MADANAPALLE INSTITUTE OF TECHNOLOGY & SCIENCE
(Deemed to be University)
MADANAPALLE
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Estd 1998

MASTER OF TECHNOLOGY
Automation and Robotics
Course Structure
&
Detailed Syllabi

For the students admitted to

Master of Technology in Automation and Robotics from the Academic Year 2026 – 27 Batch onwards

M.Tech Regular Two Year P.G. Degree Course

MADANAPALLE INSTITUTE OF TECHNOLOGY & SCIENCE

(Deemed to be University)

MADANAPALLE

M. Tech Two Year Curriculum Structure

Branch: Automation and Robotics

Total Credits	80 Credits from 2026 Admitted Batch onwards

M. Tech Automation and Robotics

R25 - Curriculum Structure
I Year I Semester

S. No.	Category	Course Code	Course Title	Hours Per Week				Credits
				L	T	P	Total	
1	PC	25MBAARTC01	Industrial Automation and IoT	3	0	0	3	3
2	PC	25MBAARTC02	Robot Kinematics and Dynamics	3	0	0	3	3
3	DE		**Discipline Elective-I** *(Refer ANNEXURE - I)*	3	0	0	3	3
4	DE		**Discipline Elective-II** *(Refer ANNEXURE - I)*	3	0	0	3	3
5	ESC	25MBCOMTC01	Research Methodology and IPR	2	0	0	2	2
6	PC	25MBAARLC01	Industrial Automation and IoT Laboratory	0	0	4	4	2
7	PC	25MBAARLC02	Robotics Laboratory	0	0	4	4	2
8	SEC	25MBAARSC01	Robot Programming	1	0	2	3	2
9	MC	25MBCIVMC01	Disaster Management	2	0	0	2	0
10	EEC		**NSDC - Certification Course – I** *(Refer ANNEXURE – III)*	0	0	2	2	0
Total				**17**	**0**	**10**	**27**	**20**

I Year II Semester

S. No.	Category	Course Code	Course Title	Hours Per Week				Credits
				L	T	P	Total	
1	PC	25MBAARTC03	Embedded System	3	0	0	3	3
2	PC	25MBAARTC04	Robot Motion Control and Path Planning	3	0	0	3	3
3	DE		**Discipline Elective-III** *(Refer ANNEXURE - I)*	3	0	0	3	3
4	DE		**Discipline Elective-IV** *(Refer ANNEXURE - I)*	3	0	0	3	3
5	OE		**Open Elective-I** *(Refer ANNEXURE – II)*	2	0	0	2	2
6	PC	25MBAARLC03	Embedded System Laboratory	0	0	4	4	2
7	PC	25MBAARLC04	Machine Vision Laboratory	0	0	4	4	2
8	SEC	25MBAARSC02	Control Systems	1	0	2	3	2
9	EEC		**NSDC - Certification Course – II** *(Refer ANNEXURE – III)*	0	0	2	2	0
Total				**15**	**0**	**10**	**25**	**20**

(L = Lecture, T = Tutorial, P = Practical, C = Credit

Tentative R25 - Curriculum Structure
II Year I Semester

S. No.	Category	Course Code	Course Title	Hours Per Week				Credits
				L	T	P	Total	
1	PC	25MBAARTC05	AI for Robotics	3	0	0	3	3
2	DE		**Discipline Elective – V** *(Refer ANNEXURE - I)*	3	0	0	3	3
3	OE		**Open Elective- II** *(Refer ANNEXURE - II)*	3	0	0	3	3
4	SEC	25MBAARSC03	Prompt Engineering	1	0	2	3	2
5	PR	25MBAARIC01	Summer Internship*	0	0	6	6	3
6	PR	25MBAARPC01	Capstone Project Phase I	0	0	20	20	10
7	EEC		**NSDC - Certification Course – III** *(Refer ANNEXURE – III)*	0	0	2	2	0
Total				**10**	**0**	**28**	**38**	**24**

* 6 Weeks Internship during I Year II Semester Summer Break and to be evaluated in II Year I Semester

II Year II Semester

S. No.	Category	Course Code	Course Title	Hours Per Week				Credits
				L	T	P	Total	
1	PR	25MBAARPC02	Capstone Project Phase II	0	0	32	32	16
Total				**0**	**0**	**32**	**32**	**16**

(L = Lecture, T = Tutorial, P = Practical, C = Credit

ANNEXURE - I

LIST OF DISCIPLINE ELECTIVE COURSES

Discipline Elective – I		
Sl. No.	**Course Code**	**Course Title**
1.	25MBAARDC01	Fluid Power System for Automation
2.	25MBAARDC02	Sensors and Actuators
3.	25MBAARDC03	Wheeled Robotics
4.	25MBAARDC04	Data Analytics for Automation
Any advanced courses can be appended in future.		

Discipline Elective – II		
Sl. No.	**Course Code**	**Course Title**
1.	25MBAARDC05	Collaborative Robotics
2.	25MBAARDC06	Smart Mobility Robots
3.	25MBAARDC07	Robot Operating System
4.	25MBAARDC08	Optimization with Applications in Robotics
Any advanced courses can be appended in future.		

Discipline Elective – III		
Sl. No.	**Course Code**	**Course Title**
1.	25MBAARDC09	Bioinspired Robotics
2.	25MBAARDC10	Digital Twin in Robotics
3.	25MBAARDC11	Fuzzy Logic and Expert System
4.	25MBAARDC12	Edge Computing in Automation
Any advanced courses can be appended in future.		

M. Tech Automation and Robotics

Discipline Elective – IV		
Sl. No.	**Course Code**	**Course Title**
1.	25MBAARDC13	Soft Robotics
2.	25MBAARDC14	Robot System Reliability and Safety
3.	25MBAARDC15	Advances in Mobile Robots and AGV
4.	25MBAARDC16	Industry 5.0 and Emerging Technologies
Any advanced courses can be appended in future.		

Discipline Elective – V (To be offered under MOOC's Category from SWAYAM – NPTEL)		
Sl. No.	**Course Code**	**Course Title**
1.	25MBAARDM01	Foundations of Cognitive Robotics
2.	25MBAARDM02	Microrobotics
3.	25MBAARDM03	Automation in Manufacturing
4.	25MBAARDM04	Automation in Production Systems and Management
Any other new Disciplinary Course which doesn't exist in the Curriculum can be appended in future.		

ANNEXURE - II

LIST OF OPEN ELECTIVE COURSES

Open Elective - I (To be offered under MOOC's Category from SWAYAM – NPTEL)		
Sl. No.	**Course Code**	**Course Title**
1.	25MBCIVOM01	Remote Sensing and GIS
2.	25MBCIVOM02	Sustainable Engineering Concepts and Life Cycle Analysis
3.	25MBMECOM01	Product Engineering and Design Thinking
4.	25MBMBAOM01	Innovation, Business Models and Entrepreneurship
5.	25MBMBAOM02	AI in Human Resource Management
Any other new Inter-Disciplinary Course offered by SWAYAM NPTEL which doesn't exist in the Curriculum can be appended in future.		

Open Elective - II (To be offered under Conventional Mode)		
Sl. No.	**Course Code**	**Course Title**
1.	25MBCSEOC01	Advanced Data Visualization Techniques
2.	25MBCSEOC02	Enterprise Cloud Computing
3.	25MBECEOC01	Community Radio Technology
Any new Interdisciplinary Course can be appended in future.		

I Year I Semester

M. Tech I Year I Semester

25MBAARTC01 INDUSTRIAL AUTOMATION AND IoT

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Course Description:
This course provides comprehensive knowledge of industrial automation systems integrated with Internet of Things (IoT) technologies used in modern smart manufacturing and Industry 4.0 environments. The course focuses on programmable automation, industrial communication protocols, SCADA systems, sensors, actuators, cyber-physical systems, cloud-based monitoring, and Industrial IoT (IIoT) architectures. Students gain hands-on exposure to PLC programming, industrial networking, edge devices, smart sensors, and IoT-enabled automation platforms used in intelligent factories and robotic manufacturing systems.

Course Objectives:
The students will be able to:
1) To understand the fundamentals of industrial automation and Industry 4.0 concepts.
2) To learn PLC, SCADA, HMI, and industrial control system design.
3) To study industrial communication protocols and networking technologies.
4) To develop IoT-enabled automation and smart monitoring systems.
5) To apply Industrial IoT concepts in smart manufacturing and robotic automation applications.

UNIT I FUNDAMENTALS OF INDUSTRIAL AUTOMATION 9 hours
Introduction to Industrial Automation, Types of Automation: Fixed, Programmable, Flexible Automation, Automation Pyramid, Industry 4.0 and Smart Manufacturing, Cyber Physical Systems (CPS), Industrial Sensors and Actuators, Signal Conditioning Systems, Introduction to Industrial Robots and Automated Production Systems.

UNIT II PLC AND INDUSTRIAL CONTROL SYSTEMS 9 hours
Architecture of PLC, PLC Hardware Components, Input/Output Modules, PLC Programming Fundamentals, Ladder Logic Programming, Timers, Counters, Sequencers, Interfacing PLC with Sensors and Actuators, Distributed Control Systems (DCS), Human Machine Interface (HMI).

UNIT III SCADA AND INDUSTRIAL COMMUNICATION 9 hours
SCADA Architecture and Components, Data Acquisition Systems, Supervisory Control and Monitoring, Industrial Communication Standards, Modbus, Profibus, CAN Bus, Ethernet/IP and Industrial Ethernet, OPC-UA Communication, Real-Time Industrial Networks, Wireless Industrial Communication Systems.

UNIT IV INTERNET OF THINGS FOR INDUSTRIAL AUTOMATION 9 hours
Fundamentals of IoT , IoT Architecture and Layers, Smart Sensors and Embedded Devices, RFID and Wireless Sensor Networks, Arduino, Raspberry Pi, ESP32 for Industrial Applications, MQTT and CoAP Protocols, Cloud Computing for Industrial IoT , Edge Computing in Smart Manufacturing, IoT Data Analytics.

UNIT V INDUSTRIAL IoT APPLICATIONS AND SMART MANUFACTURING **9 hours**

Industrial Internet of Things (IIoT), Smart Factory Architecture, Predictive Maintenance Systems, Digital Twin Concepts, AI and Machine Learning in Automation, Robotic Automation and Collaborative Robots, Industrial Cybersecurity, Energy Monitoring and Smart Grids, Case Studies in Automotive, Aerospace, and Process Industries.

Course Outcomes:

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

CO1: Explain the principles of industrial automation, Industry 4.0, and smart manufacturing systems.

CO2: Design and implement PLC-based industrial control and SCADA systems.

CO3: Analyze industrial communication protocols and networking architectures used in automation systems.

CO4: Develop IoT-based industrial monitoring and control applications using embedded platforms and cloud technologies.

CO5: Apply Industrial IoT and automation concepts for smart manufacturing, predictive maintenance, and robotic applications.

Text Books:

1. Frank Lamb, *Industrial Automation: Hands-On*, McGraw Hill Education, 2013.
2. Krishna Kant, *Computer-Based Industrial Control*, Prentice Hall India, 2010.
3. Raj Kamal, *Internet of Things: Architecture and Design Principles*, McGraw Hill Education, 3rd Edition, 2023.

Reference Books:

1. John W. Webb and Ronald A. Reis, *Programmable Logic Controllers: Principles and Applications*, Pearson Education, 6th Edition, 2015.
2. Vijay Madisetti and Arshdeep Bahga, *Internet of Things: A Hands-On Approach*, Universities Press, 2015.
3. Mikell P. Groover, *Automation, Production Systems and Computer Integrated Manufacturing*, Pearson Education, 5th Edition, 2020.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

M. Tech I Year I Semester

25MBAARTC02 ROBOT KINEMATICS AND DYNAMICS

L	T	P	C
3	0	0	3

Pre-requisite: Engineering Mechanics, Linear Algebra, Differential Equations, Basics of Robotics, and Control Systems.

Course Description:

This course introduces the mathematical foundations and physical principles governing robotic systems. It focuses on robot kinematics, dynamics, motion analysis, trajectory planning, and control of robotic manipulators. The course covers coordinate transformations, forward and inverse kinematics, velocity and acceleration analysis, Jacobian matrices, dynamic modeling using Euler-Lagrange formulation, and robotic motion control. Students gain analytical and computational skills essential for the design and control of industrial and intelligent robotic systems.

Course Objectives:

1. To understand the fundamentals of robotic manipulators and coordinate transformations.
2. To analyze forward and inverse kinematics of robotic systems.
3. To study robot velocity, acceleration, and Jacobian analysis.
4. To develop dynamic models of robotic manipulators using mathematical formulations.
5. To apply robot motion planning and control techniques in automation applications.

UNIT I FUNDAMENTALS OF ROBOT MANIPULATORS 9 hours

Introduction to Robotics and Manipulators covering robot anatomy, robot classifications, degrees of freedom, coordinate systems, homogeneous transformations, translation and rotation matrices, and Denavit–Hartenberg (DH) representation for robotic manipulators.

UNIT II ROBOT KINEMATICS 9 hours

Forward and Inverse Kinematics of robotic manipulators including kinematic chains, forward kinematic analysis, inverse kinematics, solution methods for articulated robots, workspace analysis, and singularity conditions in robotic systems.

UNIT III VELOCITY AND STATIC ANALYSIS OF ROBOTS 9 hours

Velocity and Static Analysis covering differential motion, Jacobian matrix, velocity relationships, acceleration analysis, static force analysis, singularity analysis, and trajectory generation for robotic manipulators.

UNIT IV ROBOT DYNAMICS 9 hours

Robot Dynamics including Newton–Euler formulation, Euler–Lagrange formulation, kinetic and potential energy analysis, equations of motion, dynamic modeling of robotic manipulators, and actuator dynamics.

UNIT V ROBOT MOTION PLANNING AND CONTROL 9 hours

Robot Motion Planning and Control covering trajectory planning, point-to-point and continuous path motion, joint space and Cartesian space control, PID control of robots, force control, adaptive control, and applications of robotic systems in industrial automation.

Course Outcomes:

CO1: Explain the fundamentals of robotic manipulators, coordinate systems, and transformation techniques.
CO2: Analyze forward and inverse kinematics of robotic systems.
CO3: Evaluate robot velocity, acceleration, and Jacobian-based motion analysis.
CO4: Develop dynamic models and equations of motion for robotic manipulators.
CO5: Apply robot trajectory planning and control techniques in industrial robotic applications.

Text Books:

1. John J. Craig, *Introduction to Robotics: Mechanics and Control*, Pearson Education, 4th Edition, 2018.
2. Saeed B. Niku, *Introduction to Robotics: Analysis, Control and Applications*, Wiley India, 3rd Edition, 2020.
3. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, *Robot Modeling and Control*, Wiley India, 2nd Edition, 2020.

Reference Books:

1. Richard D. Klafter, Thomas A. Chmielewski, and Michael Negin, *Robotic Engineering: An Integrated Approach*, Prentice Hall India, 2015.
2. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo, *Robotics: Modelling, Planning and Control*, Springer, 2016.
3. K.S. Fu, R.C. Gonzalez, and C.S.G. Lee, *Robotics: Control, Sensing, Vision and Intelligence*, McGraw Hill Education, 2017.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

M. Tech I Year I Semester

25MBCOMTC01 RESEARCH METHODOLOGY AND IPR

L	T	P	C
2	0	0	2

Pre-requisite Nil

Course Description:

This course aims to provide students with a comprehensive understanding of research methodology and the principles and practices of intellectual property rights (IPR). The course will equip students with the skills needed to design, conduct, and evaluate research effectively while also understanding the legal and ethical considerations surrounding intellectual property.

Course Objectives:

To impart knowledge on

1. Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
2. Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION 9 hours

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9 hours

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9 hours

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9 hours

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR, IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9 hours

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

Course Outcomes:

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

Text Book(s)

1. Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, "Research methodology for natural sciences", IISc Press, Kolkata, 2022.
3. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.

Reference Books

1. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.
2. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013.

Mode of Evaluation: Assignments, Mid Term Tests, End Semester Examination.

M. Tech I Year I Semester

25MBAARLC01 INDUSTRIAL AUTOMATION AND IoT LABORATORY

L	T	P	C
0	0	4	2

Pre-requisite: Basics of Sensors and Actuators, PLC Programming, Embedded Systems, and Fundamentals of Industrial Automation.

Course Description:

This laboratory course provides practical exposure to industrial automation systems and Industrial Internet of Things (IIoT) applications used in smart manufacturing environments. Students perform experiments related to PLC programming, SCADA systems, sensor interfacing, embedded platforms, industrial communication, cloud monitoring, and IoT-enabled automation systems. The laboratory emphasizes hands-on implementation of automation and IIoT concepts for modern industrial applications.

Course Objectives:

1. To provide practical knowledge of PLC-based industrial automation systems.
2. To develop skills in sensor interfacing and embedded system programming.
3. To implement SCADA and industrial communication techniques.
4. To perform IoT-based industrial monitoring and control experiments.
5. To design smart industrial automation applications using IoT technologies.

List of Experiments

1) Study of industrial automation components and PLC hardware.
2) PLC programming using ladder logic.
3) Timer and counter operations using PLC.
4) Conveyor belt automation using PLC.
5) Interfacing of industrial sensors and actuators.
6) SCADA-based industrial process monitoring.
7) HMI development for industrial automation systems.
8) IoT sensor data acquisition using Arduino/ESP32/Raspberry Pi.
9) MQTT-based industrial communication experiment.
10) Cloud-based industrial monitoring and smart factory automation mini-project.

Course Outcomes:

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

CO1: Demonstrate PLC programming and industrial automation techniques.

CO2: Implement sensor interfacing and actuator control for automation systems.

CO3: Develop SCADA and industrial communication applications.

CO4: Apply IoT technologies for industrial monitoring and remote control systems.

CO5: Design integrated Industrial IoT solutions for smart manufacturing applications.

Text Books:

1. Frank Lamb, *Industrial Automation: Hands-On*, McGraw Hill Education, 2013.
2. Raj Kamal, *Internet of Things: Architecture and Design Principles*, McGraw Hill Education, 2023.
3. John W. Webb and Ronald A. Reis, *Programmable Logic Controllers: Principles and Applications*, Pearson Education, 2015.

Reference Books:

1. Stuart A. Boyer, *SCADA: Supervisory Control and Data Acquisition*, ISA Publications, 2010.
2. Vijay Madisetti and Arshdeep Bahga, *Internet of Things: A Hands-On Approach*, Universities Press, 2015.
3. Mikell P. Groover, *Automation, Production Systems and Computer Integrated Manufacturing*, Pearson Education, 2020.

Mode of Evaluation: Continuous Internal Evaluation, Model Exam and End Semester Examination.

M. Tech I Year I Semester

25MBAARLC02 ROBOTICS LABORATORY

L	T	P	C
0	0	4	2

Pre-requisite: Basics of Robotics, Embedded Systems, Sensors and Actuators, and Programming Fundamentals.

Course Description:
This laboratory course provides practical training in robotic systems, industrial automation, embedded controllers, and intelligent robotic applications. Students perform experiments related to robot programming, sensor interfacing, motion control, PLC automation, path planning, and autonomous robotic systems. The laboratory emphasizes hands-on implementation of robotics concepts used in industrial automation and smart manufacturing.

Course Objectives:
1. To provide practical exposure to robotic manipulators and automation systems.
2. To develop programming skills for robotic and embedded platforms.
3. To implement sensor interfacing and actuator control in robotic applications.
4. To perform robot motion control and autonomous navigation experiments.x
5. To design and test industrial automation and robotic applications.

List of Experiments
1. Study of robotic manipulator configuration and coordinate systems.
2. Programming of robot for pick-and-place operation.
3. Interfacing of IR and ultrasonic sensors using Arduino/Raspberry Pi.
4. PLC programming using ladder logic.
5. Conveyor belt automation using PLC.
6. Line follower robot implementation.
7. Obstacle avoidance robot using sensors.
8. Mobile robot motion control experiments.
9. Robot path planning using simulation tools.
10. IoT-based robotic monitoring system.

Course Outcomes:
At the end of the course, the student will be able to:
CO1: Demonstrate robotic programming and manipulator operation techniques.

CO2: To Implement sensor interfacing and actuator control for robotic system.

CO3: Develop PLC-based industrial automation applications.

CO4: Apply robot motion control and navigation techniques in autonomous robotic systems.

CO5: Design integrated robotic and IoT-enabled automation solutions.

Text Books:

1. John J. Craig, *Introduction to Robotics: Mechanics and Control*, Pearson Education, 4th Edition, 2018.
2. Frank Lamb, *Industrial Automation: Hands-On*, McGraw Hill Education, 2013.
3. Raj Kamal, *Embedded Systems: Architecture, Programming and Design*, McGraw Hill Education, 2017.

Reference Books:

1. Saeed B. Niku, *Introduction to Robotics: Analysis, Control and Applications*, Wiley India, 2020.
2. Jonathan W. Valvano, *Embedded Microcomputer Systems: Real-Time Interfacing*, Cengage Learning, 2018.
3. Mikell P. Groover, *Automation, Production Systems and Computer Integrated Manufacturing*, Pearson Education, 2020.

Mode of Evaluation: Continuous Internal Evaluation, Model Exam and End Semester Examination.

M. Tech I Year I Semester
Skill Enhancement Course - I

25MBAARSC01 ROBOT PROGRAMMING

L	T	P	C
1	0	2	2

Pre-requisite: Nil

Course Description:
This course provides a comprehensive introduction to robot programming concepts, tools, and frameworks used in modern robotics. It covers the fundamentals of robot kinematics, motion planning, sensor integration, and actuator control. Students gain hands-on experience programming industrial and collaborative robots using standard platforms such as ROS (Robot Operating System) and MATLAB Robotics Toolbox. The course includes practical modules on path planning, inverse kinematics, manipulation tasks, and simulation using tools like Gazebo. Applications span industrial automation, pick-and-place operations, mobile robotics, and human-robot interaction.

Course Objectives:
The objectives of this course are to enable the student to:
1. To understand the fundamental concepts of robots and robotic systems
2. Learn and apply principles of robot kinematics, dynamics, and motion planning
3. Gain hands-on experience in programming robots using ROS and simulation tools
4. To understand and implement sensor integration and actuator control in robots
5. To analyze and apply robot programming for real-world automation applications

UNIT I INTRODUCTION TO ROBOTICS AND PROGRAMMING ENVIRONMENTS 9 hours
Introduction to Robots – Types and Classifications – Robot Architecture – Degrees of Freedom – Coordinate Frames and Transformations – Overview of Robot Programming Languages – Introduction to ROS (Robot Operating System) – ROS Installation and Environment Setup – Nodes, Topics, Services, and Messages in ROS – Entrepreneurship & Employability in Robotics.
Exp-1: Study of Robot Fundamentals and Programming Concepts
Exp-2: Study of ROS environment: Creating packages, nodes, and topics

UNIT II ROBOT KINEMATICS AND MOTION PLANNING 9 hours
Forward and Inverse Kinematics – Denavit-Hartenberg (DH) Parameters – Jacobian Matrix and Velocity Kinematics – Workspace Analysis – Path Planning: Joint Space vs. Cartesian Space – Trajectory Generation: Linear, Circular, and Polynomial Trajectories – Collision Avoidance Techniques.
Sample Experiments:
Exp-3: Forward Kinematics simulation using MATLAB Robotics Toolbox
Exp-4: Inverse Kinematics simulation using MATLAB Robotics Toolbox

UNIT III SENSOR INTEGRATION AND ACTUATOR CONTROL 9 hours
Types of Sensors in Robotics: Proximity, Vision, Force/Torque, IMU – Sensor Interfacing with ROS – Actuator Types: DC Motors, Servo Motors, Stepper Motors – Motor Control: PWM, PID Controller Implementation – Camera Integration and Image Processing in ROS – LiDAR and Depth Sensor Integration.
Sample Experiments:
Exp-5: Interfacing ultrasonic and IR sensors with a robot using ROS
Exp-6: PID motor speed control implementation and tuning on a robotic platform.

UNIT IV ROBOT SIMULATION AND PROGRAMMING TOOLS 9 hours

Introduction to Gazebo Simulator – Modeling Robots using URDF (Unified Robot Description Format) – Simulating Robot Motion in Gazebo – Programming Manipulators using MoveIt! – Programming Mobile Robots: Differential Drive, Odometry – Path Planning Algorithms: A*, RRT, Dijkstra – Introduction to Robot Operating System 2 (ROS2).

Sample Experiments:

Exp-7: Robot simulation using Gazebo and URDF modeling

Exp-8: Path planning using A* and RRT algorithms in ROS simulation environment.

UNIT V ADVANCED ROBOT PROGRAMMING AND APPLICATIONS 9 hours

Industrial Robot Programming: Pick and Place, Welding, Palletizing – Collaborative Robot (Cobot) Programming – Mobile Robot Navigation: SLAM (Simultaneous Localization and Mapping) – Human-Robot Interaction – Robot Learning: Introduction to Reinforcement Learning for Robots – Case Studies: Automated Warehouse Systems, Surgical Robots, Agricultural Robots.

Sample Experiments:

Exp-9: Implementation of SLAM using ROS and TurtleBot simulation

Exp-10: Pick-and-place task programming using a 6-DOF robotic arm in Gazebo.

Course Outcomes:

The students, after completing the course, will be able to:

CO1: Understand fundamental concepts of robot architecture, coordinate transformations, and programming environments including ROS.

CO2: Apply forward and inverse kinematics, trajectory generation, and motion planning algorithms to program robotic manipulators.

CO3: Integrate sensors and actuators with robotic systems and implement feedback control mechanisms using ROS.

CO4: Simulate and program robots using tools like Gazebo, URDF, and MoveIt! for manipulation and mobile robotics tasks.

CO5: Evaluate and implement robot programming solutions for real-world applications including industrial automation, SLAM, and human-robot interaction.

Text Books:

1. Bruno Siciliano et al., “Robotics: Modelling, Planning and Control”, Springer, 2009.
2. Morgan Quigley et al., “Programming Robots with ROS”, O’Reilly Media, 2015.
3. Craig, J.J., “Introduction to Robotics: Mechanics and Control”, 3rd Edition, Pearson Education, 2005.

Reference Books:

1. Koubaa, A. (Ed.), “Robot Operating System (ROS): The Complete Reference”, Springer, 2017.
2. Thrun, S., Burgard, W., and Fox, D., “Probabilistic Robotics”, MIT Press, 2005.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Mandatory Course

26BFCIVVC01 DISASTER MANAGEMENT

L	T	P	C
2	0	0	2

Pre-requisite: Nil

Course Description:

This course provides a comprehensive understanding of natural and human-induced disasters, their causes, characteristics, and consequences. It examines the social, economic, environmental, and life-safety impacts of disasters with emphasis on disaster-prone regions in India. The course introduces disaster preparedness and management through monitoring, risk evaluation, remote sensing, meteorological information, and community participation. It develops knowledge of disaster risk assessment, disaster risk reduction, early warning, and national and global cooperation. The course also focuses on structural and non-structural mitigation strategies and emerging approaches for reducing disaster vulnerability and impacts.

Course Objectives:

Upon the completion of subject student will be able to-

1. Develop fundamental knowledge of different natural and man-made disasters, their characteristics, causes, and associated hazards.
2. Examine the economic, environmental, ecological, and human consequences of disasters and identify disaster-prone regions in India.
3. Develop an understanding of disaster preparedness and management using monitoring systems, remote sensing, meteorological information, and community-based approaches.
4. Introduce the concepts, elements, and techniques of disaster risk assessment, risk reduction, early warning, and national and global cooperation.
5. Develop knowledge of structural and non-structural disaster mitigation strategies, emerging mitigation practices, and disaster mitigation programmes in India.

UNIT I DISASTER CLASSIFICATION **6 hours**

Disaster: definition, factors and significance; difference between hazard and Disaster; natural disaster: earthquakes, volcanisms, cyclones, tsunamis, floods, droughts and famines, landslides and avalanches; man-made disasters: nuclear reactor meltdown, industrial accidents, oil slicks and spills, outbreaks of disease and epidemics, war and conflicts

UNIT II REPERCUSSIONS OF DISASTERS **6 hours**

Economic damage, loss of human and animal life, destruction of ecosystem. Disaster Prone Areas in India: Study of seismic zones; areas prone to floods and droughts, landslides and Avalanches; areas prone to cyclonic and coastal hazards with special reference to tsunami.

UNIT III DISASTER PREPAREDNESS AND MANAGEMENT **6 hours**

Preparedness: monitoring of phenomena triggering a disaster or hazard; Evaluation of risk: application of remote sensing, data from meteorological and Other agencies, media reports: governmental and community preparedness.

UNIT IV RISK ASSESSMENT **6 hours**

Disaster risk: concept and elements, disaster risk reduction, global and national disaster risk situation. Techniques of risk assessment, global co-operation in risk assessment and warning.

UNIT V DISASTER MITIGATION **6 hours**

Meaning, concept and strategies of disaster mitigation, emerging trends in Mitigation. Structural mitigation and non-structural mitigation, programs of Disaster mitigation in India.

Course outcomes:

After the completion of the subject following outcomes can be achieved-

CO1: Classify natural and man-made disasters and explain their causes, characteristics, and associated hazards.

CO2: Assess the major economic, environmental, ecological, and human impacts of disasters and identify disaster-prone regions in India.

CO3: Explain disaster preparedness and management practices using hazard monitoring, remote sensing, meteorological data, and community preparedness mechanisms.

CO4: Apply appropriate techniques for disaster risk assessment and explain disaster risk reduction, early warning systems, and national and global cooperation mechanisms.

CO5: Evaluate and recommend suitable structural and non-structural mitigation measures for reducing disaster risk and impacts.

Reference Books:

1. Ghosh G.K., 2006, Disaster Management, APH Publishing Corporation
2. R. Nishith, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “’New Royal book Company.
3. Sahni, PardeepEt.Al. (Eds.),” Disaster Mitigation Experiences and Reflections”, Prentice Hall Of India, New Delhi.
4. Goel S. L., Disaster Administration And Management Text and Case Studies” ,Deep&Deep Publication Pvt. Ltd., New Delhi

Mode of Evaluation: Assignments, Mid Term Tests

I Year II Semester

M. Tech I Year II Semester

25MBAARTC03 EMBEDDED SYSTEMS

L	T	P	C
3	0	0	3

Pre-requisite: Basics of Digital Electronics, Microprocessors, Programming in C, and Fundamentals of Electronics.

Course Description:
This course provides comprehensive knowledge of embedded systems used in modern automation, robotics, and intelligent control applications. The course covers embedded system architecture, microcontrollers, interfacing techniques, real-time operating systems, embedded programming, communication protocols, and IoT-enabled embedded platforms. Students gain practical understanding of hardware-software integration for designing embedded solutions in industrial automation and robotic systems.

Course Objectives:
1. To understand the architecture and fundamentals of embedded systems.
2. To learn microcontroller programming and embedded software development.
3. To study interfacing techniques for sensors, actuators, and communication modules.
4. To understand real-time operating systems and embedded communication protocols.
5. To develop embedded system applications for automation, robotics, and IoT environments.

UNIT I FUNDAMENTALS OF EMBEDDED SYSTEMS 9 hours

Introduction to embedded systems, characteristics of embedded systems, embedded system architecture, microcontrollers and microprocessors, embedded hardware components, memory organization, embedded software, and applications of embedded systems in automation and robotics.

UNIT II MICROCONTROLLERS AND EMBEDDED PROGRAMMING 9 hours

Architecture of microcontrollers, ARM Cortex architecture, instruction sets, embedded C programming, interrupt handling, timers and counters, analog-to-digital conversion, digital-to-analog conversion, and embedded firmware development techniques.

UNIT III INTERFACING AND EMBEDDED COMMUNICATION 9 hours

Interfacing of sensors and actuators, keyboard and display interfacing, serial communication protocols, UART, SPI, I2C, CAN bus, wireless communication modules, interfacing techniques for industrial automation, and embedded system integration.

UNIT IV REAL-TIME EMBEDDED SYSTEMS 9 hours

Introduction to real-time systems, real-time operating systems (RTOS), task scheduling, multitasking, synchronization, inter-process communication, memory management, embedded system debugging, and performance analysis of real-time applications.

UNIT V EMBEDDED SYSTEMS FOR IoT AND AUTOMATION 9 hours

IoT-enabled embedded systems, Raspberry Pi and Arduino platforms, embedded networking, cloud connectivity, edge computing, embedded applications in robotics, smart manufacturing, industrial automation, autonomous systems, and case studies on embedded product development.

Course Outcomes:

CO1: Explain the architecture and operational principles of embedded systems.
CO2: Develop embedded programs using microcontrollers and embedded C programming.
CO3: Implement interfacing and communication techniques for embedded applications.
CO4: Analyze real-time operating systems and multitasking concepts in embedded environments.
CO5: Design embedded solutions for IoT, robotics, and industrial automation applications.

Text Books:

1. Raj Kamal, *Embedded Systems: Architecture, Programming and Design*, McGraw Hill Education, 3rd Edition, 2017.
2. Frank Vahid and Tony Givargis, *Embedded System Design: A Unified Hardware/Software Introduction*, Wiley India, 2019.
3. Shibu K.V., *Introduction to Embedded Systems*, McGraw Hill Education, 2nd Edition, 2016.

Reference Books:

1. Jonathan W. Valvano, *Embedded Microcomputer Systems: Real-Time Interfacing*, Cengage Learning, 2018.
2. David E. Simon, *An Embedded Software Primer*, Pearson Education, 2017.
3. Lyla B. Das, *Embedded Systems: An Integrated Approach*, Pearson Education, 2019.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

M. Tech I Year II Semester

25MBAARTC04 ROBOT MOTION CONTROL AND PATH PLANNING

L	T	P	C
3	0	0	3

Pre-requisite: Basics of Robotics, Control Systems, Linear Algebra, Differential Equations, and Embedded Systems.

Course Description:

This course provides in-depth knowledge of robot motion control and path planning techniques used in industrial and autonomous robotic systems. The course focuses on robot control architectures, trajectory generation, motion planning algorithms, feedback control, intelligent navigation, obstacle avoidance, and autonomous robot operations. Students learn classical and modern control methods along with computational approaches for efficient robot path planning in structured and unstructured environments.

Course Objectives:

1) To understand the fundamentals of robot motion control systems.
2) To study robot trajectory generation and motion planning techniques.
3) To analyze feedback control strategies for robotic manipulators and mobile robots.
4) To learn path planning and obstacle avoidance algorithms for autonomous robots.
5) To develop intelligent robotic control systems for industrial and autonomous applications.

UNIT I FUNDAMENTALS OF ROBOT MOTION CONTROL 9 hours

Introduction to robot motion control, robot control architecture, open-loop and closed-loop control systems, transfer functions, dynamic response characteristics, joint control, actuator control, servo systems, and motion control requirements in robotic applications.

UNIT II ROBOT TRAJECTORY PLANNING 9 hours

Trajectory generation concepts, point-to-point motion, continuous path motion, polynomial trajectory planning, cubic and quintic trajectories, joint space trajectory planning, Cartesian trajectory planning, velocity and acceleration profiles, and smooth motion generation techniques.

UNIT III ROBOT FEEDBACK CONTROL SYSTEMS 9 hours

PID control of robotic systems, computed torque control, feedforward and feedback control, adaptive control, force and impedance control, robust control techniques, stability analysis, and control of robotic manipulators and mobile robots.

UNIT IV ROBOT PATH PLANNING AND NAVIGATION 9 hours

Path planning concepts, configuration space representation, graph search algorithms, Dijkstra algorithm, A* algorithm, probabilistic roadmap methods, rapidly exploring random trees (RRT), obstacle avoidance techniques, localization, and autonomous navigation systems.

UNIT V INTELLIGENT MOTION PLANNING AND APPLICATIONS 9 hours

Artificial intelligence in robotic motion planning, fuzzy logic control, neural network-based robot control, machine learning approaches for navigation, swarm robotics, autonomous mobile robots, collaborative robots, industrial robot applications, and case studies in smart automation systems.

Course Outcomes:

CO1: Explain the principles of robot motion control and robotic control architectures.
CO2: Develop robot trajectory planning methods for smooth and efficient robotic motion.
CO3: Analyze feedback and intelligent control techniques for robotic systems.
CO4: Apply robot path planning and obstacle avoidance algorithms for autonomous navigation.
CO5: Design intelligent robotic motion control systems for industrial and autonomous applications.

Text Books:

1. Bruno Siciliano and Oussama Khatib, *Springer Handbook of Robotics*, Springer, 2016.
2. Richard D. Klafter, Thomas A. Chmielewski, and Michael Negin, *Robotic Engineering: An Integrated Approach*, Prentice Hall India, 2015.
3. Howie Choset et al., *Principles of Robot Motion: Theory, Algorithms, and Implementations*, MIT Press, 2017.

Reference Books:

1. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, *Robot Modeling and Control*, Wiley India, 2nd Edition, 2020.
2. John J. Craig, *Introduction to Robotics: Mechanics and Control*, Pearson Education, 4th Edition, 2018.
3. Saeed B. Niku, *Introduction to Robotics: Analysis, Control and Applications*, Wiley India, 3rd Edition, 2020.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

M. Tech I Year II Semester

25MBAARLC03 EMBEDDED SYSTEM LABORATORY

L	T	P	C
0	0	4	2

Pre-requisite: Basics of Digital Electronics, Microprocessors, Programming in C, and Fundamentals of Electronics.

Course Description:

This laboratory course provides practical exposure to embedded systems, microcontroller programming, sensor interfacing, communication protocols, and real-time embedded applications. Students perform experiments related to embedded programming, hardware interfacing, IoT-enabled embedded systems, and automation applications using embedded platforms such as Arduino, ARM, and Raspberry Pi.

Course Objectives:

1) To provide practical knowledge of embedded system architecture and programming.
2) To develop skills in microcontroller interfacing and embedded application development.
3) To implement communication protocols used in embedded systems.
4) To perform real-time embedded system experiments for automation applications.
5) To design embedded and IoT-based solutions for industrial and robotic systems.

List of Experiments

1) Study of embedded system architecture and development tools.
2) LED interfacing and programming using microcontrollers.
3) Interfacing of push buttons, switches, and displays.
4) ADC and DAC interfacing experiments.
5) Servo motor and stepper motor control using embedded platforms.
6) Sensor interfacing using Arduino/Raspberry Pi.
7) UART serial communication experiment.
8) SPI and I2C communication protocol implementation.
9) Interfacing of Ultrasonic Sensors for Obstacle Detection
10) CAN Bus Communication for Industrial and Automotive Application.

Course Outcomes:

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

CO1: Demonstrate embedded programming and hardware interfacing techniques.

CO2: Implement sensor and actuator interfacing using embedded platforms.

CO3: Develop communication-based embedded applications using standard protocols.

CO4: Apply real-time embedded concepts in automation and control applications.

CO5: Design embedded and IoT-enabled solutions for industrial and robotic systems.

Text Books:

1. Raj Kamal, *Embedded Systems: Architecture, Programming and Design*, McGraw Hill Education, 3rd Edition, 2017.
2. Frank Vahid and Tony Givargis, *Embedded System Design: A Unified Hardware/Software Introduction*, Wiley India, 2019.
3. Shibu K.V., *Introduction to Embedded Systems*, McGraw Hill Education, 2016.

Reference Books:

1. Jonathan W. Valvano, *Embedded Microcomputer Systems: Real-Time Interfacing*, Cengage Learning, 2018.
2. David E. Simon, *An Embedded Software Primer*, Pearson Education, 2017.
3. Lyla B. Das, *Embedded Systems: An Integrated Approach*, Pearson Education, 2019.

Mode of Evaluation: Continuous Internal Evaluation, Model Exam and End Semester Examination.

M. Tech I Year II Semester

25MBAARLC03 MACHINE VISION LABORATORY

L	T	P	C
0	0	4	2

Pre-requisite: Basics of Digital Image Processing, Programming Fundamentals, Embedded Systems, and Robotics.

Course Description:

This laboratory course provides practical exposure to machine vision systems, image acquisition, image processing, feature extraction, object detection, and computer vision applications used in robotics and industrial automation. Students perform experiments using image processing tools, cameras, sensors, and machine vision software for inspection, recognition, and intelligent automation applications.

Course Objectives:

1) To provide practical knowledge of machine vision systems and image acquisition techniques.
2) To develop skills in digital image processing and feature extraction methods.
3) To implement object detection and pattern recognition techniques.
4) To perform machine vision experiments for industrial automation and robotics applications.
5) To design intelligent vision-based systems for real-time applications.

List of Experiments

1) Study of machine vision hardware components and camera systems.
2) Image acquisition and preprocessing using machine vision software.
3) Image enhancement and filtering techniques.
4) Edge detection and segmentation experiments.
5) Shape and feature extraction using image processing tools.
6) Object detection and pattern recognition experiments.
7) Barcode and QR code detection using machine vision systems.
8) Color detection and sorting applications using vision sensors.
9) Vision-based robotic pick-and-place application.
10) Mini-project on industrial inspection or autonomous vision system.

Course Outcomes:

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

CO1: Demonstrate image acquisition and preprocessing techniques using machine vision systems.
CO2: Implement image enhancement, segmentation, and feature extraction methods.
CO3: Develop object detection and pattern recognition applications.
CO4: Apply machine vision techniques in robotics and industrial automation systems.
CO5: Design intelligent vision-based systems for real-time industrial applications.

Text Books:

1. Rafael C. Gonzalez and Richard E. Woods, *Digital Image Processing*, Pearson Education, 4th Edition, 2018.
2. Milan Sonka, Vaclav Hlavac, and Roger Boyle, *Image Processing, Analysis and Machine Vision*, Cengage Learning, 4th Edition, 2019.
3. E.R. Davies, *Computer and Machine Vision: Theory, Algorithms, Practicalities*, Academic Press, 5th Edition, 2017.

Reference Books:

1. Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2022.
2. Jan Erik Solem, *Programming Computer Vision with Python*, O'Reilly Publications, 2016.
3. Simon J.D. Prince, *Computer Vision: Models, Learning and Inference*, Cambridge University Press, 2018.

Mode of Evaluation: Continuous Internal Evaluation, Model Exam and End Semester Examination.

M. Tech I Year II Semester
Skill Enhancement Course - II

25MBAARSC02 CONTROL SYSTEMS

L	T	P	C
1	0	2	2

Pre-requisite: Nil

Course Description:
This course provides a strong foundation in the analysis, design, and implementation of control systems. It covers mathematical modeling of physical systems, time-domain and frequency-domain analysis, and stability criteria. Students learn to design classical controllers (PID, Lead-Lag compensators) and are introduced to state-space methods and digital control. The course emphasizes practical aspects including MATLAB/Simulink-based simulation, real-time controller tuning, and hardware-in-the-loop experimentation. Applications include process control, motion control systems, robotics, power electronics, and automotive control.

Course Objectives:
The objectives of this course are to enable the student to:
1. To understand the mathematical modeling of physical systems and their transfer functions
2. To analyze the time-domain and frequency-domain performance of control systems
3. To design classical controllers such as PID, Lead and Lag compensators for desired system performance
4. To assess system stability using Routh-Hurwitz, Root Locus, Bode, and Nyquist criteria
5. To simulate and implement control systems using MATLAB/Simulink and real hardware platforms

UNIT I MATHEMATICAL MODELING AND SYSTEM REPRESENTATION **9 hours**

Introduction to Control Systems – Open Loop and Closed Loop Systems – Types of Control: Feedback and Feedforward – Transfer Function: Derivation and Block Diagram Representation – Signal Flow Graph and Mason's Gain Formula – Modeling of Mechanical, Electrical, and Electromechanical Systems – Analogous Systems – Applications and Career Opportunities in Control Engineering.
Exp-1: Study of Open Loop systems using MATLAB/Simulink
Exp-2: Study of Closed Loop systems using MATLAB/Simulink

UNIT II TIME DOMAIN ANALYSIS **9 hours**

Standard Test Signals – Time Response of First and Second Order Systems – Transient Response Specifications: Rise Time, Peak Time, Settling Time, Overshoot – Steady-State Error and Error Constants – PID Controller: Proportional, Integral, Derivative Actions and Tuning Methods – Effect of Feedback on System Parameters.
Sample Experiments:
Exp-3: Time response analysis of first order systems and determination of transient specifications using Simulink
Exp-4: Time response analysis of second order systems and determination of transient specifications using Simulink

UNIT III STABILITY ANALYSIS 9 hours

Concept of Stability – Characteristic Equation and Roots – Routh-Hurwitz Stability Criterion – Relative Stability – Root Locus Technique: Construction Rules, Effect of Adding Poles and Zeros – Application of Root Locus for Controller Design – Introduction to Bode Plot and Phase/Gain Margins.

Sample Experiments:

Exp-5: Stability analysis using Routh-Hurwitz criterion and Root Locus plotting in MATLAB
Exp-6: Design of PID controller using Root Locus method and validation in Simulink.

UNIT IV FREQUENCY DOMAIN ANALYSIS AND DESIGN 9 hours

Frequency Response Concepts – Bode Plots: Magnitude and Phase Plots – Gain Margin and Phase Margin – Nyquist Stability Criterion – Closed-Loop Frequency Response: Bandwidth, Resonant Peak – Lead Compensator Design – Lag Compensator Design – Lead-Lag Compensator Design using Frequency Domain Approach.

Sample Experiments:

Exp-7: Bode plot analysis and frequency response of second order systems using MATLAB
Exp-8: Design and simulation of Lead-Lag compensator using Bode plot technique in MATLAB.

UNIT V STATE SPACE ANALYSIS AND DIGITAL CONTROL 9 hours

State Space Representation – State Equations and Output Equations – Conversion between Transfer Function and State Space – Controllability and Observability – State Feedback Design: Pole Placement – Introduction to Digital Control Systems – Sampling and Z-Transform – Discrete Transfer Function – Digital PID Controller – Case Studies: Process Control, Servo Motor Control, Temperature Regulation.

Sample Experiments:

Exp-9: State space modeling and pole placement controller design using MATLAB
Exp-10: Implementation and tuning of a digital PID controller for DC motor speed control.

Course Outcomes:

The students, after completing the course, will be able to:

CO1: Understand mathematical modeling techniques for physical systems and represent them using transfer functions and state-space methods.

CO2: Analyze time-domain performance of control systems and design PID controllers to meet specified transient and steady-state requirements.

CO3: Apply stability analysis techniques including Routh-Hurwitz, Root Locus, Bode, and Nyquist methods to evaluate system stability.

CO4: Design frequency domain compensators (Lead, Lag, Lead-Lag) to achieve desired gain margin, phase margin, and bandwidth specifications.

CO5: Represent systems in state space form, assess controllability and observability, and implement digital control strategies for real-world engineering applications.

Text Books:

1. Nagrath, I.J. and Gopal, M., “Control Systems Engineering”, 5th Edition, New Age International Publishers, 2007.
2. Ogata, K., “Modern Control Engineering”, 5th Edition, Prentice Hall, 2010.
3. Franklin, G.F., Powell, J.D., and Emami-Naeini, A., “Feedback Control of Dynamic Systems”, 7th Edition, Pearson, 2015.

Reference Books:

1. Dorf, R.C. and Bishop, R.H., "Modern Control Systems", 12th Edition, Pearson Education, 2011.
2. Phillips, C.L. and Harbor, R.D., "Feedback Control Systems", 4th Edition, Prentice Hall, 2000.

Mode of Evaluation: Continuous Internal Evaluation, Assignments, Mid Term Tests and End Semester Examination.

Discipline Electives

Discipline Elective - I

25MBAARDC01 FLUID POWER SYSTEM FOR AUTOMATION

L	T	P	C
3	0	0	3

Pre-requisite: Fluid Mechanics, Engineering Thermodynamics, Fundamentals of Machine Design

Course Description:

This course introduces the principles and applications of hydraulic and pneumatic systems used in industrial automation and robotic systems. It covers fluid power components, circuit design, electro-hydraulic and electro-pneumatic control, servo systems, automation integration, and maintenance practices. The course emphasizes the design and analysis of fluid power systems for manufacturing automation, robotic actuation, material handling, and intelligent industrial processes.

Course Objectives:

1. To understand the fundamentals of hydraulic and pneumatic power transmission systems.
2. To analyze and design fluid power circuits used in automation applications.
3. To study electro-hydraulic and electro-pneumatic control systems.
4. To apply fluid power technology in robotic and industrial automation systems.
5. To develop skills in troubleshooting, maintenance, and performance optimization of fluid power systems.

UNIT I FUNDAMENTALS OF FLUID POWER SYSTEMS 9 hours

Introduction to fluid power and automation applications. Properties of hydraulic fluids and compressed air systems. Hydraulic and pneumatic power generation, transmission, and distribution. Symbols and standards used in fluid power circuits. Advantages, limitations, and industrial applications of fluid power systems.

UNIT II HYDRAULIC SYSTEMS AND COMPONENTS 9 hours

Hydraulic pumps, actuators, cylinders, motors, valves, accumulators, reservoirs, and auxiliary devices. Hydraulic circuit design and analysis. Pressure, flow, and directional control systems. Hydraulic power units and energy transmission in automated machinery and robotic systems.

UNIT III PNEUMATIC SYSTEMS AND ELECTRO-PNEUMATIC CONTROL 9 hours

Air generation, preparation, and distribution systems. Pneumatic actuators, valves, sensors, and control elements. Pneumatic circuit design and sequencing methods. Electro-pneumatic control using relays, PLCs, and sensors. Applications in industrial automation, assembly, and material handling systems.

UNIT IV ELECTRO-HYDRAULIC SERVO SYSTEMS AND AUTOMATION INTEGRATION 9 hours

Electro-hydraulic control principles, servo and proportional valves, feedback systems, and closed-loop control. Hydraulic servo actuators for precision motion control. Integration of fluid power systems with PLCs, CNC machines, industrial robots, and smart manufacturing environments. Performance analysis and system optimization techniques.

UNIT V MAINTENANCE, DIAGNOSTICS, AND ADVANCED APPLICATIONS 9 hours

Condition monitoring, fault diagnosis, troubleshooting, and maintenance of hydraulic and pneumatic systems. Reliability, safety standards, and energy-efficient fluid power systems. Fluid power applications in robotics, automated production lines, mobile automation, and Industry 4.0 environments. Emerging trends in intelligent fluid power and digital hydraulics.

Course Outcomes:

CO1: Explain the operating principles and components of hydraulic and pneumatic systems.
CO2: Design and analyze hydraulic and pneumatic circuits for automation applications.
CO3: Develop electro-pneumatic and electro-hydraulic control systems using industrial automation components.
CO4: Integrate fluid power systems with PLCs, robotic systems, and industrial automation platforms.
CO5: Evaluate system performance and implement maintenance and diagnostic strategies for fluid power systems.

Text Books:

1. Anthony Esposito, "Fluid Power with Applications", 7th Edition, Pearson Education, 2014.
2. Peter Rohner, "Industrial Hydraulic Control", John Wiley & Sons, 1994.
3. Andrew Parr, "Hydraulics and Pneumatics: A Technician's and Engineer's Guide", 3rd Edition, Butterworth-Heinemann, 2011.

Reference Books:

1. S. Ilango and V. Soundararajan, **Introduction to Hydraulics and Pneumatics**, PHI Learning, 2020
2. Festo Didactic GmbH, "Pneumatics: Basic Level", Festo Didactic, 2002.
3. W. Bolton, "Pneumatic and Hydraulic Systems", Butterworth-Heinemann, 1997.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - I

25MBAARDC02 SENSORS AND ACTUATORS

L	T	P	C
3	0	0	3

Pre-requisite: Basics of Electronics, Electrical Circuits, Engineering Physics, Instrumentation Fundamentals

Course Description:

This course provides comprehensive knowledge of modern sensing and actuation technologies used in automation, robotics, and intelligent systems. It covers principles, characteristics, calibration, signal conditioning, data acquisition, and interfacing techniques. Students learn about displacement, motion, force, thermal, pressure, flow, and level measurement sensors along with electrical, electromechanical, and smart actuators. The course emphasizes industrial relevance, hands-on integration, and IoT-enabled sensor networks for advanced monitoring and control.

Course Objectives:

1. Understand the working principles, characteristics, and classifications of sensors and actuators.
2. Learn calibration, error analysis, and signal conditioning for measurement systems.
3. Study different types of industrial sensors for displacement, motion, thermal, and process variables.
4. Understand electrical, mechanical, and smart actuators along with drive/control circuits.
5. Provide competency to integrate sensors and actuators in mechatronic and automation systems.

UNIT I FUNDAMENTALS OF SENSORS AND MEASUREMENT SYSTEMS — 9 hours

Measurement system elements, classifications, and distinctions between sensors and transducers. Static/dynamic characteristics, error sources, calibration techniques, and uncertainty estimation. Introduction to signal conditioning fundamentals including amplification, filtering, ADC/DAC, and data acquisition interfaces used in automation systems.

UNIT II MECHANICAL, PROXIMITY, AND MOTION SENSORS — 9 hours

Introduction to resistive, capacitive, and inductive sensors for displacement and position measurement such as strain gauges, LVDT/RVDT, and eddy current sensors. Optical devices like encoders, photoelectric sensors, and interferometers. Velocity/acceleration measurement using tachogenerators, Doppler sensors, and IMUs along with force/torque sensors used in robotic manipulation.

UNIT III PROCESS MEASUREMENT SENSORS — 9 hours

Temperature sensing using RTDs, thermocouples, thermistors, and infrared sensors. Pressure and vacuum sensors including piezoresistive, capacitive, and MEMS types. Flow measurement devices such as turbine, electromagnetic, ultrasonic, and vortex meters and level sensors such as ultrasonic, radar, capacitive, and hydrostatic systems with industrial applications.

UNIT IV ELECTRICAL, ELECTROMECHANICAL, AND PNEUMATIC ACTUATORS — 9 hours

Principles and characteristics of DC motors, AC induction motors, BLDC, servo motors, and stepper motors. Includes solenoids, linear actuators, voice coil actuators, and pneumatic/hydraulic actuators. Discusses motor drives (H-bridge, PWM, inverters), position/velocity control, and actuator selection criteria for robotics and automation.

UNIT V SMART SENSORS, MEMS, IOT INTEGRATION, AND ADVANCED ACTUATORS **9 hours**

Introduction to MEMS technologies and sensors such as accelerometers, gyroscopes, and micro actuators. Piezoelectric, shape-memory alloy, magneto strictive, and electroactive polymer actuators. Smart sensors with self-diagnostics, embedded microcontrollers, and IoT-enabled wireless sensor networks. Basics of vision sensors and machine-vision systems for automation.

Course Outcomes:

CO1: Explain measurement system characteristics and perform calibration and error analysis.
CO2: Select and integrate displacement, motion, and force sensors for industrial applications.
CO3: Apply temperature, pressure, flow, and level sensors with relevant signal conditioning.
CO4: Analyse and design electrical/mechanical actuator systems with appropriate drive controls.
CO5: Evaluate emerging smart sensors, MEMS devices, and IoT-based monitoring solutions.

Text Books:

1. Ernest O. Doebelin and Dhanesh N. Manik, "Measurement Systems: Application and Design", 6th Edition, McGraw-Hill, 2011.
2. David A. Bell, "Electronic Instrumentation and Measurements", 3rd Edition, Oxford University Press, 2013.
3. Clarence W. de Silva, "Sensors and Actuators: Engineering System Instrumentation", 2nd Edition, CRC Press, 2015.

Reference Books:

1. Jon Wilson, "Sensor Technology Handbook", Elsevier, 2005.
2. W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", 6th Edition, Pearson, 2015.
3. Rolf Isermann, "Mechatronic Systems: Fundamentals", 2nd Edition, Springer, 2005.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - I

25MBAARDC03 WHEELED ROBOTICS

L	T	P	C
3	0	0	3

Pre-requisite: Kinematics and Dynamics of Machinery, Control Systems, Sensors and Actuators, Fundamentals of Robotics

Course Description:

This course introduces the modelling, control, navigation, and system design of wheeled mobile robots operating in structured and unstructured environments. It covers locomotion mechanics, kinematic and dynamic modelling, state estimation, perception, mapping, and motion planning. Students gain theoretical and practical skills to design, simulate, and deploy intelligent wheeled robotic platforms for industrial, logistics, and field applications.

Course Objectives:

1. To understand the locomotion principles, mechanical structures, and drive mechanisms of wheeled robots.
2. To learn kinematic and dynamic modelling of differential, skid-steer, Ackermann, and omnidirectional platforms.
3. To develop perception and localization capabilities using sensors such as LiDAR, IMU, wheel odometry, and cameras.
4. To study navigation, SLAM, mapping, and motion-planning techniques for autonomous operation.
5. To expose students to real-world applications, simulation tools, and emerging trends in wheeled robotics.

UNIT I FUNDAMENTALS OF WHEELED MOBILE ROBOTS 9 hours

Types and characteristics of wheeled platforms including differential-drive, skid-steer, omnidirectional, and Ackermann steering robots; wheel–ground interaction and locomotion principles; drive train architectures and actuation; review of robot kinematics for wheeled systems; and introduction to real-world industrial and service robot platforms.

UNIT II KINEMATIC & DYNAMIC MODELLING OF WHEELED ROBOTS 9 hours

Non-holonomic constraints and their implications; forward and inverse kinematics of common drive configurations; dynamic modelling using Newton–Euler and Lagrangian formulations; slip, traction, and wheel odometry limitations; and modelling of actuator dynamics, steering dynamics, and low-level control loops.

UNIT III PERCEPTION, LOCALIZATION & SLAM 9 hours

Sensor suite for wheeled robots including encoders, IMU, GPS, LiDAR, and cameras; fusion methods using EKF and complementary filters; map representations such as occupancy grids and point-cloud maps; visual and LiDAR-based SLAM methods; and localization in structured and unstructured environments with drift-mitigation strategies.

UNIT IV PATH PLANNING, NAVIGATION & MOTION CONTROL 9 hours

Global and local path-planning algorithms including graph-based, sampling-based, and optimization-based methods; trajectory generation and tracking; obstacle avoidance using reactive and predictive methods; navigation stack concepts (ROS/ROS2); and tracking controllers such as pure pursuit, PID based, and model predictive control (MPC).

UNIT V APPLICATIONS, SIMULATION TOOLS 9 hours

Simulation and deployment using Webots and ROS2 navigation frameworks; behaviour design for multi-robot systems and fleet coordination; outdoor autonomy challenges including uneven terrain and dynamic obstacles; mobile manipulation with integrated arms; and emerging topics such as learning based navigation and digital twins for wheeled robots.

Course Outcomes:

CO1: Explain locomotion, design principles, and drive mechanisms of wheeled robots.
CO2: Develop kinematic and dynamic models for various wheeled robot configurations.
CO3: Implement perception, localization, and SLAM algorithms for autonomous operation.
CO4: Apply navigation, planning, and control methods to enable autonomous mobility.
CO5: Design, simulate, and evaluate wheeled robotic systems for industrial and research applications.

Text Books:

1. Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011.
2. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo, "Robotics: Modelling, Planning and Control", Springer, 2009.
3. Sebastian Thrun, Wolfram Burgard, and Dieter Fox, "Probabilistic Robotics", MIT Press, 2005.

Reference Books:

1. Gregory Dudek and Michael Jenkin, "Computational Principles of Mobile Robotics", 2nd Edition, Cambridge University Press, 2010.
2. Joseph L. Jones, Anita M. Flynn, and Bruce A. Seiger, "Mobile Robots: Inspiration to Implementation", 2nd Edition, A K Peters, 1999.
3. Morgan Quigley, Brian Gerkey, and William D. Smart, "Programming Robots with ROS", O'Reilly Media, 2015.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - I

25MBAARDC04 DATA ANALYTICS FOR AUTOMATION

L	T	P	C
3	0	0	3

Pre-requisite: Probability and Statistics, Fundamentals of Automation and Control Systems

Course Description:
This course introduces data analytics methodologies for automation and robotic systems with emphasis on industrial data acquisition, statistical analysis, machine learning, predictive maintenance, and intelligent decision-making. The course explores data-driven approaches for process optimization, fault diagnosis, quality improvement, and smart manufacturing applications in Industry 4.0 environments. Students will gain knowledge of modern analytical techniques used in cyber-physical systems, Industrial IoT, and autonomous automation systems.

Course Objectives:
1. Understand data acquisition, management, and analytics in industrial automation systems.
2. Apply statistical and machine learning techniques to industrial process data.
3. Develop predictive models for process monitoring and maintenance.
4. Analyze real-time sensor and IoT data for intelligent decision-making.
5. Explore digital twins and AI-enabled automation applications.

UNIT I INDUSTRIAL DATA ACQUISITION AND ANALYTICS FUNDAMENTALS 9 hours

Introduction to data-driven automation, Industry 4.0 and smart manufacturing. Industrial data sources including sensors, PLCs, SCADA, DCS, MES, and IIoT platforms. Data types, communication protocols, data storage architectures, and cloud-edge integration. Data preprocessing techniques such as cleaning, normalization, feature extraction, and exploratory data analysis.

UNIT II STATISTICAL ANALYSIS AND MACHINE LEARNING FOR AUTOMATION 9 hours

Descriptive and inferential statistics for process analysis. Statistical Process Control (SPC), hypothesis testing, regression, and multivariate analysis. Supervised learning techniques including decision trees, SVM, and ensemble methods. Unsupervised learning, clustering, dimensionality reduction, and model performance evaluation.

UNIT III TIME-SERIES ANALYSIS AND PREDICTIVE MAINTENANCE 9 hours

Characteristics of industrial time-series data and forecasting methods. ARIMA, exponential smoothing, and feature extraction techniques. Predictive maintenance strategies using condition monitoring and Remaining Useful Life (RUL) estimation. Anomaly detection using statistical, machine learning, and deep learning approaches for fault diagnosis.

UNIT IV COMPUTER VISION AND DEEP LEARNING IN AUTOMATION 9 hours

Image acquisition and preprocessing for industrial inspection. Deep learning architectures including CNNs for classification and defect detection. Object detection, segmentation, and visual quality assessment in manufacturing systems. Applications in robotic vision, autonomous inspection, and intelligent quality control.

UNIT V DIGITAL TWINS, AND INTELLIGENT AUTOMATION 9 hours

Edge-cloud analytics, and real-time data processing. Digital twin modeling, synchronization, and performance optimization. Deployment of analytics models using MLOps frameworks and industrial

AI platforms. Explainable AI, cybersecurity, and emerging applications in autonomous and smart manufacturing systems.

Course Outcomes:

CO1: Analyze and preprocess industrial datasets acquired from automation and robotic systems.
CO2: Apply statistical and machine learning techniques for process monitoring and optimization.
CO3: Develop predictive maintenance and anomaly detection models using time-series data.
CO4: Implement computer vision and deep learning techniques for automated inspection applications.
CO5: Integrate analytics solutions with digital twin platforms for intelligent decision-making.

Text Books:

1. Jay Lee, Hung-An Kao, and Shanhu Yang, Service Innovation and Smart Analytics for Industry 4.0 and Big Data Environment**,** Springer, 2019.
2. Mohammed J. Zaki and Wagner Meira Jr., Data Mining and Machine Learning: Fundamental Concepts and Algorithms, 2nd Edition, Cambridge University Press, 2020.
3. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow, 3rd Edition, O'Reilly Media, 2022.

Reference Books:

1. Wes McKinney, “Python for Data Analysis”, 3rd Edition, O’Reilly Media, 2022.
2. Uday Kamath and John Liu, Industrial IoT and Intelligent Analytics for Predictive Maintenance, Springer, 2021.
3. Houbing Song, Danda B. Rawat, Sabina Jeschke, and Christian Brecher, Cyber-Physical Systems: Foundations, Principles and Applications, Academic Press, 2017.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - II

25MBAARDC05 COLLABORATIVE ROBOTICS

L	T	P	C
3	0	0	3

Pre-requisite: Robot Kinematics and Dynamics, Sensors and Actuators, Control Systems, Fundamentals of Robotics

Course Description:

This course explores the principles, design frameworks, and operational aspects of collaborative robots (cobots) that can safely share workspaces with humans. It covers mechanical design, compliant actuation, perception for human–robot interaction, force/impedance control, safety standards, task programming, and industrial deployment. The course also introduces advanced concepts such as learning from demonstration, shared autonomy, and AI-driven collaborative systems.

Course Objectives:

1. To introduce the architecture, sensing, actuation, and design considerations of collaborative robots.
2. To develop understanding of force control, impedance control, and compliant interaction for safe pHRI.
3. To study international safety standards, risk assessment, and functional safety requirements for cobots.
4. To train students in task-level programming, simulation, and perception for collaborative tasks.
5. To explore learning-based methods and advanced multi-agent collaboration for real-world cobot applications.

UNIT I INTRODUCTION TO COLLABORATIVE ROBOTS AND COBOT ARCHITECTURE — 9 hours

Evolution of industrial robots to collaborative robots, motivations, and design principles; types of cobots and their workspace characteristics; compliant actuators, backdrivable mechanisms, and integrated sensing; overview of leading cobot platforms such as UR, LBR iiwa, YuMi, Panda; fundamentals of kinematics, workspace analysis, and end-effector design for safe shared operations.

UNIT II FORCE CONTROL AND COMPLIANT MOTION FOR HUMAN–ROBOT INTERACTION — 9 hours

Concepts of force/torque sensing, hybrid position–force control, and compliant motion strategies; impedance and admittance control formulations for contact-rich tasks; modelling human–robot interaction dynamics for hand-guiding, cooperative manipulation, and assembly; tactile sensing, gravity compensation, collision detection and safe reaction behaviours; applications in assembly, finishing, and ergonomic co-manipulation.

UNIT III SAFETY STANDARDS, RISK ASSESSMENT, AND FUNCTIONAL SAFETY — 9 hours

ISO 10218 and ISO/TS 15066 collaborative operation modes, speed and separation monitoring, and power/force limiting; hazard identification, quantitative risk estimation, and workspace zoning for HRC; biomechanical thresholds, ergonomic considerations, and operator safety analysis; SIL/PL concepts and safety-rated systems for industrial cobots; commissioning, validation, and certification processes for collaborative workcells.

UNIT IV PROGRAMMING, SIMULATION, AND PERCEPTION FOR COBOTS **9 hours**

Task-level programming, lead-through teaching, and intuitive HMI interfaces; robot languages such as URScript, RAPID, KRL and low-code programming environments; offline programming and simulation using RoboDK, ROS-Industrial, and Gazebo; trajectory planning and singularity avoidance; perception using RGB-D cameras, pose estimation, human intention recognition, and vision-guided manipulation for collaborative tasks.

UNIT V LEARNING, SHARED AUTONOMY & ADVANCED COBOT APPLICATIONS **9 hours**

Learning from Demonstration (LfD), kinesthetic teaching, DMPs and probabilistic skill models; reinforcement learning for adaptive cobot behaviours and sim-to-real techniques; shared autonomy, adjustable autonomy and human-aware task allocation; multi-robot and dual-arm collaboration frameworks; real-world applications in smart manufacturing, healthcare, inspection, logistics, and emerging AI-driven cobot ecosystems.

Course Outcomes:

CO1: Explain cobot design principles, sensing mechanisms, and characteristics of modern collaborative platforms.

CO2: Implement force/impedance control and compliant interaction strategies for safe pHRI.

CO3: Apply safety standards and perform structured risk assessments for collaborative cells.

CO4: Programme cobots using task-level, teach-and-repeat, and simulation tools with perception integration.

CO5: Develop intelligent, adaptive collaborative applications using LfD, shared autonomy, and multi-robot coordination.

Text Books:

1. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo, “Robotics: Modelling, Planning and Control”, Springer, 2009.
2. Aude Billard, Sylvain Calinon, Rudiger Dillmann, and Stefan Schaal, “Robot Programming by Demonstration”, in Springer Handbook of Robotics, Springer, 2008.
3. Anibal T. de Almeida, Eduardo Oliveira, and A. Paulo Moreira, “Advanced Robotics: Redundancy and Optimization”, Addison-Wesley, 1996.

Reference Books:

1. Neville Hogan, “Impedance Control: An Approach to Manipulation”, ASME Journal of Dynamic Systems, Measurement, and Control, Vol. 107, 1985.
2. ISO/TS 15066:2016, “Robots and Robotic Devices – Collaborative Robots”, International Organisation for Standardisation, Geneva, 2016.
3. Agostino De Santis, Bruno Siciliano, Alessandro De Luca, and Antonio Bicchi, “An Atlas of Physical Human–Robot Interaction”, Mechanism and Machine Theory, Elsevier, Vol. 43, 2008.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - II

25MBAARDC06 SMART MOBILITY ROBOTS

L	T	P	C
3	0	0	3

Pre-requisite: Wheeled Mobile Robotics, Sensors & Actuators, Control Systems, Embedded System
s

Course Description:

This course introduces the concepts, technologies, and system integration methods behind intelligent mobile robots capable of autonomous navigation and mobility. It covers perception, localization, mapping, decision-making, motion planning, fleet management, V2X communication, and AI-enabled autonomy. Students gain exposure to real-world applications in logistics, service robotics, autonomous driving, and Industry 4.0 mobility systems.

Course Objectives:

1. To understand the architecture, hardware platforms, and autonomy stack of smart mobility robots.
2. To develop perception and environment-modelling capabilities using vision, LiDAR, radar, and multi-sensor fusion.
3. To study localization, SLAM, behaviour planning, and motion control algorithms for autonomous navigation.
4. To explore multi-robot coordination, fleet management, cloud robotics, and V2X communication technologies.
5. To examine safety standards, certification, and emerging AI-driven strategies used in modern mobility robots.

UNIT I SMART MOBILITY ROBOT FUNDAMENTALS 9 hours

Smart mobility robots: definitions, classifications, applications, and levels of autonomy; system architecture comprising perception, localization, planning, and control modules; hardware platforms including drive systems, power electronics, embedded controllers, and compute units; introduction to ROS2 and middleware frameworks; overview of AMRs, AGVs, UGVs, and autonomous delivery platforms across industrial and service domains.

UNIT II PERCEPTION AND ENVIRONMENT MODELLING 9 hours

Fundamentals of perception using 2D/3D LiDAR, camera systems, radar, and ultrasonic sensors; sensor calibration and synchronization; point-cloud processing, feature extraction, and semantic segmentation; multi-sensor fusion using Kalman filters and probabilistic models; obstacle detection, terrain assessment, and map generation for structured and unstructured environments.

UNIT III LOCALIZATION, SLAM, PLANNING & NAVIGATION 9 hours

Localization through odometry, IMU fusion, LiDAR-based and visual SLAM methods; global and local path planning using graph-based approaches, sampling-based methods, and optimization techniques; dynamic obstacle avoidance and behaviour planning strategies; trajectory generation and motion control for differential, skid-steer, and Ackermann-steer robots; navigation under uncertainty using probabilistic and AI-based models.

UNIT IV FLEET MANAGEMENT, V2X & CONNECTED MOBILITY 9 hours

Fleet management architecture for multi-robot coordination, task allocation, and traffic management; communication protocols including Wi-Fi, 5G, and mesh networking; V2X communication for infrastructure-robot and inter-robot connectivity; cloud robotics, digital twins, and remote monitoring;

integration with smart factory systems such as automated doors, elevators, docking stations, and warehouse management systems.

UNIT V SAFETY, CERTIFICATION, AI-DRIVEN AUTONOMY & APPLICATIONS **9 hours**

Safety requirements based on industrial standards (ISO 3691-4, IEC 61508) and risk-assessment frameworks; verification and validation methods including hardware-in-the-loop (HIL). Reinforcement learning, imitation learning, and foundation models for robot autonomy; edge AI for real-time perception; case studies across logistics AMRs, hospital robots, warehouse AGVs, agricultural UGVs, and last-mile autonomous delivery.

Course Outcomes:

CO1: Describe the architecture, components, and functional modules of smart mobility robots.
CO2: Develop perception pipelines with multi-sensor fusion for environment modelling.
CO3: Implement localization, mapping, navigation, and behaviour planning algorithms.
CO4: Design fleet management and communication systems integrating V2X technologies.
CO5: Apply safety standards and AI-driven methods to deploy advanced mobility robot systems.

Text Books:

1. Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011.
2. Sebastian Thrun, Wolfram Burgard, and Dieter Fox, "Probabilistic Robotics", MIT Press, 2005.
3. Bruno Siciliano & Lorenzo Sciavicco – *Robotics: Modelling, Planning and Control*, Springer.

Reference Books:

1. Morgan Quigley, Brian Gerkey, and William D. Smart, "Programming Robots with ROS", O'Reilly Media, 2015.
2. Steven Waslander – *Mobile Robotics Course Materials*, University of Toronto (Open Source).
3. ISO 3691-4:2023, "Industrial Trucks – Safety Requirements and Verification – Part 4: Driverless Industrial Trucks and Their Systems", International Organisation for Standardisation, 2023.
4. Chen Li, Hamid Jaddu, and Hamidou Tembine, "Multi-Agent Reinforcement Learning for Mobile Robot Navigation", IEEE Transactions on Intelligent Transportation Systems, 2021.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - II

25MBAARDC07 ROBOT OPERATING SYSTEM

L	T	P	C
3	0	0	3

Pre-requisite: Programming in Python and C++, Fundamentals of Robotics, Sensors and Actuators

Course Description:

This course introduces the Robot Operating System (ROS) as a software framework for the development of robotic and automation applications. The course covers ROS architecture, communication mechanisms, robot modeling, simulation, perception, localization, navigation, manipulation, and multi-robot systems. Students will learn to develop, integrate, and deploy robotic applications using ROS for industrial automation, autonomous mobile robots, and intelligent robotic systems.

Course Objectives:

1. To understand the architecture and components of Robot Operating System (ROS).
2. To develop robotic applications using ROS communication and software tools.
3. To model, simulate, and control robotic systems using ROS environments.
4. To implement perception, localization, navigation, and manipulation algorithms.
5. To integrate ROS with advanced automation and autonomous robotic systems.

UNIT I INTRODUCTION TO ROS AND ROBOTIC SOFTWARE FRAMEWORKS — 9 hours

Evolution of robot software architectures and middleware concepts. ROS architecture, distributions, workspaces, packages, nodes, topics, messages, services, and actions. ROS command-line tools, development environment setup, and software organization. Applications of ROS in industrial, service, and autonomous robotics.

UNIT II ROS COMMUNICATION AND ROBOT MODELING — 9 hours

ROS communication mechanisms including publishers, subscribers, services, actions, and parameter servers. Robot description using URDF and Xacro models. Coordinate transformations, TF framework, robot kinematics representation, and integration of sensors and actuators within ROS environments.

UNIT III ROBOT SIMULATION AND CONTROL — 9 hours

Simulation of robotic systems using Gazebo and RViz environments. Robot motion control, sensor interfacing, data visualization, and monitoring. Integration of mobile robots and manipulators in simulated environments. Development and testing of robotic applications using ROS-based simulation platforms.

UNIT IV PERCEPTION, LOCALIZATION, AND NAVIGATION — 9 hours

Sensor data processing using cameras, LiDAR, IMU, and range sensors. Localization techniques, mapping, SLAM concepts, path planning, obstacle avoidance, and autonomous navigation. ROS navigation stack and perception frameworks for intelligent robotic decision-making and environment interaction.

UNIT V ADVANCED ROS APPLICATIONS AND INDUSTRIAL INTEGRATION — 9 hours

Robot manipulation, motion planning, and MoveIt framework. Multi-robot coordination, distributed robotic systems, and cloud robotics concepts. Integration of ROS with Industrial IoT, Industry 4.0, and collaborative robots. Emerging trends including ROS2, autonomous systems, digital twins, and AI-enabled robotic applications.

Course Outcomes:

CO1: Explain the architecture, tools, and communication mechanisms of ROS.
CO2: Develop robotic software modules using ROS nodes, topics, services, and actions.
CO3: Model, simulate, and control robotic systems in ROS-based environments.
CO4: Implement localization, mapping, navigation, and perception algorithms using ROS.
CO5: Design and deploy advanced robotic applications using ROS for automation and intelligent systems.

Text Books:

1. Morgan Quigley, Brian Gerkey, and William D. Smart, "Programming Robots with ROS", O'Reilly Media, 2015.
2. Aaron Martinez and Enrique Fernández, Learning ROS for Robotics Programming, 2nd Edition, Packt Publishing, 2018.
3. Carol Fairchild and Thomas L. Harman, ROS Robotics by Example, 3rd Edition, Packt Publishing, 2022.

Reference Books:

1. Morgan Quigley, Ken Conley, Brian Gerkey and William D. Smart, ROS: An Open-Source Robot Operating System, IEEE ICRA Workshop Proceedings, 2009.
2. Kevin M. Lynch and Frank C. Park, Modern Robotics: Mechanics, Planning and Control, Cambridge University Press, 2017.
3. Michel Hidalgo, "A Concise Introduction to Robot Programming with ROS2", CRC Press, Taylor & Francis Group, 2023.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - II

25MBAARDC08 OPTIMIZATION WITH APPLICATIONS IN ROBOTICS

L	T	P	C
3	0	0	3

Pre-requisite: Linear Algebra, Calculus and Differential Equations

Course Description:

This course provides a comprehensive understanding of optimization techniques and their applications in robotics and automation systems. It covers classical and modern optimization methods, constrained and unconstrained optimization, numerical techniques, trajectory optimization, motion planning, and optimal control. The course enables students to formulate and solve engineering optimization problems encountered in robotic manipulation, autonomous systems, industrial automation, and intelligent manufacturing environments

Course Objectives:

1. To understand the mathematical foundations of optimization techniques.
2. To formulate optimization problems arising in robotics and automation.
3. To apply numerical optimization methods for engineering applications.
4. To develop optimal solutions for robotic motion planning and control.
5. To explore advanced optimization techniques used in autonomous and intelligent systems.

UNIT I FUNDAMENTALS OF OPTIMIZATION 9 hours

Introduction to optimization and engineering design problems. Mathematical formulation of optimization models, objective functions, decision variables, and constraints. Convex and non-convex optimization, optimality conditions, and problem classification. Applications of optimization in automation and robotic systems.

UNIT II CLASSICAL OPTIMIZATION TECHNIQUES 9 hours

Unconstrained optimization methods including gradient-based and search techniques. Constrained optimization using Lagrange multipliers, Karush-Kuhn-Tucker conditions, and penalty function methods. Linear and nonlinear programming concepts. Engineering applications in process and system optimization.

UNIT III NUMERICAL AND EVOLUTIONARY OPTIMIZATION METHODS 9 hours

Numerical optimization techniques for single and multi-variable problems. Dynamic programming and optimality principles. Evolutionary and population-based methods including Genetic Algorithms, Particle Swarm Optimization, and Differential Evolution. Bayesian Optimization, Grey Wolf Optimizer (GWO), Ant Bee Colony (ABC), Bacterial Foraging Optimization (BFO).

UNIT IV OPTIMIZATION IN ROBOTICS AND MOTION PLANNING 9 hours

Trajectory generation and path optimization for robotic manipulators and mobile robots. Configuration space optimization, obstacle avoidance, and collision-free motion planning. Kinematic and dynamic optimization of robotic systems. Energy-efficient and time-optimal robotic operations in industrial environments. RRT and RRT*, Graph Optimization, Trajectory optimization, Motion Planning in dynamic environments.

UNIT V OPTIMIZATION IN ROBOT LEARNING AND ESTIMATION 9 hours

Optimal control principles for robotic and automation systems. Model predictive control, multi-objective optimization, and real-time decision-making. Optimization for autonomous vehicles, swarm robotics, human-robot collaboration, and intelligent manufacturing systems. Emerging trends in AI-driven optimization and learning-based control.

Course Outcomes:

CO1: Formulate optimization problems associated with robotics and automation systems.
CO2: Apply classical optimization techniques to solve constrained and unconstrained engineering problems.
CO3: Utilize numerical and evolutionary algorithms for robotic system optimization.
CO4: Design optimized motion planning and trajectory generation solutions for robotic applications.
CO5: Implement optimal control and advanced optimization techniques in autonomous and intelligent robotic systems.

Text Books:

1. Stephen Boyd and Lieven Vandenberghe, "Convex Optimization", Cambridge University Press, 2004. (Available free at https://web.stanford.edu/~boyd/cvxbook/)
2. Jorge Nocedal and Stephen J. Wright, "Numerical Optimization", 2nd Edition, Springer, 2006.
3. Moritz Diehl and Sebastien Gros, "Numerical Optimal Control", Lecture Notes, University of Freiburg, 2020. (Available at https://www.syscop.de/teaching)

Reference Books:

1. Kevin M. Lynch and Frank C. Park, Modern Robotics: Mechanics, Planning and Control, Cambridge University Press, 2017.
2. Frank L. Lewis, Draguna Vrabie, and Vassilis L. Syrmos, "Optimal Control", 3rd Edition, John Wiley & Sons, 2012.
3. Xin-She Yang, Nature-Inspired Optimization Algorithms, 2nd Edition, Academic Press, 2021.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - III

25MBAARDC09 BIOINSPIRED ROBOTICS

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Course Description:

This course introduces biologically inspired principles and their application in robotic system design and control. It covers biological locomotion, sensing, learning mechanisms, swarm intelligence, soft robotics, and adaptive robotic systems inspired by natural organisms. The course enables students to develop robotic solutions that mimic biological behaviors for advanced applications.

Course Objectives:

1. Understand biological principles relevant to robotic systems.
2. Analyze bio-inspired locomotion and sensing mechanisms.
3. Develop intelligent robotic behaviors based on biological systems.
4. Apply swarm intelligence and adaptive algorithms in robotic design.
5. Design bio-inspired robotic solutions for real-world applications.

UNIT I FUNDAMENTALS OF BIOINSPIRED ROBOTICS 9 hours

Introduction to bioinspired systems – Biological inspiration in engineering – Natural systems and robotic adaptation – Biomimetics and bio-inspired design principles, Morphological Computing.

UNIT II BIOLOGICAL LOCOMOTION AND SENSING 9 hours

Animal locomotion mechanisms – Walking, swimming, flying robots – Biological sensory systems – Vision, tactile and auditory sensing, Brain computer Interfaces.

UNIT III SWARM ROBOTICS AND COLLECTIVE INTELLIGENCE 9 hours

Swarm intelligence principles – Ant colony optimization – Particle swarm optimization – Cooperative robotic systems – Multi-agent systems.

UNIT IV SOFT ROBOTICS AND ADAPTIVE SYSTEMS 9 hours

Introduction to soft robotics – Smart materials – Flexible actuators – Adaptive and self-reconfigurable robotic systems, Biohybrid Robotics.

UNIT V BIOINSPIRED LEARNING AND APPLICATIONS 9 hours

Neural networks in robotics – Evolutionary robotics – Reinforcement learning – Medical robotics – Search and rescue systems, Neuromorphic Robotics.

Course Outcomes:

At the end of this course students will be able to

CO1: Understand biological principles used in robotic design.

CO2: Analyze biological locomotion and sensing techniques.

CO3: Apply swarm intelligence algorithms for robotic systems.

CO4: Design adaptive and soft robotic systems.

CO5: Develop bio-inspired robotic solutions for practical applications.

Text Books:

1. Yoseph Bar-Cohen, Biomimetics: Nature-Based Innovation, CRC Press.2011
2. Shuuji Kajita, Introduction to Humanoid Robotics, Springer.2014

Reference Books:

1. Dario Floreano and Claudio Mattiussi, Bio-Inspired Artificial Intelligence, MIT Press.2008
2. Robert Full and Daniel Koditschek, Biological Principles in Robotics, Springer.2008
3. Marco Dorigo, Swarm Intelligence, Elsevier.2004

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - III

25MBAARDC10 DIGITAL TWIN IN ROBOTICS

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Course Description:

This course focuses on digital twin technology and its application in robotic systems and smart manufacturing. It includes modeling, simulation, real-time synchronization, predictive analytics, IoT integration, and applications in industrial automation and Industry 4.0.

Course Objectives:

1. Understand concepts of digital twins in robotic systems.
2. Analyze digital models and real-time data synchronization.
3. Develop virtual models for robotic systems.
4. Integrate IoT and analytics with digital twin systems.
5. Apply digital twin concepts in industrial applications

UNIT I INTRODUCTION TO DIGITAL TWIN TECHNOLOGY 9 hours

Digital transformation concepts, Industry 4.0, Levels of Digital Twins (Component, Asset, System Process) and Digital Twin Maturity Models, cyber-physical systems, architecture of digital twins, components and frameworks, challenges and opportunities.

UNIT II MODELING AND SIMULATION 9 hours

System modeling approaches, dynamic system modeling, simulation methods, mathematical models, robotic system representation, virtual environments.

UNIT III DATA ACQUISITION AND COMMUNICATION 9 hours

Sensors and IoT devices, communication protocols, cloud platforms, real-time data acquisition, edge devices, database management.

UNIT IV DIGITAL TWIN FOR ROBOTIC SYSTEMS 9 hours

Robot modeling, synchronization techniques, predictive maintenance, fault diagnosis, digital twin integration with robotic systems.

UNIT V INDUSTRIAL APPLICATIONS 9 hours

Smart manufacturing, autonomous systems, human-robot collaboration, industrial case studies, future trends and challenges

Course Outcomes:

At the end of this course students will be able to

CO1: Understand digital twin concepts and architecture.

CO2: Develop simulation models for robotic systems.

CO3: Analyze real-time synchronization techniques.

CO4: Integrate IoT and analytics with robotic systems.

CO5: Implement digital twin applications for industrial automation.

Text Books:

1. Fei Tao and Qi Qi, *Digital Twin Driven Smart Manufacturing*, Academic Press.Wiley,2019

2. Jan Holmstrom, *Digital Twins and Smart Systems*, Springer.

Reference Books:

1. Grieves M., *Digital Twin: Manufacturing Excellence through Virtual Factory Replication*.
2. Alasdair Gilchrist, *Industry 4.0*, Apress.2016
3. Rajkumar Buyya, *Internet of Things Principles and Applications*.2019

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - III

25MBAARDC11 FUZZY LOGIC AND EXPERT SYSTEM

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Course Description:

This course introduces concepts of fuzzy logic, uncertainty modeling, and expert systems for intelligent automation applications. It covers fuzzy sets, fuzzy inference, fuzzy control, knowledge representation and development of expert systems for decision-making in automation and robotics.

Course Objectives:

1. Understand fuzzy set theory and uncertainty handling.
2. Analyze fuzzy inference systems and fuzzy controllers.
3. Apply fuzzy logic techniques to automation problems.
4. Develop knowledge-based expert systems.
5. Design intelligent decision support systems.

UNIT I INTRODUCTION TO FUZZY LOGIC 9 hours

Classical and fuzzy sets – Membership functions – Operations on fuzzy sets – Fuzzy propositions – Linguistic variables. Uncertainty and ambiguity concepts.

UNIT II FUZZY RELATIONS AND INFERENCE 9 hours

Fuzzy relations – Composition of relations – Fuzzy rules – Fuzzification and defuzzification methods. fuzzy reasoning techniques.

UNIT III FUZZY CONTROL SYSTEMS 9 hours

Architecture of fuzzy controllers – Design of fuzzy systems – Rule base generation – Industrial applications. adaptive fuzzy systems.

UNIT IV EXPERT SYSTEMS 9 hours

Knowledge representation – Inference engine – Knowledge acquisition – Expert system architecture and development.

UNIT V APPLICATIONS IN AUTOMATION 9 hours

Neuro-fuzzy systems – Decision support systems – Robotics applications – Intelligent automation systems and industrial case studies.

Course Outcomes:

At the end of this course students will be able to

CO1: Explain fuzzy set concepts and operations.

CO2: Apply fuzzy inference methods to engineering problems.

CO3: Design fuzzy controllers for automation systems.

CO4: Develop expert systems using knowledge-based approaches.

CO5: Integrate fuzzy and expert systems in intelligent automation.

Text Books:

1. Timothy J. Ross, Fuzzy Logic with Engineering Applications, Wiley.2016
2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic, Pearson.1995
3. S. Rajasekaran and G.A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms.2003

Reference Books:

1. Efraim Turban, Decision Support and Expert Systems. Pearson,2005

2. J.S.R. Jang, C.T. Sun and E. Mizutani, Neuro-Fuzzy and Soft Computing. Pearson,1997

3. Kevin Passino and Stephen Yurkovich, Fuzzy Control. Addison-Wesley, **1998**

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - III

25MBAARDC12 EDGE COMPUTING IN AUTOMATION

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Course Description:

This course introduces edge computing architectures and technologies used in industrial automation systems. Topics include edge devices, real-time processing, IoT integration, communication protocols, AI at the edge and industrial automation applications.

Course Objectives:

1. Understand edge computing principles in automation.
2. Analyze edge architectures and communication systems.
3. Develop real-time edge-based applications.
4. Integrate AI and IoT technologies at the edge.
5. Apply edge computing solutions in industrial systems.

UNIT I INTRODUCTION TO EDGE COMPUTING 9 hours

Cloud computing limitations, edge computing concepts, architecture, components, fog computing, distributed computing systems.

UNIT II EDGE DEVICES AND COMMUNICATION 9 hours

Industrial sensors, embedded systems, communication protocols, MQTT, OPC-UA, Modbus, and industrial communication networks.

UNIT III REAL-TIME DATA PROCESSING 9 hours

Data acquisition techniques, stream processing, resource management, real-time processing, latency optimization techniques.

UNIT IV AI AT THE EDGE 9 hours

Machine learning at edge devices, distributed intelligence, edge analytics, AI deployment methods, security and privacy.

UNIT V INDUSTRIAL APPLICATIONS 9 hours

Smart manufacturing, predictive maintenance, autonomous systems, industrial IoT applications, case studies and future trends.

Course Outcomes:

At the end of this course students will be able to

CO1: Explain concepts and architecture of edge computing.

CO2: Analyze edge communication and data processing systems.

CO3: Develop real-time edge computing applications.

CO4: Integrate AI and IoT technologies in automation systems.

CO5: Implement edge-based industrial automation solutions.

Text Books:

1. Perry Lea, Internet of Things for Architects, Packt Publications.2018
2. David Jensen, Beginning Azure IoT Edge Computing, Apress.2019
3. Hwaiyu Geng, Industrial Internet of Things and Smart Manufacturing.Wiley,2019

Reference Books:

1. Rajkumar Buyya and Satish Narayana Srirama, Fog and Edge Computing: Principles and Paradigms.2019
2. Andrew Minteer, Analytics for the Internet of Things.2017
3. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things.2016

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - IV

25MBAARDC13 SOFT ROBOTICS

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Course Description:

This course introduces concepts, materials, design methodologies, and control strategies of soft robotic systems. The course covers smart materials, soft actuators, sensing mechanisms, modeling, fabrication techniques, and applications of soft robots in healthcare, wearable devices, and industrial automation.

Course Objectives:

1. Understand fundamentals and characteristics of soft robotic systems.
2. Analyze smart materials and soft actuators used in robotics.
3. Develop models and control strategies for soft robots.
4. Study sensing and fabrication techniques of soft robotic systems.
5. Apply soft robotic technologies for real-world applications.

UNIT I INTRODUCTION TO SOFT ROBOTICS 9 hours

Introduction to soft robotics, conventional versus soft robots, biological inspiration and biomimetic systems, characteristics and classifications of soft robots, degrees of freedom, design methodologies, advantages, limitations and challenges, applications in healthcare, automation and defense.

UNIT II SOFT MATERIALS AND ACTUATION 9 hours

Smart materials for soft robotics, Shape Memory Alloys (SMA), Shape Memory Polymers, electroactive polymers, dielectric elastomers, pneumatic and hydraulic actuation, artificial muscles, piezoelectric materials, material characterization and selection.

UNIT III MODELING AND CONTROL OF SOFT ROBOTS 9 hours

Kinematic and dynamic modeling, continuum robot mechanics, piecewise constant curvature models, finite element modeling, dynamic response analysis, trajectory planning, feedback control, adaptive and intelligent control techniques.

UNIT IV SOFT SENSORS AND FABRICATION TECHNIQUES 9 hours

Flexible sensors, strain sensors, tactile sensing, embedded sensing technologies, additive manufacturing techniques, 3D printing for soft robots, microfabrication methods, embedded electronics and control integration.

UNIT V APPLICATIONS OF SOFT ROBOTICS 9 hours

Medical and rehabilitation robotics, surgical robots, wearable devices, grippers and manipulators, industrial automation applications, search and rescue robots, biohybrid systems, future trends in soft robotics.

Course Outcomes:

At the end of this course students will be able to

CO1: Explain principles and design aspects of soft robotic systems.

CO2: Analyze materials and actuation mechanisms for soft robots.

CO3: Develop models and control strategies for soft robotic systems.

CO4: Evaluate sensing and fabrication techniques for soft robotics.

CO5: Apply soft robotics concepts to industrial and healthcare applications.

Text Books:

1. Cecilia Laschi and Barbara Mazzolai, Soft Robotics: Trends, Applications and Challenges, Springer. 2016
2. Kim Sangbae and Kevin Chen, Soft Robotics Fundamentals and Applications, Elsevier.2021
3. Barry Trimmer, Soft Robotics: Biological Inspiration and Engineering Systems, CRC Press.2017

Reference Books:

1. Paolo Dario, Bioinspired Robotics, Springer. 2021
2. Bruno Siciliano and Oussama Khatib, Springer Handbook of Robotics. 2nd Edition, Springer, 2016.
3. George Mase, Continuum Mechanics for Engineers, CRC Press. 3rd Edition, 1999

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - IV

25MBAARDC14 ROBOT SYSTEM RELIABILITY AND SAFETY

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Course Description:

This course focuses on reliability engineering principles and safety aspects of robotic systems. Topics include reliability analysis, fault diagnosis, risk assessment, safety standards, maintenance strategies, and safe human-robot interaction in automated environments.

Course Objectives:

1. Understand reliability concepts for robotic systems.
2. Analyze failure mechanisms and reliability models.
3. Apply safety standards and risk assessment methods.
4. Develop fault diagnosis and maintenance strategies.
5. Design safe and reliable robotic systems.

UNIT I FUNDAMENTALS OF RELIABILITY ENGINEERING 9 hours

Reliability concepts – Failure distributions – Reliability functions – Hazard rate models – MTBF and MTTF – Availability and maintainability – Reliability metrics – Statistical concepts in reliability engineering.

UNIT II RELIABILITY ANALYSIS TECHNIQUES 9 hours

Reliability block diagrams – Fault Tree Analysis (FTA) – Failure Mode and Effect Analysis (FMEA) – Event Tree Analysis – Markov models – Reliability prediction methods – Life testing and accelerated testing techniques.

UNIT III FAULT DIAGNOSIS AND PREDICTIVE MAINTENANCE 9 hours

Fault detection methods – Signal-based diagnostics – Condition monitoring techniques – Sensors for health monitoring – Predictive maintenance methods – Machine learning for fault prediction – Remaining Useful Life estimation.

UNIT IV SAFETY OF ROBOTIC SYSTEMS 9 hours

Robot safety standards – ISO and IEC standards – Hazard analysis – Risk assessment methodologies – Human-machine interaction – Collaborative robot safety – Safety sensors and interlocks – Emergency control systems.

UNIT V APPLICATIONS AND INDUSTRIAL CASE STUDIES 9 hours

Industrial robot reliability analysis – Autonomous vehicle safety – Human-robot collaboration – Safety validation procedures – Industrial case studies on manufacturing systems – Safety management frameworks.

Course Outcomes:

At the end of this course students will be able to

CO1: Explain reliability concepts and failure mechanisms.

CO2: Apply reliability analysis techniques for robotic systems.

CO3: Develop fault diagnosis and predictive maintenance approaches.

CO4: Evaluate robotic safety standards and risk assessment methods.

CO5: Design reliable and safe robotic systems.

Text Books:

1. Ebeling C.E., *An Introduction to Reliability and Maintainability Engineering*, McGraw-Hill.1997
2. Modarres M., *Reliability Engineering and Risk Analysis*, CRC Press.2016
3. Blanchard B.S., *Maintainability Principles and Practices*, McGraw-Hill.1995

Reference Books:

1. IEC/ISO Standards for Robotic Safety.2011
2. Oussama Khatib, *Springer Handbook of Robotics*.2012
3. Patrick O'Connor, *Practical Reliability Engineering*, Wiley.2012

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - IV

25MBAARDC15 ADVANCES IN MOBILE ROBOTS AND AGV

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Course Description:

This course provides advanced concepts of mobile robotics and Automated Guided Vehicles (AGVs). Topics include locomotion systems, navigation techniques, localization, path planning, perception systems, and intelligent autonomous vehicles used in industrial automation.

Course Objectives:

1. Understand mobile robot architectures and AGV systems.
2. Analyze navigation and localization techniques.
3. Apply path planning algorithms for autonomous robots.
4. Integrate perception systems in mobile robots.
5. Develop autonomous robotic solutions.

UNIT I FUNDAMENTALS OF MOBILE ROBOTICS 9 hours

Introduction to mobile robotics, Classification of mobile robots, Wheeled, tracked and legged robots, Locomotion principles, Kinematics and dynamics of mobile robots, Motion constraints, Differential drive, Ackerman steering.

UNIT II LOCALIZATION AND MAPPING 9 hours

Robot coordinate systems, Position estimation, Dead reckoning, Sensors for localization, GPS, IMU and LiDAR, Mapping techniques, Simultaneous Localization and Mapping (SLAM), Probabilistic methods, Reinforcement Learning for navigation.

UNIT III NAVIGATION AND PATH PLANNING 9 hours

Path planning approaches – Graph-based methods – Potential field methods – Optimization techniques – Obstacle avoidance algorithms – Trajectory generation – Autonomous navigation techniques.

UNIT IV AUTOMATED GUIDED VEHICLES 9 hours

AGV fundamentals – Guidance technologies – Magnetic guidance – Laser guidance – Vision-based navigation – Fleet management systems – Scheduling algorithms – Warehouse automation.

UNIT V ADVANCED MOBILE ROBOTICS APPLICATIONS 9 hours

Autonomous vehicles – Service robots – Agricultural robots – Mobile manipulation – Multi-robot coordination – Swarm robotics – Intelligent transportation systems – Industry applications.

Course Outcomes:

At the end of this course students will be able to

CO1: Understand mobile robot architectures and AGV systems.

CO2: Analyze localization and mapping techniques.

CO3: Apply navigation and path planning algorithms.

CO4: Integrate AGV technologies for industrial applications.

CO5: Develop intelligent autonomous robotic systems.

Text Books:

1. Siegwart, Nourbakhsh and Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press.2011
2. Roland Siegwart, Autonomous Mobile Robots, MIT Press,2004
3. Saeed B. Niku, Introduction to Robotics: Analysis, Control and Applications, **2nd Edition**, Wiley India, **2020**

Reference Books:

1. Steven M. LaValle, Planning Algorithms. Cambridge University Press, **2006**.
2. Bruno Siciliano and Oussama Khatib, Springer Handbook of Robotics, 2nd Edition, Springer, 2016.
3. Alonzo Kelly, Mobile Robotics: Mathematics, Models and Methods. Cambridge University Press, 2013.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective - IV

25MBAARDC16 INDUSTRY 5.0 AND EMERGING TECHNOLOGIES

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Course Description:

This course introduces Industry 5.0 concepts emphasizing human-centric, sustainable, and resilient manufacturing systems. The course covers collaborative robotics, AI, digital twins, edge computing, cyber-physical systems, and emerging technologies shaping future industries.

Course Objectives:

1. Understand Industry 5.0 principles and architecture.
2. Analyze emerging technologies used in smart manufacturing.
3. Integrate AI and cyber-physical systems in industrial environments.
4. Study human-robot collaboration and sustainability concepts.
5. Develop innovative solutions for next-generation industries.

UNIT I INTRODUCTION TO INDUSTRY 5.0 — 9 hours

Industrial evolution from Industry 1.0–5.0 – Human-centric manufacturing – Sustainability and resilience – Smart manufacturing principles – Digital transformation.

UNIT II EMERGING TECHNOLOGIES FOR SMART INDUSTRIES — 9 hours

Artificial Intelligence – Machine Learning – Deep Learning – Blockchain technology – Internet of Things – Big Data analytics – Augmented Reality and Virtual Reality.

UNIT III CYBER-PHYSICAL SYSTEMS AND DIGITAL TWINS — 9 hours

Cyber-physical systems architecture – Sensors and actuators – Data acquisition systems – Digital twin concepts – Modeling and simulation – Virtual factories – Industrial applications.

UNIT IV HUMAN-ROBOT COLLABORATION AND SMART SYSTEMS — 9 hours

Collaborative robots (Cobots) – Human-machine interaction – Safety in collaborative environments – Wearable technologies – Assistive technologies – Human-centered design.

UNIT V FUTURE MANUFACTURING SYSTEMS — 9 hours

Edge computing – Cloud manufacturing – Autonomous systems – Additive manufacturing – Smart supply chains – Sustainable manufacturing – Industrial case studies – Challenges and future trends.

Course Outcomes:

At the end of this course students will be able to

CO1: Explain Industry 5.0 concepts and principles.

CO2: Analyze emerging technologies in industrial systems.

CO3: Integrate cyber-physical systems and digital twins.

CO4: Evaluate human-robot collaboration strategies.

CO5: Develop innovative solutions for future manufacturing systems.

Text Books:

1. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress.2016
2. Anand Nayyar and Akshi Kumar, Industry 5.0 and Smart Manufacturing.2022
3. Rajkumar Buyya, Fog and Edge Computing: Principles and Paradigms.2019

Reference Books:

1. Klaus Schwab, The Fourth Industrial Revolution.2017
2. Fei Tao, Digital Twin Driven Smart Manufacturing.2019
3. Hwaiyu Geng, Industry 4.0 and Smart Manufacturing Technologies.2020

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.