES	9

Redundant manipulators - Resolution of redundancy using optimization techniques - Minimization of joint rotations and Cartesian motion; Tractrix-based approach for planar and spatial robots - Manipulators with variable geometry; Experimental studies on hyper-redundant robots including 8-link structures - Redundancy in high-DOF systems - Task-space and joint-space planning;

UNIT III	ROBOT DYNAMICS AND FORMULATION METHODS	9

Dynamic equations of motion for robotic systems - Lagrangian and Newton-Euler formulations - Recursive inverse dynamics - Articulated body algorithm - Dynamics of multi-link manipulators; Simulation of dynamic behavior - Pseudoinverse approach for redundancy resolution - Modal approach for trajectory execution; Dynamic modeling using computer-aided tools;

UNIT IV	CONTROL STRATEGIES FOR ROBOTIC MANIPULATORS	9

Simulation and implementation of linear control strategies - Motion planning for manipulators; Nonlinear position and force control of 6 DOF manipulators - Impedance and admittance control - Hybrid force/motion control - Task partitioning for complex operations; Feedback linearization and adaptive control techniques - Stability analysis and trajectory tracking;

UNIT V	ADVANCED AND FLEXIBLE ROBOTIC SYSTEMS	9

Numerical and analytical solutions for over-constrained systems - Modeling and analysis of deployable structures - Cable-driven robotic systems; Pneumatically actuated flexible robots - Design considerations for soft and compliant mechanisms - Biomimetic robot actuation; Application-oriented flexible manipulator systems - Real-time control and simulation of flexible robotic arms.

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	understand the kinematics of serial and parallel manipulators using D-H convention and solve related problems..	Understanding (K2)
CO2	apply redundancy resolution techniques to optimize motion in hyper-redundant manipulators.	Applying (K3)
CO3	derive the dynamic models using Newton-Euler and articulated body algorithms.	Applying (K3)
CO4	design and simulate motion planning and control strategies for 6 DOF robotic manipulators.	Analysing (K4)
CO5	analyze flexible, cable-driven, and deployable robotic systems for real-time applications.	Analysing (K4)

TEXT BOOKS

1. Robotics: Modelling, Planning and Control, Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo Springer

2. Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006

REFERENCES

1. R.K. Mittal and I.J. Nagrath, "Robotics and Control", Tata McGraw Hill.

2. John J Craig, "Introduction to Robotics: Mechanics and control", Printice Hall of India.

3. K.S.Fu, R.C.Gonzalez and C.S.G.Lee, "Robotics: Control, Sensing, Vision and Intelligence", McGraw Hill.

4. M.W.Spong and M. Vidyasagar, "Robot Dynamics and Control", Wiley India.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	1	1	1	1	1	1	2	3	2
CO2	3	3	3	3	2	1	1	1	2	1	1	2	3	3
CO3	3	3	3	3	3	1	1	1	2	1	2	2	3	3
CO4	3	3	3	3	3	2	1	1	2	2	2	3	3	3
CO5	3	3	3	3	3	2	1	1	2	2	2	3	3	3

RA23452	COMPUTER VISION AND IMAGE PROCESSING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	provide foundational knowledge of image formation, camera models, and geometric transformations in computer vision systems.
2	develop the ability to apply image enhancement, filtering, and color processing techniques for pre-processing visual data.
3	enable understanding and implementation of segmentation methods and feature extraction techniques for object representation.
4	introduce machine learning concepts relevant to vision tasks such as classification, clustering, and dimensionality reduction.
5	equip students with deep learning techniques and their application in real-world computer vision problems like detection and tracking.

UNIT I	INTRODUCTION TO COMPUTER VISION AND IMAGE FORMATION	9

Goals and applications of Computer Vision and Image Processing - image formation concepts including radiometry and optics; geometric transformations - pinhole and perspective projection camera models - camera calibration; stereo vision setup - 3D reconstruction from multiple views - photometric stereo - structure from motion - intrinsic and extrinsic camera parameters.

UNIT II	FUNDAMENTALS OF IMAGE PROCESSING	9

Image enhancement techniques - image filtering methods including smoothing and sharpening - image transforms such as Fourier, Discrete Cosine Transform (DCT), and Wavelet; color spaces including RGB, HSV, and Lab - color constancy and color correction; morphological operations - histogram processing - noise models - adaptive filtering - frequency domain processing.

UNIT III	IMAGE SEGMENTATION AND FEATURE EXTRACTION	9

Image segmentation techniques including thresholding, region-based methods, edge-based segmentation, watershed algorithm, and clustering-based segmentation - texture descriptors - color histograms and features; edges, contours, and shape representations - interest point detectors including Harris and FAST - feature descriptors such as SIFT, SURF, and HOG; saliency detection - feature matching and key point tracking.

UNIT IV	MACHINE LEARNING FUNDAMENTALS FOR VISION APPLICATIONS	9

Linear regression - decision functions - elementary statistical decision theory - parameter estimation; clustering techniques including K-means, hierarchical, and DBSCAN; dimensionality reduction using PCA and LDA; supervised and unsupervised learning - support vector machines (SVM) - ensemble methods - evaluation metrics including confusion matrix, ROC curve, and precision-recall analysis.

UNIT V	DEEP LEARNING AND ADVANCED VISION APPLICATIONS	9

Artificial Neural Networks - Convolutional Neural Networks (CNNs); Auto encoders - image segmentation

using U-Net - gesture recognition - template matching - object detection using YOLO, SSD, and RCNN - object tracking using background subtraction, kernel-based tracking, and particle filters; transfer learning - visual transformers - generative models (GANs) - vision-language models including CLIP and DINO.

		TOTAL PERIODS:45
COURSE OUTCOMES		**BT MAPPED**
At the end of the course, the students will be able to		(Highest level)
CO1	understand the principles of image formation, radiometry, and geometric camera models.	Understanding (K2)
CO2	apply image processing techniques for enhancement, transformation, and filtering of visual data.	Applying (K3)
CO3	perform image segmentation and extract robust features for recognition and analysis.	Applying (K3)
CO4	apply machine learning techniques for classification, clustering, and dimensionality reduction in vision.	Applying (K3)
CO5	design and implement deep learning models for object detection, tracking, and advanced vision tasks.	Analysing (K4)

TEXT BOOKS

1. Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006.

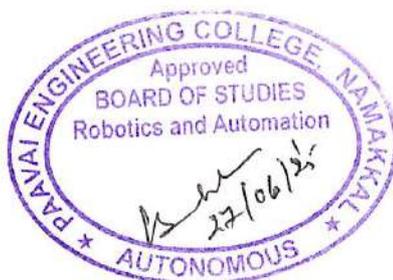2. R.K. Mittal and I.J. Nagrath, "Robotics and Control", Tata McGraw Hill

REFERENCES

1. John J Craig, "Introduction to Robotics: Mechanics and control", Printice Hall of India

2. S. K. Saha, "Introduction to Robotics", Tata McGraw Hill.

3. M.W.Spong and M. Vidyasagar, "Robot Dynamics and Control", Wiley India

4. Computer Vision: Algorithms and Applications Springer Edition: 2nd Edition

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	1	1	1	1	1	1	2	3	2
CO2	3	3	3	2	2	1	1	1	1	1	1	2	3	3
CO3	3	3	3	2	2	1	1	1	2	1	1	2	3	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3	3	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3	3	3

RA23453	FIELD AND SERVICE ROBOTICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the various components of robots and the different fields within robotics.
2	analyze the kinematics and inverse kinematics of robotic systems.
3	explore the concepts of localization, path planning, and navigation in robotics.
4	examine control strategies for robots in specific applications.
5	study the design and functionality of humanoid robots.

UNIT I	**INTRODUCTION**	9

History of service robotics – Present status and future trends – Need for service robots – Applications – Examples and specifications of service and field robots – Non-conventional industrial robots.

UNIT II	**LOCALIZATION**	9

Introduction – Challenges of localization – Map representation – Probabilistic map-based localization – Monte Carlo localization – Landmark-based navigation – Globally unique localization – Positioning beacon systems – Route-based localization.

UNIT III	**PLANNING AND NAVIGATION**	9

Introduction – Path planning overview – Road map path planning – Cell decomposition path planning – Potential field path planning – Obstacle avoidance – Case studies: Tiered robot architectures.

UNIT IV	**FIELD ROBOTS**	9

Aerial robots – Collision avoidance; Robots for agriculture, mining, exploration, underwater, civilian and military applications, nuclear applications, space applications.

UNIT V	**HUMANOIDS**	9

Wheeled and legged – Legged locomotion and balance – Arm movement – Gaze and auditory orientation control – Facial expression – Hands and manipulation – Sound and speech generation – Motion capture/Learning from demonstration – Human activity recognition using vision, touch, sound – Vision – Tactile sensing – Models of emotion and motivation – Performance – Interaction – Safety and robustness – Applications – Case studies.

	TOTAL PERIODS:45

COURSE OUTCOMES	**BT MAPPED**
At the end of the course, the students will be able to	(Highest level)
CO1	describe the basic concepts and working principles of robots.	Understanding (K2)
CO2	demonstrate the function and role of sensors in robotic systems	Applying (K3)
CO3	develop programs to operate robots for specific applications.	Applying (K3)
CO4	utilize robots across different industrial and practical applications.	Applying (K3)
CO5	analyse the functions and operations of humanoid robots.	Analysing (K4)

TEXT BOOKS

1. Siegwart, Roland- Introduction to autonomous mobile robots. - 2nd ed. / Roland 2011 Massachusetts Institute of Technology

2. Riadh Siaer, The future of Humanoid Robots- Research and applications", Intech Publications, 2012.
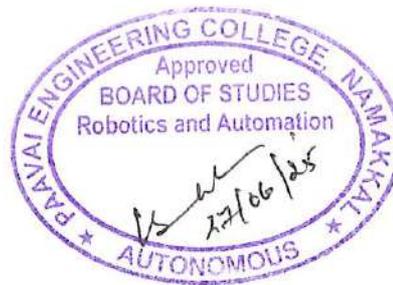
REFERENCES

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.

2. Kelly, Alonzo; Iagnemma, Karl; Howard, Andrew, "Field and Service Robotics ", Springer, 2011

3. Robin R. Murphy, Introduction to AI Robotics, MIT Press, 2nd Edition, 2019

4. Siegwart, Roland, Illah R. Nourbakhsh, and Davide Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, 2nd Edition, 2011.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	1	1	1	1	2	2	3	3	2
CO2	3	3	3	3	2	1	1	1	2	2	2	3	3	2
CO3	3	3	3	3	2	2	1	1	2	3	2	3	3	3
CO4	3	2	3	2	2	2	2	1	2	3	2	3	3	3
CO5	3	2	3	2	3	2	2	2	3	3	2	3	3	3

RA23454	ADVANCED MATERIALS FOR ROBOTICS	3	0	0	3

COURSE OBJECTIVES	
To enable the students to	
1	introduce the fundamental principles of advanced metallic materials and their role in robotics.
2	explore various structural metallic materials and recent innovations in material science that support the development of robotic systems and smart vehicles.
3	provide an in-depth understanding of composite materials and smart polymers used in robotics.
4	introduce sensor, thin film, energy, and refractory materials used in intelligent systems.
5	develop proficiency in advanced instrumentation techniques used for material characterization, especially for emerging robotic and smart mobility materials.

UNIT I	ADVANCED METALLIC MATERIALS IN ROBOTICS	9

Advanced metallic materials – Fundamental principles of advanced materials and application of advanced materials to robotics using a multidisciplinary science-based approach; Liquid-solid transformation – Nucleation and kinetics of growth – Interface morphologies – Non-equilibrium freezing – Segregation – Nucleation in the solid state – Transformations – Diffusion in solid state – Diffusion equations for steady state and transient conditions – Strengthening methods and mechanisms.

UNIT II	STRUCTURAL MATERIALS AND ALLOYS FOR ROBOTICS	9

Structural materials for robots: aluminium, copper, magnesium, steel, nickel, titanium alloys; Recent advances in materials development: high-entropy alloys, functionally gradient materials, shape memory alloys, metallic composites for soft robotics, computational metamaterials.

UNIT III	COMPOSITE MATERIALS AND SMART POLYMERS	9

Composites in robotics: types of matrices and reinforcements, principles, properties, applications; Stretchable elastomeric sensors and ionic polymers for robotics – Kevlar – Biodegradable smart materials – Macroscopic composites – Three-dimensional, periodic cellular architecture – Special processing techniques of material for robotics.

UNIT IV	THIN FILMS SENSOR MATERIALS, AND ENERGY MATERIALS	9

Introduction to thin films and sensor materials – Energy materials – Refractory materials and their relevance – Characterization overview for advanced and robotic materials; Recap of mechanical, metallurgical, chemical, thermal methods.

UNIT V	ADVANCED CHARACTERIZATION TECHNIQUES FOR ROBOTIC MATERIALS	9

Instrumentation methods: scanning electron microscopy, transmission electron microscopy, energy dispersive analysis – X-ray diffraction – Atomic force microscopy – Field array NDT techniques for futuristic materials – Surface patterning techniques.

	TOTAL PERIODS:45

COURSE OUTCOMES			BT MAPPED
At the end of the course, the students will be able to			(Highest level)
CO1		describe diffusion behavior in solid-state and diffusion equations to material systems.	Understanding (K2)
CO2		understand the significance of computational metamaterials in intelligent vehicle systems.	Understanding (K2)
CO3		demonstrate the application of stretchable elastomeric sensors and ionic polymers in robotic systems.	Applying (K3)
CO4		discuss the importance of refractory materials in high-temperature mobility applications.	Applying (K3)
CO5		utilize field array NDT techniques and surface patterning tools to evaluate futuristic robotic materials.	Analysing (K4)

TEXT BOOKS

1. Rowe Jason, "Advanced Materials in Automotive Engineering", Woodhead Publishing, 2016.

2. Sohel Rana and Raul Fangueiro, "Advanced Composite Materials for Aerospace Engineering: Processing, Properties and Applications", Woodhead Publishing, 2016.

REFERENCES

1. Cantor Brian, Hazel Assender and Patrick Grant, "Aerospace Materials", CRC Press, 2015

2. Park Joon and Roderic S. Lakes, "Biomaterials: An Introduction", Springer Science & Business Media, 2007

3. W. D. Callister, "Materials Science and Engineering: An Introduction", John Wiley & Sons, 2007

4. Ajit Behera, Advanced Materials: An Introduction to Modern Materials Science, Springer Cham,2021

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	1	-	-	-	-	1	-	1
CO2	3	3	-	-	-	-	1	-	-	-	-	1	-	1
CO3	3	3	3	-	-	-	-	-	-	-	-	1	-	1
CO4	3	3	2	-	1	-	-	-	-	-	-	1	-	1
CO5	3	3	3	-	1	-	1	-	-	-	-	1	-	1

RA23455	INTELLIGENT CONTROL OF ROBOTIC SYSTEM	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the role and applications of learning in robotics.
2	implement efficient learning control techniques for manipulation robots using feedforward neural networks.
3	apply fuzzy logic principles to design and synthesize fuzzy controllers for specific robotic tasks.
4	apply genetic algorithms to design and optimize solutions for specific robotic tasks and challenges.
5	analyze the effectiveness of neuro-fuzzy approaches in robotics through real-world examples

UNIT I	INTRODUCTION	9

Introduction – Hierarchical intelligent robotic systems – Role and application of learning in robotics – Introduction to robot learning – Application of robot learning

UNIT II	NEURAL NETWORK APPROACH IN ROBOTICS	9

Introduction – Connectionist models with application in robotics – Learning principles and learning rules applied in robotics – Neural network issues in robotics – Efficient learning control for manipulation robots by feedforward neural networks;

UNIT III	FUZZY LOGIC APPROACH IN ROBOTICS	9

Introduction - Mathematical foundations: Fuzzy sets - Operations on fuzzy sets - Fuzzy relations - Fuzzy logic - Fuzzy controller: Condition interface - Fuzzy set definition base - Control rules - Inference mechanism - Action interface - Direct applications - Synthesis of fuzzy controller - example from robotics - Fuzzy algorithms in robotics.

UNIT IV	GENETIC ALGORITHMS IN ROBOTICS	9

Introduction - Definition and characteristics of Genetic Algorithms - Role of Genetic Algorithms in optimization and problem-solving- Advantages and limitations of using Genetic Algorithms in robotics. Synthesis of GA : Representation of solutions using chromosomes and genes- Genetic Operators: Crossover, Mutation, and Selection- Fitness function and evaluation criteria in Genetic Algorithms: - example from robotics - GAs in Robotics

UNIT V	HYBRID INTELLIGENT APPROACHES IN ROBOTICS	9

Introduction - Basic Ideas of Neuro-Fuzzy Approach - Neuro-Fuzzy Algorithms in Robotics: Hybrid genetic approaches in robotics

	TOTAL PERIODS:45

COURSE OUTCOMES	**BT MAPPED**
At the end of the course, the students will be able to	(Highest level)
CO1	describe the principles of learning in robotics and their role in enhancing robotic capabilities and applications.	Understanding (K2)

CO2	summarize the use of feedforward neural networks for implementing efficient learning control in manipulation robots.	Understanding (K2)
CO3	apply fuzzy logic principles to design and develop fuzzy controllers for specific robotic tasks.	Applying (K3)
CO4	use Genetic Algorithms to design and optimize solutions for targeted robotic problems and challenges.	Applying (K3)
CO5	analyze the effectiveness of neuro-fuzzy techniques in robotics by exploring real-world examples and applications.	Applying (K3)

TEXT BOOKS

1. Behera, Laxmidhar, Swagat Kumar, Prem Kumar Patchaikani, Ranjith Ravindranathan Nair, and Samrat Dutta. Intelligent control of robotic systems. CRC Press, 2020

2. Katic, Dusko, and Miomir Vukobratovic. Intelligent control of robotic systems. Vol. 25. Springer Science & Business Media, 2013
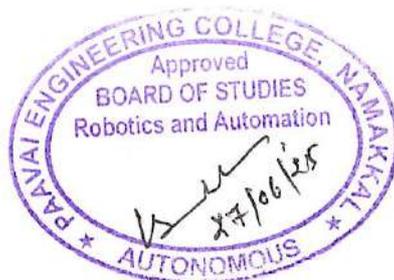
REFERENCES

1. Liu, Jinkun. Intelligent control design and Matlab simulation. Singapore: Springer, 2018

2. Liu, Dikai, Lingfeng Wang, and Kay Chen Tan, eds. Design and control of intelligent robotic systems. Vol. 177. Springer, 2009.

3. Raol, Jitendra R., and Ajith K. Gopal, eds. Mobile intelligent autonomous systems. CRC Press, 2016

4. Sudarshan K. Valluru & T. Nageswara Rao, Introduction to Neural Networks, Fuzzy Logic & Genetic Algorithms: Theory & Applications,2010

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	–	2	–	–	–	–	–	–	–	3	2
CO2	3	3	3	2	3	–	–	–	–	–	–	2	3	3
CO3	3	3	2	–	3	–	–	–	–	–	–	2	3	2
CO4	3	3	3	2	3	–	–	–	–	–	–	2	3	3
CO5	3	3	3	2	3	–	–	–	2	–	2	3	3	3

RA23456	IMMERSIVE TECHNOLOGIES AND HAPTICS	3	0	0	3

COURSE OBJECTIVES

	To enable the students to
1	identify the terminologies of haptic devices
2	understand the structure of haptic system and to aware the tele-operation for various applications
3	acquire the knowledge on modelling for haptic system development relevant to the human
4	emphasize the significance of knowledge in virtual and augmented reality
5	know the concepts and hardware of mixed reality.

UNIT I	INTRODUCTION TO HAPTICS	9

Definition - Importance of Touch - Tactile Proprioception - Tactual Stereo Genesis - Kinesthetic Interfaces - Tactile Interfaces - Human Haptics - Overview of Existing applications - Basics of Force Feedback Devices - Kinesthetic Vs. Tactile Haptic Devices - Configurations of Kinesthetic Devices -Types of Kinesthetic Devices

UNIT II	KINESTHETIC HAPTIC DEVICES AND TELEOPERATION	9

Mechatronics in Haptics System - Haptic Kinematics - Haptic Dynamics - Existing Kinesthetic Devices - Haptic Device Static Rendering - Haptic Device Dynamic Rendering - Control of Haptic Devices - Stability Analysis of Haptic Devices - Stability Analysis of the Rendered Model -Passivity of the Rendered Model. Types of Sensors - Measurement of Haptic Parameters - Types of Actuators - Types of Transmission - Admittance Type Kinesthetic Device - Admittance Control - Comparison of Impedance and Admittance

UNIT III	HUMAN HAPTICS	9

Introduction - Types of Haptic Sensing - Active vs. Passive Touch – Mechano reception – Mechano receptive Afferents - Kinesthetic Sensing - Force Sensing and Proprioception-Introduction to Psychophysics - Measurement Thresholds - Laws of Psychophysics - Weber's Law - Fechner's Law - Fitt's Law - Psychophysical Methods of Limit, Constant Stimuli and Adjustment

UNIT IV	VIRTUAL AND AUGMENTED REALITY	9

The Reality – Virtuality Continuum - Virtual Reality Definitions - Software, Hardware, Sensation and Perception - Multi-Modal Interaction Challenges - System Architecture of Virtual Reality. Aspects of Geometrical Modelling and Environmental Modelling General Solution for Calculating Geometric & Illumination Consistency in the Augmented Environment. Usability Guidelines - Design and Implementation of an Immersive User Experience -

UNIT V	MIXED REALITY	9

System Architecture of a Mixed Reality System - Common Interaction Techniques for Mixed Reality Environments - Common Navigation Techniques - Common Interface for MR - Menu Design Directions - Haptic Control Panel - Performance of an Interaction Techniques, Advanced Interaction Techniques, Design and Implementation of an Immersive User Experience - Case Study for MR

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	identify the core concepts of haptic technology and its application in various systems.	Understanding (K2)
CO2	classify the elements of haptic systems and explain tele-operation mechanisms.	Understanding (K2)
CO3	design and apply devices for human-centric haptic applications.	Applying (K3)
CO4	integrate and construct virtual and augmented reality-based haptic models.	Applying (K3)
CO5	develop and model hardware components for mixed reality applications.	Applying (K3)

TEXT BOOKS

1. Burdea, G. C. and P. Coffet. "Virtual Reality Technology", 3rd edition, Wiley-Interscience, Hoboken New Jersey, 2012.

2. Eckehard Steinbach et al, "Haptic Communications", Vol. 100, 4:937-956, 2012

REFERENCES

1. Sherman, William R. and Alan B. Craig. "Understanding Virtual Reality – Interface, Application, and Design" 2nd edition, Morgan Kaufmann, Cambridge U.S 2019

2. Yuichi Ohta, Hideyuki Tamura, "Mixed Reality: Merging Real and Virtual Worlds", Springer Verlag, Berlin, 2014

3. Kenneth Salisbury, Francois Conti and Federico Barbagli, "Haptic Rendering: IEEE Computer Graphics and Applications, v24 n2 (200403): 24-32, 2004

4. Engineering Haptic Devices: A Beginner's Guide for Engineers,Editor: Thorsten A. Kern Publisher: Springer, 1st Edition, 2009

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	-	1	-	-	-	-	-	-	2	3	2
CO2	2	1	2	-	1	-	-	-	-	-	-	2	3	2
CO3	2	1	2	-	1	-	-	-	-	-	-	2	3	2
CO4	2	1	-	-	1	-	-	-	-	-	-	2	3	2
CO5	2	1	-	-	1	-	-	-	-	-	-	2	3	2

RA23457	OPTIMIZATION FOR ROBOT MODELLING	3	0	0	3
COURSE OBJECTIVES					
To enable the students to					
1	introduce traditional and evolutionary optimization algorithms and their applications.				
2	learn and apply spatial representation methods such as Euler angles and rotation matrices.				
3	introduce methods of type and dimensional synthesis using optimization algorithms				
4	formulate and solve forward and inverse kinematic problems, and optimize manipulator configurations using Jacobians.				
5	understand and implement optimal path and trajectory planning techniques including velocity				

UNIT I	OPTIMIZATION ALGORITHMS IN ROBOTICS	9

Introduction – Traditional gradient-based optimization algorithms – Optimality criterion for unconstrained and constrained optimization problems – Heuristic, meta-heuristics, and evolutionary algorithms – Selective algorithms specific to robotic applications;

UNIT II	SPATIAL REPRESENTATION AND ORIENTATION	9

Spatial representation of a rigid body: Position – Rotational matrix – Euler angles: Problem formulation to find best Euler angles – Roll, pitch, and yaw angles – Homogeneous transformation matrix – Finding optimal values of roll, pitch, and yaw;

UNIT III	KINEMATIC SYNTHESIS AND STRUCTURAL OPTIMIZATION	9

Kinematic synthesis: Introduction – Type synthesis – Dimensional synthesis – Evolutionary method – Graph theory approach; Structural optimization: Topology optimization – Dimensional synthesis using optimization algorithms – Stiffness analysis and optimization;

UNIT IV	MANIPULATOR KINEMATICS AND JACOBIANS	9

Manipulator kinematics: Introduction – Manipulator – Formulating objective function of the forward and inverse kinematics – Identify optimum joint angle for the given position vector; Manipulator Jacobian: Finding optimum Jacobian of a manipulator

UNIT V	PATH AND TRAJECTORY PLANNING	9

Path and trajectory planning: Introduction – Path planning algorithms – Identifying optimal path using heuristic approach – Collision detection algorithms – Trajectory planning: Algorithms – Identifying optimum velocity and acceleration along the path.

	TOTAL PERIODS:45
COURSE OUTCOMES	**BT MAPPED**
At the end of the course, the students will be able to	(Highest level)
CO1	describe and compare classical, heuristic, and meta-heuristic optimization algorithms.	Understanding (K2)
CO2	analyze and compute optimal orientation parameters (Roll, Pitch, Yaw) for robotic rigid bodies	Analysing (K4)

CO3	design and optimize robotic structures and linkages using synthesis techniques and optimization algorithms.	Applying (K3)
CO4	apply optimization techniques to solve kinematic equations and derive optimal manipulator Jacobians	Applying (K3)
CO5	plan and evaluate efficient, collision-free robot trajectories using path planning and optimization strategies.	Analysing (K4)

TEXT BOOKS

1. Ghafil, Hazim Nasir, and Károly Jármai. Optimization for Robot Modelling with MATLAB. Springer International Publishing, 2020.

2. Rao, Singiresu S. Engineering optimization: theory and practice. John Wiley & Sons, 2019.

REFERENCES

1. Koubâa, Anis, Hachemi Bennaceur, Imen Chaari, Sahar Trigui, Adel Ammar, Mohamed-Foued Sriti, Maram Alajlan, Omar Cheikhrouhou, and Yasir Javed. Robot Path Planning and Cooperation. Vol. 772. Springer International Publishing, 2018.

2. Jha, Panchanand, and Bibhuti Bhusan Biswal. "Optimization Approach for Inverse Kinematic Solution." In Kinematics. IntechOpen, 2017.

3. Arora, Rajesh Kumar. Optimization: algorithms and applications. Chapman and Hall/CRC, 2019.

4. Debasish Ghose, Evolutionary Computation in Robotics, Springer, 2018

CO - PO MAPPING

<table>
<tr><td colspan="15" align="center">Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak</td></tr>
<tr><td rowspan="2">COs</td><td colspan="12">Programme Outcomes(POs)</td><td colspan="2">PSOs</td></tr>
<tr><td>PO1</td><td>PO2</td><td>PO3</td><td>PO4</td><td>PO5</td><td>PO6</td><td>PO7</td><td>PO8</td><td>PO9</td><td>PO10</td><td>PO11</td><td>PO12</td><td>PSO1</td><td>PSO2</td></tr>
<tr><td>CO1</td><td>3</td><td>3</td><td>3</td><td>2</td><td>3</td><td>1</td><td>1</td><td>1</td><td>1</td><td>2</td><td>2</td><td>3</td><td>3</td><td>2</td></tr>
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<tr><td>CO5</td><td>3</td><td>2</td><td>3</td><td>3</td><td>3</td><td>2</td><td>2</td><td>1</td><td>2</td><td>3</td><td>2</td><td>3</td><td>3</td><td>3</td></tr>
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RA23551	ROBOTICS AND AUTOMATION IN THE FOOD INDUSTRY	3	0.	0	3

COURSE OBJECTIVES		
To enable the students to		
1	describe the role of robotics and automation in the food industry, emphasizing their importance, benefits, safety, and implementation challenges.	
2	understand robotic applications in food processing and analyse case studies of robotics in the food industry	
3	implement automated quality control techniques for food safety and compliance.	
4	apply automated material handling techniques for food transportation and warehouse management	
5	explore the use of robotics in precision agriculture, AI in food processing, personalized nutrition, sustainable production, and R&D of novel food products.	

UNIT I	INTRODUCTION	9

Overview of Robotics and Automation - Importance and Benefits of Automation in the Food Industry-Types of Robots and Automation Systems used in Food Processing - Safety and Hygiene Considerations in Robotic Applications for Food - Current Challenges and Opportunities in Implementing Robotics and Automation.

UNIT II	ROBOTIC APPLICATIONS IN FOOD PROCESSING AND PACKAGING	9

Robotic Applications in Food Processing: Cutting, Slicing, and Peeling- Robotic Sorting and Grading of Food Products- Robotic Packaging and Labeling Systems- Automation in Filling, Capping, and Sealing of Food Containers- Case Studies: Successful Implementations of Robotics in Food Processing and Packaging

UNIT III	AUTOMATION IN QUALITY CONTROL OF FOOD PRODUCTS	9

Automated Quality Control Techniques for Food Safety and Compliance- Vision Systems and Image Processing in Food Inspection- Non-Destructive Testing and Sensing Technologies in Food Quality Assurance- Robotics in Food Traceability and Tracking- Regulatory Standards and Certifications for Automated Food Inspection

UNIT IV	ROBOTICS AND AUTOMATION IN FOOD MATERIAL HANDLING	9

Automated Material Handling Systems in Food Production-Conveying and Palletizing Robots in the Food Industry- Robotic Pick-and-Place Applications for Food Handling- Autonomous Vehicles and Drones for Food Transportation- Integration of Robotics in Warehouse Management and Logistics

UNIT V	FUTURE PROSPECTS IN FOOD ROBOTICS AND AUTOMATION	9

Robotics in Precision Agriculture and Smart Farming for Food Production- AI and Machine Learning in Food Processing and Quality Control- Robotics for Personalized Nutrition and Food Customization- Sustainability and Energy Efficiency in Automated Food Production-Research and Development in Robotics for Novel Food Products

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	understand the role of robotics and automation in the food industry, including their importance, benefits, safety considerations, and implementation challenges.	Understanding (K2)
CO2	interpret case studies of robotic applications in food processing to comprehend their practical use and impact in the food industry.	Understanding (K2)
CO3	apply automated quality control techniques for food safety and compliance using vision systems, image processing, non-destructive testing, sensing, and robotics.	Applying (K3)
CO4	implement automated material handling systems for efficient food transportation and warehouse operations.	Applying (K3)
CO5	analyze the use of robotics in precision agriculture, AI in food processing, and engage in R&D for novel food products integrated with automation.	Analysing (K4)

TEXT BOOKS

1. Groover, Mikell P. Automation, production systems, and computer-integrated manufacturing. Pearson Education India, 2016.

2. Caldwell, Darwin G., ed. Robotics and automation in the food industry: current and future technologies. Elsevier, 2012
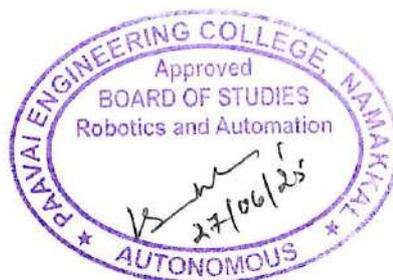
REFERENCES

1. Moore, Colin Anthony. Automation in the food industry. Springer Science & Business Media, 2012.

2. McFarlane, Ian. Automatic control of food manufacturing processes. Springer Science & Business Media,

3. Rakesh Kumar, AI & Robotics for Food Industry, Independently published, 2024

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

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COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3		-	-	-	-	-	-	-	1	2	2
CO2	3	3	3	2	-	-	-	-	-	-	-	1	2	2
CO3	3	3	3	2	1	-	-	-	-	-	-	1	2	2
CO4	3	3	3	2	2	-	-	-	-	-	-	1	2	2
CO5	3	3	3	2	2	-	-	-	-	-	-	1	2	2

RA23552	INDUSTRIAL ROBOTICS AND MATERIAL HANDLING SYSTEMS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the fundamentals, principles, and types of material handling systems and equipment
2	introduce coordinate frames, D-H representation, and inverse kinematics of multi-axis robotic arms.
3	evaluate the work envelope and perspective transformation techniques for workspace analysis of industrial robots.
4	study the Jacobian matrix, joint space singularities, and static force analysis in robotic manipulators.
5	apply dynamic modeling techniques such as Lagrangian mechanics and perform trajectory planning for robot motion control.

UNIT I	FUNDAMENTALS OF MATERIAL HANDLING	9

Material Handling – Functions, Types, analysis, Importance & Scope, Principles, - Part feeding device – types of material handling system – Unit material movement & Unit loads – Receiving, Shipping, in process handling – bulk handling equipment & methods

UNIT II	DOT AND CROSS PRODUCTS	9

Dot and cross products, Co-ordinate frames, Rotations, Homogeneous Coordinates, Link coordinates, D-H Representation, Arm equation -Two axis, three axis, four axis, five axis and six axis robots. Inverse Kinematic problem, General properties of solutions, Tool configuration, Inverse Kinematics of Two axis Three axis, Four axis and Five axis robots.

UNIT III	WORKSPACE ANALYSIS	9

Workspace analysis of Four axis, Five axis and Six axis robots, Perspective transformation, structured illumination, Camera calibration, Work envelope of Four and Five axis robots, Workspace fixtures

UNIT IV	DIFFERENTIAL MOTION AND STATICS	9

The too Configuration jacobian matrix for three axis and, four axis robots, joint space singularities, resolved motion rate control, manipulator jacobian for three and four axis joint space singularities, induced joint torques and forces.

UNIT V	DYNAMIC ANALYSIS AND FORCES	9

Introduction, Langrangian mechanics, Effects of moments of Inertia, Dynamic equation for two axis planar articulated robot. Trajectory planning, Pick and place operations, Continuous path motion, Interpolated motion, Straight-line motion.

	TOTAL PERIODS:45
COURSE OUTCOMES	**BT MAPPED**
At the end of the course, the students will be able to	(Highest level)
CO1 identify the basic concepts, components, and types of robots.	Understanding (K2)

CO2	describe the design of automated manufacturing cells using principles of robotic control.	Understanding (K2)
CO3	summarize drive systems, end effectors, sensors, machine vision, robot kinematics, and programming.	Understanding (K2)
CO4	select appropriate robots based on application requirements.	Applying (K3)
CO5	apply robots in various industrial and service applications.	Applying (K3)

TEXT BOOKS

1. John J Craig, —Introduction to Robotics: Mechanics and control, Pearson, 2009,4th Ed, 2018

2. Robert J. Schilling, —Fundamentals of Robotics Analysis and Controll, PHI Learning, 2011.
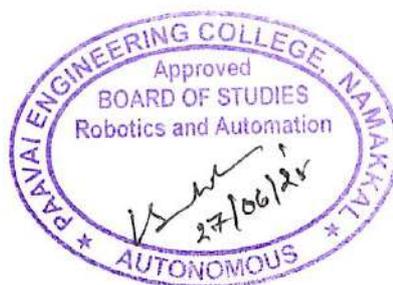
REFERENCES

1. Saha S K, —Introduction to Roboticsll, Tata McGraw Hill Education Pvt. Ltd, 2010, 2nd Ed, 2014.

2. Deb S R and Deb S, —Robotics Technology and Flexible Automationll, Tata McGraw Hill Education Pvt. Ltd, 2010.

3. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006

4. Niku S B, —Introduction to Robotics, Analysis, Systems, Applicationsll, Prentice Hall, 2001.

CO - PO MAPPING

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CO1	3	2	2	1	3	1	1	1	2	2	1	3	3	2
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CO3	3	3	3	2	3	2	2	1	2	2	2	3	3	3
CO4	3	3	3	3	3	2	1	1	2	2	2	3	3	3
CO5	3	3	3	3	3	2	2	1	2	2	2	3	3	3

Approved
BOARD OF STUDIES
Robotics and Automation
27/06/2?
PAAVAI ENGINEERING COLLEGE, NAMAKKAL
AUTONOMOUS

RA23553	AGRICULTURAL ROBOTICS AND AUTOMATION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the operation and applications of farming-related machines.
2	explore the role of global positioning and information systems in agricultural machinery.
3	learn the fundamentals of traction and machine testing.
4	familiarize with concepts of weed management using mechanized tools.
5	examine the principles and criteria for agricultural machinery selection

UNIT I	INTRODUCTION	9

History of Mechanized Agriculture - Farming Operations and Related Machines - Tillage, Planting Cultivation, and Harvesting, Agricultural Automation - Agricultural Vehicle Robot

UNIT II	PRECISION AGRICULTURE	9

Sensors – types and agricultural applications, Global Positioning System (GPS) - GPS for civilian use, Differential GPS, Carrier-phase GPS, Real-time kinematic GPS, Military GPS, Geographic Information System, Variable Rate Applications and Controller Area Networks

UNIT III	TRACTION AND TESTING	9

Hitching- Principles of hitching, Types of hitches, Hitching and weight transfer, Control of hitches, Tires and Traction models, Traction predictor spread sheet, Soil Compaction, Traction Aids, Tractor Testing

UNIT IV	SOIL TILLAGE AND WEED MANAGEMENT	9

Tillage Methods and Equipment, Mechanics of Tillage Tools, Performance of Tillage Implements, Hitching of Tillage Implements, Weed Management - Conventional Cropping Systems, Tools, Crop Rotation, Mechanical Cultivation.

UNIT V	MACHINERY SELECTION	9

Screw Conveyors, Pneumatic Conveyors, Bucket Elevators, Forage Blowers and Miscellaneous Conveyors, Machinery Selection - Field Capacity and Efficiency, Draft and Power Requirements, Machinery Costs

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	recognize potential areas in agricultural processes where robotics can be applied.	Understanding (K2)
CO2	identify appropriate sensors and systems required for specific agricultural processes.	Understanding (K2)
CO3	summarize mechanical principles involved in designing robotic parameters for agricultural tasks.	Understanding (K2)
CO4	convert mechanical linkages into robotic systems by providing actuation at	Applying (K3)

	specific joints and links.	
CO5	develop suitable robotic systems for specific agricultural tasks.	Applying (K3)

TEXT BOOKS

1. Myer Kutz, "Handbook of Farm, Dairy and Food Machinery Engineering", Academic Press, 2019

2. Qin Zhang, Francis J. Pierce, "Agricultural Automation Fundamentals and Practices", CRC Press, 2016

REFERENCES

1. Ajit K. Srivastava, Carroll E. Goering, Roger P. Rohrbach, Dennis R. Buckmaster, "Engineering Principles of Agricultural Machines", ASABE Publication, 2012.

2. Guangnan Chen, "Advances in Agricultural Machinery and Technologies", 1st Edition, CRC Press, 2021

3. Stephen L Young, Francis J. Pierce, "Automation: The Future of Weed Control in Cropping Systems", Springer, Dordrecht Heidelberg New York London, 2014.

4. R.A. Kepner, Roy Bainer, E.L. Barger, "Principles of Farm Machinery", 3rd Edition, CBS Publishers, New Delhi, 2005.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	1	1	1	1	2	2	2	3	2
CO2	3	3	3	2	3	1	2	1	2	2	2	3	3	3
CO3	3	2	3	2	3	2	2	1	2	2	2	3	3	3
CO4	3	2	3	2	2	1	2	1	2	2	2	3	3	2
CO5	3	2	3	2	3	2	1	1	2	2	2	3	3	3

Approved
BOARD OF STUDIES
Robotics and Automation
27/06/25

RA23554	MOTION CONTROL SYSTEM	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce the basics in motion control system
2	knowledge about on architecture of motion control system
3	understand the features and specifications in motion control drives
4	learn about intelligent motors and integrated drive
5	ability to know about the programming of motion controller

UNIT I	INTRODUCTION MOTION CONTROL SYSTEMS	9

Introduction to Motion Control System - Dynamic System Modeling - Control System Design Fundamentals – Parameters in Control – Actuators and Measurement in Motion Control Systems -Multi-Body Dynamics – Need for Motion Controller – Specification of Motion Control

UNIT II	ARCHITECTURE OF MOTION CONTROL SYSTEM	9

Introduction to Motion Controller – Programmable Automation Controllers – Features & Specification of Motion Controllers – Digital I/O – Analog I/O – Standards in I/O – I/O Specific to Sensors – Modular and Expansion Concepts - Drives

UNIT III	MOTION CONTROL DRIVES	9

Programmable Automation Controllers – Features & Specification of Motion Controllers – Digital I/O – Analog I/O – Standards in I/O – I/O Specific to Sensors – Modular and Expansion Concepts - Drives

UNIT IV	INTELLIGENT MOTORS WITH INTEGRATED DRIVE	9

Intelligent motors – intelligent drives – features of drives – programmable I/Os- communication protocols – features – Software - Programming – current, position and speed loops – Application in robots and portable systems

UNIT V	PROGRAMMING OF MOTION CONTROLLER	9

IEC 61131 standards and Its Programming Languages overview- CoDeSys Platform - status Diagram – PLC Open - Motion Planer - PID - Servo Tuning – Position- velocity, Acceleration and Torque Profiling – CAM Profiling – Multi- Axis Motion Controllers – CNC Machines – Robot case study

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	identify the basic concepts of motion control systems.	Understanding (K2)
CO2	describe the architecture of motion control systems.	Understanding (K2)
CO3	analyze the features and specifications of motion control drives.	Applying (K3)
CO4	illustrate the concepts of intelligent motors and integrated drives.	Applying (K3)

CO5	demonstrate programming skills for motion controllers.	Applying (K3)

TEXT BOOKS

1. Sabanovic Asif, Motion Control Systems, John Wiley & Sons Inc, 2011

2. M. Nakamura .S. Gata & N. Kyura, Mechatronic Servo System Control, Springer, 2004

REFERENCE BOOKS

1. Operating instructions Compax3 T30 Programmable motion control according to IEC61131-3, Parker Hannifin Corporation, 2008.

2. 2-Axis Motion Controller User Guide, Parker Hannifin Corporation, 1995

3. Model 4000 indexer user Guide, Parker Hannifin Corporation, 1994.

4. Programming with Easy Motion Studio – User's Manual, online, technosoftmotion.com

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	-	-	-	-	-	1	3	-
CO2	3	2	1	1	-	-	-	-	-	-	-	1	3	-
CO3	3	2	1	1	-	-	-	-	-	-	-	1	3	-
CO4	3	2	1	1	-	-	-	-	-	-	-	1	3	-
CO5	3	2	1	1	-	-	-	-	-	-	-	1	3	-

RA23555	ROBOT SAFETY AND MAINTENANCE	3	0	0	3
COURSE OBJECTIVES					

To enable the students to

1	understand key safety terms, real-world robot accidents, and the causes and impacts of robot hazards.
2	explore safety measures, devices, and protocols for robot operation, testing, and emergency handling.
3	assess human interaction with robots, biases, training, and ergonomics influencing safety and productivity.
4	understand various types of robot maintenance, inspection, tools, and safeguarding practices for maintenance personnel.
5	gain knowledge of national and international robot safety standards, risk management, and accident prevention.

UNIT I	INTRODUCTION TO ROBOT SAFETY	9

Safety-related terms and definitions, organizations concerned with safety, robotic safety problems and hazards, use of robots to enhance safety, weak points in planning and design, operations causing safety problems, real-life examples of robot accidents (Japan, Europe, US), causes and characteristics of robot accidents, effects of robot accidents, robot accident analysis and prevention.

UNIT II	ROBOT SAFETY AND SAFETY DEVICES	9

Robot safety education and training, safety during testing, start-up, commissioning, and acceptance, safety in welding and automotive applications, standard safety protocols, safety devices (STOP types, emergency stop, mode select switch, deadman switch, safeguards), operation inside the safety fence, procedures for entering the safety fence.

UNIT III	HUMAN FACTORS IN ROBOTICS	9

Robots versus humans, human factors in robotic system integration, human biases and ergonomic design improvements, benefits and drawbacks of robotization, operator and teacher safety guidelines, human factors considerations, training to reduce human error, human error data and reliability analysis.

UNIT IV	ROBOT MAINTENANCE	9

Types and functions of maintenance, maintenance needs, robot parts and special tools, preventive maintenance kits, warranty coverage, inspection procedures, safety guidelines for maintenance personnel, models and checklists for maintenance.

UNIT V	SAFETY STANDARDS FOR ROBOTIC TECHNOLOGY	9

BIS and ISO safety standards, safety management system, hazard identification, risk analysis and evaluation, audit programs, preventive maintenance, accident prevention techniques, ergonomics, safety management principles, major accident control, safety training, robotics safety requirements.

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	identify causes and effects of robot-related accidents and determine weak points in robot system design and operation.	Understanding (K2)
CO2	describe the functionality of safety devices and apply standardized safety procedures during robot operation.	Understanding (K2)
CO3	interpret human-robot interaction by incorporating human factors to improve safety, comfort, and reduce errors.	Understanding (K2)
CO4	demonstrate maintenance planning, risk mitigation, and proper inspection techniques for robotic systems.	Applying (K3)
CO5	apply ISO/BIS standards for robot safety audits, risk evaluation, and preventive safety strategies in robot deployment.	Applying (K3)

TEXT BOOKS

1. Robot Reliability and Safety, by B.S.Dhillon, 2015

2. Industrial Robotics -Technology, Programming and Applications, by Nicholas Odrey, 2017

REFERENCES

1. Industrial Robotics, Mikell Groover, 2008

2. Deborah K. Elmer, Safety of Industrial Robots, Springer, 2020.

3. Joseph F. Engelberger, Robotics in Practice: Management and Applications of Industrial Robots, Springer, 2nd Edition, 2021.

4. Garry Lee, Industrial Robot Safety Systems, Wiley, 2018.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	3	3	3	2	2	2	3	3	2
CO2	3	3	3	2	3	3	3	3	3	3	2	3	3	3
CO3	3	2	2	2	2	3	3	3	3	2	2	3	3	3
CO4	3	2	3	2	2	3	3	3	3	2	2	3	3	3
CO5	3	3	3	2	3	3	3	3	3	3	3	3	3	3

RA23556	SUSTAINABILITY FOR AUTOMATION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce the fundamental principles, historical perspectives, and global frameworks of sustainability.
2	understand key environmental sustainability issues, resource management, and relevant policies and regulations.
3	examine social and economic dimensions of sustainability including equity, community development, and corporate responsibility.
4	explore the integration of sustainability principles in robotics design, lifecycle assessment.
5	analyze the applications, impacts, and ethical considerations of sustainable robotics in environmental.

UNIT I	INTRODUCTION	9

Principles & Historical perspectives, Importance and need for sustainability in engineering and technology, impact and implications. United Nations Sustainability Development Goals (SDG), UN summit – Rio & outcome, Sustainability and development indicators

UNIT II	ENVIRONMENTAL SUSTAINABILITY	9

Climate change, Biodiversity loss, Pollution and waste management, Renewable vs. non-renewable resources, Water and energy conservation, Sustainable agriculture and forestry. National and international policies, Environmental regulations and compliance, Ecological Footprint Analysis

UNIT III	SOCIAL & ECONOMIC SUSTAINABILITY	9

Equity and justice, Community development, Smart cities and sustainable infrastructure, Cultural heritage and sustainability, Ethical considerations in sustainable development. Triple bottom line approach, Sustainable economic growth, Corporate social responsibility (CSR), Green marketing and sustainable product design, Circular economy and waste minimization, Green accounting and sustainability reporting.

UNIT IV	FOUNDATIONS OF SUSTAINABILITY IN ROBOTICS	9

Introduction to Sustainability and Robotics -Overview of sustainability concepts; Importance of sustainability in engineering and robotics, Case studies of sustainable robotics applications; recycling robots, agricultural robots, Sustainable Design Principles; Lifecycle assessment in robotics, Analysing the lifecycle of a robotic product, Energy consumption in robotics; Renewable energy sources for robotics.

UNIT V	APPLICATIONS AND IMPACTS OF SUSTAINABLE ROBOTICS	9

Environmental monitoring and conservation efforts; underwater robots for marine life monitoring, Social and Economic Impacts of Sustainable Robotics, Ethical considerations in deploying sustainable robotics, Emerging trends and innovations in sustainable robotics.

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	understand sustainability principles, historical context, and global frameworks such as the UN Sustainable Development Goals (SDGs).	Understanding (K2)
CO2	identify environmental sustainability challenges, policies, and conservation strategies.	Understanding (K2)
CO3	apply knowledge of social and economic dimensions of sustainability including equity, Corporate Social Responsibility (CSR), and circular economy concepts.	Applying (K3)
CO4	implement sustainable design practices and perform lifecycle assessments in robotics with consideration for energy efficiency.	Applying (K3)
CO5	analyze the applications, impacts, and ethical implications of sustainable robotics within environmental and social frameworks.	Analysing (K4)

TEXT BOOKS

1. Allen,D.,&Shonnard, D. R. (2011).Sustainable engineering: Concepts, design and case studies. Prentice Hall

2. Munier, N. (2005). Introduction to sustainability (pp. 3558-6). Amsterdam, The Netherlands: Springer.
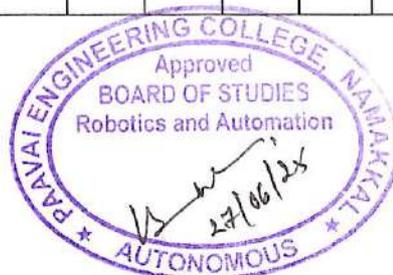
REFERENCE

1. Blackburn, W. R. (2012). The sustainability handbook: The complete management guide to achieving social, economic and environmental responsibility. Routledge

2. Clini, C., Musu, I., & Gullino, M. L. (2008). Sustainable development and environmental management. Published by Springer, PO Box, 17, 3300.

3. Bennett, M., James, P., & Klinkers, L. (Eds.). (2017). Sustainable measures: Evaluation and reporting of environmental and social performance. Routledge.

4. Stark, R., Seliger, G., & Bonvoisin, J. (2017). Sustainable manufacturing: Challenges, solutions and implementation perspectives. Springer Nature

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	1	-	-	-	-	1	2	1
CO2	3	2	1	1	-	-	1	-	-	-	-	1	2	1
CO3	3	2	1	1	-	-	1	-	-	-	-	1	2	1
CO4	3	2	1	1	-	-	1	-	-	-	-	1	2	1
CO5	3	2	1	1	-	-	1	-	-	-	-	1	2	1

RA23557	INDUSTRIAL IOT AND AUTOMATION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand Smart Objects and IoT Architectures
2	explore various IoT-related communication protocols.
3	build simple IoT systems using Arduino and Raspberry Pi.
4	understand data analytics and cloud technologies in the context of IoT.
5	develop IoT infrastructure for popular applications

UNIT I	BASICS OF IoT	9

Evolution of Internet of Things - Enabling Technologies – IoT Architectures: one M2M, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack — Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors, Actuators, Smart Objects and Connecting Smart Objects

UNIT II	IoT PROTOCOLS	9

IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4,802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRa WAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks – Application Transport Methods: Supervisory Control and Data Acquisition – Application Layer Protocols: CoAP and MQTT

UNIT III	DESIGN AND DEVELOPMENT	9

Design Methodology - Embedded computing logic - Microcontroller, System on Chips - IoT system building blocks - Arduino - Board details, IDE programming - Raspberry Pi - Interfaces and Raspberry Pi with Python Programming

UNIT IV	DATA ANALYTICS AND SUPPORTING SERVICES	9

Structured Vs Unstructured Data and Data in Motion Vs Data in Rest – Role of Machine Learning –No SQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark – Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework – Django – AWS for IoT – System Management with NETCONF- YANG

UNIT V	CASE STUDIES/INDUSTRIAL APPLICATIONS	9

Cisco IoT system - IBM Watson IoT platform – Manufacturing - Converged Plant wide Ethernet Model (CPwE) – Power Utility Industry – Grid Blocks Reference Model - Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	identify various communication protocols used in Internet of Things (IoT).	Understanding (K2)
CO2	summarize the core concepts and architecture of IoT systems.	Understanding (K2)
CO3	design a proof-of-concept (PoC) IoT system using Raspberry Pi or Arduino.	Applying (K3)
CO4	apply data analytics and cloud computing tools in IoT applications.	Applying (K3)
CO5	analyze real-time IoT applications in automation and control systems.	Analysing (K4)

TEXT BOOKS

1. IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017.

2. Arshdeep Bahga, Vijay Madisetti, ―Internet of Things – A hands-on approach‖, Universities Press, 2015
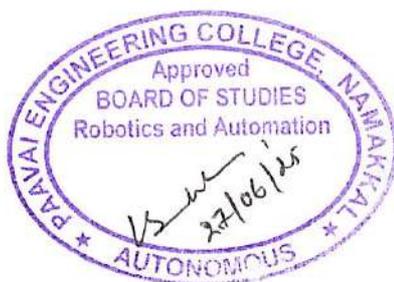
REFERENCES

1. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.

2. Olivier Hersent, David Boswarthick, Omar Elloumi, . The Internet of Things – Key applications and Protocols, Wiley, 2012

3. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), ―Architecting the Internet of Things‖, Springer, 2011

4. Michael Margolis, Arduino Cookbook, Recipes to Begin, Expand, and Enhance Your Projects, 2 nd Edition, O'Reilly Media, 2011.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	1	2	1	2	2	2	3	3	2
CO2	3	2	3	2	3	2	2	1	2	2	2	3	3	3
CO3	3	3	3	2	3	1	1	1	2	2	2	3	3	3
CO4	3	3	3	3	3	2	2	1	2	2	2	3	3	3
CO5	3	2	3	2	2	1	2	1	3	2	2	3	3	3

RA23651	GENERATIVE AI IN HUMAN COLLABORATIVE INTERACTION	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the core concepts of generative AI and collaborative robots and their integration in human-robot interaction systems.
2	apply generative AI to enable multimodal communication between humans and co-bots using language, vision, and gesture inputs
3	develop adaptive co-bot behavior using generative models for task planning, learning from demonstrations, and personalization.
4	identify and address safety, ethical, and trust-related considerations in generative AI-driven collaborative robots interactions
5	analyze real-world use cases of generative AI in co-bot applications and design simple prototypes based on industry trends

UNIT I	INTRODUCTION TO GENERATIVE AI AND COLLABORATIVE ROBOTS	9

Basics of AI and generative models - LLMs, GANs, VAEs, and diffusion models, Introduction to collaborative robots (co-bots), evolution, fundamental concepts of human-robot interaction (HRI), applications of generative AI in robotics, Generative model interaction with co-bots.

UNIT II	MULTIMODAL INTERACTION IN HUMAN-COBOT SYSTEMS	9

Natural language processing (NLP) for robot instruction, speech and gesture recognition techniques, and the use of vision-language models like BLIP and Flamingo in co-bots. Integration of multimodal inputs such as voice, text, image, and motion for seamless communication between humans and robots.

UNIT III	LEARNING, ADAPTATION, AND PERSONALIZATION WITH GENERATIVE AI	9

Few-shot and zero-shot learning using large language models, techniques for personalizing co-bot behavior based on user preferences, and adaptive task planning with generative models. Introduction to generative reinforcement learning and imitation learning methods used in human – co-bot collaboration scenarios.

UNIT IV	SAFETY, ETHICS, AND TRUST IN HUMAN – CO-BOT COLLABORATION	9

Human safety standards in shared environments, issues of bias and explainability in generative AI, ethical considerations in AI-driven robotic decisions, and frameworks for building trust and transparency in human – co-bot systems.

UNIT V	APPLICATIONS AND CASE STUDIES	9

Real-world applications of generative AI-powered co-bots in healthcare, manufacturing, education, and service industries. ChatGPT-enabled co-bots, Tesla Optimus, and Boston Dynamics robots using AI

	TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	understand the fundamentals of generative AI and the role of co-bots in intelligent human-robot collaboration.	Understanding (K2)
CO2	identify generative AI techniques to interpret and process multimodal human inputs such as voice, gestures, and visual cues.	Understanding (K2)
CO3	infer the ability to design co-bot systems that learn and adapt tasks using generative and reinforcement learning models.	Applying (K3)
CO4	identify safety, ethical, and trust-building practices required for effective and responsible co-bot deployment.	Applying (K3)
CO5	implement real-world applications of generative AI-powered co-bots through case studies and project-based learning.	Applying (K3)

TEXT BOOKS

1. Thrun, S., 2002. Probabilistic robotics. Communications of the ACM, 45(3), pp.52-57.

2. Bartneck, C., Belpaeme, T., Eyssel, F., Kanda, T., Keijsers, M. and Šabanović, S., 2024. Human-robot interaction: An introduction. Cambridge University Press.

REFERENCES

1. Coleman, D., 2015. Human-robot interactions: Principles, technologies and challenges. Nova Science Publishers, Incorporated.

2. Haddadin, S. and Croft, E., 2016. Physical human–robot interaction. In Springer handbook of robotics (pp. 1835-1874). Cham: Springer International Publishing.

3. Foster, D., 2019. Generative Deep Learning. Teaching Machines to Paint, Write, Compose and Play (2019). Beijing-Boston-Farnham-Sebastopol-Tokyo, OREILLY, p.330.

4. Corke, P.I., Jachimczyk, W. and Pillat, R., 2011. Robotics, vision and control: fundamental algorithms in MATLAB (Vol. 73, p. 2). Berlin: Springer.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	-	-	-	-	2	-	1	3	2
CO2	3	2	3	2	3	-	-	-	2	2	-	1	3	3
CO3	2	2	3	3	3	-	1	-	2	2	-	2	3	3
CO4	1	2	1	-	1	3	3	3	2	2	2	3	2	1
CO5	3	2	3		3	2	-	-	3	3	2	2	3	3

RA23652	MICRO ELECTRO MECHANICAL SYSTEMS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	provide knowledge of semiconductors and solid mechanics to fabricate MEMS devices
2	educate on the rudiments of Micro fabrication techniques
3	introduce various sensors and actuators
4	present different materials used for MEMS
5	educate on the applications of MEMS to disciplines beyond Electrical and Mechanical engineering.

UNIT I	INTRODUCTION	9

Intrinsic characteristics of MEMS – Energy domains and transducers – Sensors and actuators; Introduction to microfabrication – Silicon-based MEMS processes – New materials – Review of electrical and mechanical concepts in MEMS – Semiconductor devices – Polymers in MEMS; Polyimide – SU-8 – Liquid Crystal Polymer (LCP) – PDMS – PMMA – Parylene – Fluorocarbon;

UNIT II	SENSORS	9

Characteristics of sensors - Electrostatic sensors – Parallel plate capacitors – Piezoresistive sensors – Piezoresistive sensor materials - Stress and strain analysis – Flexural beam bending - Torsional deflection– Applications to Inertia, Pressure, Tactile and Flow sensors – Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials

UNIT III	ACTUATORS	9

Applications – Interdigitated finger capacitor – Comb drive devices – Micro grippers – Micro motors – Thermal sensing and actuation – Thermal expansion – Thermocouples – Thermal resistors – Thermal bimorph – Applications – Magnetic actuators – Micromagnetic components – Case studies of MEMS in magnetic actuators – Actuation using shape memory alloys;

UNIT IV	MICROMACHINING	9

Silicon Anisotropic Etching – Anisotropic Wet Etching – Dry Etching of Silicon – Plasma Etching– Deep Reaction Ion Etching (DRIE) – Isotropic Wet Etching – Gas Phase Etchants – Case studies - Basic surface micro machining processes – Structural and Sacrificial Materials – Acceleration of sacrificial Etch – Striction and Antirestriction methods – LIGA Process - Assembly of 3D MEMS – Foundry process

UNIT V	APPLICATIONS OF MEMS INERTIAL SENSORS	9

Application to Acceleration, Inertia, Acoustic, Tactile, Pressure, Flow and Tactile sensors- Optical MEMS – Lenses and Mirrors -Actuators for Active Optical MEMS.– RF MEMS and Microfluidics

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	recognize MEMS Energy Domains and Transducers, Sensors and Actuators	Understanding (K2)

CO2	select the Various MEMS sensors and its Stress and strain	Understanding (K2)
CO3	apply various MEMS actuators in Real time system	Applying (K3)
CO4	demonstrate various micro machining processes, Structural and Sacrificial Materials	Applying (K3)
CO5	analyze the various MEMS inertial, tactile, pressure and flow sensors in real time system	Analysing (K4)

TEXT BOOKS

1. Chang Liu, "Foundations of MEMS", Pearson Education Inc., 2014, 2ndedition

2. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2008.

REFERENCES

1. James J.Allen, "Micro Electro Mechanical System Design", CRC Press Publisher, 2010

2. Julian w. Gardner, Vijay K. Varadan, Osama O. Awadelkarim, "Micro Sensors MEMS and Smart Devices", John Wiley & Son LTD,2002

3. Nadim Maluf," An Introduction to Micro Electro Mechanical System Design", Artech House, 2000

4. Marc J. Madou, Fundamentals of Microfabrication and Nanotechnology, CRC Press, 3rd Edition (2011)

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	-	1	-	-	-	-	-	1	1	2	1
CO2	2	1	1	-	1	-	-	-	-	-	1	1	2	1
CO3	2	1	1	-	1	-	-	-	-	-	1	1	2	1
CO4	2	1	1	-	1	-	-	-	-	-	1	1	2	1
CO5	3	1	1	-	1	-	-	-	-	-	1	1	2	1

RA23653	SIGNAL PROCESSING IN ROBOTICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	examine various type of signals and its characteristics
2	explore various operations on the signals
3	analyze the signals using Fourier transform and Laplace Transform
4	learn the fundamentals of robotics and sensor technology
5	understand the controlling applications of robotics using sensor responses

UNIT I	FUNDAMENTALS OF SIGNALS AND FOURIER ANALYSIS	9

Continuous-time and discrete-time signals, their representation, classification, and basic operations such as scaling and shifting. It also includes Fourier series, continuous-time Fourier transform (CTFT), magnitude and phase response, and the relation between Laplace and Fourier transforms - a technique enabling efficient signal acquisition and reconstruction, reducing the amount of data need to process.

UNIT II	SIGNAL CONDITIONING AND CONVERSION TECHNIQUES	9

Signal conditioning for robotics, including sensing principles, preprocessing techniques such as noise reduction and detail enhancement. It also covers signal conversion processes like sampling, quantization, and encoding necessary for digital robot control and communication. AI-based Adaptive Filtering – using machine learning algorithms to dynamically filter and enhance sensor data in real time for more robust robotic perception.

UNIT III	DATA ACQUISITION AND VISION SYSTEMS	9

Data acquisition techniques including analog and digital systems with single and multi-channel configurations. It covers image processing fundamentals in robotics, including vision sensors, computer vision basics, linear filters, neighborhood operators, Fourier transforms, and geometric transformations relevant to robotic perception. Deep Learning for Computer Vision – leveraging convolutional neural networks to enable robots to understand complex visual scenes with higher accuracy.

UNIT IV	DRIVE SYSTEMS AND SENSOR TECHNOLOGIES	9

Hydraulic, pneumatic, and electric drives. It also describes key robotic sensors including touch, tactile, proximity, range, vision, force, light, and pressure sensors fundamental to robot interaction with the environment. Soft Robotics Actuators and Sensors – innovative flexible materials and sensors that allow robots to safely interact with humans and adapt to complex environments.

UNIT V	APPLICATIONS AND SIGNAL PROCESSING	9

Robotic applications in surgery, manufacturing, space, underwater, humanoid and micro-robots. It emphasizes the role of signal processing in these areas, focusing on real-time sensor data analysis, integration of sensor inputs, and improving robot performance in complex environments. Edge Computing in Robotics – processing sensor data for faster decision-making and reduce reliance on cloud connectivity.

TOTAL PERIODS:45

COURSE OUTCOMES		BT MAPPED
At the end of the course, the students will be able to		(Highest level)
CO1	differentiate continuous and discrete-time signals	Understanding (K2)
CO2	interpret sensor responses using Fourier Transform	Understanding (K2)
CO3	describe trajectory of sensor signals using Laplace Transform	Understanding (K2)
CO4	apply signal conditioning and acquisition mechanisms	Applying (K3)
CO5	demonstrate real-time applications of sensor signals in robotics	Applying (K3)

TEXT BOOKS

1. Signals and Systems, second edition-P. Rama Krishna Rao and Shankar Prakriya- Mc-Graw Hill, 2013.

2. Groover. M.P. Industrial Robotics, technology, programming and application Mc-Graw Hill 2012.
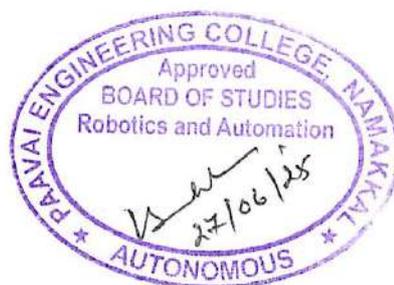
REFERENCES

1. Ramon Pallas-Areny, John G. Webster, "Sensors and Signal Conditioning", 2nd Edition, Wiley India Pvt. Ltd., India, 2012.

2. S. K. Saha, "Introduction to Robotics", Tata McGraw-Hill Publishing Company Ltd. (2008).

3. Signals and systems, second edition - Simon Haykin, Barry VanVeen, Wiley, Wiley India, 2007

4. Signals and systems, second edition-Alan. V. Oppenheim, Alan. S. Willsk,S. Hamid Nawab, PHI learning Pvt ltd,1997

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	3	1	2	1	1	2	1	1	1	3	2
CO2	3	2	3	3	1	3	2	2	2	1	1	1	3	3
CO3	3	3	3	2	1	2	2	2	2	2	1	1	3	3
CO4	3	3	3	3	2	3	2	2	2	1	1	1	3	3
CO5	3	3	3	3	2	3	3	2	3	2	2	1	3	3

RA23654	SMART SENSORS FOR ROBOTICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	provide foundational knowledge of sensor technologies and their role in robotics and automation.
2	develop understanding of vision, proximity, tactile, and force sensors for advanced applications.
3	introduce students to emerging and intelligent sensor technologies.
4	enable sensor integration, signal processing, and real-time decision-making in automated systems.
5	prepare students for applying sensors in interdisciplinary and industrial robotics use cases.

UNIT I	FUNDAMENTALS OF ROBOTIC SENSORS	9

Classification of sensors, sensor specifications, characteristics, interfacing techniques, signal conditioning, sensor calibration, data acquisition systems, sensor fusion fundamentals, and the integration of AI with basic sensor frameworks.

UNIT II	VISION AND IMAGING SYSTEM	9

RGB, stereo, and depth cameras, machine vision, structured light and Time-of-Flight (ToF) cameras, AI-powered visual recognition, hyperspectral and multispectral imaging, event-based vision sensors, and edge-computing-enabled smart cameras for real-time applications.

UNIT III	PROXIMITY RANGE, AND ENVIRONMENTAL SENSORS	9

Ultrasonic, infrared, LiDAR, and radar systems, short-range and long-range distance sensing, SLAM-based sensor applications, advanced environmental sensors (e.g., for VOC, CO_2, and particulate matter), IoT-integrated sensor networks, and AI-assisted proximity sensing for autonomous systems.

UNIT IV	TACTILE, FORCE, AND HAPTIC SENSORS	9

Piezoelectric, capacitive, and resistive tactile sensors, electronic skin (e-skin), force/torque sensors for manipulators, magnetic tactile sensors, haptic feedback systems, biomimetic sensing, flexible/stretchable sensors, and tactile sensing in soft robotics.

UNIT V	EMERGING SENSOR TECHNOLOGIES AND APPLICATIONS	9

Quantum sensors, biosensors, neuromorphic sensors, energy-harvesting and self-powered sensors, wearable and implantable sensor systems, graphene and nanomaterial-based sensors, edge-AI sensing systems, sensor miniaturization trends, and cross-domain applications in autonomous vehicles, healthcare robotics, and smart manufacturing.

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	identify sensor types, describe their working principles, and interpret signal conditioning and fusion techniques.	Understanding (K2)
CO2	classify various imaging sensors and distinguish their applications in robotic vision systems.	Understanding (K2)

CO3	utilize proximity and environmental sensors for robotic navigation and interaction.	Applying (K3)
CO4	employ tactile and haptic sensors in manipulation and collaborative robotics scenarios.	Applying (K3)
CO5	examine recent advancements in quantum and wearable sensors for their practical applications.	Applying (K3)

TEXT BOOKS

1. Siciliano, B., & Khatib, O. (Eds.). Springer Handbook of Robotics, 2nd ed., Springer, 2016

2. Sabrie Soloman. Sensors Handbook, McGraw-Hill Education, 2009.

REFERENCES

1. R. K. Rajput. Instrumentation and Control Systems, S. Chand, 2016.

2. Mohan, M. Mechatronics, PHI Learning Pvt. Ltd., 2020.

3. Karl Heinz Hoffmann. Modern Sensors Handbook, Wiley-VCH, 2022.

4. Gonzalez, R. C., & Woods, R. E. Digital Image Processing, 4th ed., Pearson, 2018.

CO - PO MAPPING
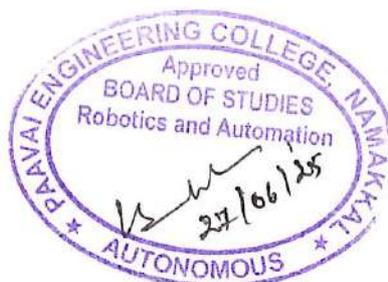
Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	1	1	1	1	1	1	2	3	2
CO2	3	2	3	3	3	1	1	1	1	1	2	2	3	3
CO3	3	3	3	3	3	1	2	2	2	2	2	2	3	3
CO4	3	2	3	3	3	1	2	2	2	2	2	2	3	3
CO5	3	3	3	3	3	2	3	3	2	2	2	3	3	3

RA23655	SOFT ROBOTICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	introduce the fundamentals, motivations, and applications of soft robotic systems
2	explore soft materials and actuation techniques suitable for robotic applications
3	understand the principles of modeling and designing compliant robotic structures
4	learn the sensing, control, and integration aspects of soft robotics
5	analyze real-world applications and examine future trends in soft robotics

UNIT I	INTRODUCTION TO SOFT ROBOTICS	9

Evolution of soft robotics, differences between soft and rigid robots, application areas including biomedical and industrial use, and the key challenges in design and control. Case studies of existing soft robots.

UNIT II	MATERIALS AND ACTUATION METHODS	9

Soft materials such as elastomers, hydrogels, and shape memory polymers, along with actuation technologies like pneumatic actuators, dielectric elastomers, shape memory alloys, and magnetically responsive materials. Fabrication techniques such as molding, 3D printing, and soft lithography.

UNIT III	DESIGN AND MODELING	9

Kinematics and dynamics of soft structures, continuum mechanics, finite element modeling, and bio-inspired design principles. Simulation tools used in soft robotics.

UNIT IV	SENSING, CONTROL, AND INTEGRATION	9

V Stretchable and embedded sensing, closed-loop control strategies, uncertainty handling, and integration with microcontrollers and flexible electronics for real-time feedback.

UNIT V	APPLICATIONS AND RECENT TRENDS	9

Biomedical applications, soft grippers, wearable devices, hybrid soft–rigid systems, and emerging trends such as self-healing materials and AI-enabled soft robots.

TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	identify the need, trace the evolution, and classify different types of soft robotic systems.	Understanding (K2)
CO2	select appropriate soft materials and actuation methods for given robotic applications.	Understanding (K2)
CO3	interpret analytical models and simulation results to define soft robotic structures.	Understanding (K2)
CO4	apply sensing and control strategies for soft robots using embedded system technologies.	Applying (K3)

CO5	investigate the use of soft robotics across biomedical, industrial, and emerging domains, considering trends.	Applying (K3)

TEXT BOOKS

1. Kim, S., Laschi, C., & Trimmer, B. (2013). Soft robotics: a bioinspired evolution in robotics. Trends in Biotechnology.

2. Rus, D. and Tolley, M.T., 2015. Design, fabrication and control of soft robots. Nature, 521(7553), pp.467-475.

REFERENCES

1. Nanayakkara, T., 2024. Handbook on Soft Robotics. Springer Nature Switzerland AG.

2. Della Santina, C., Catalano, M.G., Bicchi, A., Ang, M., Khatib, O. and Siciliano, B., 2020. Soft robots. Encyclopedia of Robotics, 489.

3. Siciliano, B. and Khatib, O., 2016. Robotics and the handbook. In Springer Handbook of Robotics (pp. 1-6). Cham: Springer International Publishing.

4. Kinji Asaka & Hidenori Okuzaki, Soft Actuators: Materials, Modeling, Applications, and Future Perspectives, Springer Tokyo, 2014

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)												PSOs	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	1	1	1	2	2	1
CO2	3	2	3	2	2	1	1	1	1	1	1	2	3	2
CO3	3	3	3	2	3	1	1	1	1	1	1	2	3	3
CO4	2	3	3	2	3	1	1	1	2	2	2	2	3	3
CO5	2	2	2	2	2	2	2	2	2	2	2	3	2	2

RA23656	DIGITAL TWINS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1	understand the basics concepts in digital twin
2	explore the application of digital twin concepts in discrete industries.
3	examine the use of digital twin technologies in process industries.
4	identify the advantages and benefits of implementing digital twins.
5	gain knowledge about the principles and impact of Industry 5.0.

UNIT I	INTRODUCTION	9

Digital twin – Definition, types of Industry and its key requirements, Importance, Application of Digital Twin in process, product, service industries, History of Digital Twin, DTT role in industry innovation, Technologies/tools enabling Digital Twin – Virtual CAD Models – control Parameters- Real time systems – control Parameters – Handshaking Through Internet – cyber physical systems

UNIT II	DIGITAL TWIN IN A PRODUCT INDUSTRY	9

Basics of Product Industry, Trends in the product industry, control system requirements in a product industry, Digital Twin of a Product, Digital Thread in Product Industry, Data collection & analysis for product & production improvements, Automation simulation, Digital Enterprise

UNIT III	DIGITAL TWIN IN A PROCESS INDUSTRY	9

Basics of Process Industry, Trends in the process industry, control system requirements in a process industry, Digital Twin of a plant, Digital Thread in process Industry, Data collection and analysis for process improvements, process safety, Automation simulation, Digital Enterprise

UNIT IV	ADVANTAGES OF DIGITAL TWIN	9

Improvement in product quality, production process, process Safety, identify bottlenecks and improve efficiency, achieve flexibility in production, continuous prediction and tuning of production process through Simulation, reducing the time to market

UNIT V	INDUSTRY 5.0	9

Industrial Revolutions, Industry 5.0 – Definition, principles, Application of Industry 5.0 in process & discrete industries, Benefits of Industry 5.0, challenges in Industry 5.0, Smart manufacturing, Internet of Things 5.0, Industrial Gateways, Basics of Communication requirements – cognitive systems 5.0

	TOTAL PERIODS:45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest level)
CO1	understand the foundational concepts, types, and enabling technologies of Digital Twin and its role in industrial innovation.	Understanding (K2)

CO2	describe Digital Twin principles for modeling, simulation, and product improvement in discrete manufacturing industries.	Understanding (K2)
CO3	apply Digital Twin strategies to optimize safety, performance, and automation in process industries.	Applying (K3)
CO4	implement Digital Twin solutions to improve quality, efficiency, flexibility, and reduce time to market across various industrial sectors.	Applying (K3)
CO5	explore the concepts, applications, and challenges associated with Industry 5.0.	Applying (K3)

TEXT BOOKS

1. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, "Digital Twin Driven Smart Manufacturing", Elsevier Science., United States, 2019

2. Alp Ustundag and Emre Cevikcan, "Industry 4.0: Managing the Digital Transformation", Springer Series in Advanced Manufacturing., Switzerland, 2017.
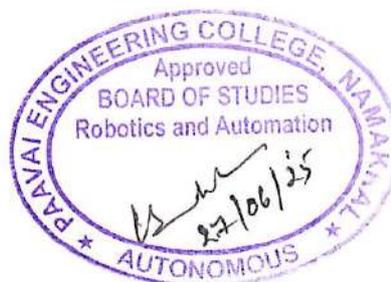
REFERENCES

1. Shyam Varan Nath, Pieter van Schalkwyk, Dan Isaacs, "Building Industrial Digital Twins Design, Develop, and Deploy Digital Twin Solutions for Real-world Industries Using Azure Digital Twins", Packt Publishing, 2021

2. Enis Karaarslan, Moharram Challenger, Ömer Aydin, Ümit Cali, "Digital Twin Driven Intelligent Systems and Emerging Metaverse", Springer Nature Singapore, 2023

3. Christoph Jan Bartodziej, "The Concept Industry 4.0 An Empirical Analysis of Technologies and Applications in Production Logistics", Springer Gambler., Germany, 2017.

4. Uthayan Elangovan, Industry 5.0: The Future of the Industrial Economy, CRC Press, 2022.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

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CO1	3	3	3	2	1	-	-	-	1	-	-	1	2	1
CO2	3	3	3	2	1	-	-	-	1	-	-	1	2	1
CO3	3	3	3	2	1	-	-	-	1	-	-	1	2	1
CO4	3	3	3	2	1	-	-	-	1	-	-	1	2	1
CO5	3	3	3	2	1	-	-	-	1	-	-	1	2	1

Approved
BOARD OF STUDIES
Robotics and Automation
27/06/25

RA23657	INDUSTRIAL NETWORKING	3	0	0	3

COURSE OBJECTIVES					

To enable the students to					

1	understand the fundamental communication principles, standards, and network architectures.
2	learn the operation and applications of industrial bus protocols used in robotic control and automation.
3	identify industrial Ethernet standards and real-time networking technologies critical for automation.
4	study wireless communication technologies and protocols applicable to mobile and distributed
5	explore real-world applications of networking in robotic automation, including Industrial IoT,

UNIT I	INTRODUCTION	9

Instrumentation and control systems in robotics and automation – Terminology – Network topologies and architectures for robotic systems – Communication mechanisms – Protocols and standards in robotic networks – Common problems and solutions – Grounding, shielding, and noise reduction in automation environments – Interface standards: EIA-232, EIA-485 – Fibre optic components and parameters for high-speed robot communications – Cable types and connections – Troubleshooting techniques

UNIT II	COMMUNICATION BUS PROTOCOLS	9

Overview of bus protocols in robotics and automation – Protocol structure and function codes – Modbus Plus protocol – AS-Interface (AS-i) – DeviceNet: physical layer, topology, device taps – Profibus PA/DP/FMS: protocol stack, – CAN Bus: bus access, arbitration, CAN protocol including CAN FD – Introduction to EtherCAT and real-time Ethernet protocols for robotic control – Cybersecurity considerations for bus protocols.

UNIT III	ETHERNET SYSTEMS	9

IEEE 802.3 Ethernet standards – Physical layer and medium access control – Collision management and Ethernet design rules – Fast Ethernet, Gigabit Ethernet, and 10 Gigabit Ethernet for industrial automation – Industrial Ethernet variants: ProfiNet, EtherNet/IP, Modbus TCP – Time-Sensitive Networking (TSN) applications in robotics – Internet layer protocols: UDP, TCP/IP – LAN components and structured cabling – Network design for redundancy and fault tolerance — Introduction to Software Defined Networking (SDN) for network management.

UNIT IV	WIRELESS COMMUNICATIONS	9

Radio spectrum and frequency allocation for industrial wireless networks – Radio modem technologies and interference management – Wireless link implementation in robotic systems – Industrial wireless protocols: RFID basics, transponders, interrogators, Wireless HART – 5G and private 5G networks for automation – Wireless mesh networks and LPWAN for mobile robots and sensors – Cybersecurity in wireless communications – AI-based wireless link optimization.

UNIT V	APPLICATIONS	9

Communication technologies in robotic automation systems – Design and networking of robotic X-by-Wire systems – IEC/IEEE Train communication network for automation – Vehicle-to-Everything (V2X)

communications for autonomous vehicles – Industrial IoT and edge computing in robotics – Digital twins for robotic system monitoring and optimization – Cybersecurity frameworks for robotic and automation networks.

		TOTAL PERIODS:45
COURSE OUTCOMES		**BT MAPPED**
At the end of the course, the students will be able to		(Highest level)
CO1	describe key networking concepts and identify communication issues in robotic automation environments.	Understanding (K2)
CO2	select appropriate bus protocols and apply them for effective communication in robotic systems.	Understanding (K2)
CO3	construct Ethernet-based networks to meet robotic performance requirements.	Applying (K3)
CO4	assess secure and efficient wireless communication links in automation settings.	Applying (K3)
CO5	implement communication systems in robotic automation environments.	Applying (K3)

TEXT BOOKS

1. Dominique Paret, Multiplexed Networks for Embedded Systems, John Wiley & Sons, 2007.
2. Richard Zurawski, The Industrial Communication Technology Handbookǁ, Taylor and Francis, 2005.

REFERENCES

1. Steve Mackay, Edwin Wright, Deon Reynders and John Park, - Practical Industrial Data Networks: Design, Installation and Troubleshooting, Newnes (Elsevier), 2004.
2. James Powell, Henry Vandelinde, Catching the Process Fieldbus an Introduction to PROFIBUS for Process Automation", Momentum Press, 2013.
3. Albert Lozano-Nieto, RFID Design Fundamentals and Applicationsǁ, CRC Press, 20
4. Deon Reynders and Edwin Wright, Practical TCP/IP and Ethernet Networking, IDC Technologies, 2006

CO - PO MAPPING

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CO3	3	3	3	3	1	3	1	2	3	2	3	1	3	3
CO4	3	3	2	2	1	2	1	2	3	2	2	1	3	3
CO5	3	3	3	3	2	3	2	2	3	3	3	2	3	3