Zeal Education Society's

ZEAL COLLEGE OF ENGINEERING & RESEARCH, PUNE – 41

(An Autonomous Institute Affiliated to Savitribai Phule Pune University)

*NAAC Accredited with **A+** Grade / ISO 21001:2018*

DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum Structure and Syllabus of

F.Y. M. Tech. - Mechanical Engineering

Robotics and Automation

(With effect from - Academic Year 2024- 25)

VISION OF THE INSTITUTE

To be a premier institute in technical education by imparting academic excellence, research, social and entrepreneurial attitude**.**

MISSION OF THE INSTITUTE

- To achieve academic excellence through innovative teaching and learning process.
- To imbibe the research culture for addressing industry and societal needs.
- To inculcate social attitude through community engagement initiatives.
- To provide conducive environment for building the entrepreneurial skills.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION:

To be a premier institute in technical education by imparting academic excellence, research, social and entrepreneurial attitude.

MISSION:

M1: To achieve academic excellence through innovative teaching and learning process.

M2: To imbibe the research culture for addressing industry and societal needs.

M3: To inculcate social attitude through community engagement initiatives.

M4: To provide conducive environment for building the entrepreneurial skills

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

PEO1: Graduates will become skilled engineers and leaders in Automation and Robotics, solving complex problems ethically and contributing to technological and societal progress.

PEO2: Graduates will engage in research and innovation, using advanced tools and techniques to drive advancements in robotics and Automation, and will embrace lifelong learning to stay current in their field.

PEO3: Graduates will develop new technologies to meet industrial and societal needs, demonstrating social and environmental responsibility, and will be prepared for careers in research, higher studies, or entrepreneurial ventures.

PROGRAM OUTCOMES (POs):

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

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PROGRAM SPECIFIC OUTCOMES (PSOs):

PSO1: Graduates will design and develop automation systems using modern tools and gain hands-on experience in key areas like robotics, automation, and mechatronics.

PSO2: Graduates will solve problems in process control and automation, and collaborate with industries to address research gaps and socio-economic challenges.

DEPARTMENT OF MECHANICAL ENGINEERING

LIST OF ABBREVIATIONS

Abbreviation	Description
PCC	Programme Core Course
PEC	Programme Elective Course
MDM	Multidisciplinary Minor
OE	Open Elective - Other than a particular program
VSEC	Vocational and Skill Enhancement Course
MC	Management Courses
DIS	Dissertation Phase
MOOC	Massive Open Online Course -I
M. Tech.	Master of Technology
L	Lecture
P	Practical
T	Tutorial
H	Hours
CR	Credits
CIE	Continuous Internal Evaluation
ETE	End Term Examination
TH	Theory
TW	Term Work
OR	Oral
PR	Practical

DEPARTMENT OF MECHANICAL ENGINEERING

M. Tech. Robotics and Automation Engineering: Semester - I

Course Code	Course Type	Course Name	Teaching Scheme (hrs/Week)						Evaluation Scheme (Marks)					
			L	P	H	CR			CIE	ETE	TW	PR	OR	Total
						TH	PR	Total						
MERA101	PSMC	Applied Mathematics	4	-	4	4	-	4	50	50	-	-	-	100
MERA102	PCC	Fundamentals of Robotic systems	4	-	4	4	-	4	50	50	-	-	-	100
MERA103	PCC	Kinematics and Dynamics of Robots	3	-	3	3	-	3	50	50	-	-	-	100
MERA104	PEC	Program Elective – I*	3	-	3	3	-	3	50	50	-	-		100
	OEC	Open Elective – I#	3	-	3	3	-	3	50	50	-	-	-	100
MERA106	LC	Robot Programming and Simulation Laboratory	-	2	2	-	1	1	-	-	25	25	-	50
MERA107	LC	Drives and Controls Laboratory	-	2	2	-	1	1	-	-	25	-	25	50
MERA108	SEM	Seminar	-	2	2	-	1	1	-	-	25	-	25	50
MERA109	MC	Audit Course – I: Technical Paper writing	1	-	1	-	-	-	-	-	-	-	-	-
Total			**18**	**6**	**24**	**17**	**3**	**20**	**250**	**250**	**75**	**25**	**50**	**650**

*** Program Elective – I: Choose any one from the following:**

Course Code	Course Type	Program Elective-I
MERA104A	PEC	Drives and Control Systems for Automation
MERA104B		Fluid Power System for Robotics & Automation

 # Open Elective – I: Choose any one from the following:

Course Code	Course Type	Open Elective – I	Offered by Department
CODS105	OEC	Cloud Computing for Data Science	Computer
EEPS105		Industrial Automation	Electrical
ETIS105		Internet of Things	E&TC
MEDE105		Product Lifecycle Management (PLM)	Mechanical

BoS Chairman

ZES's Zeal College of Engineering & Research PU/PN/Engg./285/2007 Narhe, Pune-41

Director
ZES's Zeal College of Engineering & Research
Narhe, Pune - 411041.

DEPARTMENT OF MECHANICAL ENGINEERING

M. Tech. Robotics and Automation Engineering: Semester - II

Course Code	Course Type	Course Name	Teaching Scheme (hrs/Week)						Evaluation Scheme (Marks)					
			L	P	H	CR			CIE	ETE	TW	PR	OR	Total
						TH	PR	Total						
MERA201	PCC	Research Methodology and Intellectual Property Rights	4	-	4	4	-	4	50	50	-	-	-	100
MERA202	PCC	Automation in Manufacturing	4	-	4	4	-	4	50	50	-	-	-	100
MERA203	PCC	Machine Learning & Big Data Analytics	3	-	3	3	-	3	50	50	-	-	-	100
MERA204	PEC	Professional Elective – II*	3	-	3	3	-	3	50	50	-	-	-	100
	OEC	Open Elective – II#	3	-	3	3	-	3	50	50	-	-	-	100
MERA206	LC	Automation Laboratory	-	2	2	-	1	1	-	-	25	-	25	50
MERA207	LC	Machine Learning Lab	-	2	2	-	1	1	-	-	25	-	25	50
MERA208	DIS	Dissertation Phase - I	-	2	2	-	1	1	-	-	25	-	25	50
MERA209	MC	Constitution of India	1	-	1	-	-	-	-	-	-	-	-	-
Total			**18**	**6**	**24**	**17**	**3**	**20**	**250**	**250**	**75**	**-**	**75**	**650**

*** Program Elective – II: Choose any one from the following:**

Course Code	Course Type	Program Elective - II
MERA204A	PEC	Mobile Robot, Micro-robotics and Nano Robots
MERA204B		Autonomous Robotics and Telecherics

 # Open Elective – II: Choose any one from the following:

Course Code	Course Type	Open Elective – II	Offered by Department
CODS205	OEC	IoT and Sensor Data Analysis	Computer
EEPS205		Electric Vehicles	Electrical
ETIS205		Embedded System	E&TC
MEDE205		Process Equipment and Plant Design	Mechanical

BoS Chairman

ZES's Zeal College of Engineering & Research PU/PN/Engg./285/2007 Narhe, Pune-41

Director

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SYLLABUS

SEMESTER - I

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** I	
Course: Applied Mathematics								**Code:** MERA101	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
04	-	-	04	50	50	-	-	-	100

Prerequisites:

Basics of Engineering Mathematics.

Course Objectives:

1. To find the roots of polynomials in Science and Engineering problems.
2. To differentiate and integrate a function for a given set of tabulated data, for engineering applications.
3. To understand Eigen values and Eigen Vectors to maintain relationships between two variables while solving problems.
4. To explore the techniques of linear algebra.
5. To apply various mathematical methods involving arithmetic, algebra, to solve problems.

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

CO1	Understand the basic concepts of linear algebra, numerical methods, and probability distribution.
CO2	Apply the concept of numerical methods and probability distribution to solve the problems arising in engineering field.
CO3	Analyze mathematical problems arising in engineering, using the concepts of linear algebra,
CO4	Apply the mathematical knowledge of numerical methods, and vector calculus in Engineering field.

Course Contents:

Unit	**Description**
1.	**Approximations and round off errors, Roots of polynomial and Transcendental Equation:** Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Solving polynomial: Graphical method, solving Algebraic equation: Newton-Raphson method, Secant Method. Multiple roots, Simple fixed-point iteration.
2.	**Numerical Differentiation and Integration:** Numerical Differentiation for equal width and Numerical Integration: Newton – Cotes and Gauss Quadrature Integration formulae (Simpson 1/3 rule), Romberg integration, Numerical Differentiation (equal width only) Applied to Engineering problems, High Accuracy differentiation formulae.
3.	**System of Linear Algebraic Equations and Eigen Value-vector Problems:** Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, error Analysis for direct methods, Iteration Methods.

	Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Singularities of Matrices. Matrix Decomposition Algorithms-SVD: Properties and applications, low rank approximations, Gram Schmidt process, polar decomposition.
4.	**Vector Calculus:** Multivariate and vector functions, Motion of a particle in space, Differentiation and Taylor's series expansion of univariate functions, Partial differentiation, Gradient of a vectors with respect to a matrix, Gradient of matrices with respect to a matrix, Identities for computing gradients, Back propagation and automatic differentiation, Gradients in deep neural networks, Higher order partial derivatives, Hessian, Taylor's series expansion of multivariate functions, Quadratic forms, Unconstrained optimization problems,
5.	**Linear Transformation:** Introduction to Linear Transformation, the matrix of Linear Transformation, Orthogonality using G-S method, Least Squares, SVD.
6.	**Statistical Models:** Build a model from big data, Regression; Classification; trade-off between model complexity, bias, and variance; Cluster analysis, Principal Component Analysis. **Probability:** Basic concepts of probability: Conditional probability, Bayes' theorem, independence, theorem of total probability, expectation and variance, few discrete and continuous distributions, joint distributions and covariance.

Text Books:

1. S. S. Sastry, "Introductory Methods of Numerical Analysis", PHI.
2. Steven C. Chapra, Raymond P. Canale, "Numerical Methods for Engineers", Tata McGraw Hill.
3. M K Jain, S.R.K Iyengar, R K. Jain, "Numerical methods for Scientific and Engg. Computation", New Age International.

Reference Books:

1. Pervez Moin, "Fundamentals of Engineering Numerical Analysis", Cambridge, 2010.
2. David. C. Lay, "Linear Algebra and its applications, 3rd edition, Pearson Education", 2002.
3. J.S. Rosenthal, A First Look at Rigorous Probability Theory (Second Edition). Singapore: World Scientific Publishing, 2006.

E-Resources:

1. www.digimat.in/nptel/courses/video/115103114/L02.html
2. https://www.youtube.com/watch?v=4SWMzENcgSE
3. http://www.digimat.in/nptel/courses/video/111105121/L01.html
4. http://www.digimat.in/nptel/courses/video/111105041/L01.html
5. http://www.digimat.in/nptel/courses/video/111103070/L01.html

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** I	
Course: Fundamentals of Robotic systems								**Code:** MERA102	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
04	-	-	04	50	50	-	-	-	100

Prerequisites: Mechatronics

Kinematics of Mechanism, Basics of Electrical and Electronics Engineering.

Course Objectives:

To impart knowledge about fundamental of robotics.

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

CO1	Understand the fundamental of robots and Classify various types of robotic configurations.
CO2	Select appropriate type of drive, controller, gripper and sensor for Robot.
CO3	Select appropriate robot configurations for various applications.
CO4	Understand various implementation issues for robotics.

Course Contents:

Unit	**Description**
1.	**Introduction:** Types and Classification of Robots, Law of robotics, Degrees of freedom of robots, basic robot motion, Robot configurations and concept of workspace, Overview of robot subsystems, Mechanisms and transmission, Main Elements of a Robot, Modeling and Analysis of Robots
2.	**Drives, actuators and control for Robot:** Stepper motor, DC motors, AC motors, hydraulic and pneumatic systems, Direction Control Valves(DCV), Types, hydraulic and pneumatic circuits, and application in robots, drive selection for robotics joints, Types of controllers, Actuator Selection and Design Considerations, Emerging Trends in Drive Technologies, Advanced Control Algorithms and Techniques, Innovations in Hydraulic and Pneumatic Systems
3.	**Robotic grippers and Sensors:** Robotic Grippers: Linkage activated mechanical grippers, adhesive grippers, magnetic grippers, collets, scoops, expansion bladders, soft grippers, ultrasonic grippers Sensors in Robotics: Position sensor, velocity sensor, proximity sensors, touch sensors, force sensors, temperature sensor, infrared sensor, ultrasonic sensor, capacitive sensor, laser sensors, RFID, electro-magnetic identifier, optical encoder, color sensor: color sensing, color comparator, machine vision system in robots and application in various operations, Methods of internal compensation, information coding, integrated sensor principles selection of grippers and sensors, robotic arm design and control, Integration of Sensors and Grippers, Integration of Sensors and Actuators **Applications:** Motion Control, Gripping and Manipulation, Actuation in Various Robotic Systems.

4.	**Applications of Robots:** Robot applications in Machining – Welding – Assembly – Material handling – Loading and unloading – spray painting, process operations and inspection, the advanced robotics applications, including automation systems. **Robot Implementation Issues:** Approach for implementing Robotics, Safety, Training and Maintenance Social Aspects of Robotics, robot-vehicle interaction, and collaborative robots, robotic inspection and safety considerations.
5.	**Fundamentals of Robot Operating System (ROS):** ROS Essentials, ROS: Services, Actions, Nodes, Build Robot Environment, Unified Robot Description Format (URDF), ROS parameter server, ROS Services, and parameters, Recording and playing back, reading messages from a bag file, using rosed to edit files in ROS, ROS msg and srv.

Text Books:

1. D. K Pratihar, "Fundamentals of Robotics, Narsa Publishers", 2018.
2. S.K. Saha, "Introduction to Robotics", Tata McGraw Hill, 2009.

Reference Books:

1. Saeed B. Niku, "Introduction to Robotics, Analysis, Systems, Applications", Pearson Education.
2. Y. Koren, "Robotics for Engineers", McGraw Hill International Editions.
3. Richard D. Klafter, at.el., "Robotic Engineering: An Integrated Approach", Prentice Hall of India.
4. Mikell. P. Groover, Mitchell Weiss, Nicholas G. Odrey, Roger N. Nagel and Ashish Dutta, "Industrial Robotics Technology, Programming and Applications", 2nd Edition, McGraw Hill Education (India) Private Limited, 2017.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc21_me32
2. https://onlinecourses.nptel.ac.in/noc21_me76

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** I	
Course: Kinematics and Dynamics of Robots								**Code:** MERA103	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

Fundamental of robotics, Engineering Mathematics, kinematics and dynamics of Mechanism and Machines

Course Objectives:

To impart knowledge about kinematic and dynamic analysis of robot manipulators

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

CO1	Understand the anatomy of robot and Comprehend the transformations for kinematic of manipulator.
CO2	Understand and apply the concept of direct and inverse kinematics of manipulator
CO3	Understand and apply the Velocity and Statics of Robot Manipulators
CO4	Analyze the Dynamics of Robots
CO5	Design the trajectory for specific task of n-DOF manipulator

Course Contents:

Unit	**Description**
1.	**Introduction:** Robot anatomy: links, joint and joint notation scheme, degree of freedom, arm configuration, wrist configuration, actuators, sensors, End-effector Position and orientation of objects, objects coordinate frame, Rotation matrix; Robot Coordinate System: Euler angles, Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates.
2.	**Robot Kinematics:** **DH Parameters:** Link coordinates D-H Representation. **Forward Kinematics:** The ARM equation, Newton-Euler's Equation for a single manipulator, Multi-axis Articulated Robots, SCARA Robots, Cartesian Robot, Polar Robots and Cylindrical Robots. **Inverse Kinematics:** The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics for multi-axis Articulated Robots, SCARA Robots, and Cartesian Robots.

3.	**Velocity And Statics Of Robot Manipulators:** Linear and angular velocity of links, Velocity propagation, Manipulator Jacobians for serial and parallel manipulators, Velocity ellipse and ellipsoids, Singularity analysis for serial and parallel manipulators, Loss and gain of degree of freedom, Statics of serial and parallel manipulators, Statics and force transformation matrix of a Gough Stewart platform, Singularity analysis and statics.
4.	**Dynamics of Robots:** Introduction, Lagrange's equation kinetic and potential energy. Mass and inertia of links, Link inertia Tensor, Link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot, Newton Euler formulation, Lagrange Euler formulation, D'Alembert's equation, Payload Capacity Calculations.
5.	**Motion Planning:** **Workspace Analysis**: Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations. **Trajectory Planning:** Terminology, steps in trajectory planning, joint space technique, Continuous path motion, Interpolated motion, straight line motion and Cartesian space technique in trajectory planning; Use of meta-heuristic algorithms for path planning.

Text Books:

1. John J. Craig, "Introduction to Robotics Mechanics and Control", Second Edition, Addison Wesly Longman Inc. International Student edition, 1999.
2. R. K. Mittal and I J Nagrath, "Robotics and Control", McGraw Hill Education (India) Private Limited, 2017.
3. Ashitava Ghosal, "Robotics Fundamental Concepts and Analysis", Oxford University Press, Second reprint, May 2008.

Reference Books:

1. R. N Jazar, "Theory of Applied Robotics: Kinematics, Dynamics, and Control", Springer; 2nd ed. 2010.
2. Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", PHI Learning, 2009.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc22_me39
2. https://onlinecourses.nptel.ac.in/noc22_me41
3. https://onlinecourses.nptel.ac.in/noc21_me32
4. https://onlinecourses.nptel.ac.in/noc22_me05

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)									**Semester:** I
Course: Program Elective – I (Drives and controls for Automation)									**Code:** MERA104A
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
04	-	-	03	50	50	-	-	-	100

Prerequisites:

Hydraulics and Pneumatics, Basic Electrical Engineering, Basic Mechanical Engineering, Basic Electronics Engineering

Course Objectives:

To gain comprehensive knowledge in advanced drive systems and control strategies for various motor types, focusing on their components, performance characteristics, and control techniques.

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

CO1	Analyze and apply the key components and dynamics of electrical drives to ensure optimal performance and stability.
CO2	Acquire skills in analyzing, controlling, and simulating DC motor drives, including converter and chopper control, and feedback mechanisms
CO3	Students will master advanced control techniques for induction motor drives, including scalar and vector control, and effectively manage harmonics.
CO4	Proficient in controlling and operating synchronous motor drives using various methods, including voltage source inverters and electronic commutation.
CO5	Gain expertise in the performance and control of advanced stepper and brushless motors, including harmonic control and drive controller design.

Course Contents:

Unit	**Description**
1.	**Components and Dynamics of Electrical Drives:** Components of electrical Drives, electric machines, power converter, controllers, dynamics of electric drive, torque equation, equivalent values of drive parameters, components of load torques, types of load, four quadrant operation of a motor, steady state stability, load equalization, classes of motor duty, determination of motor rating.
2.	**DC Motor Drives and Control Systems:** DC motor drives, DC motors & their performance, braking, Transient analysis of separately excited motor, converter control of DC motors, analysis of separately excited & series motor with l, phase and 3, phase converters, analysis of chopper controlled DC drives, converter ratings and closed loop control, transfer function of self, separately excited DC motors, linear transfer function model of power converters, sensing and feeds back elements, current and speed loops, P, PI and PID controllers, response comparison, simulation of converter and chopper fed DC drive.

3.	**Control Techniques and Operations of Induction Motor Drives:** Induction motor drives, stator voltage control of induction motor, torque, slip characteristics, operation with different types of loads, V/F control, Scalar and vector control of induction motor, Direct torque and flux control of induction motor, controlled current and controlled slip operation, effect of harmonics and control of harmonics, slip power recovery scheme.
4.	**Control and Operation of Synchronous Motor Drives:** Synchronous motor drives , speed control of synchronous motors, adjustable frequency operation of synchronous motors, principles of synchronous motor control, voltage source inverter drive with open loop control, self, controlled synchronous motor with electronic commutation, self, controlled synchronous motor drive using load commutated Thyristor inverter.
5.	**Advanced Stepper and Brushless Motor Drives:** Hybrid, Variable Reluctance, and PM stepper performance characteristics and time response, full and half step motor drives, micro, stepping, switched reluctance motor drive, Brushless DC motor drive, PMSM drives, BLDC drive, drive controller design. Harmonics , input harmonics study, impact on the connected grid, design of input filters; Output harmonics and impact on connected rotating machines (design considerations of driven machines).

Text Books:

1. Richard Crowder, "Electric Drives and Electromechanical Systems", 2nd Edition, Elsevier, 2019
2. Ion Boldea, S. A. Nasar," Electrical Drives", 3rd Edition, CRC Press, 2016.
3. R. Krishnan, "Electrical Motor Drives", PHI, 2001.
4. G. K. Dubey, "Fundamentals of Electrical Drives", 2nd Edition, Narosa, 2009.
5. M. A. El, Sharkawi, "Fundamentals of Electrical Drives", Cengage Learning, 2nd edition 2000.

Reference Books:

1. Vedam Subramanian, "Electric Drives", 2nd Edition, TMH, 2017.
2. Ramu Krishnan," Permanent Magnet Synchronous and Brushless DC Motor Drives", CRC Press, 2017.
3. W. Leohnard, "Control of Electric Drives", 3rd Edition, Springer, 2001.
4. Bimal K Bose, "Modern Power Electronics and AC Drives", Prentice Hall, 1st edition, 2002.

E-Resources:

1. http://nptel.ac.in/courses/108104140
2. http://nptel.ac.in/courses/108108077

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** I	
Course: Program Elective – I (Fluid Power System for Automation)								**Code:** MERA104B	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

Fluid Mechanics

Course Objectives:

The course provides fundamental knowledge of fluid power, including regulating elements, hydraulic and pneumatic circuits, and PLCs. It also covers tool materials, cutting fluids, and tool wear mechanisms.

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

CO1	Select and specify hydraulic power generators and actuators, and understand their characteristics.
CO2	Identify and describe the function of various control and regulation components in hydraulic systems.
CO3	Design and analyze hydraulic circuits for various industrial applications, focusing on component selection and safety.
CO4	Design and implement pneumatic circuits, including logic, sequential, and compound circuits.
CO5	Understand PLC functions, architecture, and programming, including Ladder Logic and advanced motion control.

Course Contents:

Unit	**Description**
1.	**Fluid power system generation and actuators:** Choosing and specifying hydraulic power generators, including pumps and their characteristics, as well as selecting, specifying, and understanding hydraulic and rotary actuators.
2.	**Control and regulation components:** Pressure, direction, and flow control valves, including relief valves, non-return valves (NRVs), safety valves, and actuation systems.
3.	**Hydraulic circuit design:** Include reciprocating and quick return circuits, sequencing circuits, and industrial applications such as press circuits, hydraulic milling machines, grinding, planning, copying, forklifts, and earth movers. Focus on component design and selection, as well as safety and emergency provisions.
4	**Pneumatic circuit design:** Including logic circuits, switching circuits, sequential circuits, compound circuits, and combination circuit design.

5.	**Programmable Logic Controller (PLC):** Functions and features of PLCs, selection criteria, architecture, and the IEC61131-3 programming standard and its types. Basics of PLC programming, including Ladder Logic Diagrams, communication in PLCs, programming timers and counters, data handling, PLC modules, and advanced motion control with multi-axis PLCs.

Text Books:

1. Majumdar. S.R., "Oil hydraulic systems: principles and maintenance", Tata McGraw Hill Publishing.
2. Majumdar. S.R., "Pneumatic systems: Principles and maintenance", Tata McGraw Hill Publishing.
3. Anthony Esposito, "Fluid Power with Applications", prentice hall international, 2009.

Reference Books:

1. Andrew Parr, "Hydraulics and Pneumatics: A technician's guide engineer's guide", Elsevier Ltd., 2011.
2. Thompson, "Introduction to fluid power", prentice hall, 2004.
3. John Pippenger, Tyler Hicks, "Industrial Hydraulics", McGraw Hill International edition, 1980.
4. Jagadeesha T., Thammaiah Gowda, "Fluid Power: Generation, Transmission and Control", Wiley.
5. B. W. Anderson, "The Analysis & Design of Pneumatic Systems", John Wiley.
6. Mc Clay Donaldson, "Control of Fluid Power Analysis and Design", Ellis Horwood Ltd.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc24_me69/preview
2. https://nptel.ac.in/courses/112105423

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Computer – Data Science)									**Semester:** I
Course: Open Elective – I (Cloud Computing for Data Science)									**Code:** CODS105
Teaching Scheme (hrs/week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

1. Basic understanding of data science concepts.
2. Familiarity with programming languages like Python or Java.
3. Knowledge of database management systems.
4. Basic understanding of distributed computing.

Course Objectives:

1. To understand the fundamentals of cloud computing and its relevance to data science.
2. To gain knowledge on various cloud service models and deployment strategies.
3. To explore cloud storage and computing solutions for data-intensive applications.
4. To learn about the architecture and implementation of big data solutions on cloud platforms.
5. To develop skills for deploying, managing, and scaling data science applications in the cloud.
6. To evaluate the security, privacy, and compliance issues in cloud environments.

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

CO1	Understand the basic concepts and evolution of cloud computing.
CO2	Identify key cloud services and their applications in data science.
CO3	Evaluate various cloud storage solutions for data science.
CO4	Implement big data analytics using cloud services.
CO5	Implement security best practices for cloud-based data science applications.
CO6	Explore cloud monitoring and management tools.

Course Contents:

Unit	**Description**
1.	**Introduction to Cloud Computing:** Definition and characteristics of cloud computing, History and evolution of cloud computing, Cloud service models: IaaS, PaaS, SaaS, Cloud deployment models: Public, Private, Hybrid, and Community.
2.	**Cloud Infrastructure and Services:** Cloud infrastructure components: data centers, networks, storage, Virtualization: concepts, types, hypervisors, Cloud services: compute, storage, networking, database services, Cloud service providers: AWS, Azure, Google Cloud.
3.	**Cloud Storage Solutions:** Cloud storage types: object storage, block storage, file storage, Cloud storage services: Amazon S3, Azure Blob Storage, Google Cloud Storage, Data lifecycle management in the cloud, Case studies and best practices for cloud storage.

4.	**Cloud Computing for Big Data:** Introduction to big data and cloud computing, Big data processing frameworks: Hadoop, Spark, Cloud-based big data services: Amazon EMR, Google Dataproc, Azure HDInsight, Data ingestion, processing, and visualization in the cloud
5.	**Cloud Security and Privacy:** Security challenges in cloud computing, Cloud security mechanisms: encryption, identity management, access control, Data privacy and compliance: GDPR, HIPAA, Best practices for securing cloud applications
6.	**Managing and Scaling Cloud Applications:** Cloud application lifecycle management, Monitoring and management tools: CloudWatch, Azure Monitor, Google Stackdriver, Auto-scaling and load balancing, Cost management and optimization in the cloud

Text Books:

1. Thomas Erl, Zaigham Mahmood, and Ricardo Puttini, "Cloud Computing: Concepts, Technology & Architecture", Prentice Hall.
2. Xiaolin Li, Jianxin (Jason) Wu, and Adam Li, "Cloud Computing for Data-Intensive Applications", Springer.

Reference Books:

1. Rajkumar Buyya, Christian Vecchiola, and S. Thamarai Selvi, "Mastering Cloud Computing: Foundations and Applications Programming", McGraw-Hill Education.
2. Arshdeep Bahga and Vijay Madisetti, "Cloud Computing: A Hands-On Approach", VPT.
3. Nir Kshetri, "Big Data and Cloud Computing for Development: Lessons from Key Industries and Economies in the Global South", Springer.

E-Resources:

1. AWS Training and Certification: [AWS Training] https://aws.amazon.com/training/
2. Microsoft Learn: [Azure Training] https://learn.microsoft.com/en-us/training/
3. Google Cloud Training: [Google Cloud raining] https://cloud.google.com/training
4. Coursera: Cloud Computing Specializations and Courses [Coursera] https://www.coursera.org/browse/information-technology/cloud-computing
5. edX: Cloud Computing Courses [edX] https://www.edx.org/learn/cloud-computing

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Electrical – Power Systems)									**Semester:** I
Course: Open Elective – I (Industrial Automation)									**Code:** EEPS105
Teaching Scheme (hrs/week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

Knowledge of Engineering fundamentals, mathematics, control systems, mechanical and manufacturing process.

Course Objectives:

1. To emphasize the role of automation techniques in manufacturing and process industries.
2. To impart the role of PLC in industry automation.
3. To familiarize with the various control techniques used in process automation.
4. To design automation systems for manufacturing and process industries.

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

CO1	Apply automation principles and strategies in manufacturing systems.
CO2	Design and analyze Detroit-type automated flow lines, transfer mechanisms, and buffer storage for enhanced machining operations.
CO3	Evaluate and design material handling systems with product identification technologies.
CO4	Apply control technologies in automation, including industrial control systems, SCADA, and PLCs.
CO5	Design and analyze automated manufacturing systems, including flexible and cellular manufacturing.
CO6	Integrate DDC, DCS, SCADA, and PLCs for process safety and control in process industries.

Course Contents:

Unit	**Description**
1.	**Introduction to automation in Manufacturing Industries:** Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Production Economics: Methods of Evaluating Investment Alternatives, Costs in Manufacturing, Break Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in-process.
2.	**Detroit-Type Automation:** Automated Flow lines, Methods of Work part Transport, Transfer Mechanism, Buffer Storage, Control Functions, and Automation for Machining Operations, Design and Fabrication Considerations. Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines Without Storage, Partial Automation, Computer Simulation of Automated Flow Lines.

3.	**Material handling and identification technologies:** The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems. Automated Storage Systems: Storage System Performance, Automated Storage/Retrieval Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing. Product identification system: Barcode, RFID etc.
4.	**Control technologies in automation:** Industrial Control Systems, Process Industries Verses Discrete Manufacturing Industries, Continuous Verses Discrete Control, Computer Process Control and its Forms. Computer Based Industrial Control: Introduction & Automatic Process Control, Building Blocks of Automation System: LAN, Analog & Digital I/O Modules, and SCADA System & RTU.
5.	**Automated Manufacturing Systems:** Components, Classification and overview of manufacturing systems, Cellular manufacturing, Flexible manufacturing system (FMS), FMS and its planning and implementation, Automated assembly system – design and types of automated assembly systems, Analysis of multi station and single station assembly machine.
6.	**Automation in Process Industries:** Introduction to computer based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures. SCADA for process industries includes understanding of RTUs, Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation, Programmable Logic Controller (PLC)- Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies. Process Safety Automation: Levels of process safety through use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control.

Text Books:

1. M. P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5th Edition, Pearson Education, 2009.
2. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.
3. Krishna Kant, "Computer-Based Industrial Control", 2nd Edition, Prentice Hall, New Delhi, 2011.
4. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw-Hill, New York.

Reference Books:

1. Curtis D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson New International, 2013.
2. Lukas M. P., "Distributed Control Systems", Van Nostrand Reinhold Co., New York, 1986.
3. N. Viswanandham, Y. Narahari, "Performance Modeling of Automated Manufacturing Systems",

1st Edition, 2009.

4. Carlos Smith and Corripio, "Principles and Practice of Automatic Process Control", 3rd Edition, John Wiley & Sons, 2006.

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (E&TC – IoT and Sensor Systems)								**Semester:** I	
Course: Open Elective – I (Internet of Things)								**Code:** ETIS105	
Teaching Scheme (hrs/week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

1. Basics of sensors and hardware components.
2. Basic networking concepts.
3. Knowledge of Microcontroller and embedded systems.

Course Objectives:

To provide students with a comprehensive understanding of sensor and actuator technologies, IoT architecture, communication protocols, and interfacing techniques, alongside their applications in smart environments, industrial systems, and healthcare.

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

CO1	Comprehend and analyze concepts of sensors, actuators, IoT and IoE.
CO2	Interpret IoT Architecture Design Aspects.
CO3	Comprehend the operation of IoT protocols.
CO4	Describe various IoT boards, interfacing, and programming for IoT.
CO5	Illustrate the technologies, Catalysts, and precursors of IIoT using suitable use cases.
CO6	Provide suitable solution for domain specific applications of IoT.

Course Contents:

Unit	**Description**
1	**Sensors, Actuators, IoT & IoE:** Definitions, Types of sensors, Types of Actuators, Example and Working, Networking Basics, RFID Principals and components, Wireless Sensor Networks, Definition, and characteristics of an IoT, Physical Design of an IoT, Logical design of IoT, Communication Models, Communication API's, What is the IoE? Difference between IoT and IoE, Pillars of the IoE, Connecting the Unconnected, Transitioning to the IoE, Bringing It All Together.
2	**IoT Architecture Design Aspects:** IoT-An Architectural Overview, building architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service (XaaS), M2M and IoT Analytics, Knowledge Management
3	**IoT Protocols:** PHY/MAC Layer (3GPP MTC, IEEE 802.11, IEEE 802.15), Wireless HART, Z Wave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4, IPv6, 6LoWPAN,

	6TiSCH, ND, DHCP, ICMP, RPL, CORPL, CARP, Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session Layer HTTP, CoAP, XMPP, AMQP, MQTT.
4	**Interfacing Boards and Programming:** Introduction to IoT Boards, Interfacing with IoT Boards, IoT deployment for Raspberry Pi /Arduino/Equivalent platform – Reading from Sensors, Communication: Connecting microcontroller with mobile devices – communication through Bluetooth, wifi and USB - Contiki OS- Cooja Simulator.
5	**Industrial IoT:** Introduction, Key IIOT technologies, Catalysts, and precursors of IIoT, Innovation and the IIoT, Applications of IIoT Examples: Healthcare, Oil and Gas Industry, Logistics and the Industrial Internet, Retail applications, IoT innovations and design methodologies, Industrial Internet Architecture Framework (IIAF): Control domain, operational domain and application domain, Three tier topology, Design of low power device network, legacy industrial protocols, Bluetooth, Zigbee IP, Z-wave, Wi-Fi backscatter in IIoT design.
6	**Applications of IoT:** Smart Environment: Forest Fire Detection, Air Pollution, Smart Cities: Parking, Structural Health, Noise Urban maps, Smart Metering: Smart Grid, Tank level, Photovoltaic Installations, Silos Stock Calculation, Health: Fall Detection, Medical Fridges, Sportsmen Care, Patients Surveillance, Ultraviolet Radiation.

List of Experiments:

1. Study of Raspberry-Pi, Beagle board, Arduino, and different operating systems for Raspberry-Pi/Beagle board/Arduino. Understanding the process of OS installation on Raspberry- Pi/Beagle board/Arduino.
2. Open-source prototype platform- Raspberry-Pi/Beagle board/Arduino -Simple program digital read/write using LED and Switch -Analog read/write using sensor and actuators.
3. Interfacing sensors and actuators with Arduino/Raspberry-pi.\
4. IoT based Stepper Motor/DC Motor Control with Arduino/Raspberry Pi.
5. Introduction to MQTT/ CoAP and sending sensor data to cloud using Raspberry-Pi/Beagle board/Arduino.
6. Get the status of a bulb at a remote place (on the LAN) through web.
7. Interfacing Arduino to Bluetooth Module.
8. Communicate between Arduino and Raspberry PI using any wireless medium like ZigBee.

Text Books:

1. Ovidiu Vermesan, Peter Fresiss, "Internet of Things" From research and innovation to market Deployment", River Publishers series in Communication, USA.
2. Olivier Hersent, David Boswarthick, and Omar Elloumi, "The Internet of Things: Key Applications and Protocols", 2nd Edition, Wiley Publications.

Reference Books:

1. Dr. Ovidiu Vermesan, Dr. Peter Friess, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers Series in Communication.
2. Giancarlo Fortino and Pawan Kumar, "Internet of Things: Case Studies", CRC Press.

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Mechanical–Design Engineering)								**Semester:** I	
Course: Open Elective – I (Product Life-cycle Management)								**Code:** MEDE105	
Teaching Scheme (hrs/week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

Knowledge of basic Engineering Science - Physics, Chemistry, Material Science, Engineering Metallurgy, Manufacturing processes, Industrial Processes, Enterprises Resource planning (ERP)s Etc.

Course Objectives:

1. To impart the latest knowledge, principles, strategies, practices, and applications in Product Life-cycle Management (PLM) domain.
2. To provide an in-depth understanding of various applications and solutions of PLM.
3. To build conceptual foundation of PLM, along with the latest industry views on PLM applications.
4. To present frameworks which provide economic justifications for PLM projects.

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

CO1	Understand PLM Fundamentals of Product Life Cycle Management (PLM), including its definition, components, and emergence
CO2	Develop PLM Strategy by defining the company's vision, setting strategic goals, and identifying principles for effective PLM implementation
CO3	Manage Product Development Process through analyzing the tools, information systems, and personnel involved in PLM to manage the product development process effectively.
CO4	Identify and apply the components and elements of PLM and its Principles to manage the entire Product Life-cycle
CO5	Select Product Life-cycle Environment to optimize the Product Life-cycle Environment by understanding Product Data and Workflow.
CO6	Implement Effective Product Data Management (PDM) to understand the benefits and terminology of PDM functions and architectures.

Course Contents:

Unit	**Description**
1.	**Introduction:** Overview, Need, Benefits, Concept of Product Life Cycle, Components / Elements of PLM, Emergence and Significance of PLM, PLM implementation cases in various industry verticals.
2.	**PLM Strategy and Vision**: PLM Strategy and Vision: Company's PLM vision, PLM Strategy, Principles for PLM strategy, Preparing for the PLM strategy, Developing a PLM strategy, Strategy identification and selection, PLM business goals.
3.	**Product Development:** Information, Tools, Information systems and people involved in PLM. Product data and processes like New Product Development, Change Management, The phases of product design

	process, Modern approaches to product design: Concurrent Design, Quality Function Development (QFD), Rapid Prototyping.
4.	**Product Life-cycle Management:** Concept of Product Life Cycle, Components / Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement, Threads of PLM-Computer Aided Design (CAD), Product data management (PDM), Comparison of PLM to Enterprises Resource planning (ERP). Integration of PLM & CAD, Introduction to PLM tools.
5.	**Product Life-cycle Environment:** Product Data and Product Workflow, The Link between Product Data and Product Workflow, Key Management Issues around Product Data and Product Workflow, Developing a PLM strategy, Strategy identification and selection, PLM System Architecture (2tier/3tier/4tier etc). Concept of cloud PLM.
6.	**Product Data Management:** Benefits and Terminology, CIM Data, PDM functions, definition and architectures of PDM systems, Engineering data, engineering workflow and PDM acquisition and implementation, product data interchange, collaborative product development, Internet and developments in client server computing, portal integration.

Text Books:

1. John W. Gosnay and Christine M. Mears, "Business Intelligence with Cold Fusion", Prentice Hall India, New Delhi, 2000.
2. David S. Linthicum, "B2B Application Integration", Addison Wesley, Boston, 2001.
3. Alexis Leon, "Enterprise Resource Planning", Tata McGraw Hill, New Delhi, 2002.
4. David Ferry and Larry Whipple, "Building and Intelligent e-Business", Prima Publishing, EEE Edition, California, 2000.
5. S. Rosenthal, "Effective Product Design and Development", Irwin, 1992.

Reference Books:

1. Grieves, Michael, "Product Lifecycle Management", McGraw-Hill, 2006.
2. Antti Saaksvuori and Anselmi Immonen, "Product Life Cycle Management", Springer, 1st Edition (Nov. 5, 2003).
3. Stark, John, "Product Lifecycle Management: Paradigm for 21st Century Product Realization", Springer Verlag, 2004.
4. Kari Ulrich and Steven D. Eppinger, "Product Design & Development", McGraw Hill International Edns, 1999.
5. Stark, John, "Product Lifecycle Management: Paradigm for 21st Century Product Realization", Springer Verlag, 2004.

E-Resources:

1. NPTEL Course on Product Design and Development, by Prof. Indradeep Singh, IIT Roorkee https://nptel.ac.in/courses/112107217

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** I	
Course: Robot Programming and Simulation Laboratory								**Code:** MERA106	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
-	02	-	01	-	-	25	-	25	50

Prerequisites:

Fundamental of robotics, Engineering Mathematics, Kinematics and Dynamics of Mechanism and Machines.

Course Objectives:

To impart knowledge about programing the motion of robot and the end effector.

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

CO1	Understand the use of teach pendant to develop and run an online program.
CO2	Develop an offline program using various languages to execute various kinds of operations.
CO3	Analyze the forward and inverse kinematics in a virtual platform.
CO4	Simulate the forward and inverse kinematics in a virtual platform.
CO5	Simulate and generate programs for robot in a virtual environment.

List of Practical:

1. Develop and run an online program using teach pendant. Use both Cartesian coordinate system and polar coordinate system for developing the program.
2. Develop an offline program using VAL for various operations (pick and place, welding, and drilling)
3. Develop an offline program using KAREL for various operations.
4. Develop an offline program using RAPID for various operations.
5. Develop an offline program using MELFA for various operations.
6. Analyze and simulate the forward kinematics of a robot using RoboAnalyzer.
7. Analyze and simulate inverse kinematics of a robot using RoboAnalyzer.
8. Develop and run the simulation of various operation of any robot using RoboDK.

Reference Books:

1. Cristian Blume and Wilfried Jakob, "Programming Languages for Industrial Robots", 1st Edition, Springer-Verlag, Springer Nature, 2011.
2. Mikell. P. Groover, Mitchell Weiss, Nicholas G. Odrey, Roger N. Nagel and Ashish Dutta, "Industrial Robotics Technology, Programming and Applications", 2nd Edition, McGraw Hill Education (India) Private Limited, 2017.
3. S. R. Deb and Sankha Deb, "Robotics Technology and Flexible Automation", Second Edition, Tata McGraw Hill Education (India) Private Limited, 2010.
4. J. J. Craig, "Introduction to Robotics Mechanics and Control", Second Edition, Addison Wesly, 1999.

DEPARTMENT OF MECHANICAL ENGINEERING

Technical Manuals:
1. R30-iA and R30-iB controller KAREL Reference Manual, FANUC America Corporation System. 2. Technical reference manual RAPID Instructions, Functions and Data types, ABB Robotics. 3. CRnQ/CRnD Controller Instructions, Mitsubishi Industrial Robot.
E-Resources:
1. https://onlinecourses.nptel.ac.in/noc21_me32/preview 2. http://vlabs.iitkgp.ac.in/mr/exp0/index.html

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** I	
Course: Drives and Controls Laboratory								**Code:** MERA107	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
-	02	-	01	-	-	25	25	-	50

Prerequisites:

Electrical Machine and Power Electronics basics.

Course Objectives:

To provide industry-oriented knowledge on AC and DC machine control practices using power electronics, and to evaluate machine performance with computer-based analysis tools.

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

CO1	Design and analyze various motor control systems using simulation tools for DC and AC drives, including thyristor, chopper, and PWM inverter controls.
CO2	Evaluate advanced braking and control methods for both DC and AC motors through practical software-based analysis.

List of Experiments:

Any eight experiments from the following,

1. Study of Thysistor controlled DC Drive.
2. Study of Chopper fed DC Drive
3. Study of AC Single phase motor-speed control using TRIAC
4. PWM Inverter fed 3 phase Induction Motor control using PSPICE / MATLAB / PSIM Software.
5. VSI / CSI fed Induction motor Drive analysis using MATLAB/DSPICE/PSIM Software.
6. Study of V/f control operation of 3F induction motor drive.
7. Study of permanent magnet synchronous motor drive fed by PWM Inverter using Software.
8. Regenerative / Dynamic braking operation for DC Motor- study using software.
9. Regenerative / Dynamic braking operation of AC motor - study is using software PC/PLC based AC/DC motor control operation

References Books:

1. N. Mohan, "Electric Machines and Drives: A First Course", Wiley, 2012.
2. Veltman, D.W.J. Pulle, and R.W. DeDoncker, "Advanced Electrical Drives: Analysis, Modeling, Control", Springer, 2011.
3. J. L. Kirtley, "Electric Power Principles: Sources, Conversion", Distribution, and Use, Wiley.
4. Veltman, D.W.J. Pulle, and R.W. DeDoncker, "Fundamentals of Electrical Drives", Springer.
5. I. Boldea and S.A Nasar, "Electric Drives", CRC Press, 2nd ed. 2006.

Text Books:

1. J. Chiasson, "Modeling and High Performance Control of Electric Machines", Wiley-IEEE.
2. P.C. Krause, O. Wasynczuk, and S.D. Sudhoff, "Analysis of Electric Machinery and Drive Systems", IEEE Press, 2nd ed., 2002.

3. B. Amin, "Induction Motors: Analysis and Torque Control", Springer, 2002.
4. N. Mohan, "Advanced Electric Drives: Analysis, Control and Modeling using Simulink", MNPERE (www.MNPERE.com), 2001.
5. W. Leonhard, "Control of Electrical Drives", Springer, 3rd ed., 2001.

E-resources:

1. https://archive.nptel.ac.in/courses/108/104/108104140/

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** I	
Course: Seminar								**Code:** MERA108	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
-	02	-	01	-	-	25	25	-	50

Prerequisites:

Students should have the knowledge of basic and advance engineering topics, Industry related advancement and current practices used.

Course Objectives:

To explore emerging technologies, enhance research and communication skills, practice presentations and report writing, evaluate engineering problems, discuss societal impacts, and provide constructive feedback.

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

CO1	Analyze current topics in Robotics and Automation Engineering/ emerging technologies by performing literature surveys.
CO2	Conduct literature reviews, evaluate models, draw conclusions, and gain skills in literature surveys and presentations.
CO3	Write comprehensive reports and aim to publish at least one review paper.

Course Contents:

Unit	**Description**
1	Under the supervision of a designated guide, each student must study current subjects in the field and related to Robotics and Automation Engineering related to the Industry.
2	Students may select a mechanical system design/Material handling/Robotic Programming/Other Automation Technique that takes into account current trends and the significance of the topic to society/Industry.
3	A thorough literature review, mathematical modeling using a specific technique and an insightful conclusion are anticipated from the seminar research.
4	The seminar report must be turned in order to comply with the subject's term work requirements.
5	As a research consequence of the seminar, at least one review paper publication is anticipated.

Activities to be conducted in Semester

1. Guide allotment, finalization of topic, planning of the work.
2. Review-1 conduction at mid of semester, at internal level - Literature review and methodology of the selected topic, Mathematical model/advancement in technology and findings and its analysis
3. Review-2 conduction at the end of semester, at external level – Comprehensive presentation on the selected topic in external examiner, guide and departmental representatives panel.
4. Seminar report writing and submission to department.

E-Resources:

1. https://onlinecourses.swayam2.ac.in/ntr20_ed30/preview
2. https://onlinecourses.nptel.ac.in/noc22_hs05

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)									**Semester:** I	
Course: Audit Course – I: Technical Paper writing									**Code:** MERA109	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**						
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**MTE**	**ETE**	**TW**	**OR**	**PR**	**Total**
01	-	-	-	-	-	-	-	-	-	-

Prerequisites:

Students should know about research and have basic knowledge of research methodology

Course Objectives:

This text focuses on technical writing skills for research, covering proposal development, information management, report drafting, and ethics, with attention to structure, citation, and avoiding plagiarism.

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

CO1	Demonstrate the characteristics of technical and business writing.
CO2	Demonstrate the stages of the writing process (prewrite/draft/revise/edit) and apply them to technical and workplace writing tasks.
CO3	Produce the basic components of letters, summaries, descriptions, process explanations, proposals, and other common forms of technical writing.
CO4	Use a variety of materials to produce appropriate visuals for documents, such as instructions, descriptions, and research reports.
CO5	Gather sources for the purpose of producing a research paper in a particular technical field.

Course Contents:

Sr. No.	**Description**
1.	Introduction to Ethics in Research, Five Principles of Ethics, Four Codes of Ethics, Discussion of Case Studies.
2.	Introduction to Technical Communication, a discussion about the need for communication and how to communicate in academic setting keeping in mind the audience and the purpose, Barriers to Successful Communication- Types of Barriers, Miscommunication, Noise, Overcoming Barriers
3.	Difference between Technical and Literary Style, Grammar, Common Errors, Sentence Formation, Technical Vocabulary. The different types of Research, Purpose and nature of research, selection and formulation of a research problem, introduction to research writing
4.	Conference abstracts, proposals, projects, research reports, presentations, different styles and different types of manuscripts, different ways of approaching thesis/dissertation writing, Formal Letters and Emails.
5.	Plagiarism, Strategies to Avoid Plagiarism, Authorship and copyright in the Digital Age, Citation styles and use, References, Footnotes, Indexing, and Bibliography
6.	Oral presentations including Voice, Modulation and Delivery, and Power Point Presentations.

Text Books:

1. J. Anderson, B.H. Durston, and M. Poole, Thesis and Assignment Writing, Wiley Eastern Limited, New Delhi, 1970. Sidney Greenbaum.
2. The Oxford English Grammar, OUP, Oxford, 1996. Wayne C. Booth and Gregory Colomb.
3. The Craft of Research, Wayne University of Chicago Press, 2008.
4. Adrian Wallwork, English for Writing Research Papers, Springer, New York, Dordrecht, Heidelberg, London, 2011.

Reference Books:

1. MLA, APA, Chicago,and other citation styles.
2. MLA Handbook 8th Edition. Davis, Clyde Parker and Detmar Straub.
3. Writing the Doctoral Dissertation: A Systematic Approach, Gordon Barrons Educational Series, 2008.
4. Gerard Genette and Jane Lewis. Narrative Discourse: An Essay in Method. Cornell UP, 1983.
5. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press

E-Resources:

1. https://www.youtube.com/watch?v=NM53k7x_jjk
2. http://www.digimat.in/nptel/courses/video/109106094/L29.html
3. https://archive.nptel.ac.in/courses/110/105/110105091/
4. http://www.digimat.in/nptel/courses/video/121106007/L20.html
5. https://onlinecourses.swayam2.ac.in/ntr20_ed30/preview
6. https://onlinecourses.swayam2.ac.in/ntr24_ed15/preview
7. https://www.youtube.com/watch?v=fySGb9OBQK0

DEPARTMENT OF MECHANICAL ENGINEERING

SYLLABUS

SEMESTER - II

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** II	
Course: Research Methodology and Intellectual Property Rights								**Code:** MERA201	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
04	-	-	04	50	50	-	-	-	100

Prerequisites:

Basic Understanding of Research Concepts and Intellectual Property.

Course Objectives:

To cover research methodology, literature reviews, research designs, data collection, report writing, and the impact of intellectual property and international agreements.

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

CO1	Discuss research methodology and the technique of defining a research problem.
CO2	Conduct literature searches, develop theoretical and conceptual frameworks, and write comprehensive reviews.
CO3	Explain various research designs and their characteristics.
CO4	Explain the art of interpretation and the art of writing research reports.
CO5	Understand intellectual property rights and their significance.
CO6	Apply procedures for patent filing, copyright, and trademark registration.

Course Contents:

Unit	**Description**
1.	**Research Methodology:** Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India.
2.	**Defining the Research Problem:** Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration.
3.	**Reviewing the literature:** Importance of the literature review in research, Bringing clarity and focus to research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.
4.	**Research Design:** Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of

	Experimental Designs, Important Experimental Designs. **Design of Sample Surveys:** Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs.
5.	**Data Collection**: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method. **Interpretation and Report Writing:** Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout.
6.	**Intellectual Property Rights:** Introduction to IPRs, Basic concepts and need for Intellectual Property – Patents, Copyrights, Geographical Indications, IPR in India and Abroad – Genesis and Development – the way from WTO to WIPO -TRIPS, Nature of Intellectual Property, Industrial Property, technological Research, Inventions and Innovations – Important examples of IPR.

Text Books:

1. Garg, B. L., Karadia, R., Agarwal, F., and Agarwal, U.K., "An Introduction to Research Methodology", RBSA Publishers, 2002.
2. Kothari, C.R., "Research Methodology: Methods and Techniques", 2nd Edition, New Age International Publishers, New Delhi, 2008.
3. Sinha, S.C., and Dhiman, A.K., "Research Methodology", Ess Ess Publications, 2nd Volume, 2002.
4. Gupta, S.P., "Statistical Methods", 37th ed. (Rev), Sultan Chand and Sons, New Delhi, 2008.
5. Leon & Leon, "Internet for Everyone", Vikas Publishing House, 2002.

Reference Books:

1. Wadehra, B.L., "Law Relating to Patents, Trademarks, Copyright, Designs and Geographical Indications", Universal Law Publishing, 2000.
2. Bulakh, Dr. P.M., Patki, Dr. P.S., and Chodhary, Dr. A.S., "Research Methodology", Expert Trading Corporation, Dahisar West, Mumbai 400068, 2010.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc24_ge21
2. https://onlinecourses.nptel.ac.in/noc22_ge08
3. http://nptel.ac.in/courses/121106007
4. Free Course: Research Methodology and IPR from NITTTR | Class Central
5. https://onlinecourses.swayam2.ac.in/cec24_ge02
6. https://onlinecourses.nptel.ac.in/noc21_hs08

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics & Automation)									**Semester:** II
Course: Automation in Manufacturing									**Code:** MERA202
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
04	-	-	04	50	50	-	-	-	100

Prerequisites: Manufacturing Technology, Flexible Manufacturing System, Sensor Technology,

Course Objectives:

To impart knowledge about strategies and development of automation in manufacturing systems.

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

CO1	Explain automation principles, design manufacturing cells, and develop control panels for robotic cells.
CO2	Analyze automated production lines and apply deep learning for programming and optimization.
CO3	Design and evaluate control systems for process and discrete manufacturing, including autonomous systems.
CO4	Design and evaluate automation systems using DDC, DCS, SCADA, and PLCs, focusing on programming and safety.
CO5	Design and assess DCS architectures and apply communication protocols.
CO6	Integrate IoT, AI, and digital technologies for process optimization and predictive maintenance.

Course Contents:

Unit	**Description**
1.	**Introduction:** Automation principle and strategies, basic elements of an automation system, advance automation function, level of automation, automation in production system, Manufacturing Metrics and Economics, Single-station automated manufacturing cells, Analysis of Single-station automated manufacturing cells. **Group Technology and Cellular Manufacturing:** Cellular manufacturing- composite part concept, machine cell design, applications of group technology, development of GT codes, Robotic Cell: Types, programming and development of Control Panel and GUI.
2.	**Automated Production Flow Lines:** Fundamentals of Automated Production Lines, analysis and design of automated production lines, methods or work part automated transport transfer, with and without buffer storage control function, partial automation, Automated Robotic Production Lines and its programming, use of various Deep Learning Algorithms used in Automated Production Lines: case studies of applications and programming to be developed for any type of industries. **Automated Assembly Systems:** Fundamentals of automated assembly system, analysis of Automated Assembly

	System, automated assembly systems in Industry 4.0 and Industry 5.0, Automated Robotic Assembly Lines and its programming, use of various Deep Learning Algorithms used in automated assembly lines: case studies of applications and programming to be developed for any type of industries.
3.	**Industrial Control System:** Process Industries and Discrete Manufacturing Industries, Continuous and Discrete Control, Autonomous Industrial Control System, Computer Aided Process Control, Retrieval & Generative type process planning system.
4.	**Automation in Process Industries:** Introduction to computer based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures. SCADA for process industries includes understanding of Remote terminal units (RTUs), Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation, Human Machine Interfaces (HMI), development of HMI panel for various applications. Programmable Logic Controller (PLC) - Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies. Process Safety Automation: Levels of process safety through use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control. Common PLC communication protocols Modbus, Ethernet/IP, Profibus, Profinet, and CANopen, Common Network: types include star, ring, bus, and mesh.
5.	**Distributed Control System:** Distributed Control System- Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS. Introduction to communication protocols- Modbus, Profibus, Field bus, HART protocols, Ethernet/IP, and IEC 61850.
6.	**Smart Manufacturing:** **Industry 4.0 in Industrial Automation**-Evolution of Industrial Revolutions, Core Technologies and Principles, Integration of IoT, AI, and Robotics, Cyber-Physical Systems (CPS) and their Impact on Manufacturing. Cyber-Physical Manufacturing Systems, Digital Twin Driven Smart Manufacturing, Scheduling and Cloud Manufacturing, Knowledge Management and Digital Supply Chains, Reconfigurable Manufacturing Systems, Web-Based Applications in Manufacturing, Data Analytics and Real-Time Data Stream Analysis, Integration of Business Inputs with Process Data, Leveraging RTU (Remote Terminal Units), Industry 5.0, M2M Communication Technologies. **Internet of Things (IoT) in Manufacturing:** Smart Sensors and Actuators, Real-Time Monitoring and Control, Data Storage, Processing, and Analysis, Cloud Platforms and Services for IoT, IoT-Based Predictive Analytics, Optimization Techniques and Tools.

	Digital Manufacturing: Virtual Prototyping and Simulation, Integration of CAD/CAM Systems, Additive Manufacturing (3D Printing), Advanced Materials and Their Digital Representations**.** **Applications in Smart Manufacturing case study**-Process Optimization, Predictive Maintenance and Fault Diagnosis.

Text Books:

1. Mikell P. Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", Fourth Edition, Pearson Education, 2016.
2. N. Viswanandham, Y. Narhari, "Performance Modeling of Automated Manufacturing Systems", Prentice-Hall.
3. Rich and Knight, "Artificial Intelligence", 3rd Edition, Tata McGraw Hill, 2014.
4. Deb S.R. and Deb S., "Robotics Technology and Flexible Automation", Tata McGraw Hill Education Pvt. Ltd., 2010.
5. Rajiv Chopra, "Deep Learning", 1st Edition, Khanna Publishing House, 2018.

Reference Books:

1. Frank D. Petreuzeulla, "Programmable Logic Controllers", Tata McGraw Hill Publication, 6th Edition, 2023.
2. John R. Hackworth, "Programmable Logic Controllers: Programming Methods and Applications", Pearson.
3. Stephen J. Derby, "Design of Automatic Machinery", Special Indian Edition, Marcel Decker, New York, Yesdee Publishing Pvt. Ltd., Chennai, 2004.
4. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 2nd Edition, Prentice Hall, 2003.
5. Andrew S. Tanenbaum, David J. Wetherall, "Computer Networks", Pearson, 5th Edition, Prentice Hall, USA, 2011.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc21_mg92/preview
2. https://nptel.ac.in/courses/106105195
3. https://yp.comsoc.org/industry-5-0-technology-that-will-transform-the-globe/
4. https://nptel.ac.in/courses/108105063
5. https://onlinecourses.nptel.ac.in/noc20_cs69/preview

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** II	
Course: Machine Learning & Big Data Analytics								**Code:** MERA203	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites

Basic programming skills (in Python), algorithm design, basics of probability & statistics.

Course Objectives

To impart knowledge about Machine Learning & Big Data Analytics.

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

CO1	Apply concepts and techniques of Machine Learning.
CO2	Develop Machine learning models for real life applications.
CO3	Analyze mathematical models of Machine Learning.
CO4	Learn big data platforms, Sample the data in a stream and Use analytic processes.

Course Contents:

Unit	**Description**
1.	Introduction: Basic definitions, types of learning, hypothesis space and inductive bias, evaluation, cross-validation, Linear regression, Decision trees, over fitting
2.	Instance based learning, Feature reduction, Collaborative filtering based recommendation, Probability and Bayes learning
3.	ML algorithms: Logistic Regression, Support Vector Machine, Kernel function and Kernel SVM Neural network: Perceptron, multilayer network, back propagation, introduction to deep neural network
4.	Computational learning theory, PAC learning model, Sample complexity, VC Dimension, Ensemble learning Clustering: k-means, adaptive hierarchical clustering, Gaussian mixture model
5.	MapReduce, Hadoop, Hive, MapR, Sharding, NoSQL Databases, S3, Hadoop Distributed File Systems, Visualization. **Introduction to big data:** Introduction to Big Data Platform, Challenges of Conventional Systems, Intelligent data analysis, Nature of Data, Analytic Processes and Tools, Analysis vs Reporting.
6.	Mining data streams: Introduction to Streams Concepts, Stream Data Model and Architecture, Stream Computing, Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Estimating Moments, Counting Oneness in a Window, Decaying Window, Real time Analytics Platform (RTAP) Applications, Case Studies, Real Time Sentiment Analysis

Text Books:

1. Tom Mitchell, "Machine Learning", First Edition, McGraw-Hill, 1997.
2. E. Alpaydin, "Machine Learning", MIT Press, 2010.

3. K. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012.
4. C. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
5. John Mueller & Luca Massaron, "Machine Learning For Dummies", John Wiley & Sons, 2016.
6. Bart Baesens, "Analytics in a Big Data World: The Essential Guide to Data Science and its Applications (WILEY Big Data Series)", John Wiley & Sons, 2014.

Reference Books:

1. T. Hastie, R. Tibshirani, and J. Friedman, "Elements of Statistical Learning", Springer, 2009.
2. Duda, Hart, and Stork, "Pattern Classification", 2000.
3. Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014.
4. Arshdeep Bahga, V. Madisetti, "Big Data Science & Analytics: A Hands-On Approach", VPT, 2016.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc21_cs85
2. https://onlinecourses.nptel.ac.in/noc21_cs24

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** II	
Course: Program Elective – II (Mobile Robot, Micro-robotics and Nano-Robots)								**Code:** MERA204A	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

Fundamentals of robots, robot kinematics and dynamics

Course Objectives:

To impart knowledge about Mobile Robot, Micro-robotics and Nano-Robots

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

CO1	Understand the fundamental of Mobile Robot, Micro-robotics and Nano-Robots.
CO2	Understand the kinematics and Dynamics of mobile robot.

Course Contents:

Unit	Description
1.	**Introduction to mobile robots and mobile manipulators:** Principle of locomotion and types of locomotion. Types of mobile robots: ground robots (wheeled and legged robots), aerial robots, underwater robots and water surface robots.
2.	**Kinematics of wheeled mobile robot:** Degree of freedom and maneuverability, generalized wheel model, different wheel configurations, and holonomic and non-holonomic robots. **Dynamics of mobile robot**: Lagrange-Euler and Newton-Euler methods. Computer based dynamic (numerical) simulation of different wheeled mobile robots.
3.	**Sensors for mobile robot navigation:** Magnetic and optical position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, tactile and proximity sensors, ultrasound rangefinder, laser scanner, infrared rangefinder, visual and motion sensing systems. **Robot navigation**: Localization, Error propagation model, Probabilistic map based localization, Autonomous map building, Simultaneous localization and mapping (SLAM).
4.	**Motion and path planning:** Collision free path planning and sensor-based obstacle avoidance. **Motion control of mobile robots**: Motion controlling methods, kinematic control, dynamic control and cascaded control

5.	**Introduction to modern mobile robots:** Swarm robots, cooperative and collaborative robots, mobile manipulators, autonomous mobile robots. Introduction to micro robot and Nano robot **Introduction:** Micro/Nano-Robotic System Overview, Scaling Effects in the Physical Parameters, Micro/Nano-Robotic System Examples around the World **Micro/Nano-Sensors:** Imaging Sensors-SEM, TEM, STM, AFM, Position Sensors: Capacitive Sensors, Linear Variable Differential Transformer, Interferometry Sensors, Force and Pressure Sensors: Strain Gauges, Deflection Based: AFM, etc., Visual Force Sensing: Bending Imaging, etc., Capacitive Force/Tactile Sensor, Accelerometers, Gyroscopes, Chemical Sensors, Flow Sensors, etc.

References

1. R. Siegwart, I.R. Nourbakhsh, D. Scaramuzza, "Introduction to Autonomous Mobile Robots", MIT Press, USA, 2011.
2. S.G. Tzafestas, "Introduction to Mobile Robot Control", Elsevier, USA, 2014.
3. A. Kelly, "Mobile Robotics: Mathematics, Models, and Methods", Cambridge University Press, USA, 2013.
4. S. Thrun, W. Burgard, D. Fox, "Probabilistic Robotics", MIT Press, USA, 2005.
5. G. Dudek, M. Jenkin, "Computational Principles of Mobile Robotics", Cambridge University Press, USA, 2010.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc21_me44

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** II	
Course: Program Elective – II (Autonomous Robotics and Telecherics)								**Code:** MERA204B	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

Fundamentals of robots

Course Objectives:

To impart knowledge about Autonomous Robotics and Telecherics

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

CO1	Understand the technologies used in autonomous robots/ Telecherics robots
CO2	Understand the technology used in Natural Language processing
CO3	Study NLP techniques and understand its utility in industrial applications
CO4	Apply automated reasoning in AI based programming

Course Contents:

Unit	Description
1.	**Introduction:** Fundamentals of mobile robotics, basic principles of locomotion, Kinematics and Mobility, Classification of mobile robots, AI for Robot Navigation. Introduction to modern mobile robots: Swarm robots, cooperative and collaborative robots, mobile manipulators, Current challenges in mobile robotics. **Autonomous Mobile Robots: N**eed and applications, sensing, localisation, mapping, navigation and control. **Telecheric robots:** Concepts of teleoperations, Need and applications of Telecheric robots, Humanoid Robots, Swarm Robotics, Robot Applications and Ethics.
2.	**Humanoid Robotics Technology and Social Robots:** Sensors in Humanoid Robot, Control of Humanoid Robot, actuation types for humanoid Robot, System Integration in Humanoid Robot, Social Robot, Need of Social Robots, Assistive and Social Robots in the Healthcare Sector and other, Case study On Humanoid Robot. **Swarm Robotics:** Characteristics, Swarm Robotics and Multi-Robotic Systems, Experimental Platforms in Swarm Robotics, Tasks in Swarm Robotics, Swarm Robots used in Real world applications, Smart Robots, Smart Robots applications, Robotics for Warfare Applications.
3.	**Human Robot Interaction (HRI):** Definition, History, Need of HRI, Ethical Issues for HRI, Multi-Modal Perception, Social, Service, and Assistive Robotics, HRI Architecture, Collaborative Robots, Definition, Types of Collaboration, Applications of collaborative robots, collaborative Robot Technology.

4.	**Industry 4.0 and Internet of Robotic things (IORT):** Introduction, Internet of Things and Robotics, Applications and developments of the Internet of Robotic Things.
5.	**Natural Language Processing:** Introduction, Classical Approaches to Natural Language Processing, Text Preprocessing, Lexical Analysis, Syntactic Parsing, Semantic Analysis, Natural Language Generation, Applications.
6	**Logics for AI and Automated Reasoning:** What is Automated Reasoning, methods of Reasoning, reasoning types, use of Automated reasoning in AI, Reasoning and its types, applications for Automated Reasoning, Mathematical consideration.

References:

1. Luger, "Artificial Intelligence", 5th Edition, Pearson, 2008.
2. Ralf Herbrick, Thore Graepel, "A Handbook on Natural Language Processing", 2nd Edition, CRC Press, 2010.
3. John M. Holland, "Designing Autonomous Mobile Robots", Elsevier, 2004.
4. Morgan Quigley, Brian Gerkey, "Programming Robots with ROS", Quigley et al., O'Reilly Publishers, Murphy, 2000.
5. Edited by Shuzhi Sam Ge, Frank L. Lewis, "Autonomous Mobile Robots", Taylor and Francis, 2006.
6. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011.
7. Peter Corke, "Robotics Vision and Control", Springer, 2011.
8. Elmer P. Dadios, "Humanoid Robot: Design and Fuzzy Logic Control Technique for Its Intelligent Behaviors", 2012.
9. Inaki Navarro and Fernando Matía, "An Introduction to Swarm Robotics", ISRN Robotics, 2013.
10. Peter Matthews, Steven Greenspan, "Automation and Collaborative Robotics", Springer Publication, 2020.
11. Jeff Faneuff, Jonathan Follett, "Designing for Collaborative Robotics", O'Reilly Media, 2016.
12. David Feil-Seifer, "Human-Robot Interaction", 2010.
13. Maria Paola Bonacina, "Automated Reasoning for Explainable Artificial Intelligence", 2018.
14. David Gunning, "Explainable Artificial Intelligence (XAI)", 2017.

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Computer – Data Science)									**Semester:** II
Course: Open Elective – II (IoT and Sensor Data Analysis)									**Code:** CODS205
Teaching Scheme (hrs/week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

1. Basic understanding of computer networks and data communications.
2. Fundamental knowledge of data structures and algorithms.
3. Programming skills in Python or similar languages.
4. Basic knowledge of statistics and data analysis techniques.

Course Objectives:

1. To understand the fundamentals of IoT and sensor technologies.
2. To analyze and process sensor data using various techniques.
3. To develop and implement algorithms for real-time data analysis.
4. To explore applications of IoT data in various domains.
5. To design and evaluate sensor-based systems and applications.

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

CO1	Understand the architecture and components of IoT systems.
CO2	Acquire and pre-process sensor data effectively to implement techniques for data cleaning and normalization.
CO3	Apply statistical and machine learning techniques to sensor data.
CO4	Integrate data from multiple sensors to enhance analysis.
CO5	Analyze the impact of security practices on sensor data analysis.
CO6	Explore real-world applications of IoT and sensor data analysis.

Course Contents:

Unit	**Description**
1.	**Overview of IoT:** Definition, Evolution, and Architecture, Sensor Technologies: Types, Characteristics, and Applications, IoT Communication Protocols: MQTT, CoAP, HTTP, etc. IoT Device Management and Integration.
2.	**Sensor Data Acquisition:** Sampling, Data Formats, and Storage, Data Preprocessing Techniques: Cleaning, Normalization, and Transformation, Handling Missing and Noisy Data. Data Storage Solutions for IoT: Cloud and Edge Storage.
3.	**Statistical Analysis of Sensor Data:** Descriptive and Inferential Statistics, Machine Learning Techniques: Classification, Regression, and Clustering, Time-Series Analysis and Forecasting, Real-Time Data Processing and Analysis.

4.	**Advanced Analytics Techniques:** Deep Learning, Anomaly Detection, Data Fusion Methods: Sensor Fusion, Multi-Modal Data Integration, Case Studies: Smart Cities, Industrial IoT, Tools and Frameworks for Advanced Analytics.
5.	**Security Challenges in IoT:** Threats and Vulnerabilities, Cryptographic Techniques and Protocols for IoT Security, Privacy Concerns and Data Protection Regulations, Security Best Practices for Sensor Data Management.
6.	**Applications in Various Domains:** Healthcare, Agriculture, Smart Homes, etc., Case Studies: Real-World Implementations and Solutions, Project Development: Designing, Implementing, and Evaluating IoT Solutions, Future Trends and Innovations in IoT and Sensor Data Analysis.

Text Books:

1. Buyya Rajkumar, Satish Narayana Srirama, "Internet of Things: Principles and Paradigms," Morgan Kaufmann.
2. Hoang D. M. T., S. B. S. Lee, "Data Science for IoT Engineers," Wiley.

Reference Books:

1. De Silva Clarence W., "Sensors and Actuators: Engineering System Instrumentation," CRC Press.
2. Liu H., and M. R. Lyu, "Data Mining for the Internet of Things: Techniques and Applications," Springer.
3. Bahga Arshdeep and Vijay Madisetti, "Internet of Things: A Hands-On Approach," VPT.

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Electrical – Power Systems)									**Semester:** II
Course: Open Elective – II (Electrical Vehicles)									**Code:** EEPS205
Teaching Scheme				**Evaluation Scheme**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

Power Electronics, Control Systems.

Course Objectives:

1. To distinguish between different configuration of electric vehicles with merits and demerits.
2. To recommend drive for EV applications with suitable energy storage technology.

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

CO1	Explore the history, development, and configurations of EVs and hybrid EVs, focusing on efficiency and energy storage.
CO2	Analyze EV battery specifications, charging cycles, drives, and converter topologies.
CO3	Examine energy sources, battery features, charging methods (conductive and inductive), and charging infrastructures, including domestic, public, and fast-charging stations.
CO4	Select appropriate motor and converter for EV applications.
CO5	Study EV power devices, power electronics converters along with its switching methods for EV operation.
CO6	Investigate particular drive for EV including speed control methods and advanced control strategies like FOC and adaptive control.

Course Contents:

Unit	**Description**
1	**Introduction to EV:** History and development of on-road Electric Vehicles (EV). Different configurations of hybrid EVs with block diagram representation, merits & demerits of different configurations in view of vehicle efficiency and energy storage system.
2	**Basics of EV batteries:** Specifications of batteries, power density, Energy density, Charging & Discharging cycle and recommended methodologies for charging. Recommended drives for EV and converter topology used in EVs.
3	**Energy Sources & Charging:** Different Batteries and Ultra-capacitors, Battery characteristics (Discharging &Charging) Battery Chargers: Conductive (Basic charger circuits, microprocessor based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication Methods Charging Infrastructure: Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging

	Station, Fast Charging Station, Battery Swapping Station, Move and-charge zone.
4	**EV Propulsion- Electric Motor:** Choice of electric propulsion system, block diagram of EV propulsion system, concept of EV Motors, single motor and multi-motor configurations, fixed & variable geared transmission, In wheel motor configuration, classification of EV motors, Electric motors used in current vehicle applications, Recent EV Motors, Comparison of Electric Motors for EV applications.
5	**Power Electronics & Control requirement for EV:** Comparison of EV power devices, introduction to power electronics converter, four quadrant DC chopper, three-phase full bridge voltage-fed inverter, soft-switching EV converters, comparison of hard-switching and soft-switching converter, three-phase voltage-fed resonance dc link inverter, Basics of Microcontroller & Control Strategies.
6	**EV Motor Drives:** DC Motor: Type of wound-field DC Motor, Torque speed characteristics DC-DC Converter, Two quadrant DC Chopper, two quadrant zero voltage transition converter-fed dc motor drive, speed control of DC Motor Induction Motor Drive: Three Phase Inverter Based Induction Motor Drive, Equal Area PWM, Three Phase Auxiliary resonant snubber (ARS) Inverter Type (ZVC & ZCS), Single Phase ARS Inverter Topology, Speed Control of Induction Motor, FOC, Adaptive Control, Model Reference Adaptive Control (MARS), Sliding mode Control.

Text Books:

1. Dr. S. Sujatha, Senthil Kumar, 'A textbook on Electric vehicle technology'Scientific International Publishing House.
2. Stefano Longo Mehrdad Ehsani, Yimin Gao, 'Modern electric, Hybrid electric & fuel cell vehicles, Taylor & Fransis Exclusive

Reference Books:

1. Amelie Ewert, Stephan Schmid, et al., 'Small Electric vehicles : An international view on light three and four wheeler, Springer publications
2. Ron Hodkinson & John Fenton, Light Weight Electric/Hybrid Vehicle design, Butterworth Publications, Heinemann.
3. Marcedle Kkeirn, H.A.Kiehne, 'Battery Technology Handbook', Sandeep Dhameja, Electric vehicle battery systems, Butterworth–Heinemann

E-Resources:

1. NPTEL :: Electrical Engineering - NOC: Electric vehicles and Renewable energy

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (E&TC – IoT and Sensor Systems)								**Semester:** II	
Course: Open Elective – II (Embedded System)								**Code:** ETIS205	
Teaching Scheme (hrs/week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

Microcontrollers

Course Objectives:

Introduce students to the principles and programming of real-time operating systems, emphasizing task management, scheduling, and data protection in embedded applications.

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

CO1	Describe the fundamental concepts, characteristics, and components of embedded systems, including the design issues, flow, and metrics.
CO2	Demonstrate proficiency in the embedded software development process and tools, including linking, locating, and integrating software into target systems.
CO3	Analyze the ARM architecture, including its design philosophy, register banking, pipelining, and interrupt handling mechanisms.
CO4	Utilize Embedded C programming to interface with peripherals on the LPC 2148 microcontroller, including LEDs, LCDs, keyboards, and ADCs.
CO5	Develop practical applications and projects using Embedded C and the LPC 2148 microcontroller, demonstrating hands-on proficiency.
CO6	Apply the concepts of real-time operating systems, including task scheduling, shared data management, and the use of semaphores to protect shared data, in embedded applications.

Course Contents:

Unit	**Description**
1.	**Introduction to Embedded Systems:** Embedded System Definition and Characteristics: Definition, characteristics, and components of an embedded system. Design Issues and Flow: Embedded system design issues, design flow, and metrics. Hardware-Software Design: Issues in hardware-software design and co-design. Introduction to IDE.
2.	**Embedded Software Development:** Development Process and Tools: Introduction to the embedded software development process and tools. Linking and Locating Software: Techniques for linking and locating software, getting embedded software into the target system.
3.	**ARM Architecture and Embedded Processor:** ARM Architecture Details: RISC architecture design philosophy, register banking, CPSR, and

	SPSR. Pipelining and Interrupts: Pipelining, exceptions, interrupts, and the vector table in ARM architecture.
4.	**LPC 2148 Microcontroller:** Microcontroller Architecture: ARM7TDMI-S microcontroller LPC-2148 architecture details, SFRs, and port structure. Peripheral Modules: Timer, counter, PWM module, and Embedded C programming for interfacing LEDs and LCDs.
5.	**Embedded C Programming:** Advanced Interfacing: Embedded C programming for interfacing with keyboards and ADC. Practical Applications: Hands-on projects and real-world applications using LPC 2148.
6.	**Real Time Operating System (RTOS):** RTOS Concepts and Architectures: Introduction to RTOS concepts and embedded software architectures: round robin, round robin with interrupts, function queue scheduling, and real-time operating systems. RTOS Programming and Task Management: Tasks and task states, task scheduling, shared data and reentrancy, semaphores, and protecting shared data using semaphores.

Text Books:

1. James K. Peckol. "Embedded Systems: A Contemporary Design Tool", John Wiley & Sons.
2. Raj Kamal. "Embedded Systems: Architecture, Programming and Design", McGraw-Hill Education.

Reference Books:

1. Joseph Yiu. "The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors", Newnes.
2. Michael Barr and Anthony Massa. "Programming Embedded Systems: With C and GNU Development Tools", O'Reilly Media.
3. Real-Time Systems: Design Principles for Distributed Embedded Applications, Springer.

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Mechanical–Design Engineering)								**Semester:** II	
Course: Open Elective – II (Process Equipment and Plant Design)								**Code:** MEDE205	
Teaching Scheme (hrs/week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
03	-	-	03	50	50	-	-	-	100

Prerequisites:

Engineering Mathematics, Machine Design, Mechanical System Design. Knowledge of Fluid Mechanics and process instrumentation.

Course Objectives:

1. To understand the importance of Elements of Material Handling System.
2. Understand the benefit of Selection of various types of material handling equipment.
3. To design of material handling systems.
4. To apply material handling/warehouse automation and safety considerations.
5. To design plant hydraulics and process vessels.
6. To know plant auxiliaries.

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

CO1	Identify the use and importance of material handling
CO2	Select various types of material handling equipment for a particular operation.
CO3	Apply the design procedures of various material handling equipment & components and design the material handling system.
CO4	Understand Material Handling / Warehouse Automation and Safety considerations
CO5	Apply Design for plant hydraulics and process vessels
CO6	Design various plant auxiliaries

Course Contents:

Unit	**Description**
1.	**Elements of Material Handling System:** Importance, Terminology, Objectives, and benefits of better Material Handling; Principles and features of Material Handling System; Interrelationships between material handling and plant layout, physical facilities, and other organizational functions; Classification of Material Handling Equipment's.
2.	**Selection of Material Handling Equipment:** Factors affecting selection; Material Handling Equation; Choices of Material Handling Equipment; General analysis Procedures; Basic Analytical techniques; The unit load concept; Selection of suitable types of systems for applications; Activity cost data and economic analysis for design of components of Material Handling Systems; functions and parameters affecting service; packing and storage of materials.
3.	**Design of Mechanical Handling Equipment:** Drives for hoisting, components, and hoisting mechanisms; rail traveling components and

	mechanisms; hoisting gear operation during transient motion; selecting the motor rating and determining breaking torque for hoisting mechanisms. Hand-propelled and electrically driven E.O.T. overheat Traveling cranes; Traveling mechanisms of cantilever and monorail cranes; design considerations for structures of rotary cranes with fixed radius ; fixed post and overhead traveling cranes; Stability of stationary rotary and traveling rotary cranes.
4.	**Material Handling / Warehouse Automation and Safety Considerations:** Storage and warehouse planning and design; computerized warehouse planning; Need, Factors, and Indicators for consideration in warehouse automation; which function, When, and How to automate; Levels and Means of Mechanizations. Safety and design; Safety regulations and discipline.
5.	**Plant Hydraulics and Process Vessels:** Plant hydraulics, Pumps, Compressors, Piping and Pipe fittings, Piping schemes for processes, and Process vessels.
6.	**Plant Auxiliaries:** Process Utilities, Plant Instrumentation and Process Control, Engineered safety.

Text Books:

1. N. Rudenko, "Material Handling Equipments", Peace Publishers, Moscow.
2. James M. Apple, "Material Handling System Design", John Wiley and Sons Publication, New York.
3. John R. Immer, "Material Handling", McGraw-Hill Co. Ltd., New York.
4. Colin Hardi, "Material Handling in Machine Shops", Machinery Publication Co. Ltd., London.

Reference Books:

1. M. P. Nexandrn, "Material Handling Equipment", MIR Publication, Moscow.
2. C. R. Cock and J. Mason, "Bulk Solid Handling", Leonard Hill Publication Co. Ltd., U.S.A.
3. Spivakovsky, A. O. and Dyachkov, V. K., "Conveying Machines", Volumes I and II, MIR Publishers, 1985.
4. Kulwiac, R. A., "Material Handling Handbook", 2nd edition, John Wiley Publication, New York.

E-Resources:

1. NPTEL course on Process Equipment Design by Prof. Shabina Khanam, IIT Roorkee - https://onlinecourses.nptel.ac.in/noc21_ch18/preview
2. NPTEL course on Equipment Design: Mechanical Aspects by Prof. Shabina Khanam, IIT Roorkee https://onlinecourses.nptel.ac.in/noc24_ch38/preview

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)								**Semester:** II	
Course: Automation Laboratory								**Code:** MERA206	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
-	02	-	01	-	-	25	25	-	50

Prerequisites:

Fundamental of Hydraulics and Pneumatics, Engineering Mathematics, Sensor Technology, Control System Engineering.

Course Objectives:

To impart knowledge about programing and developing an automation system.

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

CO1	Understand the needs of automation set-ups.
CO2	Develop a program in PLC and SCADA system for an automation system.
CO3	Analyze the forward and inverse kinematics of robot used in the automation system.
CO4	Simulate the in a virtual platform of an Automation System.
CO5	Evaluate and train the MVS using Deep Learning Algorithms.

List of Practical

1. Develop a set-up of a Flexible Manufacturing System (FMS) has at least four stations controlled by Programmable Logic Controllers (PLCs) and two 5-degrees of freedom articulated robots. Along with design of the set up the PLC programming of all stations is required using any logic. The simulation of two robots using forward kinematics must also be done to test the robots' dynamic parameters.
2. Develop a Supervisory Control and Data Acquisition (SCADA) system for a Processing Plant of at least four processing units along with Human Machine Interfacing (HMI) panel integration.
3. Develop a program for a Machine Vision System (MVS) integrated with a Welding Robot using Edge Detection image processing using OpenCV in MATLAB/Python.
4. Develop an Internet of Things (IoT)-based automatic deep learning model integrated with Image Processing for a MVS of a robot.
5. Develop and Design an Automated Storage and Retrieval System for a warehouse of an industry.
6. Industrial Visit and its report on various Automation Systems used in the industry.

Text-Books:

1. A.K. Jain, "Fundamentals of Digital Image Processing", Prentice-Hall of India.
2. Himanshu Kumar, "Advanced Industrial Automation: PLC Programming in Simplest Way with 110 Solved Examples", Notion Press.
3. Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat, "Industrial Internet of Things: Cyber Manufacturing Systems", Springer Publication.
4. Rajesh Mehra, Vikrant Vij, "PLCs & SCADA Theory and Practice", 1st Edition, 2019, Laxmi Publications Private Limited.

5. Mikell P. Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", Pearson Education.

Reference Books:

1. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", 2nd Edition, Addison-Wesley.
2. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer Nature.
3. Scott E. Umbaugh, "Computer Vision and Image Processing", Prentice-Hall International.
4. Frank D. Petreuzeulla, "Programmable Logic Controllers", Tata McGraw Hill Publication, 6th Edition, 2023.
5. Vijay Madisetti, Arshdeep Bahga, "Internet of Things: A Hands-On Approach", 2014.
6. Miroslav Kubat, "An Introduction to Machine Learning", Springer, 2017.

E-Resources:

1. https://ise.illinois.edu/research/labs/flexible-manufacturing-lab
2. http://vlabs.iitkgp.ac.in/mr/exp0/index.html

Research Papers:

1. Yifei Ge, Zhuo Li, Xuebin Yue, Hengyi Li, Qi Li, Lin Meng, "IoT-based Automatic Deep Learning Model Generation and the Application on Empty-Dish Recycling Robots", Internet of Things, Elsevier, 2024, Vol. 25.
2. Bukka Shobharani, Sreelakshmy R., V. Jyothsna, D. Rajendra Prasad, P. Chandra Sekhar Reddy, S. Farhad, Ankur Gupta, "Impact of Image Processing and Deep Learning in IoT-Based Industrial Automation System", International Journal of Intelligent Systems And Applications In Engineering (IJISAE), ISSN: 2147-6799, Vol. 12, Issue-4s, pp. 801-807.

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics and Automation Engineering)							**Semester:** II		
Course: Machine Learning Laboratory							**Code:** MERA207		
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
-	02	-	01	-	-	25	25	-	50

Prerequisites:

Mathematical Foundations for Machine Learning, Programming Skills, Core Machine Learning Concepts.

Course Objectives:

1. To understand the implementation procedures for the machine learning algorithms.
2. To understand modern notions in data analysis-oriented computing and conduct experiments to design a component or a product applying all the relevant standards with realistic constraints.

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

CO1	Apply appropriate data sets to the Machine Learning algorithms.
CO2	Identify and apply Machine Learning algorithms to solve real world problems.

List of Experiments:

Any **Eight** Experiments from the following

1. Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs.
2. Implement linear regression using python. Select appropriate data set for your experiment and plot the graphs.
3. Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Java/Python ML library classes can be used for this problem.
4. Implement k-means clustering for classification.
5. Implement an algorithm to demonstrate the significance of genetic algorithm
6. Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.
7. Implement PCA, LDA for dimensionality reduction using MATLAB. Use this model to demonstrate the diagnosis of Epilepsy patients using standard EEG Data Set.
8. Implement SVM tool for the detection of the Epilepsy patients using standard EEG Data Set. Also use standard Heart Disease Data Set to detect the heart disease.
9. Implementation of popular architectures related to CNN, ANN, RNN, LSTM and Auto-encoder
10. Implementation of Time Series Clustering and alignment algorithms
11. Implementation of Reinforcement Learning algorithms.
12. Write a program to construct a Bayesian network considering medical data. Use this model to demonstrate the diagnosis of heart patients using standard Heart Disease Data Set.

Text Books:

1. Tom Mitchell, "Machine Learning", McGraw-Hill Education, 2010.

2. Daume, H. III, "A Course in Machine Learning", 2015

Reference Books:

1. Christopher Bishop, "Pattern Recognition and Machine Learning", Springer, 2013.
2. Balas K Natarajan, "Machine Learning", Elsevier Science, 2014.

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc23_cs18/preview

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotics & Automation)									**Semester:** II
Course: Dissertation Phase – I									**Code:** MERA208
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
-	2	-	01	-	-	25	25	-	50

Prerequisites:

Basic knowledge of Machine Design, Mechanical system design, Basics of Analysis software.

Course Objectives:

Students will develop the ability to independently conduct original research that addresses significant societal, national, and global engineering challenges.

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

CO1	Analyze and review relevant research papers to identify gaps and formulate research problems that address societal and global issues in robotics and automation.
CO2	Evaluate and synthesize technical literature to analyze complex problems and propose innovative solutions.
CO3	Plan and design original research projects, integrating theory with practice, and publish at least one review paper.

Guidelines:

1. Each student must design and demonstrate a project with their assigned Supervisor/Guide.
2. Analyze and review research papers to identify gaps and formulate relevant problems with guidance from the Supervisor.
3. Publish at least one review paper as part of Dissertation Phase-I.
4. Submit a Dissertation Phase-I report including an introduction, literature survey, research gaps, and project title.

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M. Tech. (Robotic & Automation)								**Semester:** II	
Course: Audit Course – II: Constitution of India								**Code:** MERA209	
Teaching Scheme (hrs./week)				**Evaluation Scheme (Marks)**					
Lecture	**Practical**	**Tutorial**	**Credit**	**CIE**	**ETE**	**TW**	**OR**	**PR**	**Total**
01	-	-	-	-	-	-	-	-	-

Prerequisites:

1. Understanding of Indian history and political science.
2. Familiarity with constitutional law and governance.
3. Awareness of socio-economic and cultural diversity in India.
4. Knowledge of democratic processes and institutions.

Course Objectives:

1. To examine the historical development of the Indian constitution.
2. To critically analyze the philosophical foundations of the Indian constitution.
3. To explore the scope and implications of constitutional rights and duties.
4. To understand the structure and functions of key organs of governance.
5. To analyze the mechanisms and practices of local administration.
6. To evaluate the role and functioning of electoral institutions.

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

CO1	Demonstrate an understanding of the historical context and evolution of the Indian constitution.
CO2	Evaluate the philosophical foundations of the Indian constitution.
CO3	Explain the scope and significance of constitutional rights and duties.
CO4	Describe the structure and functions of key organs of governance.
CO5	Evaluate the functioning of local administration and grassroots democracy.
CO6	Analyze the role and functioning of electoral institutions.

Course Contents:

Unit	**Description**
1.	**History of Making of the Indian Constitution:** History, Drafting Committee (Composition & Working).
2.	**Philosophy of the Indian Constitution:** Preamble, Salient Features.
3.	**Contours of Constitutional Rights & Duties:** Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.
4.	**Organs of Governance:** Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

5.	**Local Administration:** District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation, Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role, Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy
6.	**Election Commission:** Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women

Reference Books:

1. "The Constitution of India", 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar, "Framing of Indian Constitution", 1st Edition, 2015.
3. M. P. Jain, "Indian Constitution Law", 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, "Introduction to the Constitution of India", Lexis Nexis.

E-Resources:

1. Constitution of India - National Portal of India https://www.constitutionofindia.net/read/ https://legislative.gov.in/constitution-of-india/
2. PRS Legislative Research - Articles on Indian Constitution https://prsindia.org/
3. Election Commission of India - Official Website