Savitribai Phule Pune University, Pune
Maharashtra, India

Faculty of Science and Technology

Curriculum Structure and Syllabus Master of Engineering (2025 Pattern) in

ME- Mechatronics

(With effect from Academic Year 2025-26)

Preface by Board of Studies

Dear Students and Teachers,

We, the members of the Board of Studies – Mechatronics Engineering, are very happy to present the First Year **Master of Engineering (Mechatronics Engineering)** syllabus effective from the Academic Year 2025-26 (2025 Pattern).

Mechatronics Engineering is an interdisciplinary discipline that integrates principles from mechanical, electronics, computer, and control engineering, supporting innovation across automation, robotics, intelligent systems, manufacturing, and Industry 4.0. This curriculum is designed to provide students with a comprehensive understanding of the fundamentals, emerging technologies, and practical applications in Mechatronics, while also equipping them to meet the demands of a rapidly evolving industry.

The curriculum revision is mainly focused on knowledge components, skill-based activities, experiential learning, and project-based activities. The revised syllabus falls in line with the objectives of **NEP-2020, Savitribai Phule Pune University, AICTE New Delhi, UGC**, and various accreditation agencies, while keeping in view technological developments, innovations, and industry requirements. Learners are now getting sufficient time for self-learning either through online courses or additional projects to enhance their knowledge and skill sets. Learners can also be advised to take up online certification courses, and upon successful completion, submit certification for the same. This will definitely help learners to enrich their knowledge based on their area of interest. We would like to place on record our gratefulness to the faculty, students, industry experts, and stakeholders for having helped us in the formulation of this syllabus.

Dr. Vaibhav V. Dixit
Chairman
Board of Studies – Mechatronics Engineering

Program Educational Objectives

Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve.

PEO	PEO Statements
PEO1	To develop students' ability to model, analyze and solve complex engineering problems by integrating mechanical, electronics, control, and computer engineering principles
PEO2	To inculcate the skills and knowledge required for addressing real-world challenges in automation, robotics, smart systems, and Industry 4.0, enabling effective contribution in multidisciplinary teams and adaptability to technological advancements..
PEO3	To prepare students for advanced studies, research, or professional practice in Mechatronics and allied domains, fostering a commitment to lifelong learning, innovation, and leadership

Program Outcomes (PO)

POs are statements that describe what students are expected to know and be able to do upon graduating from the program. These relate to the skills, knowledge, analytical ability, attitude, and behaviour that students acquire through the program. The POs essentially indicate what the students can do from subject-wise knowledge acquired by them during the program. As such, POs define the professional profile of a graduate of PG Engineering Program.

The NBA has defined the following three POs for a graduate of PG Engineering Program, adapted here for **M.E. Mechatronics:**

PO1	An ability to independently carry out research, investigation, and development work in mechatronics, robotics, automation, and intelligent systems to solve practical problems.
PO2	An ability to write, present, and effectively communicate substantial technical reports/documents, demonstrating proficiency in interdisciplinary engineering tools, simulations, and experimental results..
PO3	Students should be able to demonstrate a degree of mastery in Mechatronics Engineering — integrating mechanical, electronics, control, and computational technologies — at a level higher than the requirements in the appropriate bachelor program.

General Rules and Guidelines

1. **Dissertation (Stage I and II):**
   Stage I and Stage II must result in the publication of at least two research papers (one at each stage), preferably in reputed journals having Citation Index ≥ 2.0 and ISSN number, or in international journals/conferences recommended by the dissertation guide and approved by the BoS. Participation and paper presentation at the BoS-supported PGCON event is also encouraged.
   Each dissertation report must include:
   - A certificate of originality from the guide,
   - Plagiarism test results,
   - Published paper(s),
   - Conference participation certificates, and
   - Reviewer comments (where available).
2. **Assessment:**
   Student performance will be evaluated through:
   - **CCE (Comprehensive Continuous Evaluation)** and
   - **End-Semester Assessment**,
     with both components carrying approximately equal weightage.
3. **Mechatronics Laboratory I and II:**
   Laboratory work in Semester I and II shall consist of assignments/experiments related to the core and elective courses offered in that semester.
4. **Seminar:**
   - **Seminar I:** Based on a state-of-the-art topic of the student's choice, approved by the guide/authority.
   - **Seminar II:** Focused on the latest trends in Mechatronics or topics relevant to the chosen specialization/electives.
   - **Seminar III:** Continuation/extension of Seminar II, showcasing deeper exploration and updated findings.
5. **Project Work:**
   The project work shall be based on knowledge acquired during coursework and should preferably address societal, industrial, or research-oriented problems in Mechatronics.
6. **Project Stage I:**
   Includes problem definition, literature review, project overview, implementation plan (UML/ERD/Block Diagram/PERT chart), and preliminary design. A certified progress report must be submitted.
7. **Project Stage II:**
   Completion of the project including experimentation/simulation, analysis, validation, and conclusions. The final report must follow the prescribed format and be duly certified by the guide and Head of Department.

Note: Institutes must submit the list of candidates, guides, and project details (title, domain, problem definition, objectives, scope, and abstract; including sponsorship details, if any) to the University within one month of commencement of the third semester. A guide may supervise a maximum of eight students per academic year.

Curriculum Structure

Master of Engineering (2025 Pattern) – Mechatronics

Level 6.0

Semester I

NEP 2020 Compliant Curriculum Structure

M.E. Mechatronics - First Year (2025 Pattern)

Course Code	Course Type	Name of Course	Teaching Scheme		Examination Scheme						Credit		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	Total
PCC-501-MTX	Programme Core Course	System Modelling, Identification and Simulation	4	-	50	50	-	-	-	100	4	-	4
PCC-502-MTX	Programme Core Course	Intelligent Control Systems	4	-	50	50	-	-	-	100	4	-	4
PCC-503-MTX	Programme Core Course	Smart Sensors and IoT	4	-	50	50	-	-	-	100	4	-	4
PCC-504-MTX	Programme Core Course	Artificial Intelligence and Machine Learning.	4	-	50	50	-	-	-	100	4	-	4
PCC-505-MTX	Laboratory-I	IoT & Sensor Integration Lab	-	4	-	-	25	-	25	50	-	2	2
PEC-506-MTX	Programme Elective Course	Elective -I	3	-	50	50	-	-	-	100	3	-	3
MPR-507-MTX	Mini Project	Mini Project	-	2	-	-	25	-	25	50	-	1	1
Total			**19**	**6**	**250**	**250**	**50**	**0**	**50**	**600**	**19**	**3**	**22**

List of Elective I Courses:

PEC- 506-MTX- A	Robotics Fundamentals & Kinematics
PEC - 506-MTX-B	Additive Manufacturing for Mechatronics
PEC - 506-MTX-C	3D Printing
PEC - 506-MTX-D	Sustainable Energy Systems and Electrical Vehicle

Curriculum Structure

Master of Engineering (2025 Pattern) – Mechatronics

Level 6.0

Semester II

Course Code	Course Type	Name of Course	Teaching Scheme		Examination Scheme						Credit		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	P
PCC-508-MTX	Programme Core Course	Industrial Automation & Industry 4.0	4	-	50	50	-	-	-	100	4	-	4
PCC-509-MTX	Programme Core Course	Mechatronics and Artificial Intelligence in Autonomous Vehicles	4	-	50	50	-	-	-	100	4	-	4
PCC-510-MTX	Programme Core Course	Electric Mobility & Smart Actuators	4	-	50	50	--		-	100	4	-	4
PCC-511-MTX	Programme Core Course	Robotics & Automation Lab	-	4	-	-	25	-	25	50	-	2	2
PEC-512-MTX	Programme Elective Course	Elective II	3	-	50	50	-	-	-	100	3	-	3
PEC-513-MTX	Programme Elective Course	Elective III	3	-	50	50	-	-	-	100	3	-	3
SEM-514-MTX	Seminar	Seminar-I	-	4		--	25		25	50	-	2	2
Total			**18**	**8**	**250**	**250**	**50**	**0**	**50**	**600**	**18**	**4**	**22**

List of Elective II Courses:

PEC - 512-MTX-A	Micro-Electro-Mechanical Systems & Microsystems
PEC- 512-MTX-B	Human-Robot Interaction
PEC - 512-MTX-C	Embedded IoT Systems
PEC - 512-MTX-D	Soft Computing Techniques in Mechatronics

List of Elective III Courses:

PEC - 513-MTX-A	Digital Manufacturing
PEC - 513-MTX-B	Autonomous Vehicles
PEC - 513-MTX-C	Fault Diagnosis and Predictive Maintenance
PEC - 513-MTX-D	Autonomous Drones and Unmanned Systems

Curriculum Structure

Master of Engineering (2025 Pattern) – Mechatronics

Level 6.5

Semester III

M.E. Mechatronics - Second Year (2025 Pattern)

Course Code	Course Type	Name of Course	Teaching Scheme		Examination Scheme						Credit		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	P
RM-601-MTX	Research Methodology	Research Methodology	5	-	50	50	--		-	100	5	-	5
OJT-602-MTX	On Job Training/ Internship	On Job Training/Internship/ Short-term course	-	10	-	-	100	-	-	100	-	5	5
SEM-603-MTX	Seminar	Seminar II	-	6	-	-	25	-	25	50	-	3	3
RPR-604-MTX	Research Project	Project Stage I	-	18	-	-	25	-	25	50	-	9	9
Total			**5**	**34**	**50**	**50**	**150**	**0**	**50**	**300**	**5**	**17**	**22**

Semester IV

Course Code	Course Type	Name of Course	Teaching Scheme		Examination Scheme						Credit		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	P
SEM-605-MTX	Seminar	Seminar III	-	8	-	-	50	-	50	100	-	4	4
RPR-606-MTX	Research Project	Project Stage II	-	36	-	-	150	-	50	200	-	18	18
Total			**0**	**44**	**0**	**0**		**0**	**100**	**300**	**0**	**22**	**22**

Savitribai Phule Pune University, Pune

Maharashtra, India

ME – Mechatronics

Semester -I

Semester-I

System Modelling, Identification and Simulation [PCC-501-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-501-MTX	4	50	50	-	-	100	4

Unit I – Fundamentals of System Modelling **(08 Hours)**

Introduction to systems: definition, classification (linear/non-linear, time-variant/invariant, lumped/distributed). Physical system components and energy domains: mechanical, electrical, thermal, hydraulic, pneumatic. Mathematical modelling of physical systems using differential equations. Modelling of translational and rotational mechanical systems. Analogy between mechanical, electrical and fluid systems. Block diagram representation and signal flow graphs.

Unit II – Modelling of Mechatronic Systems **(08 Hours)**

Introduction to mechatronic system dynamics. Modelling of electromechanical systems: DC motor, stepper motor, servomotor. Modelling of sensors and actuators in mechatronic systems. State-space representation of dynamic systems. Transfer function derivation and system response analysis. Simulation basics: continuous and discrete system simulation concepts.

Unit III – System Identification Techniques **(08 Hours)**

Introduction to system identification: concepts and importance. Types of models: parametric vs non-parametric. Data acquisition and pre-processing for identification. Time-domain and frequency-domain identification methods. Least squares estimation, recursive least squares, gradient methods. Model validation, parameter estimation, and error analysis.

Unit IV – Simulation Methods and Tools **(08 Hours)**

Introduction to simulation: objectives, types, and advantages. Numerical simulation of dynamic systems using MATLAB/Simulink. Simulation of linear and nonlinear systems. Simulation of multi-domain mechatronic systems. Real-time simulation basics and hardware-in-the-loop (HIL) simulation. Introduction to simulation platforms: Simulink, LabVIEW, Modelica.

Unit V – Case Studies and Applications **(08 Hours)**

Modelling and simulation of mechatronic subsystems: robotic arm, servo control system, hydraulic actuator. System identification and control of industrial process systems. Digital twin concept and virtual prototyping. Co-simulation approaches for cyber-physical systems. Recent trends and research directions in modelling, identification and simulation of mechatronic systems.

Recommended Textbooks:

1. Ogata, K. – ***System Dynamics*****, Pearson Education.**

2. Ljung, L. – ***System Identification: Theory for the User*****, Prentice Hall.**

3. Cellier, F.E. & Kofman, E. – ***Continuous System Simulation*****, Springer.**

4. Bolton, W. – ***Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*****, Pearson**.

Semester-I

Intelligent Control Systems [PCC-502-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-502-MTX	4	50	50	-	-	100	4

Unit I- Introduction to Intelligent Control **(08 Hours)**

Fundamentals of control systems and need for intelligent control, Classical vs intelligent control - differences and evolution, Soft computing overview: fuzzy logic, neural networks, genetic algorithms. Applications in mechatronic and industrial systems.

Unit II- Fuzzy Logic Based Control **(08 Hours)**

Introduction to fuzzy sets and systems, Fuzzy logic controller structure: fuzzification, inference, defuzzification, Fuzzy modeling and system identification, Design and implementation of fuzzy controllers in mechatronics, Case studies and industrial applications.

Unit III- Neural Networks for Intelligent Control **(08 Hours)**

Basics of artificial neural networks: architectures, learning algorithms, System identification and modelling with neural networks, Neural network-based control design, Adaptive control using neural models, Case studies in robotics and automation

Unit IV- Genetic and Evolutionary Algorithms **(08 Hours)**

Introduction to genetic algorithms and their role in optimization, encoding, selection, crossover, mutation operations, Application in control systems tuning and design, Integration with fuzzy/neural control for hybrid systems, Practical and simulation examples.

Unit V- Intelligent and Hybrid Control Applications **(08 Hours)**

Neuro-fuzzy and neuro-genetic systems in control engineering, Intelligent controllers in mechatronic systems: mobile robots, process automation, embedded systems, Real-time implementation issues, Industrial case studies and recent advances, Emerging trends: machine learning in modern mechatronics.

Reference Books

1. T.J. Ross, "Fuzzy Logic with Engineering Applications," John Wiley & Sons, 2016.
2. Simon Haykin, "Neural Networks and Learning Machines," Pearson, 2010.
3. J.S.R. Jang, C.T. Sun, E. Mizutani, "Neuro-Fuzzy and Soft Computing," PHI, 2000.
4. Patrick O.J. Kaltjob, "Control of Mechatronic Systems," Wiley, 2021.
5. Ehsan Momeni et al., "Artificial Intelligence in Mechatronics and Civil Engineering," Springer,
6. R. Munnig Schmidt et al., "The Design of High Performance Mechatronics," IOS Press, 2020.
7. "Computational Intelligent Techniques in Mechatronics," Wiley, 2024

Semester-I

Smart Sensors and IoT [PCC-503-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-503-MTX	4	50	50	-	-	100	4

Unit I: Experimental Data Analysis and Basic Sensing Devices (08 Hours)

Types and causes of experimental errors, statistical analysis of experimental data, Normal distribution, chi-square test, Standard deviation, correlation coefficient, Student's t-distribution, Oscilloscopes, frequency counters, analog vs. digital instruments. General Considerations of Data Analysis.

Unit II: Mechanical Measurements -Pressure, Flow, Temperature, & Strain (08 Hours)

Distance Measurement using LVDT and Capacitive method

Pressure Measurement- Diaphragm, bellows, Bridgman, Pirani, Knudsen, Ionization, Alphatron gauges

Flow Measurement- Drag-based methods, hot-wire/film anemometers, Magnetic flow meters, Laser Doppler Anemometer.

Temperature Measurement- Thermocouples, compensation techniques, Heat flux, thermal conductivity, humidity and pH sensors

Strain Measurement- Electrical resistance strain gauges, Rosette gauges,

Unit III: Data Acquisition and Signal Processing (08 Hours)

Basic data acquisition system (DAQ), Signal conditioning techniques, ADC and DAC fundamentals and types of data transmission and display, Types of DAS and their life applications. Real-time data acquisition examples using microcontroller boards,

Unit IV: Introduction to Smart Sensors and Embedded Systems (08 Hours)

Concept of smart sensors: self-calibration, diagnostics, signal conditioning, Comparison of conventional vs smart sensors, Basics of embedded systems: Microcontrollers (Arduino, ESP32 – overview only), Sensor interfacing basics (temperature, pressure, humidity), Role of firmware and analog-digital integration

Unit V: Fundamentals of IoT in Mechatronics (08 Hours)

IoT Definition and Architecture: Device, Network, Cloud, Common communication methods: Wi-Fi, Bluetooth (overview only), Introduction to cloud-based data logging (Thing Speak / Blynk – demonstration level), Basic IoT Protocols: HTTP and MQTT (conceptual overview only), Simple IoT applications in Mechatronics:1) Remote temperature or vibration monitoring 2) Alert systems (email/SMS-based), Safety and security basics in IoT-enabled systems,

Reference Books

1. **J. P. Holman**, *Experimental Methods for Engineers*, McGraw Hill
2. **K. P. Ramachandran, G. K. Vijayaraghavan**, *Mechatronics: Integrated Mechanical Electronic Systems*, Wiley India
3. **R. K. Rajput**, *A Textbook of Mechatronics*, S. Chand
4. **Raj Kamal**, *Internet of Things: Architecture and Design Principles*, McGraw Hill India
5. **Arshdeep Bahga & Vijay Madisetti**, *Internet of Things: A Hands-on Approach*, Universities Press
6. **Bharat Sikka**, *Internet of Things (IoT)*, McGraw Hill India
7. **NPTEL / SWAYAM**: Courses on Mechatronics and IoT

Semester-I

Artificial Intelligence and Machine Learning [PCC-504-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-504-MTX	4	50	50	-	-	100	4

Unit I – Introduction to Artificial Intelligence **(08 Hours)**

Definition and scope of Artificial Intelligence (AI), History and evolution of AI in engineering systems, Applications of AI in Mechatronics, Robotics, and Automation, Intelligent agents, environments, and search strategies, Knowledge representation and reasoning techniques

Unit II – Machine Learning Fundamentals **(08 Hours)**

Introduction to Machine Learning (ML), Types of learning: Supervised, Unsupervised, and Reinforcement Learning, Regression and Classification techniques, Model selection, bias-variance trade-off, overfitting and underfitting, Evaluation metrics: Accuracy, Precision, Recall, F1-score

Unit III – Supervised and Unsupervised Learning Algorithms **(08 Hours)**

Supervised Learning: k-NN, Decision Trees, Naive Bayes, SVM, Random Forests, Unsupervised Learning: k-means, Hierarchical clustering, PCA, Feature selection and extraction techniques, Dimensionality reduction and its importance in mechatronic systems, Case studies: Predictive maintenance, Fault diagnosis in automation systems.

Unit IV – Neural Networks and Deep Learning **(08 Hours)**

Fundamentals of Artificial Neural Networks (ANN), Backpropagation and training algorithms, Deep Neural Networks, Convolutional Neural Networks (CNNs), and Recurrent Neural Networks (RNNs), Applications in image processing, robotics vision, and embedded AI, Tools: TensorFlow, Keras (basics and examples)

Unit V – AI and ML Applications in Mechatronics **(08 Hours)**

AI in mobile robots, industrial automation, smart sensors, Integration of AI with PLCs, SCADA, and IoT, Real-time constraints and edge AI in embedded systems, Recent advances: Reinforcement Learning, Federated Learning, Transfer Learning, Case Studies: Vision-based inspection, Autonomous navigation, Adaptive control

Reference Books:

1. S. Rajasekaran & G.A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic and Genetic Algorithms*, 2. PHI Learning, 2017.
2. P. Suresh Varadhan, *Artificial Intelligence for Engineers*, McGraw Hill Education India, 2020.
3. Rashid Khadria, *Machine Learning: Applications in Mechatronics and Robotics*, Wiley India, 2022.
4. T. Veeramanikandan, *Artificial Intelligence and Machine Learning*, University Science Press (Laxmi Publications), 2021.
5. B. Yegnanarayana, *Artificial Neural Networks*, PHI Learning, 2011.
6. E. Balagurusamy, *Fundamentals of Artificial Intelligence*, McGraw Hill Education India, 2021.

Semester-I

IoT & Sensor Integration Lab [PCC–505-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-505-MTX	4	-	-	25	25	50	2

ME Mechatronics – IoT & Sensor Integration Laboratory. File shall consist of the following assignments/experiments:

01 **Interfacing Sensors with Microcontrollers**
Digital and analog sensors (temperature, pressure, proximity, light)
Signal acquisition and processing using Arduino / Raspberry Pi

02 **Actuator Control and Integration**
DC motors, stepper motors, and servo motor control
PWM, direction control, and feedback integration

03 **IoT Data Acquisition and Cloud Integration**
Sending sensor data to cloud platforms (ThingSpeak, Blynk, or AWS IoT)
Visualization of real-time data

04 **Wireless Communication in IoT Systems**
Bluetooth, Wi-Fi, and LoRa-based sensor networks
Implementation of basic remote monitoring projects

05 **Mini Project: Smart Home / Industrial Automation System**
Integration of multiple sensors and actuators
Implementation of automation logic
Control via web interface or mobile app

06 **Assignment on Signal Conditioning and Data Logging**
Noise filtering, amplification, and calibration of sensor signals
Storage of data in SD cards or databases for analysis

07 **Assignment on Research Proposal / IoT Application Concept**
Proposal of a novel IoT-enabled mechatronic system
System block diagram, sensors and actuators selection, communication method

08 **Assignment on Troubleshooting and System Optimization**
Identifying and rectifying hardware/software issues in IoT setups
Optimizing data accuracy, latency, and energy consumption

Lab Work / Assignments Instructions:
Lab work has to be carried out at the respective laboratories as mentioned in the syllabus.
Work must be documented and submitted as term work at the end of the semester.
Continuous assessment of each experiment/assignment will be carried out by the respective faculty.
Assessment of term work will follow R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

Semester-I

Elective – I

Robotics Fundamentals & Kinematics [PEC-506-MTX]-A

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-506-MTX-A	3	50	50	-	-	100	3

Unit I – Introduction to Robotics **(06 Hours)**

Definition, scope, and history of robotics Types of robots: industrial, service, mobile, humanoid Components of robotic systems: sensors, actuators, controllers, end-effectors Applications in manufacturing, healthcare, defense, space, and domestic fields Emerging trends in robotics

Unit II – Robot Anatomy and Representations **(06 Hours)**

Robot configurations: Cartesian, cylindrical, spherical, articulated, SCARA, delta, mobile platforms Degrees of freedom (DOF) and workspace analysis Coordinate systems and transformations: Cartesian, cylindrical, polar Homogeneous transformations and representation of positions and orientations Classification of robots based on motion and control

Unit III – Forward Kinematics **(06 Hours)**

Kinematic chain representation of manipulators Denavit–Hartenberg (D-H) parameters and conventions Homogeneous transformation matrices for robotic links Forward kinematic analysis of serial manipulators Case studies: 2-DOF and 3-DOF robotic arms

Unit IV – Inverse Kinematics **(06 Hours)**

Concept and importance of inverse kinematics Analytical and numerical methods Solvability, redundancy, and multiple solutions Geometric and algebraic approaches for inverse kinematics Case studies: planar and 3D manipulators

Unit V – Differential Kinematics and Applications **(06 Hours)**

Differential kinematics: velocity relationships Jacobian matrix: derivation and applications Singularities and their implications in control Basics of trajectory planning and motion generation Industrial case studies: robot programming, simulation, and real-world applications

Reference Books

1. S. K. Saha, *Introduction to Robotics*, McGraw Hill Education India, 2014.
2. R. K. Rajput, *Robotics and Industrial Automation*, S. Chand Publishing, 2018.
3. K. R. Guruprasad, *Robotics: Mechanics and Control*, PHI Learning Pvt. Ltd., 2015.
4. Debashis Dutta, *Fundamentals of Robotics*, Cambridge University Press India, 2021.
5. Jisu Elsa Jacob, Manjunath N., *Robotics Simplified: Fundamentals of Robotics, Kinematics, Motion Control and Trajectory Planning*, BPB Publications, 2021.
6. M. P. Groover (Indian Edition), *Industrial Robotics: Technology, Programming and Applications*, McGraw Hill Education India, 2012.

Semester-I

Elective – I

Additive Manufacturing for Mechatronics [PEC-506-MTX]-B

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-506-MTX-B	3	50	50	-	-	100	3

Unit I – Introduction to Additive Manufacturing **(06 Hours)**

Fundamentals of manufacturing processes: subtractive vs additive vs hybrid Evolution and need for additive manufacturing (AM) in mechatronics Classification of AM, processes (ASTM standards) Benefits, limitations, and challenges of AM, Applications in prototyping, tooling, and product development

Unit II – Additive Manufacturing Processes **(06 Hours)**

Vat photo polymerization (SLA, DLP) Material extrusion (FDM, FFF) ,Powder bed fusion (SLS, SLM, EBM), Material jetting and binder jetting, Directed energy deposition (DED) and sheet lamination processes, Comparison of processes for mechatronic applications

Unit III – Materials and Design for AM **(06 Hours)**

Materials used: polymers, metals, ceramics, composites, functional materials, Material properties and selection criteria for AM, Design considerations: design for AM (DfAM), topology optimization, lightweight structures, CAD/CAM tools for AM and integration with mechatronic design, Case studies in product innovation and lightweight mechatronic components

Unit IV – Post-Processing and Quality in AM **(06 Hours)**

Post-processing methods: machining, heat treatment, surface finishing, support removal, Dimensional accuracy, surface roughness, and mechanical properties, Testing and characterization of AM parts, Process monitoring and in-situ quality control, Standards and certification in AM (ISO/ASTM guidelines)

Unit V – Applications and Future Trends **(06 Hours)**

Applications in mechatronic systems: sensors, actuators, robotic parts, medical devices, aerospace, automotive, Embedded electronics and multi-material AM for smart mechatronic devices, Sustainability and recyclability in AM, Integration with Industry 4.0: AI, IoT, and digital twins in AM, Emerging trends: 4D printing, bio printing, nano-manufacturing, and mass customization

Reference Books

1. B. L. Singh, *Additive Manufacturing*, Khanna Publishing House, 2019.
2. M. Adithan, *Additive Manufacturing and 3D Printing*, I.K. International Publishing House
3. P. M. Pandey, *Additive Manufacturing: Principles, Advances, and Applications*,
4. Deepak M. Kalaskar, *3D Printing in Medicine and Surgery*, Elsevier India, 2017.
5. P. K. Mishra, *Fundamentals of 3D Printing and Additive Manufacturing*, Katson Books
6. L. Jyothish Kumar (Ed.), *Additive Manufacturing Technologies: Select Proceedings of AIMTDR 2018*, Springer India, 2019.

Semester-I

Elective – I
3D Printing [PEC-506-MTX]-C

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-506-MTX-C	3	50	50	-	-	100	3

Unit I – Introduction to 3D Printing **(06 Hours)**
Fundamentals of additive manufacturing and 3D printing, Evolution of 3D printing technologies, Difference between conventional manufacturing, additive manufacturing, and 3D printing, Classification of 3D printing processes, Applications and benefits in engineering, healthcare, aerospace, automotive, and consumer products

Unit II – 3D Printing Processes and Technologies **(06 Hours)**
Vat photo polymerization (SLA, DLP), Material extrusion (FDM, FFF), Powder bed processes (SLS, SLM, EBM), Material jetting and binder jetting, Sheet lamination and directed energy deposition, Comparative analysis of different 3D printing technologies

Unit III – Materials for 3D Printing **(06 Hours)**
Polymers: thermoplastics, photopolymers, composites, Metals: steel, titanium, aluminum, nickel alloys, Ceramics and bio-materials, Multi-material and functionally graded materials, Material properties, limitations, and suitability for specific applications

Unit IV – Design, Modeling, and Post-Processing **(06 Hours)**
Design for 3D printing (DfAM) principles, CAD/CAM software and slicing tools for 3D printing, Process parameters and their influence on quality, Post-processing techniques: machining, polishing, heat treatment, surface finishing, Testing, standards, and certification in 3D printing

Unit V – Applications and Emerging Trends **(06 Hours)**
Industrial applications: aerospace, automotive, electronics, robotics, Medical and healthcare applications: prosthetics, implants, bioprinting, Consumer products and customized manufacturing, Sustainability, recyclability, and supply chain transformation, Emerging trends: 4D printing, hybrid printing, nano-scale 3D printing

Reference Books

1. P. M. Pandey, *Additive Manufacturing: Principles, Advances, and Applications*, Narosa Publishing House, New Delhi, 2017.
2. M. Adithan, *Additive Manufacturing and 3D Printing*, I.K. International Publishing House, New Delhi, 2018.
3. B. L. Singh, *Additive Manufacturing*, Khanna Publishing House, 2019.
4. P. K. Mishra, *Fundamentals of 3D Printing and Additive Manufacturing*, Katson Books, New Delhi, 2020.
5. Deepak M. Kalaskar, *3D Printing in Medicine and Surgery*, Elsevier India, 2017.
6. L. Jyothish Kumar (Ed.), *Additive Manufacturing Technologies*

Semester-I

Elective – I

Sustainable Energy Systems and Electrical Vehicle [PEC-506-MTX]-D

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-506-MTX-D	3	50	50	-	-	100	3

Unit I – Introduction to Sustainable Energy Systems **(06 Hours)**

Energy scenario: conventional vs renewable energy sources, Need for sustainable and clean energy systems, Principles of energy conversion and efficiency, Overview of renewable sources: solar, wind, hydro, biomass, hydrogen, geothermal, Integration of renewable energy in modern power systems

Unit II – Energy Storage Technologies **(06 Hours)**

Importance of storage in renewable and EV applications, Types of storage: electrochemical, mechanical, thermal, hydrogen-based, Battery technologies: Lead-acid, NiMH, Li-ion, Solid-state, Flow batteries, Super capacitors and hybrid storage systems, Energy management and battery recycling

Unit III – Fundamentals of Electric Vehicles **(06 Hours)**

Introduction to electric mobility and EV architecture, Types of electric vehicles: BEV, HEV, PHEV, FCEV, EV powertrain components: motors, controllers, batteries, converters, inverters, Charging infrastructure: AC/DC charging, fast charging, wireless charging, Vehicle dynamics and performance parameters

Unit IV – Control and Power Electronics in EVs **(06 Hours)**

Electric drives for EVs: DC motor, BLDC, PMSM, induction motor drives, Motor control techniques: vector control, direct torque control, Power converters: DC-DC, DC-AC, onboard chargers, Battery management systems (BMS) and thermal management, Regenerative braking and energy recovery systems

Unit V – Applications, Challenges, and Future Trends **(06 Hours)**

Integration of EVs with smart grid and renewable energy systems, Policy, incentives, and charging infrastructure development, Environmental and sustainability aspects of EV adoption, Industrial case studies: EVs in automotive and public transportation, Emerging trends: autonomous EVs, V2G (Vehicle-to-Grid), AI in energy optimization

Reference Books

1. R. K. Rajput, *Electric Machines and Drives*, S. Chand Publishing, 2019.
2. M. L. Mathur, R. P. Sharma, *Electric Vehicles: Theory and Design*, Dhanpat Rai & Co., 2018.
3. S. P. Sukhatme, *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw-Hill, 2017.
4. K. N. Bhat, *Electric and Hybrid Vehicle Technology*, New Age International Publishers, 2019.
5. R. K. Mittal, *Renewable Energy and Energy Management*, S. Chand Publishing, 2020.
6. P. K. Mishra, *Electric and Hybrid Vehicles: Fundamentals and Applications*, Katson Books, 2021.

Semester-I

Mini Project [MPR-507-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Practical /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
MPR-507-MTX	2	-	-	25	25	50	1

Title 1: System Assessment and Requirement Analysis
The objective of this phase is to study and document the current status of selected laboratory instruments. Students are expected to identify limitations in functionality or performance and define the scope of enhancement. A detailed requirement specification sheet should be prepared outlining the upgradation goals.

Title 2: Integration of Sensors and Signal Conditioning Circuits
This stage involves selecting appropriate sensors suitable for the identified parameters (such as temperature, pressure, or displacement). Students must design and implement signal conditioning circuits to ensure accurate and reliable sensor outputs. The upgraded system must be tested for proper signal acquisition.

Title 3: IoT-Based Monitoring and Data Logging
In this phase, students are to interface the upgraded instruments with microcontrollers (such as Arduino, ESP32, or Raspberry Pi) to enable Internet of Things (IoT) functionality. The goal is to develop a real-time monitoring and data logging system using cloud platforms or local dashboards, ensuring remote accessibility and data analysis capabilities

Title 4: PLC Integration for Control Automation
This stage focuses on integrating a Programmable Logic Controller (PLC) for automated control of the instrument. Students must develop a PLC program using ladder logic or equivalent languages, implement necessary control logic, and test the system for process automation and reliability under operating conditions.

Title 5: Validation, Calibration, and Safety Compliance
The final phase involves calibrating the upgraded instrument using reference standards. The performance of the enhanced system must be validated through experimental trials. Students must also evaluate the system for compliance with laboratory safety standards and ensure stable, repeatable operation.

Submission and Assessment Guidelines
The mini project field work shall be submitted as part of term work at the end of the semester. Continuous assessment will be conducted by the respective faculty member throughout the semester. Final assessment of the term work will be carried out in accordance with R-1.4 and R-1.5 of the PG Rules and Regulations of the Credit System.

Savitribai Phule Pune University, Pune

Maharashtra, India

ME – Mechatronics

Semester- II

Semester-II

Industrial Automation & Industry 4.0 [PCC-508-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-508-MTX	4	50	50	-	-	100	4

Unit I – Fundamentals of Industrial Automation **(08 Hours)**

Introduction to automation: definition, need, and scope in modern industries. Classification of automation systems: fixed, programmable, and flexible automation. Components of industrial automation systems: sensors, actuators, controllers, and communication modules. Introduction to mechatronics in industrial automation. Overview of industrial control systems: open-loop and closed-loop control. Case studies on automation in manufacturing and process industries.

Unit II – Programmable Logic Controllers (PLC) **(08 Hours)**

Introduction to PLC: architecture, operation, and components. PLC hardware: CPU, power supply, I/O modules, memory. Programming languages: Ladder diagram, Function block diagram, Structured text (IEC 61131-3 standards). PLC programming concepts: timers, counters, latching, sequencing, interlocking, analog processing. PLC interfacing with sensors, actuators, and field devices. Industrial applications of PLCs in manufacturing, robotics, and process industries.

Unit III – Supervisory Control and Data Acquisition (SCADA) **(08 Hours)**

Introduction to SCADA systems: components, architecture, and communication protocols. Human Machine Interface (HMI): design principles and implementation. Real-time data acquisition, monitoring, and control. Communication networks in industrial automation: fieldbus, Modbus, Profibus, Ethernet/IP. Integration of PLC and SCADA for industrial control. SCADA applications in power plants, smart manufacturing, and industrial safety systems

Unit IV – Industrial Robotics and Automation **(08 Hours)**

Basics of robotics: classification, structure, and components. Robot kinematics, dynamics, and control fundamentals. Industrial robot programming: online and offline programming, teach pendants. Robot sensors and vision systems in automation. Collaborative robots (Cobots) and mobile robots in Industry 4.0 environments. Robotic applications: material handling, assembly, welding, inspection, and additive manufacturing.

Unit V – Industry 4.0 and Smart Manufacturing **(08 Hours)**

Evolution from Industry 1.0 to Industry 4.0: key principles and enabling technologies. Cyber-Physical Systems (CPS) and Industrial Internet of Things (IIoT). Digital twins, cloud computing, and edge computing in automation. Artificial Intelligence, machine learning, and predictive maintenance in smart factories. Data analytics, digital supply chains, and intelligent decision-making. Future trends: Industry 5.0, human–robot collaboration, and sustainable automation.

Recommended Textbooks:

1.Mikell P. Groover – *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson.
2. Frank D. Petruzella – *Programmable Logic Controllers*, McGraw-Hill.
3. Stenerson, Jon – *Industrial Automation and Process Control*, Pearson.
4. Klaus Schwab – *The Fourth Industrial Revolution*, World Economic Forum.
5. Craig, J.J. – *Introduction to Robotics: Mechanics and Control*, Pearson.

Semester-II

Mechatronics and Artificial Intelligence in Autonomous Vehicles [PCC-509-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-509-MTX	4	50	50	-	-	100	4

Unit I – Introduction to Autonomous Vehicles and Mechatronic Systems (08 Hours)
Evolution of autonomous vehicles (AVs) and intelligent transportation systems, Levels of driving automation (SAE levels), Role of mechatronics in AVs: sensors, actuators, and controllers, Drive-by-wire systems: steering, throttle, braking, Mechatronic system integration and architecture of AVs

Unit II – Perception Systems and Sensor Fusion (08 Hours)
Sensors in AVs: LiDAR, Radar, Ultrasonic, GPS, IMU, and Cameras, Signal processing and sensor modeling, Sensor fusion techniques: Kalman Filter, Extended Kalman Filter, Particle Filter, SLAM (Simultaneous Localization and Mapping) basics, Indian road conditions and challenges in perception

Unit III – Artificial Intelligence in Perception and Decision Making (08 Hours)
AI for object detection, lane detection, traffic sign recognition (using CNNs, YOLO, etc.), Path planning and obstacle avoidance: Dijkstra, A*, RRT, Deep learning and reinforcement learning in AVs, Behaviour prediction and decision-making models, Case studies: AI-based vision systems for Indian traffic

Unit IV – Control Systems for Autonomous Vehicles (08 Hours)
Control strategies: PID, Model Predictive Control (MPC), Fuzzy Logic, Adaptive Control, Trajectory tracking and lateral control, Longitudinal control and cruise control, AI-enhanced vehicle dynamics and adaptive driving, Real-time control challenges in dynamic environments

Unit V – System Integration, Simulation, and Case Studies (08 Hours)
ROS (Robot Operating System) and middleware platforms, Vehicle simulation platforms: CARLA, Gazebo, MATLAB/Simulink, Hardware-in-the-loop (HIL) and Software-in-the-loop (SIL) testing, Autonomous vehicle projects and start-ups in India (e.g., Minus Zero, Ati Motors, Swaayatt Robots), Emerging trends: V2X communication, ethical AI, cybersecurity in AVs

Reference Books

1. Rajesh Rajamani, *Vehicle Dynamics and Control*, Springer India, 2012 (widely used in Indian institutes)
2. R.K. Rajput, *Mechatronics*, S. Chand Publishing, Latest Edition
3. Nitin Shrivastava, *Artificial Intelligence in Autonomous Vehicles*, BPB Publications, 2022
4. E. Balagurusamy, *Artificial Intelligence*, McGraw Hill Education India, 2021
5. Ashok Deshpande, *Artificial Intelligence for Robotics*, TechKnowledge Publications (India), 2020
6. J. S. R. Jang, C. T. Sun, E. Mizutani, *Neuro-Fuzzy and Soft Computing*, PHI (Indian Edition), 2000
7. Mohan Kumar, *Sensors and Actuators*, Vikas Publishing House, 2018

Semester-II

Electric Mobility & Smart Actuators [PCCC-510-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-510-MTX	4	50	50	-	-	100	4

Unit I – Introduction to Electric Mobility **(08 Hours)**

Overview of electric mobility: concepts and evolution, Need for electric vehicles: environmental, economic, and technological aspects, Types of electric vehicles: BEV, HEV, PHEV, FCEV, Components of electric mobility systems: motors, batteries, power electronics, controllers, Advantages, challenges, and future trends in electric mobility

Unit II – Electric Drives and Power Electronics **(08 Hours)**

Basics of electric drives for mobility: DC, AC, BLDC, PMSM, induction motors, Motor control techniques: vector control, direct torque control, Power electronics in EVs: converters, inverters, chargers, Energy efficiency, regenerative braking, and thermal management, Case studies of Indian EV implementations

Unit III – Smart Actuators: Fundamentals **(08 Hours)**

Introduction to actuators: definition, types, and working principles, Smart actuators: piezoelectric, shape memory alloys, electroactive polymers, Sensors and actuators integration in mechatronic systems, Applications of smart actuators in robotics, automotive, aerospace, and industrial automation, Performance metrics and selection criteria

Unit IV – Control and Embedded Systems for Smart Actuators **(08 Hours)**

Embedded controllers and microcontrollers in actuator systems, Feedback and adaptive control for precision actuation, Signal conditioning and actuator interfacing, Communication protocols and IoT integration for smart actuation, Case studies: Indian industrial and automotive applications

Unit V – Applications and Emerging Trends **(08 Hours)**

Electric mobility: EVs, hybrid vehicles, electric two-wheelers, buses, and smart transportation systems, Smart actuators in robotics, biomedical devices, aerospace, and process automation, Integration with renewable energy and smart grids, Industry 4.0 and IoT-enabled actuator systems, Future trends: AI-enabled actuators, energy harvesting actuators, autonomous mobility

Reference Books

1. R. K. Rajput, *Electric Machines and Drives*, S. Chand Publishing, 2019.
2. M. L. Mathur, R. P. Sharma, *Electric Vehicles: Theory and Design*, Dhanpat Rai & Co., 2018.
3. K. N. Bhat, *Electric and Hybrid Vehicle Technology*, New Age International Publishers, 2019.
4. R. K. Mittal, *Actuators and Control Systems in Mechatronics*, S. Chand Publishing, 2020.
5. P. K. Mishra, *Smart Actuators and Sensors in Mechatronics*, Katson Books, 2021.
6. B. L. Singh, *Electric Vehicles and Energy Storage Systems*, Khanna Publishing House, 2019.
7. S. P. Sukhatme, *Renewable Energy and Electric Mobility*, Tata McGraw-Hill, 2017.

Semester-II

Robotics & Automation Lab [PCC–511-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-511-MTX	4	-	-	25	25	50	2

Laboratory Work / Assignments

The term work shall consist of the following **experiments and assignments**:

01 **Trajectory Planning and Simulation for a Robotic Arm using MATLAB/ROS or Equivalent Software**
Implement joint-space and Cartesian-space trajectory planning.
Simulate motion of 2-DOF and 3-DOF robotic arms using standard software tools.

02 **Forward and Inverse Kinematics of a Multi-DOF Robot**
Derive and solve kinematic equations for robotic manipulators.
Verify kinematic solutions using simulation tools or robotic simulation environments like V-REP, ROS, or MATLAB Robotics Toolbox.

03 **Dynamic Modelling and Simulation of a Robotic Manipulator**
Perform dynamic analysis using Lagrange-Euler or Newton-Euler formulations.
Validate the model with simulations and analyze joint torques, forces, and accelerations

04 **Path Planning and Obstacle Avoidance using Simulation Environment (e.g., Gazebo with ROS)**
Implement algorithms like A*, RRT, or Dijkstra.
Simulate autonomous mobile robot navigation in a mapped environment with static/dynamic obstacles.

05 **Control of a DC/Stepper/Servo Motor using Arduino/Simulink/PLC**
Design open-loop and closed-loop control schemes.
Test motor response under varying inputs and feedback mechanisms.

06 **PID Control Design and Tuning for Motion Control Applications**
Design a PID controller for position or speed control of motors or robotic joints.
Tune the controller and analyze performance metrics like overshoot, settling time, and steady-state error.

07 **Sensor Integration for Robotics Applications**
Interface proximity, ultrasonic, IR, and/or vision sensors with microcontrollers.
Implement basic sensor fusion logic for robotic control or automation tasks.

08 **PLC Programming and HMI Integration for Automation Systems**
Develop ladder logic for sequential control operations.
Integrate PLC with HMI software for real-time monitoring and control.

09 **Implementation of Vision-Based Object Detection or Tracking**
Use Open CV/MATLAB to implement object detection using color, shape, or feature-based tracking.
Integrate vision feedback into robot control systems.

Semester-II

Elective – II

Micro-Electro-Mechanical Systems & Microsystems [PEC-512-MTX]-A

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-512-MTX-A	3	50	50	-	-	100	3

Unit I – Introduction to MEMS and Microsystems **(06 Hours)**
Definition and overview of MEMS and Microsystems, Evolution and interdisciplinary nature of MEMS, Typical MEMS devices and applications: accelerometers, pressure sensors, gyroscopes, Scaling laws and miniaturization concepts, MEMS market trends and industrial scenario in India

Unit II – Materials and Microfabrication Techniques **(06 Hours)**
MEMS materials: silicon, polymers, metals, ceramics, Bulk micromachining and surface micromachining, LIGA process, etching (isotropic and anisotropic), deposition methods, Lithography: photolithography, electron beam lithography, Cleanroom requirements and contamination control

Unit III – Microsensors and Microactuators **(06 Hours)**
Principles of microsensors: piezoresistive, capacitive, piezoelectric, thermal, optical sensors, Microactuators: electrostatic, thermal, piezoelectric, electromagnetic actuators, Design and performance parameters of sensors and actuators, Integration with signal conditioning circuits, Case studies of MEMS sensors used in automotive and biomedical applications

Unit IV – Design, Modeling, and Simulation **(06 Hours)**
Design considerations for MEMS devices, System-level design and layout, Modeling of MEMS structures using lumped and distributed parameter models, Introduction to simulation tools: COMSOL Multiphysics, CoventorWare, IntelliSuite, Mechanical behavior of microstructures: bending, stress, vibration

Unit V – Microsystems Packaging and Applications **(06 Hours)**
Packaging challenges: mechanical, thermal, electrical considerations, Wafer bonding and encapsulation techniques, Reliability and testing of MEMS devices, Applications in automotive (airbag, tire pressure sensors), healthcare (lab-on-chip, drug delivery), aerospace, and IoT, MEMS industries and research centers in India

Reference Books and Resources:

1. T. R. Hsu, *MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering*, Wiley India, Latest Edition
2. G.K. Ananthasuresh, *Micro and Smart Systems*, Wiley India, 2010
3. Nitaigour Mahalik, *MEMS*, Tata McGraw-Hill Education, 2007
4. C.R. Rajan and S. Rajendra, *Microsystem Technology*, MJP Publishers, 2020
5. Shubham Kher, *Introduction to MEMS*, Khanna Publishing House, 2022
6. Journals from **IITs and IISc**, and conference proceedings from **IEEE MEMS India Chapter**

Semester-II

Elective – II
Human-Robot Interaction [PEC-512-MTX]-B

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-512-MTX-B	3	50	50	-	-	100	3

Unit I – Introduction to Human-Robot Interaction **(06 Hours)**
Definition and scope of HRI, Historical development and interdisciplinary nature of HRI, Types of human-robot interaction: remote, supervisory, collaborative, and social, Key challenges: safety, transparency, autonomy, and acceptance, Domains of application: industrial, healthcare, military, education, home, and entertainment

Unit II – Human Factors and Perception in HRI **(06 Hours)**
Human cognitive and physical capabilities relevant to HRI, Perception and situational awareness, Ergonomics and anthropometrics in robotic system design, User-centered design principles, Trust, mental models, workload, and decision support

Unit III – Robot Perception and Behavior Modeling **(06 Hours)**
Sensors for HRI: vision, speech, haptics, proximity, force, Emotion recognition and gesture recognition, Behavior modeling and intent recognition, Social cues and affective computing in robots, Adaptive and personalized robot behavior

Unit IV – Communication and Interfaces **(06 Hours)**
Communication modalities: speech, gesture, haptics, graphical interfaces, Multimodal interaction and fusion, Natural Language Processing (NLP) in robotics, Teleoperation and shared autonomy, Interfaces for disabled and elderly interaction (assistive HRI)

Unit V – Safety, Ethics, and Applications **(06 Hours)**
Physical human-robot interaction (pHRI) and safety standards, ISO standards and safety mechanisms in collaborative robots (cobots), Ethical issues in HRI: privacy, autonomy, bias, transparency, Human-robot teaming and collaborative task execution, Case studies: collaborative manufacturing (e.g., UR robots), medical assistance (e.g., surgical robots), and social robots in Indian context

Reference Books:

1.Dinesh K. Anvekar, *Human-Robot Interaction: Concepts and Applications*, TechKnowledge Publications, 2021
2. Ravindra K. Ahuja, *Introduction to Robotics and HRI*, Khanna Book Publishing, 2022
3. Maja J. Mataric, *The Robotics Primer*, MIT Press (Indian Edition), 2014
4. Robin R. Murphy, *Introduction to AI Robotics*, PHI Learning India, 2011
5. K. S. Fu, R. C. Gonzalez, C. S. G. Lee, *Robotics: Control, Sensing, Vision, and Intelligence*, McGraw-Hill Education India
6. Selected Research Papers from Indian journals (e.g., IJIRSET, ARPN, JCISE) on HRI applications in Indian manufacturing and healthcare

Semester-II

Elective – II
Embedded IoT Systems [PEC-512-MTX]-C

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-512-MTX-C	3	50	50	-	-	100	3

Unit I- IoT Fundamentals **(06 Hours)**

IoT Architecture and Design Concepts: IoT – An architectural overview, Main Design Principles and capabilities, M2M & IOT Technology Fundamentals- End Devices and gateways, Local and wide area networking,

Sensors: different types/classes of sensors, 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

Unit II- IoT Protocols **(06 Hours)**

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

Unit III- Interfacing Embedded Boards and Programming **(06 Hours)**

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

Unit IV- Industrial IoT **(06 Hours)**

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.

Unit V- Applications of IoT **(06 Hours)**

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

Reference Books

1. Olivier Hersent, David Boswarthick, and Omar Elloumi, "The Internet of Things: Key Applications and Protocols", 2 nd Edition, Wiley Publications.
2. Arshdeep Bahga and Vijay Madisetti , "Internet of Things: A Hands-On Approach", Orient Blackswan Private Limited - New Delhi; First Edition (1 January 2015).
3. Simon Monk , "Programming Raspberry Pi", McGraw Hill TAB; 2nd edition

Semester-II

Elective – II

Soft Computing Techniques in Mechatronics [PEC-512-MTX]-D

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-512-MTX-D	3	50	50	-	-	100	3

Unit I – Introduction to Soft Computing and Mechatronics Applications (06 Hours)

Overview of soft computing and conventional computing, Importance of soft computing in intelligent mechatronic system design, Characteristics of soft computing techniques: tolerance to imprecision, uncertainty, and learning, Mechatronic system challenges requiring soft computing: nonlinearities, adaptiveness, noise, Examples: intelligent control, pattern recognition, fault diagnosis

Unit II – Fuzzy Logic Systems (06 Hours)

Basics of fuzzy set theory and fuzzy logic, Membership functions, fuzzy rules, and linguistic variables, Fuzzy inference systems: Mamdani and Sugeno models, Fuzzification, rule evaluation, defuzzification, Applications in fuzzy control of DC motors, robotics, process systems

Unit III – Artificial Neural Networks (06 Hours)

Structure and working of artificial neural networks (ANNs), Perceptron, multi-layer perceptrons (MLP), backpropagation learning, Activation functions and learning rules, Neural network modeling and control, Applications: system identification, inverse kinematics, motor control in mechatronics

Unit IV – Genetic Algorithms and Evolutionary Techniques (06 Hours)

Introduction to optimization and genetic algorithms (GA), Operators: selection, crossover, mutation, Fitness evaluation and convergence criteria, GA-based design and tuning of controllers, Application examples: trajectory planning, tuning of fuzzy/NN controllers

Unit V – Hybrid Soft Computing Systems and Case Studies (06 Hours)

Neuro-fuzzy systems: ANFIS architecture and training, Genetic-fuzzy and genetic-neural systems, Design of hybrid intelligent controllers, Real-time implementation issues in mechatronic systems, Case studies in robotics, manufacturing automation, and process control using MATLAB and LabVIEW

Reference Books and Resources:

1. S. Rajasekaran and G.A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic and Genetic Algorithms*, PHI Learning, 2017
2. N.P. Padhy, *Artificial Intelligence and Intelligent Systems*, Oxford University Press India, 2005
3. Ashok D. Belegundu, *Soft Computing and Intelligent Systems*, Khanna Publishing House, 2021
4. Priti Srinivas Sajja, *Essentials of Soft Computing*, Springer India, 2020
5. R. Rajasree, *Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications*, New Age International Publishers, 2022
6. Selected research papers and case studies from Indian journals such as *Journal of Intelligent & Fuzzy Systems* and *IJAREEIE*

Semester-II

Elective – III
Digital Manufacturing [PEC-513-MTX]-A

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-513-MTX-A	3	50	50	-	-	100	3

Unit I – Introduction to Digital Manufacturing **(06 Hours)**
Definition and scope of digital manufacturing, Evolution from traditional to digital and smart manufacturing, Core technologies: CAD, CAM, CAE, CNC, PLM, Role of Mechatronics in digital manufacturing, Overview of Industry 4.0 and its relevance in India

Unit II – Automation and Control in Digital Manufacturing **(06 Hours)**
Industrial automation systems: PLCs, SCADA, DCS, Integration of robotics and CNC machines, Closed-loop control in manufacturing processes, Adaptive and predictive control systems, Sensors, actuators, and IoT for real-time data acquisition

Unit III – Digital Twins, Simulation and Virtual Commissioning **(06 Hours)**
Concept of digital twins in manufacturing, System modeling and simulation tools (MATLAB/Simulink, Siemens NX, etc.), Virtual manufacturing and factory simulation, Virtual commissioning of automated systems, Case studies of digital twin implementations in production lines

Unit IV – Data-Driven Manufacturing and Analytics **(06 Hours)**
Manufacturing data lifecycle: acquisition, storage, processing, Machine Learning and AI for predictive maintenance and quality control, Cloud computing and edge computing in manufacturing, Cybersecurity in connected manufacturing systems, Applications of big data analytics in shop floor operations

Unit V – Advanced Topics and Case Studies **(06 Hours)**
Additive Manufacturing (3D printing) and its integration with digital workflows, Human-Machine Collaboration in smart factories, Cyber-Physical Production Systems (CPPS), Implementation challenges and roadmap for Indian industries, Case studies from Indian manufacturing (e.g., Tata Motors, BHEL, Bharat Forge, Maruti Suzuki)

Reference Books:

1. Amitabh Ghosh, *Rapid Prototyping: Principles and Applications*, East West Press, 2015
2. N. Venkata Reddy, *Product Design and Manufacturing*, New Age International, 2010
3. P. N. Rao, *CAD/CAM Principles and Applications*, Tata McGraw-Hill Education, 2017
4. Umesh Shanker, *Digital Manufacturing and Automation*, Khanna Publishing House, 2021
5. Amit Joshi & S.B. Patil, *Industry 4.0: Smart Manufacturing*, BPB Publications, 2020
6. Reports and publications from NASSCOM, CII, Smart Manufacturing Platform

Semester-II

Elective – III
Autonomous Vehicles [PEC-513-MDE]-B

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-513-MTX-B	3	50	50	-	-	100	3

Unit I – Introduction to Autonomous Vehicles **(06 Hours)**
Overview and history of autonomous vehicles, SAE levels of driving automation, Key components of AV systems: perception, decision, control, and actuation, System architecture and block diagram of an autonomous vehicle, Challenges in Indian driving scenarios: traffic complexity, road infrastructure, regulations

Unit II – Sensing and Perception **(06 Hours)**
Sensors used in AVs: LiDAR, radar, ultrasonic, camera, GPS, IMU, Sensor characteristics and selection, Environment perception: object detection, tracking, and classification, Introduction to computer vision and deep learning in perception, Data fusion techniques: Kalman Filter, Extended Kalman Filter, Particle Filter

Unit III – Localization and Mapping **(06 Hours)**
Basics of localization and need for accurate positioning, GPS-IMU integration, Simultaneous Localization and Mapping (SLAM), Map types: topological, metric, semantic, Occupancy grids and sensor map generation

Unit IV – Path Planning and Control **(06 Hours)**
Motion planning algorithms: A*, D*, RRT, potential field methods, Behavior planning and trajectory generation, Vehicle kinematics and dynamics for control, Path tracking controllers: Pure Pursuit, Stanley, Model Predictive Control (MPC), Obstacle avoidance and real-time constraints

Unit V – System Integration and Case Studies **(06 Hours)**
Software architecture for AVs: ROS, middleware frameworks, Autonomous vehicle simulation platforms: CARLA, Gazebo, MATLAB, Human-machine interaction and safety, Ethics, legal, and regulatory issues in AV deployment, Case studies of autonomous vehicle projects (e.g., Waymo, Tesla Autopilot, Indian startups like Swaayatt Robots, Ati Motors)

Reference Books and Resources:

1.Rajesh Rajamani, *Vehicle Dynamics and Control*, Springer India, 2012
2. Siva Yellampalli, *Autonomous Vehicles: Technologies, Legal and Ethical Issues*, Cengage India,
3. Shashank Pandey, *Introduction to Self-Driving Cars*, Khanna Publishing House, 2023
4. Barbara M. Osborn, *Autonomous Driving Technologies*, Wiley India, 2021
5. Jackie Kay et al., *Programming Self-Driving Cars*, Pearson Education

Semester-II

Elective – III

Fault Diagnosis and Predictive Maintenance [PEC-513-MTX]-C

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-513-MTX-C	3	50	50	-	-	100	3

Unit I – Introduction to Fault Diagnosis and Maintenance **(06 Hours)**

Definitions: fault, failure, error, and degradation, Types of maintenance: reactive, preventive, predictive, and condition-based, Importance of fault diagnosis and predictive maintenance in mechatronics, Maintenance strategies in industrial systems, Basic reliability concepts: MTBF, MTTR, availability

Unit II – Fault Detection and Isolation (FDI) Basics **(06 Hours)**

Fault detection vs. fault diagnosis, Classification of faults: abrupt, incipient, intermittent, Introduction to model-based and data-driven FDI methods, Performance metrics for FDI systems (sensitivity, specificity), Examples: sensor faults, actuator faults, system-level faults

Unit III – Condition Monitoring Techniques **(06 Hours)**

Overview of condition monitoring, Common monitoring parameters: vibration, temperature, current, acoustic signals, Sensors and signal acquisition systems, Signal processing for fault detection: FFT, STFT, wavelet transform, Vibration analysis for rotating machinery

Unit IV – Predictive Maintenance Techniques **(06 Hours)**

Basics of predictive analytics and remaining useful life (RUL) estimation, Use of statistical and machine learning methods (basic overview), Trend analysis, thresholding, and regression techniques, Simple health indicators and degradation modeling, Introduction to tools: MATLAB, Python, Scikit-learn

Unit V – Case Studies and Industrial Applications **(06 Hours)**

Applications in motors, pumps, gearboxes, bearings, and CNC machines, PLC-based and SCADA-based fault monitoring, Basic implementation in smart factories and Industry 4.0 context, Indian case studies: manufacturing, process plants, and automotive sectors, Challenges and limitations in real-time fault monitoring

Reference Books:

1.R. A. Collacott, Mechanical Fault Diagnosis and Condition Monitoring, CRC Press (Indian Edition)
2. Amit Sehgal, Industrial Maintenance, S. Chand Publishing, 2021
3. P. Balaji, Condition Monitoring of Machines, Yes Dee Publishing, 2015
4. B.K. N Rao, Handbook of Condition Monitoring, Elsevier India, 2006
5. S. K. Saha, Fault Diagnosis and Monitoring of Electrical Systems, Universities Press, 2022
6. NPTEL/ SWAYAM courses: Condition Monitoring Techniques, Maintenance Engineering

Semester-II

Elective – III

Autonomous Drones and Unmanned Systems [PEC-513-MTX]-D

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-513-MTX-D	3	50	50	-	-	100	3

Unit I – Introduction to Drones and Unmanned Systems **(06 Hours)**

Classification of unmanned systems: aerial (UAV), ground (UGV), and marine (USV, UUV), Types of drones: fixed-wing, rotary-wing (quadcopter, hexacopter), hybrid, Components of a drone: frame, motors, ESCs, propellers, flight controller, battery, GPS, Basic working principles of drones and quadrotors, Overview of DGCA guidelines and UAV regulations in India

Unit II – Drone Dynamics and Flight Control **(06 Hours)**

Degrees of freedom and coordinate frames, Basic quadcopter dynamics and equations of motion, Flight modes: manual, altitude hold, position hold, autonomous, Introduction to PID control for roll, pitch, yaw, and altitude, Stability considerations and basic tuning

Unit III – Navigation and Sensor Integration **(06 Hours)**

Onboard sensors: IMU, barometer, GPS, magnetometer, ultrasonic, LiDAR, Sensor fusion basics: complementary filter and Kalman filter (introductory level), Waypoint navigation and autonomous flight using GPS, Introduction to SLAM (concept only), Fail-safe features and return-to-home logic

Unit IV – Mission Planning and Autonomy **(06 Hours)**

Ground control software: Mission Planner, Q Ground Control, Autonomous mission planning: mapping routes, setting waypoints, Introduction to MAVLink protocol and telemetry systems, Real-time communication and telemetry, Overview of obstacle avoidance (basic concepts)

Unit V – Applications and Case Studies **(06 Hours)**

Applications in agriculture, surveillance, mapping, disaster management, and logistics, Case studies from Indian startups and government projects (e.g., Garuda Aerospace, ideaForge, DRDO), Challenges in Indian environments: GPS denial, interference, power management, Safety, legal, and ethical issues in drone deployment, Recent trends: drone swarms, AI in UAVs, BVLOS operations

Reference Books and Resources:

1. K. Venkateswara Rao, *Unmanned Aerial Vehicles: Design and Development*, Notion Press, 2020
2. B. M. Patre & G. S. Birajdar, *Drone Technologies and Applications*, Technical Publications, 2021
3. Anil V. Deshpande, *Introduction to Flight Vehicles: Design and Control*, Wiley India, 2017
4.DGCA India: *Civil Aviation Requirements (CAR) for RPAS*

Seminar – I, II, and III

[SEM-514-MTX, SEM-603-MTX, SEM-605-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Pr. Hrs/Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
SEM- 514-MTX	4	-	-	25	25	50	2
SEM - 603-MTX	6	-	-	25	25	50	3
SEM - 605-MTX	8	-	-	50	50	100	4

Assessment of the Seminar has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

- **INSTRUCTIONS FOR SEMINAR REPORT WRITING**
- It is important that the procedures listed below be carefully followed by all the students of
- M.E. (Mechatronics).
- Prepare **3 COPIES** of your manuscript.
- Report size limits:
- **Seminar I:** 15–20 manuscript pages
- **Seminar II:** 20–25 manuscript pages
- **Research Project Based Seminar:** 25–30 manuscript pages
- Formatting Guidelines
- **Footer** must include:
- Institute Name, *M.E. (Mechatronics Engineering)*, Times New Roman, 10 pt., centered.
- Page number on second line of footer, Times New Roman, 10 pt., centered.

- **Text Style:**
- Times New Roman, 12 pt., justified.
- **Line spacing:** 1.5
- **Paragraphs:** one blank line between each, no indentation.
- **Spacing:** Entire report shall be **one single chapter** (No multiple chapters for Seminar I, II, or III).
- **Concluding Part:** Seminar I shall end with *Summary only*, not *Conclusions*.

Paper Size: 8.5" × 11" OR A4 (210 × 297 mm).

Margin Location	Paper 8.5" × 11"	Paper A4 (210 × 197 mm)
Top	1"	25.4 mm
Left	1.5"	37 mm
Bottom	1.25"	32 mm
Right	1"	25.4 mm

- **Margins:** Headings
- **Section Titles:** Bold, 14 pt., ALL CAPITALS, left aligned.
- **Sub-Section Headings:** Bold, 12 pt., Title Case, left aligned.
- **Numbering:** Sections as 1, 2, 3…; Subsections as 1.1, 1.2…; Sub-subsections as 2.1.1, 2.1.2…
- Figures & Illustrations
- Insert figures, charts, drawings, or photographs **within the text**.
- Use only **relevant and original illustrations** (no direct internet downloads).
- Not more than **two illustrations per page** (preferably one).
- **Figure Number & Title:** Below figure, 12 pt.
- **Legends:** Below title, 10 pt.
- Maintain clear margins; figures should be **sharp, black & white**.
- Photographs, if used, must be glossy prints.
- Avoid Xerox copies.
- Report Order
- **Cover Page & Front Page** *(as per specimen, on separate sheets)*
- **Certificate from Institute** *(as per specimen)*
- **Acknowledgement**
- **List of Figures**
- **List of Tables**
- **Nomenclature**
- **Contents**
- **Abstract** *(max 150 words, Times New Roman, 12 pt., center heading, body justified. Include motive, method, key results, and summary.)*
- **Introduction**
- **Main Seminar Content**
- **Summary / Conclusions (for Seminar II & III only)**
- **References**
- References Style
- **Books:**
  Collier, G. J. and Thome, J. R., *Convective Boiling and Condensation*, 3rd ed., Oxford University Press, UK, 1996, pp. 110–112.
- **Journal Papers:**
  Jung, D. S. and Radermacher, R., Transport properties and surface tension of pure and mixed refrigerants, *ASHRAE Trans.*, 1991, 97 (1), pp. 90–98.
- **Conference Papers:**
  Colbourne, D. and Ritter, T. J., Quantitative assessment of flammable refrigerants in room air conditioners, *Proc. of the 16th International Compressor Engineering Conference*, Purdue University, Indiana, USA, 2002, pp. 34–40.
- **Reports/Handbooks:**
  United Nations Environmental Programme, *Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Option Committee*, 2002.
- **Patents:**
  Patent No., Country (in parenthesis), date of application, title, year.
- **Web References:**
  www.(Site) [Give full-length URL]

Format for front page and Certificate

A Seminar I / II / III (TNR, 16pt, centrally aligned)

Title (TNR, 27pt, Bold, Centrally Aligned, Title Case)

By (TNR, 16pt, Centrally Aligned)

Mr. Student's Name (TNR, 16pt, Centrally Aligned)

Guide (TNR, 16pt, Centrally Aligned)

Guide's Name (TNR, 16pt, Centrally Aligned)

Institute Logo

(ME-Mechatronics)
Department of Mechanical Engineering

Name of the Institute

[2025-26] (TNR, 22pt, Title Case Centrally Aligned)

Name of the
Institute

Institute Logo

C E R T I F I C A T E

This is to certify that *Mr* , has successfully completed the seminar I/II/III entitled " " under my supervision, in the partial fulfilment of Master of Engineering in Mechatronics of Savitribai Phule Pune University, Pune.

Date:
Place:

Guide's Name
Guide

Head
Department and Institute Name

External Examiner

College Seal

Principal,
Institute Name

Savitribai Phule Pune University, Pune

Maharashtra, India

ME – Mechatronics

Semester- III

Semester-III

Research Methodology [RM-601-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
RM-601-MTX	5	50	50	-	-	100	5

Unit I – Introduction **(08 Hours)**

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, Criteria of Good Research

Unit II – Research Problem and Research Design: **(08 Hours)**

Definition of good research problem, Feasibility study of research problem, Importance of research problem, Sources of research problem, Criteria of good research problem, Meaning of Hypothesis, Characteristics of Hypothesis, Errors in selecting a research problem, Concept & need of research design, Meaning of variable, Selection of variables

Unit III – Mathematical Modelling and prediction of performance: **(08 Hours)**

Steps in Setting up a computer model to predict performance of experimental system, Validation of results, Multi-scale modelling and verifying performance of process system, Nonlinear analysis of system and asymptotic analysis, verifying if assumptions hold true for a given apparatus setup, plotting family of performance curves to study trends and tendencies, Sensitivity analysis.

Unit IV – Basic instrumentation: **(08 Hours)**

Instrumentation schemes, Static and dynamic characteristics of instruments used in experimental set up, Performance under flow or motion conditions, Data collection using a digital computer system, Linear scaling for receiver and fidelity of instrument, Role of DSP in data collection in noisy environment, Good measurement practice.

Unit V – Applied statistics: **(08 Hours)**

Regression analysis, curve fitting and developing Correlation, Parameter estimation, Multivariate statistics, Principal component analysis, Moments and response curve methods, State vector machines and uncertainty analysis, Probable errors in the research, Error analysis and methods to reduce errors in research process.

Unit VI- Research report writing and Publication **(08 Hours)**

Research Report: Dissemination of research findings, outline and structure of research report, different steps and precautions while writing research report, methods and significance of referencing

Publishing Research work: Selection of suitable journal for publishing research work, Open access Vs Subscription Journals, identifying indexing of selected journals, Impact factor of the journal, structure of research paper, Check for plagiarism of the article, Research paper submission and review process.

Lab Practice:

- Write Sample research proposal of the planned research topic giving details of topic, significance, funding required etc.
- Write a research paper on review of at least 5 research papers for a research topic (Language, formatting and authors guidelines to be strictly followed from standard Springer or Elsevier Journals and referred journal details to be mentioned in the Lab practice file) and verify the research article for plagiarism and attach the plagiarism report.

Reference Books:

1. Research methodology: An Introduction for Science & Engineering students, by Stuart Melville and Wayne Goddard
2. Research Methodology: Methods and Trends, by Dr. C. R. Kothari
3. Research Methodology: An Introduction by Wayne Goddard and Stuart Melville
4. Research Methodology: A Step by Step Guide for Beginners, by Ranjit Kumar, 2nd Edition
5. Operational Research by Dr. S.D. Sharma, Kedar Nath Ram Nath & Co.
6. Software Engineering by Pressman

Semester-III

On Job Training/ Internship/ Short term course [OJT-602-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
OJT-602-MTX	10	-	-	100	-	100	5

Purpose

The Internship / On-Job Training (OJT) is designed to bridge the gap between academic learning and practical industry exposure for ME Mechatronics students. It provides hands-on experience, exposure to industrial practices, and the opportunity to develop technical, professional, and soft skills such as communication, teamwork, problem-solving, and innovation. The internship also allows students to explore career options and relate classroom knowledge to real-world applications.

Course Objectives

- To apply theoretical knowledge in practical industry settings and research environments.
- To interact and learn from experienced professionals in mechatronics and allied fields.
- To understand and adhere to professional and ethical standards in the workplace.
- To gain insight into professional communication including meetings, reports, presentations, and client interactions.
- To develop initiative, self-motivation, and independent problem-solving skills.
- To complete a mandatory short-term online/offline certificate course in an area relevant to Mechatronics (e.g., IoT, Robotics, CAD/CAM, PLC programming, Machine Learning, Embedded Systems).

Course Outcomes (COs)

- Upon successful completion of the internship, students will be able to:
- Gain practical experience in industry, R&D organizations, or reputed institutes.
- Apply classroom knowledge to real-world industrial projects.
- Develop and refine oral and written professional communication skills.
- Acquire knowledge of administration, finance, project planning, and engineering documentation.
- Understand emerging technologies in Mechatronics through short-term certificate courses.
- Demonstrate initiative, teamwork, and problem-solving in professional environments.

Course Description

The ME Mechatronics Internship provides hands-on experience in industrial and research environments. Students will engage in tasks including:

- Mechatronic system design, automation, robotics, and control projects
- Equipment handling, maintenance, and process monitoring
- Time and stress management, interactive skills, and team coordination
- Presentations, project documentation, and reporting
- Participation in short-term professional certificate programs (mandatory)

The internship can be carried out in:

- Industries related to Mechatronics and Automation
- R&D Organizations and Research Institutes
- Institutes of national/international repute
- R&D Centres of parent institutes

A faculty member will be nominated by the department to supervise and mentor students throughout the internship.

Guidelines

Internship Duration and Academic Credentials

- Mode: Online or Offline (industry-approved certificate programs accepted)
- Time commitment: 10–12 hours/week, totaling 160–170 hours
- Minimum duration: 8 weeks
- Short-term certificate course (online/offline) in a relevant Mechatronics/Automation/Smart Systems topic is **mandatory**.

Type of Internship

1. **Industry/Government Organization Internship**: Work directly with companies or government bodies.
2. **Research Internship**: Focus on projects in collaboration with R&D labs or academic institutions.
3. **Innovation/Entrepreneurship**: Develop new products, processes, or start-ups.

Social Internship: Engage in community-based projects related to engineering solutions.

Indicative Areas for OJT

- Robotics, Automation, and Mechatronic Systems
- Embedded Systems, IoT, AI/ML, and Smart Actuators
- Manufacturing, Industry 4.0, and Digital Twin Technologies
- Automotive, Aerospace, and Industrial Equipment
- Healthcare, Biomedical Devices, and Smart Systems
- Sustainable Technologies and Renewable Energy Applications

Faculty and External Supervision

- **Internal Faculty Guide:** Supervises and mentor's students, ensuring alignment with academic objectives.
- **External Mentor:** Assigned by the host organization to provide technical guidance and assess performance.

Documentation and Reporting

1. Joining Report: Submit within 1 week of starting the internship.
2. Daily/Weekly Diary: Record observations, tasks, and learning progress.
3. Internship Report: Detailed report including work done, learning outcomes, and achievements. Must be signed by the host organization and faculty mentor.
4. Completion Certificate: Issued by the host organization confirming successful completion.
5. Certificate of Short-Term Course: Proof of completion for mandatory professional course.

Assessment and Evaluation

- **Term Work (TW):** 100 marks
- Daily/weekly diary submission and logbook verification by HoD/faculty
- Report evaluation including project details, learning outcomes, and certificate submission
- **Performance Evaluation:**
- Based on feedback from industry mentor
- Viva-voce and presentation assessment by internal faculty
- **Weightage:** Practical learning, documentation, certificate course completion, and professional conduct

Mandatory Short-Term Certificate Course

- Students must complete at least one short-term online/offline certificate course in a field relevant to Mechatronics during the internship period. Examples include:
- Robotics and Automation
- PLC and Industrial Control Systems
- IoT and Embedded Systems
- AI, Machine Learning, Deep Learning for Mechatronics
- CAD/CAM, 3D Printing, and Additive Manufacturing
- Smart Sensors and Actuators

Certificates must be submitted along with the internship report for assessment.

Note:

It is **mandatory** for each student to complete **at least one** of the following during the internship period:

- **On-Job Training (OJT)**
- **Internship**
- **Short-Term Certificate Course(Online/Offline)** (in a relevant area of Mechatronics)

Completion of at least one among the three is **compulsory** for fulfilling the course requirements.

Project Stage – I and II [RPR-604-MTX, RPR-606-MTX]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	RP Hrs. / Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
RPR-604-MTX	18	-	-	25	25	50	9
RPR-606-MTX	36	-	-	150	50	200	18

Assessment of Project Stage-I/II has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

INSTRUCTIONS FOR DISSERTATION WRITING

It is important that the procedures listed below be carefully followed by all the students of M.E. (Mechatronics).

1. Prepare **Three Hard Bound Copies** of your manuscript.
2. Limit your Dissertation report to 80 – 120 pages (preferably)
3. The footer must include the following:
    i. Institute Name, M.E. (Mechatronics) Times New Roman 10 pt. and centrally aligned.
4. Page number as second line of footer, Times New Roman 10 Pt, centrally aligned.
5. Print the manuscript using
    a. Letter quality computer printing.
    b. The main part of the manuscript should be Times New Roman 12 pt. with
    c. Use 1.5-line spacing
    d. The entire report shall be of 5- 7 chapters

6. Use the paper size **8.5'' × 11''** or **A4 (210 × 197 mm).** Please follow the margins given below.

Margin Location	Paper 8.5'' × 11''	Paper A4 (210 × 197 mm)
Top	1''	25.4 mm
Left	1.5''	37 mm
Bottom	1.25''	32 mm
Right	1''	25.4mm

7. All paragraphs will be 1.5 lines spaced with a one blank line between each paragraph. Each paragraph will begin with without any indentation.
8. Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.
9. Sub-Section headings should be aligned at the left with 12 pt, bold and Title Case (the first letter of each word is to be capitalized).

10. Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, **black and white. Illustrations downloaded from the internet are not acceptable.**

a. Illustrations should not be more than **two** per page. One could be ideal
b. Figure No. and Title at bottom with **12 pt**
c. Legends below the title in **10 pt**
d. Leave proper margin in all sides
e. Illustrations as far as possible should not be photocopied.

11. Photographs if any should of glossy prints
12. Please use the SI system of units only.
13. Please number the pages on the front side, centrally below the footer
14. References should be either in order as they appear in the thesis or in alphabetical order by last name of first author
15. Symbols and notations if any should be included in nomenclature section only
16. Following will be the order of report
    16.1 Cover page and Front page as per the specimen on separate sheet
    16.2 Certificate from the Institute as per the specimen on separate sheet
    16.3 Acknowledgements
    16.4 List of Figures
    16.5 List of Tables
    16.6 Nomenclature
    16.7 Contents
    16.8 **Abstract (A brief abstract of the report not more than 150 words. The heading of abstract i.e. word "Abstract" should be bold, Times New Roman, 12 pt and should be typed at the center. The contents of the abstract should be typed on a new line without space between heading and contents. Try to include one or two sentences each on motive, method, key-results and conclusions in Abstract**

1. **Introduction (2-3 pages) (TNR – 14 Bold)**
a. Problem statement (TNR – 12)
b. Objectives
c. Scope
d. Methodology
e. Organization of Dissertation
2. **Literature Review (20-30 pages)**
Discuss the work done so far by researchers in the domain area and their significant conclusions. No derivations, figures, tables, graphs are expected.
3. **This chapter shall be based on your own simulation work (Analytical/** Numerical/FEM/CFD) (15- 20 pages)
4. **Experimental Validation - This chapter shall be based on your own experimental work (15-20 pages)**
5. **Concluding Remarks and Scope for the Future Work (2-3 pages)**
6. **References ANNEXURE (if any)**
(Put all mathematical derivations, Simulation program as Annexure)

- All section headings and subheadings should be numbered. For sections use numbers 1, 2, 3, …. and for subheadings 1.1, 1.2, …. etc and section subheadings 2.1.1, 2.1.2, …. etc.
- References should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If figures and tables are taken from any reference, then indicate the source of it. Please follow the following procedure for references

Reference Books

- Collier, G. J. and Thome, J. R., Convective boiling and condensation, 3rd ed., Oxford University Press, UK, 1996, pp. 110 – 112.

❖ **Papers from Journal or Transactions**

Jung, D. S. and Radermacher, R., Transport properties and surface tension of pure and mixed refrigerants, ASHRAE Trans, 1991, 97 (1), pp. 90 – 98.
Bansal, P. K., Rupasinghe, A. S. and Jain, A. S., An empirical correction for sizing capillary tubes, Int. Journal of Refrigeration, 1996, 19 (8), pp.497 – 505.

❖ **Papers from Conference Proceedings**

Colbourne, D. and Ritter, T. J., Quantitative assessment of flammable refrigerants in room air conditioners, Proc. of the Sixteenth International Compressor Engineering Conference and Ninth International Refrigeration and Air Conditioning Conference, Purdue University, West Lafayette, Indiana, USA, 2002, pp. 34 – 40.

❖ **Reports, Handbooks etc.**

United Nations Environmental Programme, Report of the Refrigeration, Air Conditioning and Heat Pumps, Technical Option Committee, 2002, Assessment - 2002.
ASHRAE Handbook: Refrigeration, 1994 (Chapter 44)

❖ **Patent**

Patent no, Country (in parenthesis), date of application, title, year.

❖ **Internet**

www.(Site) [Give full length URL]

A Project Stage -I Report on (TNR, 16pt, centrally aligned)

Title (TNR, 27pt, Bold, Centrally Aligned, Title Case)

By (TNR, 16pt, Centrally Aligned)

Mr. Student's Name (TNR, 16pt, Centrally Aligned)

Guide

Guide's Name (TNR, 16pt, Centrally Aligned)

Institute Logo

Department of Mechanical Engineering Name of the Institute

[2025-26](TNR, 22pt, Title Case Centrally Aligned)

Name of the
Institute Institute

Logo

C E R T I F I C A T E

This is to certify that *Mr*……., has successfully completed the Project Stage -I entitled "……." under my supervision, in the partial fulfillment of the Master of Engineering Mechatronics of Savitribai Phule Pune University, Pune.

Date :

Place :

Guide's Name
Guide

Head
Department and Institute Name

External Examiner

Seal

Principal,
Institute Name

A Dissertation on (TNR, 16pt, centrally aligned)

Title (TNR, 27pt, Bold, Centrally Aligned, Title Case)

By (TNR, 16pt, Centrally Aligned)

Mr. Student's Name (TNR, 16pt, Centrally Aligned)

Guide

Guide's Name (TNR, 16pt, Centrally Aligned)

Institute Logo

Department of Mechanical Engineering Name of the Institute

[2026-27] (TNR, 22pt, Title Case Centrally Aligned)

Name of the Institute

Institute Logo

C E R T I F I C A T E

This is to certify that ……, has successfully completed the Dissertation entitled "……." under my supervision, in the partial fulfilment of the Master of Engineering in Mechatronics of Savitribai Phule Pune University, Pune.

Date :

Place:

Guide's Name
Guide

Head
Department and
Institute Name

External Examiner

Seal

Principal, Institute Name

Task Force for Curriculum Design and Development

Program Coordinator

Dr. Dhanajay V Khankal - Member, Board of Studies – Mechatronics Engineering
Dr. Amar P. Pandhare- - Member, Board of Studies – Mechanical Engineering

Team Members for Course Design

Dr. A. P. Kaldate, Sinhgad College of Engineering, Vadgaon BK, Pune
Dr. S. O. Rajankar, Electronics & Telecommunication Department, SCOE Pune-41
Dr. V. B. Baru, Electronics & Telecommunication Department, SCOE Pune-41
Prof. Sagar S. Navale, Sinhgad College of Engineering, Vadgaon BK, Pune

Chairman

Dr. Vaibhav V Dixit - Board of Studies Mechatronics Engineering

Savitribai Phule Pune University, Pune

Dean

Dr. Pramod Patil - Dean – Science and Technology

Savitribai Phule Pune University, Pune