Semester- II

Modelling and Simulation of Mechatronics System			
Course Code	**MMRM201**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives: Students will be able to

1. Gain Knowledge of basics concepts and methodologies of modeling and simulation
2. Understand the concepts of discrete event simulation, random number generation, test for random numbers & random varieties used in simulation study.
3. Develop simulation model by simulation package for queuing system, production system and maintenance system

Module-1

System and system environment: Component of a system – Continuous and discrets systems – Types of model; Steps in Simulation study; simulation of an event occurrence using random number table – Single server queue- two server queue- inventory systems. Discrets Event Simulation: Concepts in discreet event simulation, manual simulation using event scheduling, single channel queue, two server queue, and simulation of inventory problem.

Module-2

Random number generations: Properties of random numbers – Generation of Pseudo – Random numbers – techniques of generating pseudo random numbers; Test for random number; the Chisquare test-the kolmogrov smimov test – Runs test – Gap test – poker test. FCV, symbolic representation.

Module-3

Random – Variate Generation: Inverse transform technique for Exponential, Uniform. Triangular, weibull, empirical, uniform and discrete distribution. Acceptance rejection method for Poisson and gamma distribution; Direct Transformation for normal distribution.

Module-4

Analysis of simulated Data: Data collection, identifying the distribution, parameter estimations, and goodness of fit tests, verification and validation of simulation models.

Module-5

Comparison and selection of GPSS, SIMSCRIPT, SLAM: Arena simulation languages: development of simulation models using arena simulation package for queuing system, Productions systems, maintenance system.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**

to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Discrete, Event system Simulation, Banks J., Carson J.S. and Nelson B.L., 3rd Edition, Pearson education, Inc 2004 (ISBN 81-7808-505-4).
2. System Simulation, Geoffrey Gorden, Prentice Hall of India, 2003.
3. System Simulations and Modeling,. Narsingh deo., Prentice Hall of India 2003.
4. Computer simulations and Modeling, Francis Neelamkovil, , john Wiley & Sons, 1987
5. Simulation Modeling with Pascal, Rath M.Davis & Robert M O Keefe, Prentice Hall Inc. 1989

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/112/101/112101304/
- https://onlinecourses.nptel.ac.in/noc24_me14/preview

Skill Development Activities Suggested

- Usage of MATLAB/Simulink and its related tool boxes for modelling of mechatronic system
- Application of modelling and simulation techniques to real world mechatronic system design projects

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	have fundamental knowledge of modeling and simulation.	L2
CO2	understand the techniques of discrete event simulation, random number generation, test for random number, random variants used in simulation study & simulation packages	L3
CO3	apply simulation packages for queuing system, production system and maintenance system.	L3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**2**	**2**	**3**	**2**	**2**
CO2	**2**	**3**	**3**	**2**	**3**	**3**
CO3	**2**	**2**	**2**	**3**	**3**	**3**

Semester - II

Robotics: Advanced Concepts and Analysis			
Course Code	**MMRM202**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Identify the various configurations of robots, their anatomy and transformation matrices
- Given an industrial manipulator, students will be able to analyse the kinematics by applying DH Parameters and enumerate the principles of statics associated with them
- Students will be able to analyze the dynamics of manipulators by deriving the equation of motions
- Students will be able to elucidate the issues associated with mobile robots such as its kinematics, localization, obstacle avoidance, sensing and perception
- Students will be able to enumerate the various motion control techniques and application of AI for robots.

MODULE-1

Serial Linkage Robots: Laws of Robotics, classification of serial manipulator, Anatomy of Robot, Gripper mechanisms, Automation and Robotics, Notation, Position and Orientation of a Rigid Body, Representation of a pure rotation about an axis. Some Properties of Rotation Matrices, Successive Rotations, Euler Angles For fixed frames X-Y-Z and moving frame ZYZ. Transformation between coordinate system, Homogeneous coordinates. Robot Design Process.

MODULE-2

Kinematics of serial manipulators: Representation of Links using Denvit- Hartenberg Parameters, L ink transformation matrices, Transformation matrices of 3R manipulator, PUMA560 manipulator, SCARA manipulator. Direct kinematics of 2R, manipulator, Inverse kinematics of manipulator. Velocity and Statics of Manipulators: Differential relationships, Jacobian, Differential motions of a frame (translation and rotation), Linear and angular velocity of a rigid body, Linear and angular velocities of links in serial manipulators, 2R manipulators, Jacobian of serial manipulator, Velocity ellipse of 2R manipulator, Singularities of 2R manipulator, Statics of serial manipulators

MODULE-3

Dynamics of Manipulators:

Kinetic energy, Potential energy, Equation of motion using Lagrangian, Equation of motions of one- and two-degree freedom spring mass damper systems using Lagrangian formulation, Inertia of a link, Recursive formulation of Dynamics using Newton Euler equation, Equation of motion of 2R manipulator using Lagrangian, Newton- Euler formulation.

MODULE-4

Mobile Robotics:

Classification, Key Issues in Locomotion using Legged and Wheeled Robots, Mobile Robot Kinematics, Mobile Robot Manoeuvrability, Mobile Robot Workspace, Motion Control, Sensors for Mobile Robots. Mobile Robot Localization Techniques, Path Planning & Obstacle Avoidance, Navigation Architectures. Sensing and Perception Perception Process, Force and Tactile Sensors, Inertial Sensors, GPS, and Odometry, Sonar Sensing, Multisensor Data Fusion Methods, Multisensor Fusion Architectures, Applications

MODULE 5

Motion Control

Joint Space Versus Operational Space Control, Independent-Joint Control, PID Control, Tracking Control, Computed-Torque Control, Adaptive Control, Optimal and Robust Control, Digital Implementation, Learning

Control. AI Reasoning Methods for Robotics: Knowledge Representation and Inference, KR Issues for Robots, Action Planning, Robot Learning

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

3. Two Unit Tests each of **25 Marks**
4. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**

to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

6. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
7. The question paper will have ten full questions carrying equal marks.
8. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
9. Each full question will have a sub-question covering all the topics under a module.
10. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Textbooks

(1) Introduction to Robotics, Analysis, Control, Applications by Niku S B, Wiley Publication (2011)

(2) Handbook of Robotics Compiled by Bruno Siciliano, Oussama Khatib Published by Springer (2008)Reference Books

(1) Fundamentals of Robotics, Analysis and Control by Schilling R. J, Published by PHI (2010)

(2) Robotics and Control, by Mittal and Nagrath, Tata Mc Grew Hill Publication

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/112105249
http://www.roboanalyzer.com/
https://www.robotc.net/.

Skill Development Activities Suggested

- Robot Prototype Design using TETRIX STEM Kits
- Analysis of DH Parameters using RoboAnalyzer
- Interface Sensors and Control System for Robots
- Program the robot using Arduino & RobotC
- Solve Open Ended Complex Engineering Problems

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Comprehend Representation of Rigid Bodies in 2D/3D space and apply Mathematical Techniques for transformation of bodies between coordinates	L2
CO2	Apply DH parameters and determine the forward, inverse kinematics and statics of manipulators	L3
CO3	Analyse the dynamics of manipulators using lagrangian equations and Newton- Euler formulation	L4
CO4	Comprehend the fundamentals of Mobile Robots, kinematics, sensing and its perception	L2

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			**3**	**2**		**2**
CO2		**2**	**3**	**2**		**2**
CO3		**2**	**3**	**2**		**2**
CO4		**2**	**3**	**2**		**2**

Semester - II

Manufacturing Technology for Robots			
Course Code	**MMRM203**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

The course will enable the students to:

- Introduce students to different methods of fabrication used in the manufacturing of robotic components.
- Develop an understanding of the materials used in robotic component fabrication and their properties. Familiarize students with traditional manufacturing processes commonly employed in the robotics industry.
- Provide an overview of additive manufacturing techniques and their applications in robotics.
- Introduce students to CNC programming and machining for precise fabrication of robotic components.

MODULE-1

Methods of Fabrication: Introduction to Fabrication Methods, Definition of fabrication methods, Importance of fabrication in robotics and automation, Overview of different fabrication techniques. Welding and Joining Techniques, Types of welding processes (arc welding, spot welding) Principles and applications of welding in robotic, component fabrication, Joint design considerations, Machining Processes, Introduction to machining operations (turning, milling, drilling, etc.).

Machining tools and equipment: used in robotic component fabrication, Cutting parameters and tool selection, Sheet Metal Fabrication, Basics of sheet metal fabrication, Techniques for bending, cutting, and Forming sheet metal, Applications of sheet metal in robotic component manufacturing.

MODULE-2

Materials for Robotic Components: Material Selection for Robotic Components, Introduction to materials used in robotics (metals, polymers and composites), Material properties and their significance in robotic component design, Factors influencing material selection for specific applications.

Metal Alloys and Composites: Overview of commonly used metal alloys in robotics, Properties and advantages of composite materials, Application areas and considerations for using composites in robotic components, Polymers and Elastomers, Properties and characteristics of polymers and elastomers, Use of polymers and elastomers in robotic component fabrication, Selection criteria and limitations of polymer-based materials.

MODULE-3

Traditional Manufacturing: Casting and Molding, Principles and processes of casting and molding, Different types of casting techniques (sand casting, investment casting.) Molding techniques for robotic component production, Forming and Stamping, Introduction to forming and stamping processes, Presses and tools used in forming and stamping operations, Applications and advantages of forming and stamping in robotics.

Machining and CNC Operations: Advanced machining techniques for robotic component fabrication, Introduction to Computer Numerical Control (CNC) machines, Programming basics for CNC machining.

MODULE-4

Additive Manufacturing: Introduction to Additive Manufacturing, Definition and principles of additive manufacturing, Various additive manufacturing technologies (3D printing, selective laser sintering, etc.), Benefits and limitations of additive manufacturing in robotics.

Additive Manufacturing Techniques: Detailed study of different additive manufacturing processes, Materials used in additive manufacturing for robotic components, Design considerations and optimization for additive manufacturing, Applications of Additive Manufacturing in Robotics, Case studies showcasing the use of additive manufacturing in robotics, Rapid prototyping and customization possibilities with additive manufacturing, Future trends and advancements in additive manufacturing for robotics.

MODULE 5

CNC Programming and Machining: Introduction to CNC Programming, Fundamentals of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM), Basics of CNC programming language (G-code, M- code), Programming techniques and syntax for CNC machining operations, CNC Machining Operations, Detailed study of CNC machining processes (turning, milling, drilling, etc.).

Machining strategies and tool selection for specific operations: Troubleshooting common issues in CNC machining, CNC Machining of Robotic Components, Programming and machining of simple robotic parts using CNC machines, Precision requirements and dimensional tolerances in robotic component fabrication, Inspection and quality control techniques for CNC machined parts.

PRACTICAL COMPONENT OF IPCC*(May cover all / major modules)*

Sl.NO	Experiments
1	Joining Processes: Students should practice for joining processes, such as Soldering, Brazing and welding (any two models on each).
2	Machining Practice: Students should practice for machining operations (turning, milling, and drilling) on sample work pieces to develop their machining skills.
3	Sheet Metal Fabrication: Students should practice for Sheet metal operations for preparing frustum of cone, cylinder and tray. (Optional)
4	Casting and Molding: Students should practice to prepare different patterns to pour molten metal by using sand casting
5	Additive Manufacturing Workshop: Organize workshop for students in designing and 3D printing simple robotic components using different materials and printing techniques.
6	CNC Programming and Machining: Students should practice for program CNC machines for machining robotic components using CAM software.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **25 Marks**
2. Two assignments each of **25 Marks/One Skill Development Activity of 50 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The **15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for **10 marks**. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test at the end /after completion of all the experimentsshall be conducted for **50 marks** and scaled down to **05 marks.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by the University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course (CIE+SEE)

Suggested Learning Resources:

Text Books

1. "Manufacturing Engineering and Technology" by Serope Kalpakjian and Steven R. Schmid. Kalpakjian, Serope. 6th edition in SI units Serope Kalpakjian Illinois Institute of Technology Steven R. Schmid The University of Notre Dame SI Conversion by Hamldon Musa Universiti Teknologi Malaysia Prentice Hall Singapore London." (2007).

2. "Materials Science and Engineering: An Introduction" by William D. Callister Jr. and David G. Rethwisch. 10th edition, John Wiley & Sons, 2020.

3. "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing" by Ian Gibson, David W. Rosen, and Brent Stucker. 2nd edition, Springer Publications 2015.

4. "CNC Programming Handbook" by Peter Smid., 2nd edition, Industrial Press Inc. 2003.

Reference Books/Journal

1. Introduction to Robotics: Mechanics and Control Authors: John J. Craig.

2. Renfrew, Alasdair. "Introduction to robotics: Mechanics and control." International Journal of Electrical Engineering & Education 41.4 (2004): 388.

3. Industrial Robotics: Technology, Programming, and Applications, Groover, Mikell P., Mitchell Weiss, andRoger N. Nagel. Industrial robotics: technology, programming and application. McGraw-Hill Higher Education, 1986.

Web links and Video Lectures (e-Resources):

1. Robotics Online (https://www.robotics.org/) Description: This website provides comprehensive resources related to robotics, including articles, industry news, and information on fabrication methods.

2. Video Lecture Series: MIT Open Course Ware - Introduction to Robotics (https://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/)

Description: This video lecture series covers various topics in robotics, including fabrication methods, materials, and manufacturing processes.

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Fabrication Method Demonstration: Conduct hands-on demonstrations of different fabrication methods, such as welding, milling, 3D printing, and laser cutting, to help students understand the practical aspects.

Material Selection Exercise: Assign students a project where they have to analyze the requirements of a robotic component and select the most suitable material based on its properties.

Traditional Manufacturing Case Study: Present a case study of a real-world robotic component manufacturing process and discuss the challenges faced and the solutions employed in the industry.

Additive Manufacturing Workshop: Organize a workshop where students can experiment with additive manufacturing techniques like fused deposition modeling (FDM) or stereo lithography (SLA) to create robotic component prototypes. **CNC Programming and Machining Lab:** Provide students with hands-on experience in CNC programming and machining by allowing them to design and manufacture simple robotic components using CNC machines

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand various fabrication methods and their applications in the robotics field.	L2
CO2	Understand the material behavior and analyze its usages for different robotic components based on their properties.	L3
CO3	Apply traditional manufacturing processes to fabricate robotic components accurately.	L3
CO4	Adopt additive manufacturing techniques for rapid prototyping and production of robotic components.	L3
CO5	Demonstrate proficiency in CNC programming and machining operations to create precise robotic components.	L3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		**2**	**3**	**3**	**3**	**3**
CO2		**3**	**3**	**2**	**2**	**2**
CO3		**2**	**3**	**3**	**3**	**3**
CO4		**3**	**2**	**2**	**2**	**3**
CO5				**3**	**3**	**3**

Professional Elective -3

Signal Processing in Mechatronic Systems			
Course Code	MMRM214A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Understand the various aspects of signals and systems.
- Compute the response of discrete-time Linear and Time-Invariant Systems
- Represent the discrete-time signals and systems in frequency domain
- Design analog and digital filters for signal processing.

MODULE-1

Introduction: Signals and Systems-Definition and Examples, Basic Elements of a Digital Signal Processing System, Advantages of Digital Signal Processing over Analog Signal Processing, Classification of Signals, The Concept of Frequency in Continuous-Time and Discrete-Time Signals, Analog to Digital Conversion (Block Diagram Discussion)
Discrete-Time Signals: Elementary Discrete-Time Signals, Classification of Discrete-Time signals, Manipulation of Discrete-time Signals

MODULE-2

Discrete-Time Systems: Input-Output Description of Systems, Block Diagram Representation, Classification of Systems (From Text-1)
Analysis of Discrete-Time Systems: Representation of Discrete-Time Signals using Impulses, Response of LTI Systems-Convolution Sum, Properties of Convolution Sum and Interconnection of LTI systems, Stability and Causality of LTI Systems, Difference Equation Representation of LTI systems

MODULE-3

Z-Transforms: Definition, Properties, Rational Z-Transforms, Inverse Z-Transforms (Partial Fraction Expansion, Long Division methods), Analysis of LTI systems in Z-domain (Stability and Causality), Relationship between Impulse Response, System Function and Difference Equation Representation

MODULE-4

Design of FIR Filters: Characteristics of practical frequency-selective filters, Design of Linear-phase FIR (low pass and High pass) filters using windows – Rectangular and Hamming windows. Structure for FIR Systems: Direct form, Cascade form

MODULE 5

IIR Filter Design: Infinite Impulse response Filter Format, Bilinear Transformation Design Method, Analog Filters using Low pass prototype transformation, Normalized Butterworth Functions, Bilinear Transformation Design Procedure, Digital Butterworth (Lowpass and Highpass) Filter Design using BLT. Realization of IIR Filters in Direct form I and II, Cascade and Parallel forms

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

5. Two Unit Tests each of **25 Marks**
6. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**

to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

11. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
12. The question paper will have ten full questions carrying equal marks.
13. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
14. Each full question will have a sub-question covering all the topics under a module.
15. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Textbooks

(1)John G Proakis and Dimitris G Manolakis, "Digital Signal Processing", Pearson, 4th Edition, 2012

Reference Books:

1. Alan V Oppenheim and Ronald W Schafer, "Discrete Time Signal Processing", Pearson, 3rd Edition, 2014.
2. S Salivahanan, "Digital Signal Processing", Mc Graw Hill Education, 3rd Edition, 2017

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/courses/112/107/112107298/
https://archive.nptel.ac.in/courses/112/103/112103174/
https://archive.nptel.ac.in/courses/108/108/108108109/

Skill Development Activities Suggested

To be conducted using MATLAB or any computational tool:

(i) Generate standard signals and plot them

(ii) Obtain Z-transform of step-sequence, exponential sequence and sinusoidal sequence

(iii) Perform Linear convolution of two sequences and verify commutative, distributive and associative laws

(iv) Design and implementation of IIR (Butterworth) low pass filter to meet given specifications.

(v) Design and implementation of IIR (Butterworth) high pass filter to meet given specifications.

(vi) Design and implementation of low pass FIR filter to meet given specifications.

(vii) Design and implementation of high pass FIR filter to meet given specifications.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Classify the signals.	L2
CO2	Perform operations on discrete-time signals, and classify the systems.	L3
CO3	Compute the response and determine the properties of LTI systems using Z-transforms	L4
CO4	Design FIR and IIR Digital Filters.	L2

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**3**	**3**	**2**	**3**	**2**
CO2	**2**	**2**	**3**	**2**	**2**	**2**
CO3	**3**	**2**	**3**	**2**	**3**	**2**
CO4	**2**	**2**	**3**	**2**	**2**	**2**

Microprocessors and Embedded Systems			
Course Code	MMRM214B	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To provide fundamental operating concepts of microprocessors and microcontrollers.
- This course aims to provide students with a solid theoretical basis as well as comprehensive professional understanding of Arduino and Raspberry Pi.

MODULE-1

Microprocessors: 8085-architecture, operation, pin configuration and functions, bus organization, control signal generation for external operations- fetch, IO/M, read/write, machine cycles and bus timings. Addressing mode, instruction set, Overview/concept of peripheral interfacing devices-8251, 8253, 8255 and 8279.

MODULE-2

Microcontrollers: 8051-architecture, operation, pin configuration and functions, memory organization, register, I/O ports, addressing modes, instruction sets, instruction classification. Assembly language programming, Interrupts in 8051. Timer/Counter programming for time delay generation and waveform generation. Interfacing with ADC, DAC, LEDs and seven segment display.

MODULE-3

Z-Transforms: Definition, Properties, Rational Z-Transforms, Inverse Z-Transforms (Partial Fraction Expansion, Long Division methods), Analysis of LTI systems in Z-domain (Stability and Causality), Relationship between Impulse Response, System Function and Difference Equation Representation

MODULE-4

Design of FIR Filters: Characteristics of practical frequency-selective filters, Design of Linear-phase FIR (low pass and High pass) filters using windows – Rectangular and Hamming windows. Structure for FIR Systems: Direct form, Cascade form

MODULE 5

IIR Filter Design: Infinite Impulse response Filter Format, Bilinear Transformation Design Method, Analog Filters using Low pass prototype transformation, Normalized Butterworth Functions, Bilinear Transformation Design Procedure, Digital Butterworth (Lowpass and Highpass) Filter Design using BLT. Realization of IIR Filters in Direct form I and II, Cascade and Parallel forms

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

7. Two Unit Tests each of **25 Marks**
8. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**

to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

16. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
17. The question paper will have ten full questions carrying equal marks.
18. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
19. Each full question will have a sub-question covering all the topics under a module.
20. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Textbooks

(1)John G Proakis and Dimitris G Manolakis, "Digital Signal Processing", Pearson, 4th Edition, 2012

Reference Books:

1. Alan V Oppenheim and Ronald W Schafer, "Discrete Time Signal Processing", Pearson, 3rd Edition, 2014.
2. S Salivahanan, "Digital Signal Processing", Mc Graw Hill Education, 3rd Edition, 2017

Web links and Video Lectures (e-Resources):

https://archive.nptel.ac.in/courses/108/105/108105102/

https://nptel.ac.in/courses/117104072

Skill Development Activities Suggested

To be conducted using MATLAB or any computational tool:

(i) Generate standard signals and plot them

(ii) Obtain Z-transform of step-sequence, exponential sequence and sinusoidal sequence

(iii) Perform Linear convolution of two sequences and verify commutative, distributive and associative laws

(iv) Design and implementation of IIR (Butterworth) low pass filter to meet given specifications.

(v) Design and implementation of IIR (Butterworth) high pass filter to meet given specifications.

(vi) Design and implementation of low pass FIR filter to meet given specifications.

(vii) Design and implementation of high pass FIR filter to meet given specifications.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Classify the signals.	L2
CO2	Perform operations on discrete-time signals, and classify the systems.	L3
CO3	Compute the response and determine the properties of LTI systems using Z-transforms	L4
CO4	Design FIR and IIR Digital Filters.	L2

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1		**3**	**3**	**2**	**2**	**2**
CO2		**2**	**3**	**2**	**3**	**2**
CO3		**2**	**3**	**2**	**2**	**2**
CO4		**2**	**3**	**2**	**3**	**2**

Artificial intelligence for Mechatronics			
Course Code	MMRM214C	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Understand the basic ideas and techniques in the design of intelligent systems.
- Explore the advanced representation formalism and search techniques.
- Deal with uncertain and incomplete information.

MODULE-1

Introduction to Artificial Intelligence Introduction, History of Artificial Intelligence, Intelligent Systems: Categorization of Intelligent System, Components of AI Program, Foundations of AI, Sub-areas of AI, Applications of AI, Current trends in AI. AI applications in Mechanical and Industrial Engineering.

MODULE-2

Intelligent Agents Agents and Environments, The concept of rationality, The nature of environment, The structure of Agents, Types of Agents, Learning Agent. Solving problem by Searching: Problem Solving Agent, Formulating Problems, Example Problems

MODULE-3

Problem solving Uninformed Search Methods: Breadth First Search (BFS), Depth First Search (DFS), Depth Limited Search, Depth First Iterative Deepening (DFID), Informed Search Methods: Greedy best first Search, A* Search, Memory bounded heuristic Search. Local Search Algorithms and Optimization Problems: Hill climbing search Simulated annealing, Genetic algorithms. Adversarial Search: Game Playing, Min-Max Search, Alpha Beta Pruning.

MODULE-4

Knowledge and Reasoning Knowledge based Agents, Brief Overview of propositional logic, First Order Logic: Syntax and Semantic, Inference in FOL, Forward chaining, backward Chaining. Knowledge Engineering in First-Order Logic, Unification, Resolution Uncertain Knowledge and Reasoning: Uncertainty, Representing knowledge in an uncertain domain, The semantics of belief network, Simple Inference in belief network.

MODULE 5

Planning and Learning The planning problem, Planning with state space search, Partial order planning, Hierarchical planning, Conditional Planning. Learning: Forms of Learning, Theory of Learning, PAC learning. Introduction to statistical learning (Introduction only) Introduction to reinforcement learning: Learning from Rewards, Passive Reinforcement Learning, Active reinforcement Learning.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

9. Two Unit Tests each of **25 Marks**
10. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**

to attain the Cos and Pos

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

21. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
22. The question paper will have ten full questions carrying equal marks.
23. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
24. Each full question will have a sub-question covering all the topics under a module.
25. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", Fourth Edition, Pearson Education, 2020.
2. Saroj Kaushik, "Artificial Intelligence", Cengage Learning, First edition, 2011
3. George F Luger, "Artificial Intelligence", Low Price Edition, Fourth edition, Pearson Education,2005

Reference Books:

1. Nils J Nilsson, Principles of Artificial Intelligence, Narosa Publication.
2. Deepak Khemani, A First Course in Artificial Intelligence, McGraw Hill Publication.
3. Patrick H Winston, Artificial Intelligence, 3rd edition, Pearson Education.
4. Elaine Rich and Kevin Knight, Artificial Intelligence, Third Edition, McGraw Hill Education, 2017

Web links and Video Lectures (e-Resources):

https://onlinecourses.nptel.ac.in/noc21_ge20/preview
https://terna.digimat.in/nptel/courses/video/112107298/L20.html

Skill Development Activities Suggested

1. Case Studies
2. Implement AI Capabilities in searching and motion control
3. AI algorithms for Localization and mapping
4.Tracking and controlling

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Develop a basic understanding of AI building blocks presented in intelligent agents	L2
CO2	Choose an appropriate problem solving method and knowledge representation technique	L3
CO3	Analyze the strength and weaknesses of AI approaches to knowledge–intensive problem solving	L4
CO4	Design models for reasoning with uncertainty and unreliable information.	L2
CO5	Design and develop AI applications in real world scenarios	L3

Program Outcome of this course

Sl. No.	Description	Pos
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**3**	**3**	**2**	**2**	**2**
CO2	**3**	**2**	**3**	**2**	**2**	**2**
CO3	**2**	**2**	**3**	**2**	**3**	**2**
CO4	**2**	**2**	**3**	**2**	**2**	**2**
CO5	**2**	**3**	**3**	**3**	**3**	**2**

Mechatronics System Design			
Course Code	MMRM214D	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Gain knowledge of basics of Mechatronics system design and sensors.
- Understanding various techniques of Mechatronics system design for solving engineering problems.
- Understanding Dynamic responses of systems and Fault detection techniques
- Determination of optimization solutions, effective decision making, Convert the data in real time interfacing.
- Understand real time mechatronic system design through case study

MODULE-1

Introduction to mechatronics System Design: Mechatronics Definition, integrated design issues in Mechatronics, the Mechatronics design process, the key elements, Application of Mechatronics.
Sensors in Mechatronics: sensors for motion and position measurement. Force and pressure sensors. Sensors for temperature measurements.

MODULE-2

Modeling and Simulation of Physical Elements:Operator notation and transfer functions, Block diagrams, manipulations and simulation, block diagram modeling- Direct method and analogy approach, Electrical systems, Mechanical systems(Rotational and Translational), electrical Mechanical Coupling, Fluid systems

MODULE-3

Dynamic responses of systems and Fault Finding. Modelling of dynamic systems, Terminology, first order systems and second order systems. Fault detection techniques, Parity and error coding checks, Common hardware faults. Microprocessor systems. Emulation and simulation.

MODULE-4

Signal Conditioning and Real time Interfacing: Introduction, elements of Data Acquisition and Control System, Transducers and Signal Conditioning, Devices for data conversion, Data conversion process, Application software.

MODULE 5

Case Studies:Comprehensive and Data acquisition case studies, data acquisition and control case studies.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

11. Two Unit Tests each of **25 Marks**
12. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**

to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

26. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
27. The question paper will have ten full questions carrying equal marks.
28. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
29. Each full question will have a sub-question covering all the topics under a module.
30. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books:

1. Mechatronics System Design by Devdas Shetty and Richard A Kolk, Second edition, Thomson Learning Publishing Company, Vikas publishing house, 2001.
2. W. Bolton, "Mechatronics" - Addison Wesley Longman Publication, 1999.
3. Shetty and Kolk "Mechatronics System Design"- Cengage Learning, 2010

Web links and Video Lectures (e-Resources):

https://onlinecourses.nptel.ac.in/noc21_me129/preview
http://digimat.in/nptel/courses/video/112107298/L01.html

Skill Development Activities Suggested

- Usage of softwares such as MATLAB/SIMULINK/SIMSCAPE to model, simulate and verify mechatronic system
- Use of PLC softwares to develop PLC ladder programs and implement in real world systems

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Discuss about Mechatronics design process and select the sensor and Actuator for a Mechatronics application	L2
CO2	Choose an appropriate problem solving method and knowledge representation technique	L3
CO3	Analyze the strength and weaknesses of AI approaches to knowledge–intensive problem solving	L4
CO4	Design models for reasoning with uncertainty and unreliable information.	L2
CO5	Design and develop AI applications in real world scenarios	L3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**3**	**3**	**2**	**3**	**2**
CO2	**2**	**2**	**3**	**2**	**2**	**2**
CO3	**3**	**2**	**3**	**2**	**2**	**2**
CO4	**2**	**2**	**3**	**2**	**3**	**2**
CO5	**3**	**3**	**3**	**2**	**2**	**3**

Professional Elective-4

Professional Elective-4			
Vehicle Dynamics and Multi-body Systems			
Course Code	MMRM215A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Applying Newtonian mechanics to analyze forces and moments acting on a vehicle during motion.
- Studying concepts like longitudinal, lateral, and vertical dynamics.
- Examining the impact of tire forces, suspension systems, and aerodynamic forces on vehicle behavior.
- Learning the theoretical basis of multi-body dynamics, including joint types, constraints, and equations of motion.
- Developing detailed multi-body models of vehicles, incorporating components like chassis, suspension, wheels, and drivetrain.

MODULE-1

Introduction to vehicle dynamics: Vehicle coordinate systems; loads on axles of a parked car and an accelerating car. Acceleration performance: Power-limited acceleration, traction- limited acceleration.

Tire models: Tire construction and terminology; mechanics of force generation; rolling resistance; tractive effort and longitudinal slip; cornering properties of tire; slip angle; camber thrust; aligning moments.

MODULE-2

Aerodynamic effects on a vehicle: Mechanics of airflow around the vehicle, pressure distribution, aerodynamic forces; pitching, rolling and yawing moments; crosswind sensitivity.

MODULE-3

Braking performance: Basic equations for braking for a vehicle with constant deceleration and deceleration with wind-resistance; braking forces: rolling resistance, aerodynamic drag, driveline drag, grade, tire-road friction; brakes, anti-lock braking system, traction control, braking efficiency.

MODULE-4

Steering systems and cornering: Geometry of steering linkage, steering geometry error; steering system models, neutral steer, under-steer, over-steer, steering ratio, effect of under- steer; steering system force and moments, low speed and high speed cornering; directional stability of the vehicle; influence of front-wheel drive. **Suspension and ride:** Suspension types—solid axle suspensions, independent suspensions; suspension geometry; roll centre analysis; active suspension systems; excitation sources for vehicle rider; vehicle response properties, suspension stiffness and damping, suspension isolation, active control, suspension non-linearity, bounce and pitch motion. **Roll-over:** Quasi-static roll-over of rigid vehicle and suspended vehicle; transient roll-over, yaw-roll model, tripping.

MODULE 5

Multi-body systems: Review of Newtonian mechanics for rigid bodies and system of rigid bodies; coordinate transformation between two set of axes in relative motion between one another; Euler angles; angular velocity, angular acceleration, angular momentum etc. in terms of Euler angle parameters; Newton-Euler equations of motion; elementary Lagrangian mechanics: generalised coordinates and constraints; principle of virtual work; Hamilton's principle; Lagrange's equation, generalized forces. Lagrange's equation with constraints, Lagrange's multiplier.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

13. Two Unit Tests each of **25 Marks**
14. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**

to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

31. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
32. The question paper will have ten full questions carrying equal marks.
33. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
34. Each full question will have a sub-question covering all the topics under a module.
35. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1. T.D. Gillespie, —Fundamental of Vehicle Dynamics||, SAE Press (1995)
2. J.Y. Wong, —Theory of Ground Vehicles||, 4th Edition, John Wiley & Sons (2008).
3. Reza N. Jazar, —Vehicle Dynamics: Theory and Application||, 1st Edition, 3rd Printing, Springer (2008).
4. R. Rajamani, —Vehicle Dynamics and Control||, Springer (2006).
5. A.A. Shabanna, —Dynamics of Multibody Systems||, 3rd Edition, Cambridge University Press (2005).

Reference Books

1. G. Genta, —Motor Vehicle Dynamics||, World Scientific Pub. Co. Inc. (1997).
2. H.B. Pacejka, —Tyre and Vehicle Dynamics||, SAE International and Elsevier (2005).
3. Dean Karnopp, —Vehicle Stability||, Marcel Dekker (2004).
4. U. Kiencke and L. Nielsen, —Automotive Control System||, Springer-Verlag, Berlin.
5. M. Abe and W. Manning, —Vehicle Handling Dynamics: Theory and Application||, 1st Edition, Elsevier (2009).
6. L. Meirovitch, —Methods of Analytical Dynamics||, Courier Dover (1970).
7. H. Baruh, —Analytical Dynamics||, WCB/McGraw-Hill (1999).

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/107106080
https://www.youtube.com/watch?v=NADjothYea4
https://ed.iitm.ac.in/~shankarram/Course_Files/ED5220/ED5220.htm

Skill Development Activities Suggested

- Develop a simple vehicle model in a multi-body dynamics software to analyze basic vehicle handling characteristics.
- Simulate different suspension designs and compare their impact on ride comfort and handling.
- Model and analyze the effects of different tire models on vehicle dynamics.
- Investigate the influence of aerodynamic forces on vehicle stability.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the concept of vehicle dynamics and analyze various parameters affecting it.	L4
CO2	Analyze the effect of aerodynamics and braking systems on the performance of vehicle	L4
CO3	Analyze the steering systema ns suspension system effect on the performance of vehicle	L4
CO4	Apply various mathematical models to understand the dynamics of Multi-body systems	L3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**4**	**3**	**3**	**3**	**3**	**3**
CO2	**4**	**4**	**3**	**3**	**3**	**3**
CO3	**3**	**4**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**	**3**

Professional Elective-4			
Smart Factory and Industry 4.0			
Course Code	MMRM215B	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Understand the basics of smart factory and Manufacturing
- Gain knowledge on different tools of smart design and fabrication
- Understand basics of smart applications
- Understanding Internet of things in Industries
- Concepts of smart and empowered workers in Industries

MODULE-1
Introduction to Smart Manufacturing - Dimensions -Demand-Driven and Integrated Supply Chains; Dynamically Optimized Manufacturing Enterprises (plant + enterprise operations); Real-Time, Sustainable Resource Management (intelligent energy demand management, production energy optimization, and reduction of GHG).
MODULE-2
Smart Design/Fabrication: Smart Design/Fabrication - Digital Tools, Product Representation and Exchange Technologies and Standards, Agile (Additive) Manufacturing Systems and Standards. Mass Customization, Smart Machine Tools, Robotics and Automation (perception, manipulation, mobility, autonomy), Smart Perception –Sensor Networks and Devices.
MODULE-3
Smart Applications: Online Predictive Modeming, Monitoring, and Intelligent Control of Machining/Manufacturing and Logistics/Supply Chain Processes; Smart Energy Management of manufacturing processes and facilities
MODULE-4
Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Service, Cloud Computing and Industry 4.0, Data acquisition mechanisms, Data interpretation techniques and tools, Development of feedback systems.
MODULE 5
Smart and Empowered Workers: Eliminating Errors and Omissions, Deskilling Operations, Improving Speed/Agility, Improving Information Capture/Traceability, Improving Intelligent Decision Making under uncertainty Assisted/Augmented Production, Assembly, Quality control, Maintenance, Warehouse Operations, and Assisted Training

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

15. Two Unit Tests each of **25 Marks**
16. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**

to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

36. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
37. The question paper will have ten full questions carrying equal marks.
38. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
39. Each full question will have a sub-question covering all the topics under a module.
40. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1. Michael Deng, Colin Koh, Smart Factory: Transforming Manufacturing for Industry 4.0 (Industry 4.0 in ASEAN Region Series)-ISBN-13: 979-8583886425.
2. Banken, and Alasdair Gilchrist; Industry 4.0, Apress Berkeley, CA, ISBN978-1-4842-2047-4
3. Carlos Toro, Wei Wang, and Humza Akhtar, Implementing Industry 4.0, Springer Cham, ISBN978-3-030-67269-0.
4. Erwin Rauch and Manuel Woschank, Industry 4.0 for SMEs - Smart Manufacturing and Logistics for SMEs, ISBN 978-3-03936-567-8.

Web links and Video Lectures (e-Resources):

https://onlinecourses.nptel.ac.in/noc20_cs69/preview
https://www.youtube.com/watch?v=De8MQWbhu3k

Skill Development Activities Suggested

- data visualization tools
- Use of sensor technologies, network protocols, and data acquisition systems used to connect industrial devices to the cloud.
- 3D printing technologies
- cloud platforms for data storage, processing, and application deployment in industrial settings.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	To understand the concepts of smart design and manufacturing in Industries	L2
CO2	To know the importance of different components of smart factory systems	L3
CO3	To apply the concepts of Internet of Things technology in Industry	L2
CO4	To analyze the production and logistics process in Smart factory system	L3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**3**	**3**	**2**	**2**	**2**
CO2	**3**	**2**	**3**	**2**	**3**	**2**
CO3	**3**	**2**	**3**	**2**	**3**	**2**
CO4	**2**	**2**	**3**	**2**	**2**	**2**

Professional Elective-4			
Digital Image Processing and Robot Vision			
Course Code	MMRM215C	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Understand the fundamentals of digital image processing.
- Understand the image enhancement techniques in spatial domain used in digital image processing.
- Understand the Color Image Processing and frequency domain enhancement techniques in digital image processing.
- Understand the image compression techniques and methods used in digital image processing.
- Relate to the vision techniques used in robotics.

MODULE-1

Digital Image Processing Fundamentals: What is Digital Image Processing?, Examples of fields that use DIP, Fundamental Steps in Digital Image Processing, Elements of an Image Processing System,

Digital Image Fundamentals: Elements of Visual Perception, Image Sensing and Acquisition, Image Sampling and Quantization, Tonal and Spatial Resolutions, Image File Formats: BMP, TIFF and JPEG.RGB Color model. Text 1

MODULE-2

Enhancement in Spatial Domain: Some Simple Intensity Transformations, Histogram Processing, Fundamentals of Spatial Filtering, Smoothing Spatial Filters, Sharpening Spatial Filters Frequency domain image enhancement techniques. Text 1

MODULE-3

Frequency Domain: Basics of Filtering in the Frequency Domain, Image Smoothing and Image Sharpening Using Frequency Domain Filters.

Color Image Processing: Color Fundamentals, Color Models, Pseudo-color Image Processing. Text 1

MODULE-4

Image Compression Fundamentals: Coding Redundancy, Inter-pixel Redundancy, Psycho visual Redundancy Lossless Compression Techniques: Run Length Coding, Huffman Coding, Lossy Compression Techniques: Predictive Coding, Improved Gray Scale Quantization, Transform Coding, JPEG Standard. Text 1.

MODULE 5

Low-level vision: optical sensors, camera models, camera geometry in homogeneous coordinates, intensity transformations, thresholding, basic spatial domain image processing techniques such as edge operators and gradients.

High-level vision: Image segmentation, optimum thresholding, region and edge based segmentation, split-merge techniques, feature extraction including boundary and region descriptors, three dimensional image segmentation, pattern recognition and scene interpretation.

Text 2: Chapters 7 & 8 (Note: Use only the theory portion, avoid mathematical derivations & descriptions from Text 2)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

17. Two Unit Tests each of **25 Marks**
18. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**

to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

41. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
42. The question paper will have ten full questions carrying equal marks.
43. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
44. Each full question will have a sub-question covering all the topics under a module.
45. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1. Digital Image Processing- Rafael C Gonzalez and Richard E Woods, PHI, 3rd Edition 2010.
2. Robotics: Control, Sensing, Vision, and Intelligence, K S Fu, R C Gonzalez, and C S G Lee, McGraw-Hill

Reference Book:

Digital Image Processing- S Jayaraman, S Esakkirajan, T Veerakumar, Tata McGraw Hill, 2014.

Web links and Video Lectures (e-Resources):

- Image databases, https://imageprocessingplace.com/root_files_V3/image_databases.htm
- Student support materials, https://imageprocessingplace.com/root_files_V3/students/students.htm
- NPTEL Course, Introduction to Digital Image Processing, https://nptel.ac.in/courses/117105079
- Computer Vision and Image Processing, https://nptel.ac.in/courses/108103174
- Image Processing and Computer Vision – Matlab and Simulink, https://in.mathworks.com/solutions/image-video-processing.html

Skill Development Activities Suggested

Programming languages: Python is widely used with OpenCV library for image processing tasks.

OpenCV functionalities: Learn to utilize OpenCV functions for image reading, manipulation, feature extraction, object detection, etc.

Project development: Build projects like:

Pick and place robot: Using vision to identify and pick up specific objects.

Autonomous navigation: Guiding a robot through an environment using visual cues.

Inspection system: Detecting defects on a product using image analysis.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the fundamental concepts of image processing.	L2
CO2	Conduct independent study and analysis of Image Enhancement techniques.	L2
CO3	Apply image processing techniques in frequency (Fourier) domain.	L2
CO4	Describe the image compression techniques.	L3
CO5	Discuss the low-level and high-level vision concepts applied in robotics vision.	

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**2**	**3**	**2**	**2**	**2**
CO2	**2**	**2**	**3**	**2**	**3**	**2**
CO3	**3**	**2**	**3**	**2**	**2**	**2**
CO4	**3**	**2**	**3**	**2**	**3**	**2**

Professional Elective-4			
Control Systems and Engineering			
Course Code	MMRM215D	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :0 : 1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Students will gain the knowledge on the concept of time response and frequency response of the control system.
- Students will able to explain different control system stability techniques.
- Students will able to apply root locus technique, bodeplot to determine stability of the control system
- Students will able to apply polar plot to techniques to determine stability of the control system.
- Students will know the concept of state variables and state model.

MODULE-1

Time Response of control systems: Standard test signals, Unit step response of First and Second order Systems. Time response specifications, Time response specifications of second order systems, steady state errors and error constants. Introduction to PI, PD and PID Controllers (excluding design).

MODULE-2

Frequency domain Analysis: Introduction to frequency domain analysis, Correlation between time & frequency response.

Concepts of stability: The Concept of stability. Necessary conditions for stability. Hurwitz stability criterion. Routh stability criterion. Relative stability analysis using RH Criterion.

MODULE-3

The Root Locus Technique: Introduction to Root locus concepts. Construction of root loci. Stability analysis using Root locus technique .Numerical problems on all topics

MODULE-4

Frequency Domain Analysis: frequency domain specifications, polar plot, The Nyquist criterion. Construction of Bode plots and Stability analysis using Bode plots.

MODULE 5

State space Analysis: Concept of state, state variables and state model. State diagrams and State models for Linear continuous-time systems (Electrical systems): State space representation using Physical and Phase variables.Derivation of transfer functions from the state model. Numerical problems on all topics.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

19. Two Unit Tests each of **25 Marks**
20. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**

to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

46. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
47. The question paper will have ten full questions carrying equal marks.
48. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
49. Each full question will have a sub-question covering all the topics under a module.
50. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1. "Control Systems Engineering", I.J. Nagarath and M. Gopal ,New Age International (P) Limited, Publishers, Fifth edition – 2012.2.
2. "Modern Control Engineering ", K. Ogata, Pearson Education Asia/ PHI, 4th Edition, 2002

Reference Books

1. "Automatic Control Systems", Benjamin C. Kuo, John Wiley India Pvt. Ltd., 8th Edition, 2008.
2. "Feedback and Control System", Joseph J Distefano III et al., Schaum's Outlines, TMH, 2nd Edition 2007

Web links and Video Lectures (e-Resources):

- Image databases, https://imageprocessingplace.com/root_files_V3/image_databases.htm
- Student support materials,
- https://imageprocessingplace.com/root_files_V3/students/students.htm
- NPTEL Course, Introduction to Digital Image Processing, https://nptel.ac.in/courses/117105079
- Computer Vision and Image Processing, https://nptel.ac.in/courses/108103174
- Image Processing and Computer Vision – Matlab and Simulink,
- https://in.mathworks.com/solutions/image-video-processing.html

Skill Development Activities Suggested

- Usage of simulation software to analyze system dynamics and evaluate control strategies before implementation. Languages like Ladder Logic, Structured Text, or C++ for PLC (Programmable Logic Controller) programming and control system implementation.
- Use of different types of sensors and transducers used in control systems to measure process variables.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Discuss Time and frequency domain analysis of the control systems	L2
CO2	Discuss the concept of state variables and state model	L2
CO3	Apply the RH criterion techniques and root locus techniques to solve the stability of the control systems	L2
CO4	Analyze the stability of the systems using Bode Plots, Polar and Nyquist plot.	L3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**2**	**3**	**2**	**2**	**2**
CO2	**2**	**2**	**3**	**2**	**3**	**2**
CO3	**3**	**2**	**3**	**2**	**2**	**2**
CO4	**3**	**2**	**3**	**2**	**2**	**2**

Industrial Automation			
Course Code	MMRM206	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3: 0 :2 : 0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Acquire the basic understanding of automation in production system
- Acquire a basic understanding of material handling and identification technologies
- Understanding of Automated Manufacturing systems
- Acquire a basic understanding of computer based industrial automation
- Acquire a basic understanding of Distributed Control Systems

MODULE-1

Introduction: 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.

MODULE-2

Material handling and identification technologies: Overview of material handling systems, Types of material handling equipment, Design of the system, Conveyor system, Automated guided vehicle system, Automated storage systems, Interfacing handling and storage with manufacturing, Overview of Automatic Identification Methods.

MODULE-3

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.

MODULE-4

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

MODULE 5

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- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data, Leveraging RTU (as different from PLCs and DCS)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

21. Two Unit Tests each of **25 Marks**
22. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks**

to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

51. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
52. The question paper will have ten full questions carrying equal marks.
53. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
54. Each full question will have a sub-question covering all the topics under a module.
55. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

1. M.P.Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5th Edition, Pearson Education, 2009
2. Curtis D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson New International, 2013.
3. Lukas M.P, "Distributed Control Systems", Van Nostrand Reinhold Co., New York, 1986.

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc21_me67/preview
- http://www.digimat.in/nptel/courses/video/108105062/L20.html

Skill Development Activities Suggested

Programming language
Sensor Technology
Networking
Robotics

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the need and basics of Industrial Automation,	L2
CO2	Understand knowledge on Automated Manufacturing system	L2
CO3	Analyze different types of automated manufacturing systems	L2

CO4	Design material handling system in Manufacturing system	L3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**2**	**2**	**3**	**2**	**2**	**2**
CO2	**2**	**2**	**3**	**2**	**3**	**2**
CO3	**2**	**2**	**3**	**2**	**3**	**2**
CO4	**2**	**2**	**3**	**2**	**3**	**2**

Robot Programming & Simulation Lab			
Course Code	MMRML207	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Credits	2	Exam Hours	03

Course objectives:

- To introduce different types of robotics and demonstrate them to identify different parts and components.
- To write programming for simple operations

Sl.NO	Experiments
1	Determination of maximum and minimum position of links.
2	Verification of transformation (Position and orientation) with respect to gripper and world coordinate system.
3	Estimation of accuracy, repeatability and resolution.
4	Robot programming and simulation for pick and place.
5	Robot programming and simulation for Colour identification.
6	Robot programming and simulation for Shape identification
7	Robot programming and simulation for machining (cutting, welding).
8	Robot programming and simulation for any industrial process (Packaging, Assembly)
	Demonstration Experiments (For CIE) if any
9	Robot programming and simulation for writing practice
10	Robot programming and simulation for multi process.

LIST OF EQUIPMENTS BATCH OF 30 STUDENTS:

ROS (Robotic Operating System)

30 Systems with server

Verification of direct kinematics equations and inverse kinematics equations of 1DOF “Rconfiguration” robot.

Verification of direct kinematics equations and inverse kinematics equations of 2DOF “R-Rconfiguration” robot.

Course outcomes (Course Skill Set):

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

- Use of any robotic simulation software to model the different types of robots and calculate work volume for different robots.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marksis scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.
- General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be

evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners) • Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero. The duration of SEE is 03 hours
Suggested Learning Resources: • https://www.coppeliarobotics.com/ • https://www.youtube.com/watch?v=MX3VXvZFk0U

Ability Enhancement course			
Robotics Ecosystem			
Course Code	MMRM258A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	1: 0 :0 : 0	SEE Marks	50
Total Hours of Pedagogy	16	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- To introduce the functional elements of Robots
- To educate on carious concepts in robot anatomy and control
- To impart knowledge on end effectors and drive systems in robots
- To know about different types and functions of sensors in robotics
- To describe different applications of robots.

MODULE-1

Robotics Definition, Robot-Basic concepts, Need, Laws of Robotics, History, Types of Robots, Classification, specifications of Robotics.

MODULE-2

Anatomy of Robots, Types of Joints, Robot configurations- cartesian, cylinder, polar and articulate.
Basics of control: open loop- closed loop, Transfer functions, Control laws: P, PD, PID

MODULE-3

End effectors-Classification, Types of Mechanical actuation, Gripper design, Robot drive system- Hydraulic, Pneumatic and Electrical Drive systems.

MODULE-4

Sensors in robotics- Touch Sensors, Tactile sensor, Proximity and range sensors, Force sensor, Pressure sensors.

MODULE 5

Applications: Industrial applications of robots, Medical, Household, Entertainment, Space, Underwater, Defence,Disaster management

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

Three Tests (preferably in MCQ pattern with 20 questions) each of 20 Marks (duration 01 hour)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of 10 Marks

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Quiz/Group discussion/Seminar, any two of three suitably planned to attain the COs and POs for 20 Marks (duration 01 hours)

The sum of total marks of three tests, two assignments, and quiz /seminar/ group discussion will be out of 100 marks and shall be scaled down to 50 marks

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of 01 mark. The pattern of the question **paper is** MCQ (multiple choice questions). The time allotted for SEE is 01 hour. The student has to secure minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Text Books

1. M.P.Groover, M.Weiss, R.N. Nageland N. G.Odrej, Industrial Robotics, McGraw-Hill Singapore, 1996.
2. R.K.Mittal and I.J.Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi,4th Reprint, 2005.
3. JohnJ.Craig ,Introduction to Robotics Mechanics and Control, Third edition, Pearson Education, 2009.

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc24_me24/preview
- https://onlinecourses.nptel.ac.in/noc24_ge31/preview

Skill Development Activities Suggested

3D modeling and CAD software (SolidWorks, Fusion 360)
Kinematics and dynamics analysis
Mechanism design (joints, linkages, actuators)
Material selection for robotic components
Microcontroller programming (Arduino, Raspberry Pi)
Sensor integration (vision, force, proximity)

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the functions of different elements of robots.	L1
CO2	Apply the knowledge of sensors and end effectors in robotics	L2
CO3	Analyze the use of different types of robots for different applications.	L2

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**1**	**2**	**1**	**2**	**1**	**2**
CO2	**2**	**2**	**2**	**2**	**1**	**2**
CO3	**2**	**2**	**2**	**2**	**2**	**2**

Robot Programming & Simulation Lab			
Course Code	MMRM258B	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Credits	1	Exam Hours	02

Course objectives:

- Demonstrate the use of Anaconda or PyCharm IDE to create Python Applications
- Develop Python programming language to develop programs for solving real-world problems
- Utilize Object-Oriented Programming concepts in Python.
- Analyse the working of various documents like PDF, Word file

Sl.NO	Experiments
1	Develop a python program to find the best of two test average marks out of three test's marks accepted from the user
2	Develop a python program to find the smallest and largest number in a list
3	Develop a python program to arrange the numbers in ascending and descending order
4	Develop a binary search program in python
5	Develop a bubble sort program in python
6	Develop a Python program to check whether a given number is palindrome or not and also count the number of occurrences of each digit in the input number.

7	Write a Python program that accepts a sentence and find the number of words, digits, uppercase letters and lowercase letters.
8	Write a Python program for pattern recognition with and without using regular expressions
	Demonstration Experiments (For CIE) if any
9	Demonstrate python program to read the data from the spreadsheet and write the data in to the spreadsheet
10	Demonstration of reading, writing and organizing files.

Course outcomes (Course Skill Set):

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

- Demonstrate proficiency in handling of loops, lists and creation of functions.
- Identify the commonly used operations involving regular expressions and file system.
- Examine working of PDF and word file formats

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 35% (18 Marks out of 50) in the semester-end examination(SEE).

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is 50 Marks.

The split-up of CIE marks for record/ journal and test are in the ratio 60:40.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for theevaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability. Rubrics suggested in Annexure-II of Regulation book
- The average of 02 tests is scaled down to 20 marks (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly

adhered to by the examiners. OR based on the course requirement evaluation rubrics shall be decided jointly by examiners.
Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.
Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.
General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)
Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.
The duration of SEE is 03 hours
Rubrics suggested in Annexure-II of Regulation book

Suggested Learning Resources:

1. Charles R. Severance, “Python for Everybody: Exploring Data Using Python 3” 1st Edition, CreateSpace Independent Publishing Platform, 2016. (http://do1.drchuck.com/pythonlearn/EN_us/pythonlearn.pdf)

2. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist”, 2nd Edition, Green Tea Press, 2015. (http://greenteapress.com/thinkpython2/thinkpython2.pdf) (Download pdf files from the above links)

3. Al Sweigart, “Automate the Boring Stuff with Python”,1stEdition, No Starch Press, 2015. (Available under CC-BY-NC-SA license at https://automatetheboringstuff.com/)

4. ReemaThareja “Python Programming Using Problem Solving Approach” Oxford University Press

Ability Enhancement course			
Fuzzy logic for Robotics			
Course Code	MMRM258C	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	1: 0 :0 : 0	SEE Marks	50
Total Hours of Pedagogy	16	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:`

- Understand Fuzzy Logic Principles: Develop a solid understanding of fuzzy logic theory and its application in robotics.
- Implement Fuzzy Controllers: Learn to design and implement fuzzy logic controllers for robotic systems to handle imprecise or uncertain information.
- Solve Complex Robotic Decision Problems: Acquire the skills to apply fuzzy logic to address complex decision-making problems in robotics, such as path planning and obstacle avoidance.
- Optimize Robotic Systems: Explore techniques to optimize robotic systems' performance and behaviour using fuzzy logic-based control strategies.
- Apply Fuzzy Logic to Real-world Scenarios: Apply fuzzy logic concepts and techniques to practical robotic applications, demonstrating the ability to enhance robot adaptability and autonomy in uncertain environments.

MODULE-1
Fuzzy set theory – Fuzzy sets – Operation on fuzzy sets – Scalar cardinality, fuzzy cardinality, union and intersection, complement (Yager and Sugeno),
MODULE-2
Fuzzy Arithmetic, Fuzzy Relations & Possibility Theory, Fuzzy Logic, Uncertainty based Information,
MODULE-3
Modelling of non-linear systems using fuzzy models – TSK model – Fuzzy logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification – Adaptive fuzzy systems
MODULE-4
Introduction to Neural Networks Differences between Biological and Artificial Neural Networks – Typical Architecture, Common Activation Functions,
MODULE 5
Neural Networks: Case Studies: Inverted Pendulum, CMAC, Robotics, Image compression, and Control systems

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

Three Tests (preferably in MCQ pattern with 20 questions) each of 20 Marks (duration 01 hour)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of 10 Marks

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Quiz/Group discussion/Seminar, any two of three suitably planned to attain the COs and POs for 20 Marks (duration 01 hours)

The sum of total marks of three tests, two assignments, and quiz /seminar/ group discussion will be out of 100 marks and shall be scaled down to 50 marks

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of 01 mark. The pattern of the question **paper is** MCQ (multiple choice questions). The time allotted for SEE is 01 hour. The student has to secure minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Books

1. Fuzzy Sets and Fuzzy Logic – Theory and Applications, George J. Klir& Bo Yuan, Prentice Hall of India Private Limited.
2. Fuzzy Sets, Uncertainty and Information, George J. Klir& Tina A. Folger, Prentice Hall of India Private Limited.
3. Jacek M. Zurada, 'Introduction to Artificial Neural Systems', Jaico Publishing home, 2002.
4. Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 2009.

Reference Books:

5. LaureneFausett, Englewood cliffs, N.J., 'Fundamentals of Neural Networks', Pearson Education, 2008.
6. Simon Haykin, 'Neural Networks', Pearson Education, 2003.
7. George.J.Klir, 'Fuzzy Sets and Fuzzy Logic – Theory and Applications', Pearson, 2015..

Web links and Video Lectures (e-Resources):

https://onlinecourses.nptel.ac.in/noc22_ge04/preview
https://onlinecourses.nptel.ac.in/noc23_ee21/preview

Skill Development Activities Suggested

Robot Navigation, Obstacle Avoidance, Path Following, Grasping and Manipulation

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Mastery of Fuzzy Logic Concepts: Achieve a high level of proficiency in understanding and applying fuzzy logic principles in the context of robotics.	L1
CO2	Fuzzy Controller Design Skills: Develop the ability to design, implement, and fine-tune fuzzy logic controllers for robotic systems to handle uncertain and complex environments.	L2
CO3	Effective Problem Solving: Demonstrate the capacity to use fuzzy logic to solve intricate robotic decision making problems, including navigation, localization, and sensor fusion	L2
CO4	Improved Robotic Performance: Apply fuzzy logic-based control strategies to enhance robotic systems' performance, adaptability, and robustness in real-world scenarios.	L3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document	PO2
3	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.	PO3
4	Students should be able to Design solutions for complex engineering problems using modern tools & techniques with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations	PO4
5	Students should be able to Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings with professional ethics and norms of the engineering practice.	PO5
6	Students should be able to Demonstrate knowledge and understanding of the engineering and management principles and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	PO6

Mapping of COS and Pos

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**1**	**1**	**2**	**2**	**2**	**2**
CO2	**2**	**2**	**2**	**2**	**3**	**2**
CO3	**2**	**2**	**3**	**2**	**2**	**2**
CO4	**3**	**2**	**3**	**2**	**3**	**2**

Numerical Programming for Mechanical Engineers (Using MATLAB/NumPy)		Semester	02
Course Code	**MMRM258D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:0:2	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	1 Hour
Examination type (SEE)	**MCQ**		

Note: Instead of MATLAB any equivalent open source and commercial software can be used

Course objectives:

By the end of this course, students will be able to:

- Gain knowledge of basic numerical methods and algorithms used in mechanical engineering.
- Understand the mathematical foundations and applications of numerical techniques.
- Learn to use MATLAB and NumPy for numerical problem-solving in mechanical engineering contexts.
- Familiarize with key concepts in solving linear and nonlinear equations, interpolation, and numerical differentiation.
- Learn to apply numerical methods for mechanical engineering simulations and error analysis.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Hands-On Coding Assignments
2. Lab Sessions
3. Project-Based Learning
4. Interactive Demonstrations
5. Comparative Analysis
6. Visualizations
7. Regular Quizzes and Tests
8. Continuous Feedback and Assessment

Module-1

Introduction to Numerical Programming

Overview of Numerical Methods: Basic definitions and examples of numerical methods, Significance of numerical programming in engineering. **Introduction to MATLAB and NumPy:** Syntax, commands, and basic operations, Understanding variables, matrices, and vectors. **Basic Programming Constructs:** Loops, conditional statements, and functions, Debugging techniques in MATLAB/NumPy

Module-2

Solving Linear and Nonlinear Equations:

Linear Systems of Equations: Gaussian elimination, LU decomposition. **Iterative methods:** Jacobi and Gauss-Seidel. **Nonlinear Equations:** Bisection method, Newton-Raphson method, Fixed-point iteration

Module-3

Numerical Differentiation and Integration:

Numerical Differentiation: Forward and backward difference methods, Central difference approximation. **Numerical Integration:** Trapezoidal rule, Simpson's rule

Module-4

Interpolation and Curve Fitting:

Polynomial Interpolation: Lagrange and Newton interpolation methods,Application to curve fitting.**Least Squares Method:** Fitting a linear model to data points

Module-5

Numerical Solutions of Ordinary Differential Equations (ODEs)

Introduction to ODEs: Types of ordinary differential equations in mechanical engineering, Initial value and boundary value problems.

Numerical Methods for ODEs: **Euler's method, Runge-Kutta methods (4th order)**

Course outcome (Course Skill Set)

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

1. Identify the appropriate numerical method for a given engineering problem.
2. Understand and recognize various methods for solving equations, integration, and interpolation.
3. Select suitable algorithms for solving ODEs in mechanical engineering.
4. Evaluate the accuracy of numerical methods and identify common sources of error.
5. Apply numerical methods to basic mechanical engineering problems using MATLAB/NumPy.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of the 01 marks. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Books

1. **"Numerical Methods for Engineers"** by Steven C. Chapra and Raymond P. Canale
2. **"Applied Numerical Methods with MATLAB for Engineers and Scientists"** by Steven C. Chapra
3. **"Numerical Methods in Engineering with Python 3"** by Jaan Kiusalaas
4. **"MATLAB for Engineers"** by Holly Moore
5. **"Python for Engineers and Scientists"** by E.M. Kranakis

Web links and Video Lectures (e-Resources):

1. **MATLAB Documentation:** https://www.mathworks.com/help/matlab/
2. **NumPy Documentation:** https://numpy.org/doc/stable/
3. **MIT OpenCourseWare - Numerical Methods:** https://ocw.mit.edu/courses/mechanical-engineering/
4. **Coursera - Numerical Methods for Engineers:**https://www.coursera.org/learn/numerical-methods-engineering
5. **SciPy Documentation (for advanced numerical computing):** https://docs.scipy.org/doc/scipy/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Collaborative Learning
- Gamification of Learning
- Online Code Repositories