Semester- II

Industrial Robotics			
Course Code	**MRAI201**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Understand the concept of robotics and its drives.
- Understand the sensors applications and images recognition mechanism.
- Program robot and analyze the computational element of robot computer system.
- Transform robot manipulator using knowledge kinematics and mathematical methods.
- Design and control robot cells and understand the application of robots.

Module-1

FUNDAMENTAL CONCEPTS OF ROBOTICS: History, present status and future trends, Robotics. Robot, Definition. Robotics Systems and Robot Anatomy, Specification of Robotics. Resolution, Repeatability and Accuracy of a Manipulator.

ROBOT DRIVES: Power transmission systems and control Robot drive mechanisms, hydraulic-electric-pneumatic drives. Mechanical transmission method – Rotary-to-Rotary motion conversion. Rotary-to-linear motion conversion end effectors – types-grip and problem Remote-Centered compliance Devices- Control of Actuators in Robotic Mechanisms.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-2

SENSORS AND INTELLIGENT ROBOTS: Sensory devices – Non-optical-Position sensors – Optical position sensors – velocity sensors – proximity sensors: Contact and non-contact type- Touch and slip sensors – Force and Torque Sensors – AI and Robotics.

COMPUTER VISION FOR ROBOTICS SYSTEMS: Robot vision systems – Imaging components – Image representation – Hardware aspects- Picture coding – Object Recognition and Categorization- Visual inspection – software considerations – applications – commercial – Robotic vision systems.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-3

IPUTER CONSIDERATIONS FOR ROBOTIC SYSTEMS: Computer architecture for robots, hardware, Computational elements in robotic applications – Robot programming – sample programs path planning – Robot's computer system.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-4	
TRANSFORMATIONS AND KINEMATICS: Homogeneous Co-ordinates – Co-ordinate Reference Frames – Homogeneous Transformations for the manipulator – the forward and inverse problem of manipulator kinematics – Motion generation – Manipulator dynamics – Jacobian in terms of D.H.Matrices controller architecture.	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.
Module-5	
ROBOT CELL DESIGN AND CONTROL: Specifications of Commercial Robots – Robot Design and Process specifications – motor selection in the design of a robotic joint – Robot Cell layouts – Economic and Social aspects of robotics. **ICATIONS OF ROBOTS:** Capabilities of Robots – Robotics Applications – Obstacle avoidance – Robotics in India – The future of Robotics.	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks**to attain the COs and POs

The sum of three 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.
   The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Robotics Engineering An integrated approach - Richard D Klafter, Thomas A Chmielewski, Michael Negin Prentice Hall of India Pvt. Ltd.
2. Robotics: Control Sensing, Vision, intelligence - Fu KS Gomaler R C, Lee C S G - McGraw Hill
3. Handbook of Industrial Robotics - Shuman Y. Nof - John Wiley & Sons, New York - 1985.
4. Robotics Technology and Flexible Automation - Deb SR - McGraw Hill BookCo. - 1994.

Web links and Video Lectures (e-Resources):

- https://intelitek.com/fundamentals-of-robotics/
- https://www.youtube.com/watch?v=7Bahzh3rniw
- https://www.electronicsforu.com/technology-trends/tech-focus/sensors-robotics-artificial-intelligence
- https://www.youtube.com/watch?v=QJ1wixdSlRc
- https://www.youtube.com/watch?v=zyOv6rn3X88
- https://www.therobotreport.com/6-robotics-applications-new-markets/

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome

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

Sl. No.	Description	Blooms Level
CO1	Describe the concept of robotics and its drives.	L1, L2, L3, L4
CO2	Able to explain working of sensors and applications and images recognition mechanism.	L1, L2, L3, L4,L5
CO3	Program for robot and explain the computational element of robot computer system.	L1, L2, L3, L4,L5
CO4	Explain robot manipulator using knowledge kinematics and mathematical methods	L1, L2, L3, L4,L5
CO5	Design and control robot cells and understand the application of robots.	L1, L2, L3, L4

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	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated uses and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and POs (Note : High - 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	2	2	3	3	3	1
CO2	2	2	3	3	3	3	2
CO3	2	2	3	3	3	3	2
CO4	2	2	2	3	3	3	3
CO5	1	2	2	2	3	3	2

Artificial Intelligence in Manufacturing			
Course Code	**MRAI202**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To understand the modern manufacturing concepts.
- To learn the concept of AI based methods for process controls.
- To analyze the automated material handling systems.

Module-1

duction to Modern Manufacturing and AI Based Applications:

luction to Modern Manufacturing Process, Industry 4.0, Introduction to AI and its applications in manufacturing, Design in Manufacturing and AI Requirements.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-2

AI based Methods for Process Control & Monitoring:

Machine Learning methods, AI based Monitoring and control of discrete manufacturing process, Online process monitoring in additive manufacturing, Industrial Machine Vision, Development of Digital Twins.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-3

AI based Design Space Exploration:

Multi objective heuristic search for DSE, Algorithms for Customizable Manufacturing, Allocation and Layout, Scheduling for flexible manufacturing systems**.**

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.
Module-4	
AI & Robotics: AI based Robot Architecture & Applications in Automated Manufacturing, Robot Vision & Motion, Multi agent and swarm robotics, Robot to Robot and Robot to human coordination (Cobots - collaborative robotics) Reliable & Trusted AI in Robotics.	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.
Module-5	
nated material Handling Storage: Material functions, types of material handling equipment, analysis of material handling systems, design of system, conveyor system, automated guided vehicle systems, automated storage/retrieval systems, caroused storage systems work in process storage, interfacing handling & storage with manufacturing.	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks**to attain the COs and POs

The sum of three 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. Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig, 3rd Edition, Prentice Hall, 2009.
2. Deep Learning - Ian Goodfellow, YoshuaBengio, Aaron Courville, MIT Press, 2018
3. Additive manufacturing of Metals: The Technology, Materials , Design and Production; Ed. Li Yang, et al.; Springer International Publishing AG 2017
4. Laser Materials Processing, by W M Steen, J. Mazumder, 4th Ed. Springer
5. Handbook of Industrial Robotics by Shimon Y. Nof (Editor), ISBN 9788126540303.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=lTsvhSYstAE
- https://www.forbes.com/sites/bernardmarr/2018/09/02/what-is-industry-4-0-heres-a-super-easy-explanation-for-anyone/?sh=162dc3409788
- https://professional.mit.edu/news/articles/4-ways-ai-will-change-design-and-manufacturing
- https://www.hpe.com/in/en/what-is/machine-learning.html?jumpid=ps_u8bvx1ziqh_aid-520061736&ef_id=Cj0KCQjwmuiTBhDoARIsAPiv6L9QsMm4otXbOHvIYNeBMp2VcsEEtY3bvg3k77Xbh_JHpT8f4l48jPMaAiuMEALw_wcB:G:s&s_kwcid=AL!13472!3!558204153004!e!!g!!types%20of%20machine%20learning!14386686693!128518518145&
- https://theconversation.com/five-ways- -intelligence-can-help-space-exploration-153664
- https://aibusiness.com/author.asp?section_id=789&doc_id=773741#:~:text=Robotics%20and%20artificial%20intelligence%20are%20two%20related%20but%20entirely%20different,'
- https://www.systema.com/automated-material-handling-systems#:~:text=Automated%20material%20handling%20systems%20ensure,even%20in%20two%20separate%20buildings.

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome

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

Sl. No.	Description	Blooms Lev
CO1	Learn how AI methods can be used in a manufacturing workflow for process optimization and control	L1, L2, L3,
CO2	Discover AI/machine learning methods that enable design automation and customization	L1, L2, L3, L
CO3	Explore AI/machine learning methods for performance-driven design that automatically translate functional specifications of objects to manufacturable designs	L1, L2, L3, L
CO4	Learn AI based Robot Architecture & Applications in Automated Manufacturing, Robot Vision & Motion, Multi agent and swarm robotics.	L1, L2, L3, L
CO5	Explore Material functions, types of material handling equipment, analysis of material handling systems, design of system, conveyor system.	L1, L2, L3,

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	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and POs (Note : High - 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	2	2	3	3	2
CO2	1	2	2	2	3	3	2
CO3	1	2	2	2	3	3	2
CO4	1	2	2	2	3	3	2
CO5	1	2	2	2	3	3	2

Mobile Robots and Perception			
Course Code	**MRAI203**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40hrs+10-12 Labs	Total Marks	100
Credits	04	Exam Hours	03

Course Learning objectives:

- Understand the concept of robotics and its drives.
- Understand the sensors applications and images recognition mechanism.
- Program robot and analyze the computational element of robot computer system.
- Transform robot manipulator using knowledge kinematics and mathematical methods.
- Design and control robot cells and understand the application of robots.

Module-1

Introduction to Mobile robots: Intelligence and embodiment, A roboticist's problem, challenges of mobile autonomous robots, Locomotion, static and dynamic stability, degrees of freedom. Coordinate systems and frames of reference, forward kinematics, inverse kinematics, inverse kinematics using feedback control.

Path Planning: Map representations, path planning algorithms, sampling based path planning, path smoothing, planning at different length scales. Uncertainty and error propagation in robotics, probabilistic robotics, basic concepts in probability.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-2

rsive State Estimation: Robot environment interaction, Bayes filter, representation and computation. Gaussian filters, Kalman filter, extended kalman filter, information filter, histogram filter, particle filter.

Robot Motion: Kinematic configuration, probabilistic kinematics, velocity motion model, odometry motion model.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-3

Robot Perception: Maps, Beam models of range finders, likelihood fields for range finders, correlation-based sensor models, feature-based sensor models.

Mobile Robot Localization: Markov and Gaussian: Mobile robot localization, Markov localization, EKF localization, Estimating correspondences, multi-hypothesis tracking, grid localization, Monte Carlo localization.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-4

Occupancy Grid Mapping: Occupancy grid mapping, Simultaneous localization and mapping, RGB-D SLAM. **APPLICATIONS OF MOBILEROBOTS:** Capabilities of Robots – Robotics Applications – Obstacle avoidance – Robotics in India – The future of Robotics.	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.
Module-5	
ODUCTION TO PE ANDELECTRIC DRIVE SYSTEMS - Power Electronics, Applications of Power Electronics, Types of Power Electronic Circuits, Peripheral Effects, Characteristics and Specifications of Switches. Basic components of an Electric drive system: Mechanical loads, electric motors, power sources, converters and controllers. **STEPPER MOTOR** ple of Stepper motor, Classification of Stepper motor, Principle of variable reluctant stepper motor, Principle of Permanent magnet stepper motor, Principle of hybrid stepper motor, driver for stepper motor, Applications of Stepper motor.	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

PRACTICAL COMPONENT OF IPCC

Course objectives:

- Implement and evaluate Mobile Robot programming language.

·To analyze big data using machine learning techniques

Sl.No.	Experiments
1	To study the mixture of electronics and movable parts, motors and accessories of Robotics.
2	Describe the characteristics of a robotic system from its dynamic model.
3	Analyze the stability of robotic systems with the help of theorems.
4	Illustrate the various task space control schemes available.
5	Discuss about the various Non Linear Control schemes
6	Design and fabricate simple grippers for pick and place application
7	Identify the right Robot for a given industrial application.
8	Select the right material handling system for a given application

	Experiments/Activities/Demonstrations/Visits/Analytics etc., that enhances the skill of the learners **(Activities are only for CIE)**
9	Exercises on conducting method study for assembling simple components by automation.
10	Development of programming for quality inspection by robot
11	Determination of standard assembly time using programming

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**to attain the COs and POs

The sum of three 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. Robotics Engineering An integrated approach - Richard D Klafter, Thomas A Chmielewski, Michael Negin Prentice Hall of India Pvt. Ltd.
2. Robotics: Control Sensing, Vision, intelligence - Fu KS Gomaler R C, Lee C S G - McGraw Hill
3. Handbook of Industrial Robotics - Shuman Y. Nof - John Wiley & Sons, New York - 1985.
4. Robotics Technology and Flexible Automation - Deb SR - McGraw Hill BookCo. - 1994.
5. Sebastian Thrun, Wolfram Burgard& Dieter Fox, " Probabilistic Robotics", The MIT Press
6. Eugene Kagan, NirShvalb&Irad Ben-Gal, "Autonomous Mobile Robots and Multi-Robot Systems ", First Edition, John Wiley & Sons Ltd, 2020.
7. NikolausCorrell, Introduction to Autonomous Robots, 1st edition

Web links and Video Lectures (e-Resources):

- https://intelitek.com/fundamentals-of-robotics/
- https://www.youtube.com/watch?v=7Bahzh3rniw
- https://www.electronicsforu.com/technology-trends/tech-focus/sensors-robotics-artificial-intelligence
- https://www.youtube.com/watch?v=QJ1wixdSlRc
- https://www.youtube.com/watch?v=zyOv6rn3X88
- https://www.therobotreport.com/6-robotics-applications-new-markets/

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome

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

Sl. No.	Description	Blooms Level
CO1	Describe the concept of robotics and its drives.	L1, L2, L3, L4
CO2	Able to explain working of sensors and applications and images recognition mechanism.	L1, L2, L3, L4,L5
CO3	Program for robot and explain the computational element of robot computer system.	L1, L2, L3, L4,L5
CO4	Explain robot manipulator using knowledge kinematics and mathematical methods	L1, L2, L3, L4,L5
CO5	Design and control robot cells and understand the application of robots.	L1, L2, L3, L4

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	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated uses and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and POs (Note : High - 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	2	2	3	3	3	1
CO2	2	2	3	3	3	3	2
CO3	2	2	3	3	3	3	2
CO4	2	2	2	3	3	3	3
CO5	1	2	2	2	3	3	2

Augmented Reality and Virtual Reality (Tract: AI)			
Course Code	**MRAI206**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Understand the concept of robotics and its drives.
- Understand the IoT applications and images recognition mechanism.
- Program robot and analyse the computational element of robot computer system.
- Transform robot manipulator using IoT.
- Design and control robot cells and understand the application of robots.

Module-1

Introduction to Augmented Reality: Defining augmented reality, history of augmented reality, The Relationship Between Augmented Reality and Other Technologies-Media, Technologies, Other Ideas Related to the Spectrum Between Real and Virtual Worlds, applications of augmented reality, Working, Concepts Related to Augmented Reality, Ingredients of an Augmented Reality Experience.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-2

Augmented Reality Architecture: Audio Displays, Haptic Displays, Visual Displays, Other sensory displays, Visual Perception, Requirements and Characteristics, Spatial Display Model. Processors – Role of Processors, Processor System Architecture, Processor Specifications. Tracking & Sensors - Tracking, Calibration, and Registration, Characteristics of Tracking Technology, Stationary Tracking Systems, Mobile Sensors, Optical Tracking, Sensor Fusion.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-3

Techniques: Marker-based approach- Introduction to marker-based tracking, types of markers, marker camera pose and identification, visual tracking, mathematical representation of matrix multiplication Marker types- Template markers, 2D barcode markers, imperceptible markers. Marker-less approach- Localization based augmentation, real world examples Tracking methods- Visual tracking, feature based tracking, hybrid tracking, and initialisation and recovery.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-4

Introduction to Virtual Reality: Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality. **Virtual World Motion tracking:** Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR and Haptic Representation in VR, Motion in Real and Virtual Worlds- Velocities and Accelerations	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.
Module-5	
l Worlds & Human Vision: Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations, Human Eye, eye movements & implications for VR. estibular System, Physics in the Virtual World, Mismatched Motion and Vector Tracking- Tracking 2D & 3D Orientation, Tracking Position and Orientation, Tracking Attached Bodies.	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three 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. Oliver Bimber and Ramesh Raskar, “Spatial Augmented Reality: Merging Real and Virtual Worlds”, 2005.
2. Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig, William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009.
3. Gerard Jounghyun Kim, “Designing Virtual Systems: The Structured Approach”, 2005.
4. Steven M. LaValle, “Virtual Reality”, Cambridge University Press, 2016.
5. Burdea, Grigore C and Philippe Coiffet, “Virtual Reality Technology”, Wiley Interscience, India, 2003.
6. William R Sherman, Alan B Craig, “Understanding Virtual Reality: Interface, Application and Design”, “The Morgan Kaufmann Series in Computer Graphics”, Morgan Kaufmann Publishers, San Francisco, CA, 2002.

Web links and Video Lectures (e-Resources):

- https://intelitek.com/fundamentals-of-robotics/
- https://www.youtube.com/watch?v=7Bahzh3rniw
- https://www.electronicsforu.com/technology-trends/tech-focus/sensors-robotics-artificial-intelligence
- https://www.youtube.com/watch?v=QJ1wixdSlRc
- https://www.youtube.com/watch?v=zyOv6rn3X88
- https://www.therobotreport.com/6-robotics-applications-new-markets/

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome

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

Sl. No.	Description	Blooms Level
CO1	Understand and analyze the hardware requirement of AR..	L1, L2, L3, L4
CO2	Describe AR systems work and list the applications of AR.	L1, L2, L3, L4,L5
CO3	Understand the design and implementation of the hardware that enables VR systems to be built.	L1, L2, L3, L4,L5
CO4	Explain the concepts of motion and tracking in VR systems.	L1, L2, L3, L4,L5
CO5	Understand the opportunities, challenges brought about by AR	L1, L2, L3, L4

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	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated uses and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and POs (Note : High - 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	2	2	3	3	3	1
CO2	2	2	3	3	3	3	2
CO3	2	2	3	3	3	3	2
CO4	2	2	2	3	3	3	3
CO5	1	2	2	2	3	3	2

Robot Programming Laboratory			
Course Code	MRAIL207	**CIE Marks**	50
Teaching Hours/Week (L:P:SDA)	0:0:2	**SEE Marks**	50
Credits	02	**Exam Hours**	03

Course objectives:

- To introduce the basic concepts, parts of robots and types of robots.
- To make the student familiar with the various drive systems for robot, sensors and their applications in robots and programming of robots.
- To select the robots according to its usage.
- To discuss about the various applications of robots, justification and implementation of robot.
- To know about welding application in a system.

Sl. No	Experiments
1	Robot Programming using Flex Pendant- Lead through programming including Coordinate systems of Robot.
2	Wrist Mechanism-Interpolation-Interlock commands.
3	VAL language commands motion control, hand control, program control, pick and place applications.
4	Palletizing applications using VAL.
5	Object detection and Sorting.
6	Robot welding application using VAL program.
Experiments beyond the syllabus (For CIE only)	
1	RAPID Language and AML.
2	Programming using Robot studio software.

Syllabus for Experiments:

- Introduce the way VAL II allows to define the robot locations, variables, and compound transformations
- A 'Point' or a 'Position' is a cartesian reference (X Y Z) in the work space. A 'Location' is a point plus an orientation. For example, when executing a motion instruction the robot moves so that the tool point goes to the specified destination point and the tool frame is oriented to the specified destination orientation.
- Application of Robots in continuous arc welding, Spot welding, Spray painting, assembly operation, cleaning, robot for underwater applications.
- Gripper force analysis and gripper design for typical applications, design of multiple degrees of freedom, active and passive grippers.
- Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection, software considerations.

Course outcomes

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

- Use fundamental and technical knowledge of robot Programming.
- Learn Robot Programming using teach Pendant for various applications.
- Use RAPID Language and AML.
- Program a Robot for Industrial applications.
- Program using Robot studio 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. 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 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 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.
- 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.

Suggested Text Books:

1. Hughes Cameron, "Robot Programming", Pearson Publishers, 2016.
2. J. Srinivas, "Robotics: Control and Programming", Narosa Publication, 2009.
3. Lentin Joseph, "Learning Robotics Using Python", Second Edition Design, simulate, program, and prototype an autonomous mobile robot using ROS, Open CV, PCL, and Python, Packt Publishing Paperback – 1 January 2018.
4. Staple Danny, "Learn Robotics Programming", Packt Publishing Limited, Feb 2021.
5. Kailashi Chandra Mahajan, Prashant Kumar Patnnaik, Raghvendra Kumar, "Robotics for Engineers", Vikas Publishing House, 2016.

	Agile Manufacturing			
	Course Code	MRAI214A	CIE Marks	50
	Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
	Total Hours of Pedagogy	40	Total Marks	100
	Credits	03	Exam Hours	03
	Course Learning objectives: ● Understand the agile manufacturing and conceptual framework. ● Analyse the four core concept of agile manufacturing. ● Study the implication of advanced manufacturing system. ● Understand and design the agile manufacturing enterprises. ● Design skill and knowledge enhancing technology fragile manufacturing			
	Module-1			
	duction - What is agile Manufacturing? - Competitive environment of the future the business case for agile manufacturing conceptual frame work for agile manufacturing.			
	Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.		
	Module-2			
	Four Core Concepts: Strategy driven approach - integrating organization, people technology interdisciplinary design methodology.			
	Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.		
	Module-3			
	Agile Manufacturing and Change Management: The change implications. Post failures in advanced manufacturing, changes on the way, traditional management accounting, paradigm, investment appraisal, product costing - performance, measurement and control systems, Traditional organization, control technological and design paradigms traditional problems in workplace- organizational issues – role of technology.			
	Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation..		
	Module-4			

	Agile Manufacturing Enterprise Design: Agile manufacturing - enterprise design.. system concepts as the basic manufacturing theory - joint technical & organizational design and a model for the design of agile manufacturing enterprise, enterprise design process insights into design processes, what is interdisciplinary design, Main issues - simple design example.	
	Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.
	Module-5	
	Skill & Knowledge Enhancing Technologies for Agile Manufacturing: Skill and Knowledge enhancing Technologies - scheduling - technology design strategic-Design Concepts. Design and Skill of Knowledge enhancing Technologies for machine tool systems - Historical overview, Lessons, problems and Future development. .	
	Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks**to attain the COs and POs

The sum of three 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. Agile manufacturing - Forging new Frontiers - Paul T. Kidd - Addison Wesley Publication
2. Agile Manufacturing – Proceedings of International Conference - Dr. M.P Chowdiah (Editor) – TataMcGraw Hill Publications
3. On Agile manufacturing - Tata McGraw Hill Publications
4. Agile manufacturing - Forging Neat Furniture's - Paul T Kidd – Addition Wesley Publications

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=_n28vUPJzxM
- https://www.youtube.com/watch?v=HQEkn-mJnas
- https://www.youtube.com/watch?v=7M_uMhxZtC4
- https://www.youtube.com/watch?v=VDz-SS6-P4s
- https://www.youtube.com/watch?v=G_0bl6FHo_c

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome

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

Sl. No.	Description	Blooms Level
CO1	Explain the agile manufacturing and conceptual framework.	L1, L2, L3, L4
CO2	Explain the four core concept of agile manufacturing.	L1, L2, L3, L4
CO3	Discuss the implication of advanced manufacturing system.	L1, L2, L3, L4
CO4	Plan and design the agile manufacturing enterprises.	L1, L2, L3, L4,L5
CO5	Invent skill and knowledge enhancing technology for agile manufacturing.	L1, L2, L3, L4,L5,L6

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	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and POs (Note : High - 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**1**	**2**	**2**	**2**	**3**	**3**	**2**
CO2	**1**	**2**	**3**	**3**	**3**	**3**	**2**
CO3	**2**	**2**	**2**	**2**	**3**	**3**	**2**
CO4	**1**	**2**	**2**	**3**	**3**	**3**	**2**
CO5	**1**	**2**	**2**	**3**	**3**	**3**	**2**

CAE and CIM			
Course Code	**MRAI214B**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To learn the basic concepts of Computer Aided Engineering and different discretization methods.
- To learn the different meshing techniques.
- To imbibe the basic knowledge of CAD, CA and CIM
- To develop the fundamental skill sets in CNC Programming
- To inculcate the fundamental knowledge automated material handling and storage system.

MODULE-1

ental Properties: Introduction to Computer Aided Engineering, CAE in product development discretization methods – Finite Element Method (FEM), Finite Difference Method (FDM) and Finite Volume Method (FVM), CAE tools Pre processor, Solver, Post processor.

ent Shapes: 1D, 2D and 3D elements, Nodal unknowns and Field variables.

Teaching-Learning Process	Chalk and Talk, Power point presentation, Animations

MODULE-2

Meshing Techniques: Discretization of a structure, 1D, 2D and 3D element meshing, Elements selection criteria, Refining mesh, Effect of mesh density in critical region, use of symmetry.

Problems on Beams and Trusses

Teaching-Learning Process	Chalk and Talk, Power point presentation, Animations

MODULE-3

Production development through CIM: Computers in Industrial manufacturing, Product cycle & Production development cycle, Introduction of CAD/CAM & CIM, sequential and concurrent engineering, soft and hard prototyping. **Computer Process Monitoring:** Process control methods, direct digital control, supervisory computer control, steady state optimal control, on line search strategies, adaptive control.	
Teaching-Learning Process	Chalk and Talk, Power point presentation, Animations

MODULE-4
puter Integrated Manufacturing: Fundamentals of CAD/CAM, Computerized Manufacturing planning systems, shop floor control & automatic identification techniques. Computer Network for manufacturing and the future automated factor.

Teaching-Learning Process	Chalk and Talk, Power point presentation, Animations

MODULE 5
Automated material Handling Storage: Material functions, types of material handling equipment, analysis of material handling systems, design of system, conveyor system, automated guided vehicle systems, automated storage/retrieval systems, caroused storage systems work in process storage, interfacing handling & storage with manufacturing.

Teaching-Learning Process	Chalk and Talk, Power point presentation, Animations

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks**to attain the COs and POs

The sum of three 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.

Suggested Learning Resources:Books

1. CAD/CAM -Zimmers& Grover – PHI
2. CAD/CAM/CIM - P.Radhakrishna - New Age International - 2nd edition
3. CAD/CAM - P.N.Rao - TMH

Web links and Video Lectures (e-Resources):

https://www.youtube.com/watch?v=fQ17i9RThvk
https://www.youtube.com/watch?v=NXel87Do0bA
https://www.youtube.com/watch?v=5qQCNg0Ja5Y
https://www.youtube.com/watch?v=Sx_j50K5qZo
https://www.youtube.com/watch?v=1_Bv9BJE2lI

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

- Quizzes
- Assignments
- Seminars

Course outcome

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

Sl. No.	Description	Blooms Level
CO1	Different element properties	L1, L2, L3, L4
CO2	Meshing techniques	L1, L2, L3, L4
CO3	Categorize computer aided quality control work for manufacturing.	L1, L2, L3, L4
CO4	List and explain different flow lines and transfer mechanisms	L1, L2, L3, L4,L5
CO5	Categorize Automated material Handling Storage system.	L1, L2, L3, L4

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	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and POs (Note : High - 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**2**	**3**	**3**	**3**	**-**	**2**
CO2	**3**	**2**	**2**	**2**	**3**	**-**	**2**
CO3	**-**	**-**	**3**	**3**	**3**	**3**	**2**
CO4	**-**	**3**	**3**	**2**	**3**	**-**	**2**
CO5	**2**	**-**	**2**	**-**	**3**	**-**	**2**

	DECISION MAKING TECHNIQUES			
	Course Code	MRAI214C	CIE Marks	50
	Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
	Total Hours of Pedagogy	40	Total Marks	100
	Credits	03	Exam Hours	03

Course Learning objectives:

- To provide greater insight into decision-making processes with strong fundamentals.
- To understand how people perceive and decide about risk and transform domain situation to LPP and solve it.
- To formulate domain situations into Transportation, Assignment, and Travelling salesman problems and derive Optimum solutions.
- To formulate game theory problems and obtain solutions using different methods and to understand the fundamentals of Queues.
- To develop an appropriate network diagram for the given problem and analyse the project using CPM/PERT, Crash the project and obtained minimum cost/time schedule.

Module-1

Introduction: Statistics and managerial decisions, statistical data and Operations Research techniques.

mentals of Statistics and Probability: Presentation and Analysis of Statistical Data, Measures of Central tendency and Location, Measure of Dispersion, Skewness and Kurtosis: Numerical Problems, Introduction to Probability and basic rules of probability**.**

Teaching-Learning Process	Chalk and Talk, Power point presentation, Animations

Module-2

Decision Making under Uncertainty: Alternative criteria for decision under uncertainty. Numerical Examples; **Linear Programming Problem**: Formulation of LPPs, Solution of LPPs by graphical method.

Solution of LPP by simplex method: Concept of duality and solution of dual problems, Solution of LPP by dual simplex method and Sensitivity analysis.

Teaching-Learning Process	Chalk and Talk, Power point presentation, Animations

Module-3

	portation and Assignment Problems: Structure of transportation problem and various methods to find IBFS, Optimality test of transportation problems by MODI method, Solution of degeneracy and unbalanced transportation problems, Time minimisation problems, Assignment problems and solution by Hungarian method, Flight scheduling problems, and Travelling Salesman-problem (TSP).	
	Teaching-Learning Process	Chalk and Talk, Power point presentation, Animations
	Module-4	
	Theory of Games: Two person zero sum game, Mini-max & Maxi-min strategies, Solution of game by dominance rules, arithmetic and algebraic methods, m×2 and 2×n games: Solution by method of sub games and graphical method. 3×3 games: Solution by method of matrices, approximate method using iterative procedure. **Waiting Line:** Basic structure of queuing systems and characteristics, Expressions for [(M/M/I):(FCFS/∞/∞)] queuing model**.** Simple Problems	
	Teaching-Learning Process	Chalk and Talk, Power point presentation, Animations
	Module-5	
	Network Analysis: PERT and CPM, Network construction and determination of critical path, Calculation of ES, EF, LS, LF, TF, FF and IF, Crashing of projects to obtain minimum cost/minimum time schedule. **Simulation of Management Systems:** Simulation and Monte Carlo method, Waiting line and inventory simulation models.	
	Teaching-Learning Process	Chalk and Talk, Power point presentation, Animations

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

attain the COs and POs

The sum of three 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:

Text Books:

1. Quantitative Techniques for Managerial Decisions – U K Srivastava, G V Shenoy, and S C Sharma, - New Age International (P) Ltd., Publishers
2. Operations Research: P K Gupta and D S Heera – S Chand & Company Ltd.

Reference Books

1. Operations Research - H. A. Taha- Prentice Hall of India
2. Introduction to Operations Research - Hillier and Liberman- McGraw Hill International
3. Operations Research – S. D Sharma, KedarNath Ram Nath& Company Ltd.

Web links and Video Lectures (e-Resources):

- https://www.bbau.ac.in/dept/UIET/EME-601%20Operation%20Research.pdf
- https://www.youtube.com/watch?v=FdKgeeb4q3w
- https://www.youtube.com/watch?v=jemAWA_WQCE
- https://www.youtube.com/watch?v=gbL3vYq3cPk
- https://www.youtube.com/watch?v=M8POtpPtQZc
- https://www.youtube.com/watch?v=-YBlR1UF-UY
- https://www.youtube.com/watch?v=rCLlyT547MY
- https://www.youtube.com/watch?v=lwX8HvF7DYM
- https://www.youtube.com/watch?v=JxnPBrNccqY
- https://www.youtube.com/watch?v=Wgkcrtjrr7s
- https://www.youtube.com/watch?v=v5ZfvATEoDY

Skill Development Activities Suggested

- At the end of the lecture/presentation, numerical exercises are to be taken up to solve problems related to the topics covered. Additional problems are to be given for practice and also as assignments under each of the topics covered.
- Field visits are to be made to collect empirical data pertaining to various decision-making models and subsequently the appropriate model is to be applied to solve the problems.

Course outcome

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

Sl. No.	Description	Blooms Level
CO1	To explain the need for Statistics in managerial decision making and compute the various measures of central tendency, dispersion, skewness and kurtosis for the collected statistical data	L1, L2, L3, L4
CO2	Identify situations of DMUR and solve it. Formulate LPP and derive optimal solutions using graphical method or Simplex method of different varieties	L1, L2, L3, L4
CO3	Identify the situations appropriate for the application of Transportation, Assignment, and Travelling salesman problems and derive optimum solution.	L1, L2, L3, L4
CO4	Identify the areas of application of Game theory and formulate mathematical problems with competitive situations and derive solutions. Explain waiting line problems and derive solution for $[(M/M/I):(FCFS/\infty/\infty)]$ queuing model.	L1, L2, L3, L4, L5
CO5	Apply the appropriate network techniques (PERT/CPM) to projects and Obtain optimum time/cost Networks through crashing. Apply Monte-Carlo simulation for waiting line and inventory situations.	L1, L2, L3, L4, L5

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	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and POs (Note : High - 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**2**	**2**	**1**	**1**	**-**	**-**
CO2	**2**	**2**	**3**	**2**	**1**	**-**	**-**
CO3	**2**	**2**	**3**	**2**	**1**	**-**	**1**
CO4	**2**	**2**	**2**	**2**	**1**	**-**	**1**
CO5	**3**	**2**	**3**	**2**	**2**	**1**	**1**

Product Design and Manufacturing

Course Code	**MRAI214D**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Understand modern product development processes.
- Understand and explain the concept of Industrial design and robust design concepts.
- Understand the concept of Design for manufacture and assembly.
- Understand the legal factors, social issues, engineering ethics related to product design

Module-1

Product Data Management : Product life cycle, Complexity in Product Development, General Description of PDM

Basic functionality of PDM: Information architecture, PDM System architecture, Applications used in PDM systems. Trends in PDM.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.
Module-2	
Document Management Systems: Document management and PDM, Document life cycle, Content Management, Document management and related technologies, Document management resources on the Internet.	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.
Module-3	
Workflow Management in PDM: Structure Management, Engineering Change Management, Release Management, Version Management, Configuration Management.	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.
Module-4	
Creating Product Structures: Part centric approach, CAD centric approach, Product Structure configuration, Managing Product Structures, PDM Tools: Matrix One, Team Center, Windchill. Enovia, PDM resources on the Internet.	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.
Module-5	
Implementation Case Studies: Sun Microsystems, Inc., Mentor Graphics Corporation, Ericsson Radio Systems AB, Ericsson Mobile Communications AB, ABB Automation Technology Products, SaabTech Electronics AB	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks**

attain the COs and POs

The sum of three 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. Computer Integrated Design and Manufacturing - David Bed worth. Mark Henderson &. Philips Wolfe - McGraw Hill Inc
2. Visual Modeling with Rational Rose and UML - Terry Quatrain –
3. Wind-chill - RS.O Reference manuals - 2000.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=oTqtY8yjUw4
- https://www.youtube.com/watch?v=bxHbP-q9InU
- https://www.youtube.com/watch?v=0XFuRPPkZvA
- https://www.technia.com/blog/cad-data-management-on-the-3dexperience-platform/
- https://www.youtube.com/watch?v=JvQI0jkv89k

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome

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

Sl. No.	Description	Blooms Level
CO1	Use the Product Design and Development Process, as a means to manage the development of an idea from concept through to production.	L1, L2, L3, L4
CO2	Employ research and analysis methodologies as it pertains to the product design process, meaning, and user experience.	L1, L2, L3, L4,L5
CO3	Apply creative process techniques in synthesizing information, problem-solving and critical thinking.	L1, L2, L3, L4
CO4	Demonstrate and employ hand drawing and drafting principles to convey concepts.	L1, L2, L3, L4,L5
CO5	Use basic fabrication methods to build prototype models for hard-goods and soft-goods and packaging.	L1, L2, L3, L4

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	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and POs (Note : High - 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	2	2	3	3	2
CO2	1	2	2	2	3	3	2
CO3	1	2	2	2	3	3	2
CO4	1	2	2	2	3	3	2
CO5	1	2	2	2	3	3	2

Internet of Robotic Things (IoRT)			
Course Code	**MRAI215A**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Understand the concept of robotics and its drives.
- Understand the IoT applications and images recognition mechanism.
- Program robot and analyse the computational element of robot computer system.
- Transform robot manipulator using IoT.
- Design and control robot cells and understand the application of robots.

Module-1

IoT Foundations: Introduction to Internet of Things, An Overview Introduction – Definition and characteristics of IoT, Physical design of IoT-Things in IoT, IoT protocol, Logical design of IoT – IoT functional blocks, IoT Communication Models,

Introduction to SDN: SDN for IoT, Data Handling and Analytics, Cloud Computing, Sensor-Cloud, Fog Computing, Examples of IoT based Systems: Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-2

IoT Architecture and its Protocols: Basics of Networking, Communication Protocols, Sensor Networks, Machine-to-Machine Communications, Interoperability in IoT.

Introduction: Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-3

ors for IoT: Sensing and actuation, types of sensors, Occupancy Sensors, Motion sensor, velocity, temperature, pressure, chemical, Gyroscopic sensor, Optical sensors, Humidity, Water Quality sensors, Sensor applications.

ator for IoT: Actuator types, working principle of actuators, integration of sensors and actuators with arduino, formation of actuators, selection criteria for right actuator, maintenance of actuators, smart material actuators.

Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

Module-4	
Applications of IoT in Robotics: Future farming with the Internet of things, drones for surveillance, Soft low-power robotics, Tracking sensors for underwater robotics, Disaster response, Medical services, Smart restaurant, Analysis of IoT applications and Sensors, Space robotics for science and space exploration, Satellite based Internetworking, Tele operators, Space component systems like rover mobility, locomotion and guidance.	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.
Module-5	
e of RIOT: Powering insect-scale wireless robotics, Big data analysis, Augmented Reality, Additive manufacturing, Cyber security, the industrial internet	
Teaching-Learning Process	Chalk and Talk / White board, Power Point Presentation, Video Demonstration or Simulation.

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three 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.
   The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Vijay Madisetti and ArshdeepBahga, Internet of Things (A Hands-on Approach), 1st Edition, VPT, 2014.Ltd.
2. Korf Richard, "Space Robotics", Carnegie-Mellon University, The Robotics Institute, 1982.
3. Lewin A.R.W. Edwards, "Open source robotics and process control cookbook", Elsevier Publications, 2005.
4. Francis DaCosta, Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, 1st Edition, Apress Publications, 2013.
5. WimerHazenberg, Menno Huisman and Sara Cordoba Rubino, Meta Products: Building the Internet of Things, BIS publishers, 2012.
6. Pethuru Raj and Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.
7. ArshdeepBahga and Vijay Madisetti Internet of Things: A Hands-on Approach", Universities Press, 2014.

Web links and Video Lectures (e-Resources):

- https://intelitek.com/fundamentals-of-robotics/
- https://www.youtube.com/watch?v=7Bahzh3rniw
- https://www.electronicsforu.com/technology-trends/tech-focus/sensors-robotics-artificial-intelligence
- https://www.youtube.com/watch?v=QJ1wixdSlRc
- https://www.youtube.com/watch?v=zyOv6rn3X88
- https://www.therobotreport.com/6-robotics-applications-new-markets/

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome

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

Sl. No.	Description	Blooms Level
CO1	Understand the drivers and enablers of Industry 4.0.	L1, L2, L3, L4
CO2	Appreciate the smartness in Smart Factories, Smart cities, smart products and smart services.	L1, L2, L3, L4,L5
CO3	Able to outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world.	L1, L2, L3, L4,L5
CO4	Appreciate the power of Cloud Computing in a networked economy.	L1, L2, L3, L4,L5

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	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated uses and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and POs (Note : High - 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**1**	**2**	**2**	**3**	**3**	**3**	**1**
CO2	**2**	**2**	**3**	**3**	**3**	**3**	**2**
CO3	**2**	**2**	**3**	**3**	**3**	**3**	**2**
CO4	**2**	**2**	**2**	**3**	**3**	**3**	**3**
CO5	**1**	**2**	**2**	**2**	**3**	**3**	**2**

	Design of Experiments			
	Course Code	MRAI215B	CIE Marks	50
	Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
	Total Hours of Pedagogy	40	Total Marks	100
	Credits	03	Exam Hours	03
	Course Learning objectives: ● Plan data collection, to turn data into information and to make decisions that lead appropriate action. ● Apply the methods taught to real life situations. ● Plan, analyze, and interpret the results of experiments. ● To understand the Orthogonal arrays. ● Analyze the Parameter and tolerance design concepts.			
	Module-1			
	Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments. **Concepts of random variable,** probability, density function cumulative distribution function. Sample and population, Measure of Central tendency; Mean median and mode, Measures of Variability, Concept of confidence level. Statistical Distributions: Normal, Log Normal & Weibull distributions. Hypothesis testing, Probability plots, choice of sample size. Illustration through Numerical examples.			
	Teaching-Learning Process	Chalk and talk, Videos, PowerPoint Presentation, Animations		
	Module-2			
	Classical Experiments: Factorial Experiments: Terminology: factors, levels, interactions, treatment combination, randomization, Two-level experimental designs for two factors and three factors. Three-level experimental designs for two factors and three factors, Factor effects, Factor interactions, Fractional factorial design, Saturated Designs, Central composite designs. Illustration through Numerical examples.			
	Teaching-Learning Process	Chalk and talk, Videos, PowerPoint Presentation, Animations		
	Module-3			

	Measures of variability, Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples. **Quality, Western and Taguchi's quality philosophy,** elements of cost, Noise factors causes of variation. Quadratic loss function & variations of quadratic loss function. Robust Design: Steps in Robust Design: Parameter design and Tolerance Design. Reliability Improvement through experiments, Illustration through Numerical examples**.**	
	Teaching-Learning Process	Chalk and talk, Videos, PowerPoint Presentation, Animations
	Module-4	
	Types of Orthogonal Arrays, selection of standard orthogonal arrays, Linear graphs and Interaction assignment, Dummy level Technique, Compound factor method, Modification of linear graphs. Illustration through Numerical examples.	
	Teaching-Learning Process	Chalk and talk, Videos, PowerPoint Presentation, Animations
	Module-5	
	Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-better type, Nominal-the –better-type, Largerthe- better type. Signal to Noise ratios for Dynamic problems. Illustration through Numerical examples. **Parameter and tolerance design concepts,** Taguchi's inner and outer arrays, parameter design strategy, tolerance design strategy. Illustration throughNumericalexamples.	
	Teaching-Learning Process	Chalk and talk, Videos, PowerPoint Presentation, Animations

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks**to attain the COs and POs

The sum of three 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

- Design and Analysis of Experiments, Douglas C Montgomerry, Wiley, 8th Edition
- Design and Analysis of Experiments, R. Panneerselvam, PHI
- Quality Engineering Using Robust Design, MadhavS,Phadke, PHI
- Design of Experiments with Minitab, Paul Mathews, New Age International
- Design of Experiments with Minitab, Virgil L Anderson and Robert A Mclean, Taylor and Francis

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=G_IAeHoukvE
- https://www.youtube.com/watch?v=KhjM8YI3agk
- https://www.youtube.com/watch?v=1fgvi1dXfMg
- https://www.youtube.com/watch?v=dmvo_B91vlc
- https://www.youtube.com/watch?v=sIRl1xWrViY

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome

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

Sl. No.	Description	Blooms Level
CO1	Plan data collection, to turn data into information and to make decisions that lead appropriate action.	L1, L2, L3, L4, L5
CO2	Plan, analyze, and interpret the results of experiments, To understand the Orthogonal arrays.	L1, L2, L3, L4, L5
CO3	Analyze the Parameter and tolerance design concepts.	L1, L2, L3, L4, L5

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	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and POs (Note : High - 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**1**	**2**	**3**	**3**	**-**	**2**
CO2	**1**	**1**	**2**	**3**	**3**	**-**	**2**
CO3	**1**	**1**	**2**	**3**	**3**	**-**	**2**

	Simulation and Modelling of Production Systems			
	Course Code	MRAI215C	CIE Marks	50
	Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
	Total Hours of Pedagogy	40	Total Marks	100
	Credits	03	Exam Hours	03

Course Learning objectives:

- Define the basics of simulation modeling and replicating the practical situations in organizations
- Generate random numbers and random variates using different techniques.
- Develop simulation model using heuristic methods.
- Analysis of Simulation models using input analyzer, and output analyzer
- Explain Verification and Validation of simulation model.

Module-1

Principle of Computer Modelling and Simulation: Monte Carlo simulation. Nature ofcomputer- modeling and simulation. Limitations of simulation, areas of applications. System and Environment: Components of a system -discrete and continuous systems, Models of a system –a variety of modeling approaches. Simulation Software: Selection of simulation software, simulation packages.

Teaching-Learning Process	Chalk and talk, Videos, PowerPoint Presentation, Animations, Analytical methods, Problem solving, Numerical exercises, Creating conducive environment in classroom for discussions and understanding through peer learning, promoting self learning activities and Giving assignments

Module-2

Discrete Event Simulation: Concepts in discrete event simulation, manual simulation using event scheduling, single channel queue, too server queue, simulation of inventory problem.

Statistical Models in Simulation: Discrete distributions, continuous distributions. **Discrete Event Simulation:** Concepts in discrete event simulation, manual simulation using event scheduling, single channel queue, too server queue, simulation of inventory problem.

Statistical Models in Simulation: Discrete distributions, continuous distributions.

	Teaching-Learning Process	Chalk and talk, Videos, PowerPoint Presentation, Animations, Analytical methods, Problem solving, Numerical exercises, Creating conducive environment in classroom for discussions and understanding through peer learning, promoting self learning activities and Giving assignments
	Module-3	
	Random Number Generation: Techniques for generating random numbers- Mid square method -the mod product method -Constant multiplier technique -Additive congruential method –Linear congruential method -Tests for random numbers -The Kolmogorov-Smimov test -the Chi-square test.	
	Teaching-Learning Process	Chalk and talk, Videos, PowerPoint Presentation, Animations, Analytical methods, Problem solving, Numerical exercises, Creating conducive environment in classroom for discussions and understanding through peer learning, promoting self learning activities and Giving assignments
	Module-4	
	Random Variable Generation: Inversion transforms technique-exponential distribution, uniform distribution, weibul distribution, continuous distribution, generating approximate normal variates-Erlang distribution.	
	Teaching-Learning Process	Chalk and talk, Videos, PowerPoint Presentation, Animations, Analytical methods, Problem solving, Numerical exercises, Creating conducive environment in classroom for discussions and understanding through peer learning, promoting self learning activities and Giving assignments
	Module-5	
	Empirical Discrete Distribution: Discrete uniform -distribution poisons distribution –geometricdistribution -acceptance -rejection technique for Poisson distribution gamma distribution **DesignandEvalution of Simulation Experiments:** variance reduction techniques -antithetic variables, variables-verification and validation of simulation models.	
	Teaching-Learning Process	Chalk and talk, Videos, PowerPoint Presentation, Animations, Analytical methods, Problem solving, Numerical exercises, Creating conducive environment in classroom for discussions and understanding through peer learning, promoting self learning activities and Giving assignments

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks**to attain the COs and POs

The sum of three 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

EXT BOOKS:

Discrete Event System Simulation - Jerry Banks & .John S Carson II - Prentice Hall Inc.-1984.

Systems Simulation - Gordan. G. - Prentice Hall India Ltd - 1991.

EFERENCE BOOKS:

System Simulation with Digital Computer - NusingDeo - Prentice Hall of India - 1979.

Computer Simulation and Modeling - Francis Neelamkovil - John Wilely& Sons - 1987.

Simulation Modeling with Pascal - RathM.Davis& Robert M O Keefe - Prentice Hall Inc. -1989.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=gbOn3jRc_Wc
- https://www.youtube.com/watch?v=Wp3jyLkfBQs
- https://www.youtube.com/watch?v=WfEZMhpzsT8
- https://www.youtube.com/watch?v=DBmYYpxjqvM
- https://www.youtube.com/watch?v=O46ZlKEjjHE
- https://www.youtube.com/watch?v=OH8MRT8eqRI
- https://www.youtube.com/watch?v=yN6cvjtlQtY
- https://www.youtube.com/watch?v=pt4v5l8-Pjw
- https://www.youtube.com/playlist?list=PL3l_ZG2nBXNLoPB26LeNRVDP6oG6Sz8tu
- https://www.youtube.com/watch?v=Oomz_iZ5d-0

Skill Development Activities Suggested

- At the end of the lecture/presentation, numerical exercises are to be taken up to solve problems related to the topics covered. Additional problems are to be given for practice and also as assignments under each of the topics covered.

Course outcome

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

Sl. No.	Description	Blooms Level
CO1	Describe the role of important elements of discrete event simulation and modeling paradigm.	L1, L2, L3, L4
CO2	Develop skills to apply simulation software to construct and execute goal-driven system models.	L1, L2, L3, L4, L5
CO3	Interpret the model and apply the results to resolve critical issues in a real world environment.	L1, L2, L3, L4, L5

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	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**1**	**2**	**2**	**2**	**3**	**3**	**2**
CO2	**1**	**2**	**3**	**3**	**3**	**3**	**2**
CO3	**2**	**2**	**2**	**2**	**3**	**3**	**2**

Mapping of COS and POs (Note : High - 3, Medium – 2, and Low – 1)

	Non Destructive Testing			
	Course Code	MRAI215D	CIE Marks	50
	Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
	Total Hours of Pedagogy	40	Total Marks	100
	Credits	03	Exam Hours	03
	Course Learning objectives: ● To inspect a component in a safe, reliable and cost effective manner without causing damage to the equipment ● To weld inspectors can determine whether a weld is strong or has potential defects that could compromise it integrity ● Ultrasonic testing is to detection of defect, measurement of their parameters assessment of their hazard assessment feasibility operation of the particular tested objected ● Liquid penetrate testing is to provide visual evidence of surface discontinuities in solid non-porous materials ● Magnetic Particle inspection is a NDT method, to detect surface and subsurface flaws in ferromagnetic Materials			
	Module-1			
	Introduction: Definition of Non-destructive testing,Need for NDT techniques and its applications, Types of NDT techniques, benefits from Non-destructive Testing, nature of flaws ,various steps involved in NDT, uses of Non-destructive techniques. **Non-Destructive Testing of Welds:** Definition of weld, types of weld joints, Welding processes; Gas welding,shielded metal arc welding, TIG spot welding, submerged arc welding, Defects in welded joints, Defects associated with residual stresses, Testing, measurement and control (TMC) of welds, Testing of welded joints; destructive test, Non-destructive tests			
	Teaching-Learning Process	Introduction about Non-destructive testing, and NDT of welds, Chalk and talk used for draw figures and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.		
	Module-2			

	Ultrasonic Testing : Introduction frequency of ultrasonic Waves, Generation of Ultrasonic waves, Piezo-electric materials for Ultrasonic Transducers, Types of Ultrasonic Waves, Different kinds of Ultrasonic Transducers,Types of ultrasonic waves, Reflection, Refraction and scattering of Ultrasonic beam, working of ultrasonic Flaws detectors, industrial application, Pulse-echo and through transmission Testing, Scanner assemblies for transmission and pulse-echo techniques, types of scan, shear wave and surface wave applications, Resonance techniques, use of Ultrasonic for thickness measurements.	
	Teaching-Learning Process	Discussed about ultrasonic testing and Chalk and talk used for draw figures and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
	Module-3	
	Liquid Penetrants Testing: Types of Penetrants, Types of developers, Penetration time, Inspection, Post emulsifiable fluorescent penetrants system, Water washable fluorescent Penetrants, Low and High temperature Penetrants, High sensitivity fluorescence penetrant examination, Advanced LPT techniques; Ultrasonic pumping to enhance performance, ultrasonically enhanced penetrant inspection of small weldments, Mechanised remote liquid penetrant testing of piping of reactors.	
	Teaching-Learning Process	Discussed about liquid penetrant testing and Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
	Module-4	
	Eddy current Testing: instrumentation of ECT, inspection of welds, advanced eddy current testing,Multi-frequency ECT, 3D phase array ECT, Remote field ECT, Magnetically based eddy current. Flux leakage, Computer modelling of ECT, Digital signal Processing, Eddy current imaging; eddy current imaging system, imaging and characterisation of defects, Eddy current array instrumentation for fixed position scanning.	
	Teaching-Learning Process	Discussed about liquid Eddy current testing and Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
	Module-5	
	Magnetic particle Flaws detection: Principle of Magnetic Flaw detection, Types and methods of Magnetisation, Magnetic particles, Dry and Wet methods of Magnetic Particles inspection, Use of fluorescent Coated Magnetic particles, Industrial applications, Working of a Few Commercially available Magnetic Crack Detectors, Flaw detection in Rods, pipes and a short work piece, Precautions, Limitations, Residual magnetism, Need for Demagnetisation Research Techniques using Magnetic Particle Methods.	

Teaching-Learning Process	Discussed about liquid Magnetic particle Flaws detection and Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks**to attain the COs and POs

The sum of three 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

- Non-Destructive Testing Techniques Ravi Prakash 3rd Edition 2010 New Age International (P) Ltd., publishers
- Non-destructive Testing of Welds Baldev Raj C.V. Subramanian T. Jayakumar Revised Edditon 2000Narosa Publishing House
- Welding Technology O.P. KhannaDhanpatRai Publication 2008

Web links and Video Lectures (e-Resources):

- https://www.asnt.org/MajorSiteSections/About/Introduction_to_Nondestructive_Testing.aspx#:~:text=Nondestructive%20testing%20(NDT)%20is%20the,part%20can%20still%20be%20used.
- https://www.youtube.com/watch?v=tlE3eK0g6vU
- https://www.youtube.com/watch?v=9qw0Dka_YcU
- https://www.youtube.com/watch?v=qpgcD5k1494
- https://www.youtube.com/watch?v=bHTRmTQDZzg

Skill Development Activities Suggested

1. Contents related activities (Activity-based discussions)
2. For active participation of students to learnt about welds, Ultrasonic, Liquid Penetrant, Eddy current and some other testing of demonstration in Labs
3. Instruct the students individual to prepare module wise ppt
4. Organizing Group wise discussions and NDT based activities , Quizzes and Discussions.

Course outcome

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

Sl. No.	Description	Blooms Level
CO1	Distinguish the destructive and non-destructive testing and find effectiveness.	L1, L2, L3, L4
CO2	Ultrasonic testing is to detection of defect, measurement of their parameters assessment of their hazard assessment feasibility operation of the particular tested objected	L1, L2, L3, L4
CO3	Find the surface defect using liquid penetrate and magnetic particle test and eddy current test.	L1, L2, L3, L4, L5

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	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and Pos (Note : High – 3, Medium – 2, and Low – 1)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO1	**2**	**2**	**2**	**3**	**3**	**3**	**2**
CO2	**1**	**1**	**2**	**2**	**3**	**-**	**2**
CO3	**2**	**2**	**2**	**3**	**3**	**-**	**2**

	Nano Technology			
	Course Code	MRAI258A	CIE Marks	50
	Teaching Hours/Week (L:P:SDA)	00:02/01:00	SEE Marks	50
	Total Hours of Pedagogy	30/15	Total Marks	100
	Credits	01	Exam Hours	03

Course Learning objectives:

- To provide an intensive and in-depth learning to the students in field of Nanotechnology.
- Beyond simulating, learning, understanding the techniques, the course also addresses the underlying recurring problems of disciplines in today scientific and changing business world.
- To develop awareness & knowledge of different organization requirement and subject knowledge through varied subjects and training methodology in students.
- To train the students to take up wide variety of roles like researchers, scientists, consultants, entrepreneurs, academicians, industry leaders and policy.

Module-1	
Metal based nanocomposites- Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Metal-metal nanocomposites, some simple preparation techniques and their new electrical and magnetic properties	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-2	
Design of Super hard materials- Super hard nano composites, its designing and improvements of mechanical properties. **Nanofiller synthesis** - applications, Polymer nano composites, particulate and fibre modified nano composites, matrices and fibres, polymer- filler interphase, pull- out strength, effect of various treatments	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-3	

	Mechanics of polymer nanocomposites, Interfacial adhesion and characterisation, factors influencing the performance of nanocomposites, physical and functional properties. Nano composite fabrication, matrices, methods, additives, moulding processes.	
	Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
	Module-4	
	Polymer-carbonnanotubesbasedcomposites-processingmethods and characterization using OM, SEM, XRD, TEM	
	Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
	Module-5	
	Characterization of Polymer nanotubes based composites for Mechanical, Electrical and Thermal Properties and their applications - Polymer / nanofillers (metallic nanopowders) systems, Rheological measurements, processing characteristics. Testing of nanocomposites, ThermalanalysissuchasTGA,TMA,DSC,DMTA.	
	Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks** to attain the COs and POs
3. The sum of three 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

Textbooks

1. **PolymerScienceandTechnology**-JoelR.Fried-Prentice-Hall, Inc. EnglewoodCliffs, N. J., USA - 2000.
2. **New Developments and Technology** -Hand book of Elastomers - (Eds. A. K.Bhowmic and H. C. Stephense), Marcel - Dekker Inc., New York - 1995.
3. **PolymerBlends**-D.R.PaulandS.Newman-AcademicPress, New York - 1978.
4. **PolymerScience** -FredW.Billimeyer,Jr-WileyInterscience Publication – thirdedition , 1994

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	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**2**	**2**	**3**	**3**	**3**	**2**
CO2	**1**	**1**	**2**	**2**	**3**	**-**	**2**
CO3	**2**	**2**	**2**	**3**	**3**	**-**	**2**

Mapping of COS and Pos (Note : High – 3, Medium – 2, and Low – 1)

	Smart Materials			
	Course Code	MRAI258B	CIE Marks	50
	Teaching Hours/Week (L:P:SDA)	00:02/01:00	SEE Marks	50
	Total Hours of Pedagogy	30/15	Total Marks	100
	Credits	01	Exam Hours	03

Course Learning objectives:

- Learn about composite materials, smart materials, their properties, classification and applications
- Understand types of smart material based on their electrical and magnetic properties
- Characterize piezoelectric, ferroelectric and multi-ferroic materials,
- Identify novel functions of smart materials,
- Apply the acquired knowledge of smart materials in different applications
- Evaluate the importance of smart materials in day-to-day life.

Module-1

Introduction: Closed loop and Open loop Smart Structures. Applications of Smart structures, Piezoelectric properties. Inchworm Linear motor, Shape memory alloys, Shape memory effect- Application, Processing and characteristics. Shape Memory Alloys: Introduction, Phenomenology, and Influence of stress on characteristic temperatures, Modelling of shape memory effect. Vibration control through shape memory alloys. Design considerations, multiplexing embedded NiTiNOL actuators

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-2

Electro rheological and Magneto rheological Fluids: Mechanisms and Properties, Characteristics, Fluid composition and behaviour, Discovery and Early developments, Summary of material properties. Applications of ER and MR fluids (Clutches, Dampers, others). Fibre Optics: Introduction, Physical Phenomenon, Characteristics, Fibreoptic strain sensors, Twisted and Braided Fibre Optic sensors, Optical fibres as load bearing elements, Crack detection applications, Integration of Fibre optic sensors and shape memory elements.	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-3	
Vibration Absorbers: Introduction, Parallel Damped Vibration Absorber, Analysis, Gyroscopic Vibration absorbers, analysis & experimental set up and observations, Active Vibration absorbers. Control of Structures: Introduction, Structures as control plants, Modelling structures for control, Control strategies and Limitations. Biomimetics: Characteristics of Natural structures. Fibre reinforced: organic matrix natural composites, Natural creamers, Mollusks. Biomimeticsensing,Challengesandopportunities.	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-4	
MEMS: History of MEMS, Intrinsic Characteristics, Devices: Sensors and Actuators. Microfabrication: Photolithography, Thermal oxidation, Thin film deposition, etching types, Doping, Dicing, Bonding. Microelectronics fabrication process flow, Silicon based, Process selection and design. Piezoelectric Sensing and Actuation:Introduction, Cantilever Piezoelectric actuator model, Properties of Piezoelectric materials, Applications. Magnetic Actuation: Concepts andPrinciples,MagnetizationandNomenclatures,Fabricationandcase studies, Comparison of major sensing and actuation methods	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-5	
Polymer MEMS& Micro fluidics: Introduction, Polymers in MEMS (Polyimide, SU8,LCP,PDMS, PMMA, Parylene,Others) Applications(Acceleration, Pressure, Flow, Tactile sensors).Motivation for micro fluidics, Biological Concepts, Design and Fabrication of Selective components. Channels and Valves. Case Studies: MEMS Magnetic actuators, BP sensors, Microphone, Acceleration sensors, Gyro, MEMSProduct development:Performance, Accuracy, Repeatability, Reliability, Managing cost, Market uncertainties	

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

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. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks** to attain the COs and POs

The sum of three 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

Textbooks

1. "Smart Structures –Analysis and Design", A.V.Srinivasan, CambridgeUniversityPress,NewYork,2001,(ISBN:0521650267).
2. "SmartMaterialsandStructures",M.V.GandhiandB.S.Thompson Chapmen & Hall,London, 1992 (ISBN:0412370107
3. Duerig,T. W.**,** Melton, K. N, Stockel, D. and Wayman, C.M., "Engineering aspects ofShapememory Alloys", Butterworth – Heinemann, 1990.
4. Rogers,C.A.,SmartMaterials,"StructuresandMathematical issues", TechnomicPublishing Co., U.S.A, 1989.
5. MelSchwartz(Ed),EncyclopaediaofSmartMaterials"Volume –I and II, John Wiley &Sons, Inc.2002

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	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**2**	**2**	**3**	**3**	**3**	**2**
CO2	**1**	**1**	**2**	**2**	**3**	**-**	**2**
CO3	**2**	**2**	**2**	**3**	**3**	**-**	**2**

Mapping of COS and Pos (Note : High – 3, Medium – 2, and Low – 1)

	Precision Engineering			
	Course Code	MRAI258C	CIE Marks	50
	Teaching Hours/Week (L:P:SDA)	00:02/01:00	SEE Marks	50
	Total Hours of Pedagogy	30/15	Total Marks	100
	Credits	01	Exam Hours	03
	Course Learning objectives: ● A basic understanding of Precision Engineering, its machines and the different techniques of super finishing. ● To learn the calculation of allowances, tolerances and DOE techniques. ● To learn about tool materials and its different coating methods for Precision Machining. ● To learn the techniques used for quality control and quality improvement and the different quality standards. ● To learn the importance of reliability concepts and a modern quality systems.			
	Module-1			
	CONCEPTSOFACCURACYANDMACHINETOOLS: PartAccuracy – errors, accuracy of machine tools – spindle accuracy – displacement accuracy – errors due to numerical interpolation – definitionofaccuracyofN.C system –errorsintheNCmachines– feed stiffness – zero stability			
	Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.		
	Module-2			

	STIFFNESS,THERMALEFFECTSANDFINISHMACHINING: Overall stiffness of Lathe – compliance of work piece – errors caused by cutting forces – deformation in turning – boring – milling – heat sources – thermal effects – Finish Turning, boring, grinding – Surface roughness	
	Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
	Module-3	
	DIMENSIONING: Definitionofterms–Keydimension– Superfluous dimension – dimensional stepped shaft –Assigningtolerancesintheconstituentdimensions– dimensional chains.	
	Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
	Module-4	
	MICRO-MACHININGMICRO-FABRICATION: MicroMachining–Photoresistprocess–Lithography–LIGAProcess– Optical,processingofmaterials– electronbeammachining–beam machining–microforming,diamondturning–micropositioning devices – etching – physical vapour deposition – Chemical vapour deposition.	
	Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
	Module-5	
	SMARTSTRUCTURES,MATERIALSANDMICRO **ACTUATORS:** Smart structures – Smart materials types and applications – smart sensors – micro valves –MEMS – Micro motors – Micropumps– microdynamometer– micromachines– microoptics–micronozzles	

	Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks** to attain the COs and POs

The sum of three 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

Textbooks

1. MurthyR.L.,"PrecisionEngineeringinManufacturing",NewAge International Pvt, 2005.
2. JuliarW.Gardner.VijayK.Varadan,"Microsensors,MEMSand Smart Devices", John Wiley and sons, 2001.
3. StephenA.Campbell,"TheScienceandEngineeringofMicroelectronicFabrication",OxfordUniversityPress,1996.
4. RaadyFrank,"UnderstandingSmartSensors",Artech.House, Boston, 1996.
5. MEMSHandBook,CRCPress,2001.

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	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	2	2	3	3	3	2
CO2	1	1	2	2	3	-	2
CO3	2	2	2	3	3	-	2

Mapping of COS and Pos (Note : High – 3, Medium – 2, and Low – 1)

Advanced Processing of Materials			
Course Code	MRAI258D	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	00:02/01:00	SEE Marks	50
Total Hours of Pedagogy	30/15	Total Marks	100
Credits	01	Exam Hours	03

Course Learning objectives:

- Impart knowledge to students in the latest technological topics on Production and Industrial Engineering and to provide them with opportunities in taking up advanced topics in the field of study.
- Create a congenial environment that promotes learning, growth and imparts ability to work with multi-disciplinary groups in professional, industry and research organizations.
- Broaden and deepen their capabilities in analytical and experimental research methods, analysis of data and drawing relevant conclusions for scholarly writing and presentation.
- Provide guidance to students for their choices in research and professional career outlook and to encourage students to take up research.

Module-1

Casting Process: Introduction, various manufacturing processes, convectional casting processes, special casting processes, squeeze casting processes, foam casting, melting processes, Types of furnace, melting using cupola furnace, Resistance furnace, Induction furnace.

Powder Metallurgy Process: Introduction, benefits of power metallurgy process, limitations and applications of process, flow chart of process, various methods of production of powder, powder treatment, powder characteristics, compaction of powder and its methods, pre-sintering, operation before sintering, sintering, operatingAftersintering.

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-2

Mechanical Alloying: Introduction and process of mechanical alloying, milling parameters in mechanical alloying, material synthesizing using mechanical alloying, phase formed in mechanical alloying,mechanicalalloyingofmisciblesystems, mechanicalalloying of immiscible systems, oxide dispersion strengthened alloys, reactive milling, phase transition observed in mechanical alloying.	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-3	
Advance Processing and Forming: Introduction: abrasive finishing, Chemical mechanical polishing (CMP) technology, photochemical machining, high voltage forming of metal, explosive forming or fabrication, Electrochemical hydraulic forming, magnetic pulse forming	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-4	
Processing of polymer materials and latest trends inmanufacturing processes: Introduction, processing of plastic, compression moulding, injection molding, extrusionmolding, blow molding, ageing of polymer, Effect of temperature, UV and solar radiations,Introduction to agile manufacturing and greenmanufacturing, Advantages and application ofagilemanufacturing,Advantagesandapplicationofgreenmanufacturing	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-5	
Metal injection moulding (MIM) and self-propagating high temperature synthesis processes: Introduction, steps in MIM, Advantages and requirements of MIM, materialsprocesses of MIM, SHS process: Introduction, Types of SHS, reaction mechanics, parametersto be considered in SHS, Types of SHS products and applications microwaves sintering ofmetals process, Types of SHS products and applications, process parameters for microwavesintering,Advantagesandlimitations	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Assessment Details (both CIE and SEE)

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Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **oneSkill Development Activity of 40 marks** to attain the COs and POs

The sum of three 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

Textbooks

1. ModernmachiningprocessesbyPCPandeyandshah,TataMc Grew Hill, NewDelhi.
2. PrinciplesofmaterialsscienceandengineeringbyWFSMITH, Tata Mc Grew Hill
3. ManufacturingengineeringandtechnologybyKalpakjain
4. MANUFACTURINGTECHNOLOGYbyROAPN,TATAMc, GrewHill1996
5. MurthyR.L.,"PrecisionEngineeringinManufacturing, " New Age International Pvt, 2005.
6. 2) JuliarW.Gardner.VijayK.Varadan, "Micro sensors, MEMS and Smart Devices", John Wiley and sons, 2001.
7. (1)StephenA.Campbell,"TheScienceandEngineeringofMicroelectronicFabrication",OxfordUniversityPress,1996.

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
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4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and Pos (Note : High – 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**2**	**2**	**3**	**3**	**3**	**2**
CO2	**1**	**1**	**2**	**2**	**3**	**-**	**2**
CO3	**2**	**2**	**2**	**3**	**3**	**-**	**2**