MEHNC7003: Additive Manufacturing Design		
Teaching Scheme	**Examination Scheme**	
Lectures: 04 Hrs. / Week	**ISEI**	**15 Marks**
Credits: 04	**ISEII**	**15 Marks**
	ISE III	**10 Marks**
	ESE	**60 Marks**

Course Outcomes:
After completing the course students will able to

Course Outcomes	
CO1	Use the principles of additive manufacturing processes to select suitable AM techniques for engineering applications.
CO2	Implement Design for Additive Manufacturing (DfAM) guidelines to develop functional and optimized product designs.
CO3	Utilize material selection criteria and process parameters for polymer, metal and composite additive manufacturing processes.
CO4	Employ software tools for CAD modeling, STL generation, slicing, build orientation and process planning in additive manufacturing.
CO5	Integrate post-processing methods, quality inspection techniques and sustainability principles into additive manufacturing applications.

Detailed Syllabus:

Unit 1	**Introduction to Additive Manufacturing** Introduction to Additive Manufacturing (AM), Evolution of Rapid Prototyping to, Additive Manufacturing, Classification of AM processes (ISO/ASTM 52900), Advantages and limitations of AM, Comparison between conventional and additive manufacturing, Industrial applications of AM, Design challenges to additive manufacturing
Unit 2	**Design for Additive Manufacturing (DfAM)** Introduction to DfAM, Design rules and guidelines, Part orientation, Support structure design, Lattice structures, Cellular structures, Topology optimization, Lightweight design, Part consolidation, Design optimization using AM
Unit 3	**Materials and AM Processes** Polymer materials, Metal powders, Composite materials, Ceramic materials, Material properties, FDM, SLA, SLS, DMLS, Binder Jettin, Material Jetting, Directed Energy Deposition
Unit 4	**Digital Workflow and Process Planning** CAD modelling for AM, STL file generation, STL errors and repair, Mesh optimization, Slicing software, Build orientation, Tool path generation, Support generation, Process parameter optimization, Build time estimation
Unit 5	**Post Processing, Inspection and Industrial Applications** Support removal, Heat treatment, Surface finishing, Machining of AM parts Dimensional inspection, Mechanical testing, Defect analysis, Quality assurance, Sustainability in AM, Industrial applications in aerospace, automotive, biomedical and tooling, Future trends in additive manufacturing

Text and Reference Books
1. Martin Gebhardt, *Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing*, 2nd Edition, Hanser Publications, 2012. 2. Liou W. Frank and Ming C. Leu, *Additive Manufacturing: Fundamentals and Applications*, CRC Press, 2020. 3. Amit Bandyopadhyay and Susmita Bose, *Additive Manufacturing*, CRC Press, 2015. 4. NPTEL – Additive Manufacturing https://nptel.ac.in 5. ASTM International – Additive Manufacturing Standards https://www.astm.org 6. America Makes – National Additive Manufacturing Innovation Institute https://www.americamakes.us 7. EOS Additive Manufacturing Knowledge Center https://www.eos.info 8. Materialise Learning Center https://www.materialise.com 9. Autodesk Design for Additive Manufacturing Resources https://www.autodesk.com

Program Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO 1	3	2	2	-	2	-	-	-	-	-	-	3	1
CO 2	2	3	3	1	2	-	1	-	-	-	-	3	2
CO 3	3	2	3	2	2	-	1	-	-	-	1	3	2
CO 4	2	2	3	2	3	-	-	-	1	1	-	3	2
CO 5	2	2	2	2	3	1	3	2	1	1	1	2	2

1 – high 2 – Medium 3 - Low

Assessment:
ISE I: Shall be on the basis of Class Tests on First and Second unit.
ISE II: Shall be based on class test on third, fourth units.
ISE III: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/Presentations.

Assessment Pattern:

Assessment Pattern Level	Knowledge Level	ISE I	ISE II	ISE III	End Semester Examination
K1	Remember	2	2	2	
K2	Understand	3	3	3	
K3	Apply	2	2	3	
K4	Analyze	3	3	2	
K5	Evaluate	5	5		
K6	Create				
Total Marks 100		15	15	10	60

Assessment table:

Assessment Tool	K1 and K2	K2 and K3	K4 and K5	K1 and K2	K2 and K3	K4 and K5
	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**CO5**
ISE I (15 Marks)	4	6	5			
ISE II (15 Marks)				4	6	5
ISEIII (10 Marks)	1	2	2	1	2	2
ESE Assessment (60 Marks)	05	10	15	05	10	15
Total Marks 100	10	18	22	10	18	22

MEHNC7004: 3D Printing and Application		
Teaching Scheme	**Examination Scheme**	
Lectures: 04 Hrs. / Week	**ISEI**	**15 Marks**
Credits: 04	**ISEII**	**15 Marks**
	ISE III	**10 Marks**
	ESE	**60 Marks**

Course Outcomes:

After completing the course students will able to

Course Outcomes	
CO1	Understand fundamentals of 3D printing technologies.
CO2	Explain CAD modeling, slicing, and data preparation for 3D printing.
CO3	Analyze different AM processes such as FDM, SLA, SLS, and DED.
CO4	Implement 3D printing techniques in engineering applications.
CO5	Evaluate advantages, limitations, and selection of AM processes for industries.

Detailed Syllabus:

Unit 1	**Introduction to 3D Printing** Introduction to 3D Printing and Additive Manufacturing (AM), History and evolution , Difference between subtractive, formative, and additive manufacturing, Basic principles of layer-by-layer fabrication CAD to physical part workflow, Advantages, limitations, and applications of 3D Printing, Digital manufacturing ecosystem
Unit 2	**Cad modelling & data preparation** Role of CAD in 3D printing, Solid modeling techniques (parametric modeling basics), STL file format and its importance, File conversion and slicing, Slicing software (Cura, PrusaSlicer – overview), Layer thickness and resolution, Support structures generation, Toolpath generation, G-code basics
Unit 3	1.Material Extrusion: FDM (Fused Deposition Modeling), Working principl, Materials used (PLA, ABS) 2.Vat Photopolymerization: SLA (Stereolithography), DLP (Digital Light Processing), Photopolymer resins 3.Powder Bed Fusion: SLS (Selective Laser Sintering), SLM (Selective Laser Melting), EBM (Electron Beam Melting) 4.Material Jetting: Inkjet-based AM 5.Direct Energy Deposition (DED): Laser cladding process
Unit 4	**Materials, process parameters & post processing** Materials used in 3d printing: Polymers, Metals, Ceramics, Composites, Material properties required for AM, Process parameters: Layer thickness, Build

	orientation, Temperature control, Print speed, Post-processing techniques: Surface finishing, Heat treatment, Support removal, Machining & polishing, Defects in 3D printing: Warping, Delamination, Porosity
Unit 5	**Applications & industrial uses** Engineering Applications: Aerospace components, Automotive prototyping, Tooling and jigs/fixtures, Medical Applications: Prosthetics, Implants, Bio-printing (basic idea): Industrial Applications, Rapid prototyping, Customized manufacturing, Spare parts production, Advanced Concepts: 4D printing (introduction), Industry 4.0 integration, Digital manufacturing and smart factories, Economic & Environmental Aspects: Cost comparison with conventional methods, Waste reduction, Sustainability benefits

Text Books and Reference Books

1. Gibson, I., Rosen, D. W., & Stucker, B. (2021). *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing* (3rd ed.). Springer Nature.
2. Chua, C. K., Leong, K. F., & Lim, C. S. (2010). *Rapid Prototyping: Principles and Applications* (3rd ed.). World Scientific Publishing.
3. Gebhardt, A., & Hötter, J.-S. (2016). *Additive Manufacturing: 3D Printing for Prototyping and Manufacturing*. Hanser Publishers.
4. Ligon, S. C., Liska, R., Stampfl, J., Gurr, M., & Mülhaupt, R. (2017). *Polymers for 3D Printing and Customized Additive Manufacturing*. *Chemical Reviews*, 117(15), 10212–10290.
5. Ngo, T. D., Kashani, A., Imbalzano, G., Nguyen, K. T. Q., & Hui, D. (2018). *Additive Manufacturing (3D Printing): A Review of Materials, Methods, Applications and Challenges*. *Composites Part B: Engineering*, 143, 172–196.
6. Wohlers, T., & Campbell, I. (Eds.). (2024). *Wohlers Report 2024: Additive Manufacturing and 3D Printing State of the Industry*. Wohlers Associates, Inc.
7. Gu, D. (2015). *Laser Additive Manufacturing of High-Performance Materials*. Springer.
8. Liou, F. W. (2008). *Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development*. CRC Press.
9. Horn, T. J., & Harrysson, O. L. A. (2012). *Overview of Current Additive Manufacturing Technologies and Selected Applications*. *Science Progress*, 95(3), 255–282.
10. Kumar, L. J., & Kruth, J. P. (2008). *Comprehensive Review of Additive Manufacturing Processes*. *Journal of Materials Processing Technology*, 209(15–16), 548–560.
11. Singh, R. (2016). *Introduction to Basic Manufacturing Processes and Workshop Technology*. New Age International Publishers. *(Useful for comparing conventional and additive manufacturing processes.)*
12. Bandyopadhyay, A., & Bose, S. (2015). *Additive Manufacturing*. CRC Press.
13. Zhang, Y., Bernard, A., Gupta, R. K., & Harik, R. (Eds.). (2019). *Additive Manufacturing: Design, Methods, and Processes*. CRC Press.
14.

Standards and Technical References

1. ASTM International. (2021). *ASTM F2792/F2792M – Standard Terminology for Additive Manufacturing Technologies*. ASTM International.

2. ISO/ASTM International. (2021). *ISO/ASTM 52900: Additive Manufacturing – General Principles – Fundamentals and Vocabulary*. ISO.
3. ISO/ASTM International. (2019). *ISO/ASTM 52910: Additive Manufacturing – Design Requirements, Guidelines and Recommendations*. ISO.
4. ISO/ASTM International. (2020). *ISO/ASTM 52921: Standard Terminology for Coordinate Systems and Test Methodologies in Additive Manufacturing*. ISO.

These textbooks and references collectively cover the complete syllabus, including **CAD modeling, STL generation, slicing, FDM, SLA, SLS, SLM, EBM, DED, material properties, process parameters, post-processing, applications, Industry 4.0 integration, and standards**, making them appropriate for undergraduate and postgraduate engineering courses.

Online Resources

NPTEL Courses

1. Additive Manufacturing — IIT Kanpur / IIT Bombay (varies)
2. Introduction to Additive Manufacturing — IIT Madras
3. Rapid Manufacturing / Rapid Prototyping — IIT Kharagpur
4. 3D Printing: Applications and Design — IIT Guwahati

NPTEL Portal: https://nptel.ac.in

Assessment:

ISE I: Class test / assignments on Units 1 & 2
ISE II: Class test / assignments on Units 3 & 4
ISE III: Teachers assessment,

Assessment pattern:

Assessment pattern levels no.	Knowledge levels	ISE I	ISE II	ISE II	ESE
K1	Remember	2	–	–	10
K2	Understand	5	5	2	20
K3	Apply	8	10	5	20
K4	Analyze	–	–	3	10
K5	Evaluate	–	–	–	–
K6	Create	–	–	–	–
Total Marks 100		**15**	**15**	**10**	**60**

Assessment table:

Assessment Tool	K, K2 and K3	K2 and K3	K1, K2, K3	K1, K2, K3	K1, K2, K3
	Co1	C02	Co3	Co4	Co5
ISE I (15 Marks)	10	5	–	–	–
ISE II (15 Marks)	–	5	10	–	–
ISE III (10 Marks)	2	2	2	2	2

ESE (60 Marks)	10	15	15	10	10
Total (100 Marks)	**22**	**27**	**27**	**12**	**12**

Special Instruction if any: Nil

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1	1	1	1	-	-	-	-	1	-	3	2
CO2	3	2	2	2	2	-	-	-	-	1	-	3	2
CO3	3	3	3	3	2	-	-	-	-	1	-	3	3
CO4	2	3	3	3	3	2	-	-	-	2	-	2	3
CO5	2	2	3	2	2	-	-	-	-	2	-	2	3

1 – Low 2- Medium 3- High

MEHNC7008: Industrial Automation		
Teaching Scheme	**Examination Scheme**	
Lectures: 04 Hrs. / Week	**ISEI**	**15 Marks**
Credits: 04	**ISEII**	**15 Marks**
	ISE III	**10 Marks**
	ESE	**60 Marks**

Course Outcomes:
After completing the course students will able to

Course Outcomes	
CO1	Implement industrial automation principles for identifying suitable automation systems in manufacturing applications.
CO2	Utilize appropriate industrial sensors, actuators, pneumatic and hydraulic components for industrial automation systems.
CO3	Implement basic PLC ladder logic programs for simple industrial control applications.
CO4	Employ SCADA, HMI and industrial communication techniques for monitoring and controlling industrial processes.
CO5	Use Industry 4.0 concepts and modern automation technologies to improve manufacturing productivity and operational efficiency.

Detailed Syllabus:

Unit 1	**Fundamentals of Industrial Automation** Introduction to Industrial Automation, Evolution of Automation, Types of Automation: Fixed, Programmable, Flexible and Integrated Automation, Automation Pyramid, Industrial Control Systems, Advantages and Limitations of Automation, Mechatronics in Industrial Automation, Industrial Safety and Standards, Applications of Automation in Manufacturing
Unit 2	**Industrial Sensors and Actuators** Introduction to Sensors and Transducers , Classification of Sensors , Position, Proximity, Temperature, Pressure, Flow and Level Sensors , Signal Conditioning , Actuators and Their Classification , Pneumatic Actuators , Hydraulic Actuators , Electric Motors and Servo Drives, Solenoid Valves and Industrial Applications
Unit 3	**Programmable Logic Controllers (PLC)** Introduction to PLC , PLC Architecture and Components , PLC Input and Output Modules , PLC Memory Organization , PLC Scan Cycle , Ladder Logic Programming , Logic Gates in PLC , Timers and Counters , Basic PL, Programming Applications, PLC-Based Industrial Automation Systems
Unit 4	**SCADA, HMI and Industrial Communication** Introduction to SCADA , SCADA Architecture and Functions , Human Machine Interface (HMI) , Data Acquisition Systems , Industrial Communication Networks , Modbus , Profibus , Industrial Ethernet , Introduction to Industrial Internet of Things (IIoT), Industrial Cyber Security Basics
Unit 5	**Modern Industrial Automation and Industry 4.0** Automated Material Handling Systems , Flexible Manufacturing Systems (FMS) , Computer Integrated Manufacturing (CIM), CNC Machine Automation , Introduction to Industrial Robotics, Industry 4.0 Concepts , Smart Factory , Cloud Manufacturing , Digital Twin (Introduction), Future Trends in Industrial Automation

Text and Reference Books

1. Hugh Jack, Automating Manufacturing Systems with PLCs, Version 5.0.
2. Frank D. Petruzella, Programmable Logic Controllers, McGraw-Hill.
3. Krishna Kant, Computer-Based Industrial Control, PHI Learning.
4. Bolton W., Mechatronics, Pearson Education.
5. Mikell P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson.
6. Stenerson J., Industrial Automation and Process Control, Pearson.
7. Webb J.W., Programmable Logic Controllers: Principles and Applications, Pearson.
8. R. K. Rajput, A Textbook of Industrial Automation, Laxmi Publications.

Program Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO 1	3	2	-	-	2	-	-	-	-	-	-	2	-
CO 2	2	2	-	-	2	-	-	-	-	-	-	3	-
CO 3	3	2	1	-	3	-	-	-	-	-	-	3	1
CO 4	2	2	1	-	3	-	-	-	-	1	-	2	1
CO 5	2	2	2	-	3	1	2	-	-	1	1	2	2

1 – high 2 – Medium 3 - Low

Assessment:
ISE I: Shall be on the basis of Class Tests on First and Second unit.
ISE II: Shall be based on class test on third, fourth units.
ISE III: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/Presentations.

Assessment Pattern:

Assessment Pattern Level	Knowledge Level	ISE I	ISE II	ISE III	End Semester Examination
K1	Remember	2	2	2	
K2	Understand	3	3	3	
K3	Apply	2	2	3	
K4	Analyze	3	3	2	
K5	Evaluate	5	5		
K6	Create				
Total Marks 100		15	15	10	60

Assessment table:

Assessment Tool	K1 and K2	K2 and K3	K4 and K5	K1 and K2	K2 and K3	K4 and K5
	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**CO5**
ISE I (15 Marks)	4	6	5			
ISE II (15 Marks)				4	6	5
ISEIII (10 Marks)	1	2	2	1	2	2
ESE Assessment (60 Marks)	05	10	15	05	10	15
Total Marks 100	10	18	22	10	18	22

MEHNC7009: **Artificial Intelligence in Robotics**		
Teaching Scheme	**Examination Scheme**	
Lectures: 04 Hrs. / Week	**ISEI**	**15 Marks**
Credits: 04	**ISEII**	**15 Marks**
	ISE III	**10 Marks**
	ESE	**60 Marks**

Course Outcomes:

After completing the course students will able to

Course Outcomes	
CO1	Explain the principles of AI integration in robotic systems, including neural networks, decision-making, and autonomy frameworks.
CO2	Implement convolutional neural networks (CNNs) and YOLOv8 for real-time object recognition in robotic environments.
CO3	Design and deploy reinforcement learning and genetic algorithm–based strategies for autonomous robot navigation and manipulation.
CO4	Analyze AI-powered decision-making systems, including expert systems, speech recognition, and NLP for human–robot interaction.
CO5	Evaluate ethical considerations and career implications in AI robotics, and create a prototype intelligent robot application.

Detailed Syllabus:

Unit 1	**Unit 1: Foundations of AI and Robotics Integration** **Robotics and AI – Overview and Motivation-** Roles of AI in modern robotics: decision-making, learning, and autonomy,Comparison of traditional control vs. AI-driven control in robots,Survey of robot types: manipulators, mobile robots, humanoids, collaborative robots (cobots) **Neural Networks for Robotics-**Biological inspiration and architecture of artificial neural networks (ANN),Feedforward networks, activation functions, backpropagation,Training, overfitting, regularization, and model evaluation **Reinforcement Learning Concepts-**Markov Decision Processes (MDP), states, actions, rewardsm Q-learning, policy gradient methods, exploration vs. exploitation, OpenAI Gym / simulation environments for robotics **Autonomous Behavior Design-** Deliberative, reactive, and hybrid architectures, Subsumption architecture: layered behavior design, Introduction to ROS 2 (Robot Operating System 2)
Unit 2	**Unit 2: Robot Hardware, System Design and Setup** **Robot Anatomy and Hardware Components-**Actuators, servo motors, stepper motors, and motor drivers, Sensors: encoders, IMU, LIDAR, ultrasonic, IR, camera modules,Microcontrollers vs. single-board computers: Arduino, Raspberry Pi, Jetson Nano **Robotic System Configuration and ROS 2 Setup-**ROS 2 architecture: nodes, topics, services, and actions, Launch files, URDF robot models, and Gazebo simulation, Hardware–software integration and debugging tools **Systems Engineering Approach to Robot Design-**Requirements elicitation: use-case analysis and storyboarding, Hardware/software requirements and design constraints, Prototyping strategies and rapid iteration

Unit 3	**Unit 3: Computer Vision and Object Recognition** **Image Processing Fundamentals-** Digital image representation, filtering, and edge detection,Color spaces, histogram equalization, and morphological operations, OpenCV library: practical image processing pipelines **Convolutional Neural Networks (CNNs)-**CNN architecture: convolution, pooling, fully connected layers, Transfer learning: VGG, ResNet, MobileNet, Training CNNs with custom robotics datasets **Object Detection with YOLOv8-**Single-stage vs. two-stage detectors (YOLO vs. R-CNN), YOLOv8: architecture, anchor-free detection, and loss functions, Real-time object detection deployment on Jetson Nano / Raspberry Pi **Supervised Learning for Classification Tasks-**Dataset collection, annotation (LabelImg / Roboflow), Training, validation, precision-recall curves, and mAP, Integration with robotic grasping and sorting tasks
Unit 4	**Unit 4: Autonomous Navigation, Manipulation and Path Planning** **Reinforcement Learning for Robot Manipulation-** Q-learning for grasping: reward shaping and environment modelling, Deep Q-Networks (DQN): experience replay and target networks, Sim-to-real transfer: training in Gazebo, deploying on physical robots **Genetic Algorithms for Path Planning-**Evolutionary computation: encoding, fitness function, crossover, mutation, GA-based trajectory optimization and obstacle avoidance, Comparison with A*, Dijkstra, and RRT algorithms **Navigation and Obstacle Avoidance-**SLAM (Simultaneous Localization and Mapping): GMapping, Cartographer,AMCL localization, Nav2 stack in ROS 2,Stair detection and vertical obstacle avoidance strategies **Putting It Together – AI-Driven Object Handling-**Decision trees for object categorization and storage decisions, Expert systems: rule-based reasoning for pick-and-place tasks,End-to-end pipeline: detect → decide → manipulate → place
Unit 5	**Unit 5: Human–Robot Interaction, Personality and AI Ethics** **Speech Recognition and Natural Language Processing (NLP)-** Speech-to-Text (STT) and Text-to-Speech (TTS) pipelines, NLP models: tokenization, intent recognition, named entity recognition, Implementing voice commands using Mycroft / Whisper / Google STT **Artificial Personality and Emotion Simulation-** Finite State Machines (FSM) for behavior modelling,Emotion simulation: valence-arousal model, facial expression generation,Conversational AI integration for human–robot interaction **AI Ethics, Risks, and Responsible Robotics-**Ethical frameworks in AI development: fairness, accountability, transparency, Knowing when to stop: safety-critical AI and fail-safe design,Societal impact of intelligent robots: employment, privacy, and autonomy **Careers and Future of AI in Robotics-** Career pathways: robotics engineer, AI researcher, automation specialist,Emerging trends: embodied AI, foundation models for robotics, edge AI,Capstone project discussion and review

Text Books

1. Russell, S. J. and Norvig, P., *Artificial Intelligence: A Modern Approach*, 4th Edition, Pearson, 2020.
2. Siciliano, B., Sciavicco, L., Villani, L. and Oriolo, G., *Robotics: Modelling, Planning and Control*, Springer, 2009.

3. Chollet, F., *Deep Learning with Python*, 2nd Edition, Manning Publications, 2021.
4. Koubaa, A. (Ed.), *Robot Operating System (ROS 2): The Complete Reference*, Springer, 2023.

Reference Books and Online Resources

1. Goodfellow, I., Bengio, Y. and Courville, A., *Deep Learning*, MIT Press, 2016. Available at: https://www.deeplearningbook.org
2. Thrun, S., Burgard, W. and Fox, D., *Probabilistic Robotics*, MIT Press, 2005.
3. Redmon, J. and Farhadi, A., *YOLOv3: An Incremental Improvement*, arXiv:1804.02767, 2018.
4. Artificial Intelligence for Robotics, Coursera.
5. OpenCV Official Documentation: https://docs.opencv.org
6. ROS 2 Official Documentation: https://docs.ros.org
7. TensorFlow Documentation: https://www.tensorflow.org
8. PyTorch Documentation: https://pytorch.org

MOOCs and Online Learning Resources

Coursera Courses

1. Artificial Intelligence for Robotics (Coursera)
   https://www.coursera.org/learn/packt-artificial-intelligence-for-robotics
2. AI for Autonomous Vehicles and Robotics (University of Michigan, Coursera)
   https://www.coursera.org/learn/ai-for-autonomous-vehicles-and-robotics
3. Modern Robotics: Mechanics, Planning and Control Specialization (Northwestern University, Coursera)
   https://www.coursera.org/specializations/modernrobotics
4. Robotics Engineering and Applications (Coursera)
   https://www.coursera.org/learn/robotics-engineering--applications

NPTEL Courses

1. Introduction to Robotics – IIT Bombay
2. Artificial Intelligence – IIT Kharagpur
3. Machine Learning – IIT Madras
4. Deep Learning – IIT Ropar
5. Intelligent Control of Robotic Systems – IIT Kanpur
6. Computer Vision – IISc Bangalore
7. Robotics and Control: Theory and Practice – IIT Roorkee

NPTEL Portal: https://nptel.ac.in

Assessment:
ISE I: Shall be on the basis of Class Tests on First and Second unit.
ISE II: Shall be based on class test on third, fourth units.
ISE III: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/Presentations.

Assessment pattern:

Assessment pattern	Knowledge	ISE I	ISE II	ISE II	ESE

levels no.	levels				
K1	Remember	2	–	–	10
K2	Understand	5	5	2	20
K3	Apply	8	10	5	20
K4	Analyze	–	–	3	10
K5	Evaluate	–	–	–	–
K6	Create	–	–	–	–
Total Marks 100		**15**	**15**	**10**	**60**

Assessment table:

Assessment Tool	K, K2 and K3	K2 and K3	K1, K2, K3	K1, K2, K3	K1, K2, K3
	Co1	C02	Co3	Co4	Co5
ISE I (15 Marks)	10	5	–	–	–
ISE II (15 Marks)	–	5	10	–	–
ISE III (10 Marks)	2	2	2	2	2
ESE (60 Marks)	10	15	15	10	10
Total (100 Marks)	**22**	**27**	**27**	**12**	**12**

Special Instruction if any: Nil

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	–	2	2	–	–	1	–	–	–	3	–
CO2	3	–	3	–	3	–	–	1	–	–	–	3	2
CO3	3	2	3	2	3	–	1	–	1	–	–	3	2
CO4	3	2	2	2	2	–	1	1	–	1	–	3	2
CO5	2	–	2	–	3	2	1	–	–	2	1	2	3

1 – Low 2- Medium 3- High

MEHNC7013: Industrial Safety and Fire Audit		
Teaching Scheme	**Examination Scheme**	
Lectures: 04 Hrs. / Week	**ISEI**	**15 Marks**
Credits: 04	**ISEII**	**15 Marks**
	ISE III	**10 Marks**
	ESE	**60 Marks**

Course Outcomes:

After completing the course students will able to

Course Outcomes	
CO1	Utilize industrial safety principles to identify workplace hazards and recommend suitable control measures.
CO2	Select and apply appropriate fire prevention, detection and fire protection systems for industrial applications.
CO3	Implement safe working practices and hazard control techniques to minimize industrial accidents and occupational risks.
CO4	Conduct basic fire and safety audits using standard audit procedures, checklists and documentation.
CO5	Employ industrial safety regulations, emergency preparedness procedures and accident investigation methods to improve workplace safety.

Detailed Syllabus:

Unit 1	**Fundamentals of Industrial Safety** Introduction to Industrial Safety, Safety Concepts and Terminology, Causes an, Prevention of Industrial Accidents, Hazard Identification and Risk Assessment (HIRA), Safety Signs and Symbols, Personal Protective Equipment (PPE), Safety Management Systems, Industrial Safety Rules and Regulations
Unit 2	**Fire Science and Fire Protection Systems** Fundamentals of Fire, Fire Triangle and Fire Tetrahedron, Classes of Fire, Causes of Industrial Fires, Fire Prevention Techniques, Fire Detection Systems, Fire Alarm Systems, Types of Fire Extinguishers and Their Applications, Fixed Fir, Protection Systems (Hydrant, Sprinkler, Foam, CO_2)
Unit 3	**Industrial Hazards and Safety Practices** Mechanical Hazards,Electrical Hazards, Chemical Hazards, Occupational Health Hazards, Machine Guarding, Lockout–Tagout (LOTO), Material Handling Safety, Safety in Boilers, Pressure Vessels and Lifting Equipment, Emergency Response and Evacuation Procedures
Unit 4	**Fire Audit and Safety Audit** Introduction to Fire Audit, Objectives and Scope of Fire Audit, Types of Safety Audits, Fire Risk Assessment, Fire Load Calculation (Introduction), Fire Audit Checklist, Inspection of Fire Protection Systems, Documentation and Audit Reports, Corrective and Preventive Actions
Unit 5	**Industrial Safety Management and Legal Requirements** Safety Organization and Responsibilities , Accident Investigation Techniques , Incident Reporting , Safety Training and Awareness , National Building Code (Fire Safety Provisions), Factory Safety Requirements , Disaster Management , Emergency Preparedness Plan, Case Studies on Industrial Accidents and Fire Audits

Text and Reference Books

1. R. K. Jain and Sunil S. Rao, *Industrial Safety, Health and Environment Management Systems*, Khanna Publishers (4th Edition, 2023). Comprehensive coverage of industrial safety management, fire protection, risk assessment, and occupational health.
   Book Link: Khanna Publishers – Industrial Safety, Health and Environment Management Systems
2. Anupama Prashar, *Industrial Safety & Environment*, S. K. Kataria & Sons. Covers industrial hazards, safety legislation, occupational health, ergonomics, and environmental safety.
   Book Link: S. K. Kataria – Industrial Safety & Environment
3. Akhil Kumar Das, *Principles of Industrial Safety Management: Understanding the Ws of Safety at Work*, Prentice Hall India, 2021. Focuses on safety management principles, hazard identification, and risk control.
4. N. Sesha Prakash, *Manual of Fire Safety*, CBS Publishers & Distributors. Covers fire science, fire prevention, fire protection systems, and fire safety practices.
   Book Link: CBS – Manual of Fire Safety
5. R. Craig Schroll, *Industrial Fire Protection Handbook* (2nd Edition), CRC Press. A practical guide to industrial fire prevention, fire protection systems, emergency planning, and hazard control.
6. E. Scott Dunlap, *Loss Control Auditing: A Guide for Conducting Fire, Safety, and Security Audits*, CRC Press. Covers safety auditing methods, audit planning, inspection procedures, documentation, and reporting.
7. Luca Fiorentini and Fabio Dattilo, *Fire Risk Management: Principles and Strategies for Buildings and Industrial Assets*, Wiley, 2023. Explains modern fire risk assessment and fire safety engineering practices.
8. SFPE Handbook of Fire Protection Engineering (5th/6th Edition), Society of Fire Protection Engineers (SFPE). An authoritative reference on fire dynamics, fire protection systems, and fire safety engineering.
   Book Link: SFPE Handbook of Fire Protection Engineering

Program Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO 1	3	3	2	-	2	3	2	2	-	1	-	3	1
CO 2	2	2	3	-	3	3	2	2	-	1	-	3	1
CO 3	3	3	2	1	2	3	3	2	1	1	-	3	2
CO 4	3	3	2	2	3	2	2	2	1	2	1	2	2
CO 5	3	3	3	2	2	3	3	3	1	2	2	3	3

1 – high 2 – Medium 3 - Low

Assessment:
ISE I: Shall be on the basis of Class Tests on First and Second unit.
ISE II: Shall be based on class test on third, fourth units.
ISE III: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/Presentations.

Assessment Pattern:

Assessment Pattern Level	Knowledge Level	ISE I	ISE II	ISE III	End Semester Examination
K1	Remember	2	2	2	
K2	Understand	3	3	3	
K3	Apply	2	2	3	
K4	Analyze	3	3	2	
K5	Evaluate	5	5		
K6	Create				
Total Marks 100		15	15	10	60

Assessment table:

Assessment Tool	K1 and K2	K2 and K3	K4 and K5	K1 and K2	K2 and K3	K4 and K5
	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**CO5**
ISE I (15 Marks)	4	6	5			
ISE II (15 Marks)				4	6	5
ISEIII (10 Marks)	1	2	2	1	2	2
ESE Assessment (60 Marks)	05	10	15	05	10	15
Total Marks 100	10	18	22	10	18	22

MEHNC7014: HEAT EXCHANGER DESIGN		
Teaching Scheme	**Examination Scheme**	
Lectures: 04 Hrs. / Week	**ISEI**	**15 Marks**
Credits: 04	**ISEII**	**15 Marks**
	ISE III	**10 Marks**
	ESE	**60 Marks**

Course Outcomes:

After completing the course students will able to

Course Outcomes	
CO1	Use LMTD and NTU–Effectiveness methods to analyze and design heat exchangers (double pipe, shell & tube).
CO2	Analyze condensers, feed water heaters, and boiler heat transfer equipment in power plants.
CO3	Understand and apply design concepts of industrial heaters (fuel oil heaters, fire heaters, etc.).
CO4	Analyze air pre-heaters (regenerative and recuperative types) with temperature distribution.
CO5	Employ the Merkel equation and NTU methods to evaluate the performance of cooling towers and spray ponds.

Detailed Syllabus:

Unit 1	**Heat Exchangers Design Methods:** LMTD Method: For design when inlet/outlet temps are known. Derivations, correction factors for multi-pass HX.NTU-Effectiveness Method: When outlet temps unknown. ε-NTU relations for parallel, counter, cross flow. Double Pipe HX: Simplest type. Series/parallel arrangements, hairpin design. Shell & Tube HX: Most important. TEMA standards, shell types E/F/G/H, tube layouts, baffle types, tube count, pressure drop ΔP, fouling factors. Kern’s method.
Unit 2	**Condensers & Power Plant Equipment** Steam condensers: Surface & jet condensers, design calculations.Feed water heaters: LP & HP heaters, drain coolers. Boiler components: Furnace water wall tubes, super heater, re-heater, economizers - heat transfer in each.
Unit 3	**Heaters** Fuel oil heater, Floor coil heater, Fuel oil suction heater, Fires heaters: Application-based design.
Unit 4	**Air Pre-heaters** Regenerative: Ljungstrom type, matrix design. Recuperative: Tubular, plate type. Temperature distribution.
Unit 5	**Mass Transfer Equipment** Cooling towers: Theory, range & approach, Merkel equation, NTU method for CT, types - natural/induced draft. Spray ponds: Basic analysis.

Text Books and Reference Books

1. Heat Exchanger Design Handbook (VDI Heat Atlas)
2. Process Heat Transfer — Donald Q. Kern
3. Fundamentals of Heat and Mass Transfer — Frank P. Incropera
4. Heat and Mass Transfer: A Practical Approach — Yunus A. Çengel
5. Heat Transfer — J. P. Holman
6. Heat Exchanger Design — Arthur P. Fraas & M. N. Ozisik

Online Resources

NPTEL Courses

1. Heat Transfer — IIT GuwahatiArtificial Intelligence – IIT Kharagpur
2. Conduction and Convection Heat Transfer — IIT Kharagpur
3. Convective Heat Transfer — IIT Bombay
4. Heat Transfer — IIT Madras / IIT Delhi (varies by offering year)
5. Heat Exchangers: Fundamentals and Design Analysis — IIT Kharagpur
6. Heat Exchanger Design and Simulation — IIT Madras / IIT Kharagpur
7. Process Heat Transfer — IIT Kharagpur

NPTEL Portal: https://nptel.ac.in

Assessment:
ISE I: Shall be on the basis of Class Tests on First and Second unit.
ISE II: Shall be based on class test on third, fourth units.
ISE III: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/Presentations.

Assessment pattern:

Assessment pattern levels no.	Knowledge levels	ISE I	ISE II	ISE II	ESE
K1	Remember	2	–	–	10
K2	Understand	5	5	2	20
K3	Apply	8	10	5	20
K4	Analyze	–	–	3	10
K5	Evaluate	–	–	–	–
K6	Create	–	–	–	–
Total Marks 100		**15**	**15**	**10**	**60**

Assessment table:

Assessment Tool	K, K2 and K3	K2 and K3	K1, K2, K3	K1, K2, K3	K1, K2, K3
	Co1	C02	Co3	Co4	Co5
ISE I (15 Marks)	10	5	–	–	–
ISE II (15 Marks)	–	5	10	–	–
ISE III (10 Marks)	2	2	2	2	2
ESE (60 Marks)	10	15	15	10	10
Total (100 Marks)	**22**	**27**	**27**	**12**	**12**

Special Instruction if any: Nil

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3	2	2	1	1	1	2	1	1	3	2
CO2	3	3	2	–	2	2	2	1	1	1	1	3	2
CO3	2	2	3	2	2	2	2	1	2	1	2	3	3
CO4	2	3	3	2	2	2	2	1	2	1	1	2	2
CO5	3	3	3	–	3	2	3	2	2	2	2	3	3

1 – Low 2- Medium 3- High

MEHNC7018: Product Design		
Teaching Scheme	**Examination Scheme**	
Lectures: 04 Hrs. / Week	**ISEI**	**15 Marks**
Credits: 04	**ISEII**	**15 Marks**
	ISE III	**10 Marks**
	ESE	**60 Marks**

Course Outcomes:
After completing the course students will able to

Course Outcomes	
CO1	Explain the fundamentals, principles, and significance of product design, including the role of product designers and ethical considerations in engineering design.
CO2	Employ the Design Thinking process and user research techniques for identifying customer needs and developing innovative product concepts.
CO3	Implement product development methods for concept selection, material selection and preparation of product specifications.
CO4	Evaluate sustainable product design practices, emerging technologies, intellectual property rights, and their impact on society, industry, and the environment.
CO5	Integrate sustainable design principles, manufacturing considerations and intellectual property concepts into product development.

Detailed Syllabus:

Unit 1	**Introduction to Product** Definition and scope of product design, Importance of product design in industry, Evolution of product design, Product design process overview, Principles of good design ,Functionality, Aesthetics, Ergonomics, Usability, Innovatio, Types of products, Consumer products , Industrial products, Digital products, Role of product designers, Ethics in product design
Unit 2	**Design Thinking and User Research** Introduction to Design Thinking, Five stages of Design Thinking, Empathize, Define, Ideate, Prototype, Test, Understanding users and stakeholders, User needs and pain points, User research techniques, Interviews, Observation, Surveys, Focus group, Persona development, Customer journey mapping, Brainstorming techniques, Idea evaluation methods
Unit 3	**Product Development Process** Product Development Life Cycle (PDLC), Market opportunity identification, Product requirements, Concept generation techniques, Concept screening and selection, Product specifications, Material selection, Manufacturing considerations Cost estimation, Design for Manufacturing (DFM), Design for Assembly (DFA), Product documentation, Introduction to Computer-Aided Design (CAD)
Unit 4	**Prototyping, Testing, and Evaluation** Importance of prototyping, Types of prototypes, Paper prototype, Physical prototype, Digital prototype, Rapid prototyping, 3D printing basics, Usability testing, Product validation, Feedback collection methods, Product improvement cycle, Quality standards, Safety considerations
Unit 5	**Sustainable Product Design and Emerging Trends** Sustainable product design, Eco-friendly materials, Life Cycle Assessment (LCA), Circular economy, Universal design, Inclusive design, Smart products, Internet of Things (IoT) in product design, Artificial Intelligence (AI) in product development Industry 4.0, Intellectual Property Rights (IPR), Product design case studies

Text and Reference Books
1. Karl T. Ulrich, Steven D. Eppinger, Maria C. Yang, *Product Design and Development*, 7th Edition, McGraw-Hill Education, 2020. (Recommended as the primary textbook for the course.) Publisher: McGraw-Hill – Product Design and Development (7th Edition) 2. George E. Dieter, Linda C. Schmidt, *Engineering Design*, 5th Edition, McGraw-Hill Education, 2013. Publisher: McGraw-Hill 3. Clive L. Dym, Patrick Little, Elizabeth J. Orwin, R. E. Spjut, *Engineering Design: A Project-Based Introduction*, 4th Edition, Wiley, 2013. Publisher: Wiley 4. Product Design and Development Companion Resources 5. MIT Product Design and Development Resources 6. Autodesk Design Academy 7. SolidWorks Education 8. NPTEL Courses

Program Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO 1	3	2	2	-	-	1	1	2	-	1	-	2	-
CO 2	2	3	3	2	1	-	-	-	1	1	-	3	1
CO 3	3	3	3	2	2	1	1	-	-	1	1	3	2
CO 4	2	2	3	3	3	-	1	-	1	1	-	3	1
CO 5	2	2	2	1	2	2	3	2	1	2	1	2	2

1 – high 2 – Medium 3 - Low

Assessment:
ISE I: Shall be on the basis of Class Tests on First and Second unit.
ISE II: Shall be based on class test on third, fourth units.
ISE III: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/Presentations.

Assessment Pattern:

Assessment Pattern Level	Knowledge Level	ISE I	ISE II	ISE III	End Semester Examination
K1	Remember	2	2	2	
K2	Understand	3	3	3	

K3	Apply	2	2	3	
K4	Analyze	3	3	2	
K5	Evaluate	5	5		
K6	Create				
Total Marks 100		15	15	10	60

Assessment table:

Assessment Tool	**K1 and K2**	**K2 and K3**	**K4 and K5**	**K1 and K2**	**K2 and K3**	**K4 and K5**
	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**CO5**
ISE I (15 Marks)	4	6	5			
ISE II (15 Marks)				4	6	5
ISEIII (10 Marks)	1	2	2	1	2	2
ESE Assessment (60 Marks)	05	10	15	05	10	15
Total Marks 100	10	18	22	10	18	22

MEHNC7019: Computer Aided Analysis		
Teaching Scheme	**Examination Scheme**	
Lectures: 04 Hrs. / Week	**ISEI**	**15 Marks**
Credits: 04	**ISEII**	**15 Marks**
	ISE III	**10 Marks**
	ESE	**60 Marks**

Course Outcomes:

After completing the course students will able to

Course Outcomes	
CO1	Use matrix algebra and structural mechanics principles to compute elemental equations and global stiffness matrices for discrete systems.
CO2	Solve 1D structural, truss, and thermal conduction problems to find displacements, stresses, and temperature distributions.
CO3	Construct structural and thermal simulation models by determining appropriate element types, mesh density, and boundary configurations.
CO4	Employ basic fluid boundary conditions and properties for performing simple internal/external flow simulations.
CO5	Document simulation workflows, evaluate component structural adequacy against yield criteria, and execute basic design adjustments in a team setting.

Detailed Syllabus:

Unit 1	**Applied Matrix Operations & 16-Bar/Truss Modeling** Application of stress-strain relationships to construct element stiffness matrices. Step-by-step assembly of the global stiffness matrix for 1D stepped bars and 2D structural trusses. Application of elimination and penalty methods to incorporate boundary constraints. Computation of nodal displacements, element stresses, and reaction forces.
Unit 2	**2D Modeling and Meshing Implementation** Practical selection criteria for 1D, 2D, and 3D elements based on component geometry. Computing shape functions and strain-displacement matrices for Constant Strain Triangle (CST) elements. Applying manual mesh refining techniques on stress concentration areas. Solving for coordinates and element properties using Gauss Quadrature methods.
Unit 3	**Computational Thermal and Dynamic Analysis** Formulation and solution of steady-state 1D heat transfer equations for composite walls and matrix fins under conduction and convection boundary conditions. Computing natural frequencies and mode shapes for simple 1D structures using lumped and consistent mass matrices (Eigenvalue problems).
Unit 4	**Practical CFD Application** Setting up computational fluid domains. Applying velocity inlets, pressure outlets, no-slip walls, and symmetric boundary conditions. Implementing the Finite Volume discretization workflow for a basic 1D fluid flow profile. Solving basic continuity and pressure drop scenarios across simple channels.
Unit 5	**Applied Post-Processing, Validation, and Reporting** Extracting and validating simulation results (Von-Mises stress, directional displacement, heat flux) against textbook analytical solutions. Applying safety factor formulas to check structural compliance. Drafting structured technical CAE test reports. Executing modeling modifications to resolve component over-stressing.

Text Books and Reference Books

1. "Introduction to Finite Elements in Engineering" *Authors:* Tirupathi R. Chandrupatla and Ashok D. Belegundu
2. "A First Course in the Finite Element Method"*Author:* Daryl L. Logan
3. "Textbook of Finite Element Analysis"*Author:* P. Seshu
4. "An Introduction to Computational Fluid Dynamics: The Finite Volume Method"*Authors:* H. Versteeg and W. Malalasekera

Online Resources

NPTEL Courses

1. Computer Aided Design and Manufacturing-IIT Delhi
2. Computer Aided Design and Manufacturing I-IIT Delhi
3. Computer Aided Design and Manufacturing II-IIT Delhi
4. Computer Aided Engineering Design-IIT Kanpur
5. Computer Aided Power System Analysis-IIT Roorkee

NPTEL Portal: https://nptel.ac.in

Assessment:
ISE I: Shall be on the basis of Class Tests on First and Second unit.
ISE II: Shall be based on class test on third, fourth units.
ISE III: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/Presentations.

Assessment pattern:

Assessment pattern levels no.	Knowledge levels	ISE I	ISE II	ISE II	ESE
K1	Remember	2	–	–	10
K2	Understand	5	5	2	20
K3	Apply	8	10	5	20
K4	Analyze	–	–	3	10
K5	Evaluate	–	–	–	–
K6	Create	–	–	–	–
Total Marks 100		**15**	**15**	**10**	**60**

Assessment table:

Assessment Tool	K, K2 and K3	K2 and K3	K1, K2, K3	K1, K2, K3	K1, K2, K3
	Co1	C02	Co3	Co4	Co5
ISE I (15 Marks)	10	5	–	–	–
ISE II (15 Marks)	–	5	10	–	–
ISE III (10 Marks)	2	2	2	2	2
ESE (60 Marks)	10	15	15	10	10
Total (100 Marks)	**22**	**27**	**27**	**12**	**12**

Special Instruction if any: Nil

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	-	2	-
CO2	3	3	2	1	-	-	-	-	-	-	-	3	-
CO3	2	2	2	-	3	-	-	-	-	-	-	2	-
CO4	3	2	1	-	3	-	1	-	-	-	-	2	-
CO5	-	2	2	-	2	1	-	1	3	3	2	2	3

1 – Low 2- Medium 3- High

MEHNC7005: Mini Project (Additive Manufacturing)						
Teaching Scheme	**L**	**T**	**P**	**ISE III**	**ESE**	**Total**
Credits: 02	0	0	4 Hrs / Week	**30**	**30**	**60**

Course Outcomes:
After completing the course students will able to

Course Outcomes	
CO1	Identify and define engineering problems suitable for Additive Manufacturing solutions using literature survey and current AM trends.
CO2	Review relevant literature on AM processes, materials, and DfAM methodologies to establish project scope and identify gaps.
CO3	Design CAD models applying Design for Additive Manufacturing Competency principles including topology optimization, support minimization, and geometric complexity.
CO4	Plan and execute AM process parameters and fabricate functional prototypes using FDM, SLA, SLS, or DMLS processes.
CO5	Prepare structured project reports and deliver technical presentations demonstrating project findings effectively.

Project Guidelines

Problem Identification & Literature Review

- Introduction to Additive Manufacturing technologies (FDM, SLA, SLS, DMLS, Binder Jetting)
- Literature review on AM applications, materials, and recent innovations
- Problem identification: industrial gaps, design limitations, or functional improvement opportunities
- Defining project objectives, scope, and feasibility for AM-based solution
- Preparation of project proposal with AM process justification
- Deliverable: Problem statement, literature survey (min. 10 references), project proposal

Concept Development & DfAM

- Concept generation using morphological chart, TRIZ, or benchmarking
- DfAM principles: minimizing supports, wall thickness, overhangs, and orientation
- Topology optimization using software (Altair OptiStruct, nTopology, or Fusion 360)
- Material selection for AM: polymers, metals, composites — criteria matrix
- Concept screening and selection using weighted decision matrix
- Deliverable: Concept designs with DfAM rationale and material selection justification

CAD Modelling & Process Planning

- Detailed CAD modelling (SolidWorks, CATIA, Fusion 360, or equivalent)
- STL file generation, mesh repair (Meshmixer/Netfabb), and slicing
- Layer-by-layer process planning: infill, layer height, support strategy
- Simulation of print process where applicable (Materialise Magics, Amphyon)
- Bill of Materials and cost estimation for AM process

- Deliverable: Final CAD model, STL file, process plan with parameter justification

Prototype Fabrication

- Machine setup, calibration, and pre-processing for AM equipment
- Prototype fabrication using selected AM process (FDM / SLA / SLS / DMLS)
- Post-processing operations: support removal, surface finishing, heat treatment
- Quality inspection: dimensional accuracy, surface roughness, visual inspection
- Maintaining AM process log and fabrication record
- Deliverable: Fabricated prototype with process log and quality inspection report

Testing, Validation & Optimization

- Mechanical testing: tensile, flexural, hardness, or fatigue as applicable
- Functional testing and performance evaluation against design targets
- Comparison of results with conventional manufacturing or literature benchmarks
- Iterative design modification based on test outcomes
- Environmental and sustainability evaluation of AM vs. conventional process
- Deliverable: Test reports, validated performance data, comparison analysis

Report Writing & Presentation

- Documentation of all project phases in standard report format
- Technical report: abstract, introduction, literature, methodology, results, conclusions
- Preparation of presentation slides and poster
- Final project presentation and viva voce
- Submission of Project Diary / Workbook
- Deliverable: Final project report, presentation, project diary

Project Diary / Project Workbook

1. Each student must maintain a personal Project Diary / Workbook throughout the semester.
2. The diary must record day-to-day observations, impressions, data collected, calculations, supervisor suggestions, and decisions taken.
3. The diary must be signed by the internal supervisor at every practical session and by the external supervisor (if applicable) weekly.
4. The Project Diary must be submitted to the guide immediately after the completion of the project.
5. Incomplete or poorly maintained diaries will attract deduction in the ISE continuous assessment marks.

Project Report Format

Students must submit a final report following the standard technical report format given below. The report must be word-processed (font: Times New Roman 12 pt, line spacing 1.5, A4 paper) and bound.

Ch.	Title	Contents
1	Introduction	Background, motivation, problem statement, objectives, scope, and organization of the report.
2	Literature Review	Critical survey of at least 15 recent papers/patents; identification of research gaps; research questions.
3	Methodology	Design/experimental/simulation methodology; materials, tools, equipment; flow chart of work; mathematical

		modelling if applicable.
4	Results & Discussion	Presentation of results (graphs, tables, figures); comparison with theoretical/literature values; discussion and engineering interpretation.
5	Conclusions & Future Scope	Summary of key findings; conclusions mapped to objectives; limitations; recommended future work.
Ref	References	IEEE or ASME citation format; minimum 15 references including recent journal articles, conference papers, and standards.
App	Appendices	Raw data, design drawings, simulation files, code snippets, sample calculations, ethics/consent forms if applicable.

Assessment Scheme

Total Marks: 60 | Distribution across two reviews and final evaluation:

Assessment Component	**Marks ISE III**	**Marks ESE II**
Problem Identification & Literature Review	3	3
Concept Development & DfAM Documentation (Review1)	3	3
CAD Model & Process Plan	4	4
Prototype Fabrication Quality & Process Log	4	4
Testing & Validation Report (Review 2)	3	3
Final Project Report	3	3
Final Presentation & Viva Voce	3	3
Total	30	30

Note: A minimum of two formal reviews are conducted — two in the first half and two in the second half of the semester. Each review is assessed by the project guide and an internal reviewer.

CO–PO–PSO Mapping

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO 1**	**PSO 2**
CO 1	3	1	1	2	2	2	–	–	1	–	–	3	1
CO 2	2	1	1	2	1	2	–	–	1	1	–	2	1
CO 3	2	2	3	2	2	–	1	–	1	1	–	2	3
CO 4	2	2	3	1	2	–	–	–	2	1	–	2	3
CO 5	2	3	1	2	2	1	–	–	1	1	–	2	2

3 – High 2 – Medium 1 – Low

Ethics, Integrity and Intellectual Property

1. Students must adhere to academic integrity and plagiarism policy; the final report must have a plagiarism index of less than 10% (Turnitin or iThenticate).
2. Any data from industry / research organization must be used with proper permission and must not violate confidentiality agreements.
3. Students generating intellectual property (patents, designs) during the project shall be guided on IP filing as per Institute policy aligned with NEP 2020 innovation thrust.
4. Proper attribution of all referenced material (IEEE / ASME citation style) is mandatory.

Special Instructions

1. Project work identification should be initiated before the commencement of the semester.
2. A student/ group of student may opt for Innovation / Entrepreneurship activities resulting in a start-up or a demonstrable prototype as the project deliverable.
3. Students are encouraged to collaborate with MSME, Govt. R&D labs, startups, and NGOs for socially impactful projects.
4. The Department Project Committee will review all projects at the end of each phase and may provide corrective guidance.

MEHNC7010: Mini Project (Robotics & Automation)						
Teaching Scheme	**L**	**T**	**P**	**ISE III**	**ESE**	**Total**
Credits: 02	0	0	4 Hrs / Week	**30**	**30**	**60**

Course Outcomes:
After completing the course students will able to

Course Outcomes	
CO1	Identify and define automation or robotics engineering problems through literature review and industrial/societal needs analysis.
CO2	Review existing robotic and automation solutions to identify gaps and plan a feasible project methodology with defined objectives.
CO3	Design the robot/automation system architecture including mechanical structure, sensor-actuator selection, and control logic.
CO4	Develop and integrate hardware-software components including PLC/microcontroller, sensors, and actuators for the automation system.
CO5	Prepare structured project reports and deliver technical presentations demonstrating project findings effectively.

Project Guidelines

Problem Identification & Literature Review

- Introduction to industrial robotics, cobots, automation systems, and smart manufacturing
- Literature survey on robotic applications: manufacturing, medical, logistics, agriculture
- Problem identification: process automation gap, hazardous operation, or precision requirement
- Defining project objectives, performance targets, and system constraints
- Preparation of project proposal with system concept and justification
- Deliverable: Problem statement, literature survey (min. 10 references), project proposal

System Concept & Architecture Design

- Concept generation: serial/parallel robot, gantry, mobile, or collaborative system
- Degrees of freedom analysis, workspace envelope, and kinematic configuration
- Sensor selection: proximity, vision, force-torque, encoder, IMU
- Actuator selection: servo, stepper, pneumatic, hydraulic, DC/BLDC motor
- Control architecture: open-loop / closed-loop / PID / adaptive
- Deliverable: System block diagram, component selection matrix, architecture document

Simulation & Control Programming

- Robot simulation using ROS/Gazebo, MATLAB Robotics Toolbox, or V-REP/CoppeliaSim
- Forward/inverse kinematics solution and trajectory planning
- PLC ladder logic programming or Arduino/Raspberry Pi/STM32 coding
- Motion control: velocity profiling, point-to-point, and continuous path
- HMI design (SCADA / touchscreen panel / web dashboard)

- Deliverable: Simulation results, control code, trajectory plan documentation

Hardware Integration & Prototype Development

- Mechanical fabrication / assembly of robot structure or automation rig
- Wiring, interfacing, and integration of sensors, actuators, and controllers
- Embedded programming and I/O configuration
- Initial commissioning and debugging of the integrated system
- Safety interlocking and emergency stop implementation
- Deliverable: Integrated prototype, wiring diagram, commissioning checklist

Testing, Validation & Optimization

- Performance testing: accuracy, repeatability, speed, payload, and cycle time
- Sensor calibration and feedback loop tuning (PID gains optimization)
- Comparison of actual vs. simulated performance metrics
- Iterative refinement of mechanical and control parameters
- Energy consumption and safety evaluation
- Deliverable: Test reports, performance validation data, optimization summary

Report Writing & Presentation

- Structured documentation of all project phases
- Technical report: introduction, system design, implementation, results, conclusions
- Preparation of final presentation and demonstration video
- Final project presentation and viva voce
- Submission of Project Diary / Workbook
- Deliverable: Final project report, presentation, project diary

Project Diary / Project Workbook

1. Each student must maintain a personal Project Diary / Workbook throughout the semester.
2. The diary must record day-to-day observations, impressions, data collected, calculations, supervisor suggestions, and decisions taken.
3. The diary must be signed by the internal supervisor at every practical session and by the external supervisor (if applicable) weekly.
4. The Project Diary must be submitted to the guide immediately after the completion of the project.
5. Incomplete or poorly maintained diaries will attract deduction in the ISE continuous assessment marks.

Project Report Format

Students must submit a final report following the standard technical report format given below. The report must be word-processed (font: Times New Roman 12 pt, line spacing 1.5, A4 paper) and bound.

Ch.	Title	Contents
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3	Methodology	Design/experimental/simulation methodology; materials, tools, equipment; flow chart of work; mathematical

		modelling if applicable.
4	Results & Discussion	Presentation of results (graphs, tables, figures); comparison with theoretical/literature values; discussion and engineering interpretation.
5	Conclusions & Future Scope	Summary of key findings; conclusions mapped to objectives; limitations; recommended future work.
Ref	References	IEEE or ASME citation format; minimum 15 references including recent journal articles, conference papers, and standards.
App	Appendices	Raw data, design drawings, simulation files, code snippets, sample calculations, ethics/consent forms if applicable.

Assessment Scheme

Total Marks: 60 | Distribution across two reviews and final evaluation:

Assessment Component	Marks ISE II	Marks ESE II
Problem Identification & Literature Review	3	3
System Architecture & Component Selection (Review 1)	3	3
Simulation & Control Programming Output	4	4
Prototype Fabrication & Hardware Integration	4	4
Testing, Validation & Performance Report (Review 2)	3	3
Final Project Report	3	3
Final Presentation & Viva Voce	3	3
Total	30	30

Note: A minimum of two formal reviews are conducted — two in the first half and two in the second half of the semester. Each review is assessed by the project guide and an internal reviewer.

CO–PO–PSO Mapping

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2
CO 1	3	1	1	2	2	2	–	–	1	–	–	3	1
CO 2	2	1	1	2	1	2	–	–	1	1	–	2	1
CO 3	2	2	3	2	2	–	1	–	1	1	–	2	3
CO 4	2	2	3	1	2	–	–	–	2	1	–	2	3
CO 5	2	3	1	2	2	1	–	–	1	1	–	2	2

3 – High 2 – Medium 1 – Low– No Correlation

Ethics, Integrity and Intellectual Property

1. Students must adhere to academic integrity and plagiarism policy; the final report must have a plagiarism index of less than 10% (Turnitin or iThenticate).
2. Any data from industry / research organization must be used with proper permission and must not violate confidentiality agreements.
3. Students generating intellectual property (patents, designs) during the project shall be guided on IP filing as per Institute policy aligned with NEP 2020 innovation thrust.
4. Proper attribution of all referenced material (IEEE / ASME citation style) is mandatory.

Special Instructions

1. Project work identification should be initiated before the commencement of the semester.
2. A student/ group of student may opt for Innovation / Entrepreneurship activities resulting in a start-up or a demonstrable prototype as the project deliverable.
3. Students are encouraged to collaborate with MSME, Govt. R&D labs, startups, and NGOs for socially impactful projects.
4. The Department Project Committee will review all projects at the end of each phase and may provide corrective guidance.

MEHNC7015: Mini Project (Energy Systems)						
Teaching Scheme	**L**	**T**	**P**	**ISE III**	**ESE**	**Total**
Credits: 02	0	0	4 Hrs / Week	**30**	**30**	**60**

Course Outcomes:
After completing the course students will able to

Course Outcomes	
CO1	Identify energy inefficiency problems or renewable energy potential through site analysis, literature review, and audit techniques
CO2	Review literature on energy technologies, policies, and performance benchmarks to formulate project objectives and methodology.
CO3	Design or model a thermal/renewable energy system using thermodynamic analysis, system sizing, and component selection
CO4	Simulate and analyse energy system performance using engineering software and validate against theoretical or experimental data.
CO5	Prepare structured project reports and deliver technical presentations demonstrating project findings effectively.

Project Guidelines

Problem Identification & Literature Review

- Overview of energy scenario: global, national, and sector-specific trends
- Renewable energy technologies: solar, wind, biomass, geothermal, hydrogen
- Thermal systems: HVAC, industrial heat recovery, cogeneration, refrigeration
- Energy audit fundamentals: data collection, energy balance, performance indices
- Problem identification: energy inefficiency, renewable integration, or system optimization
- Deliverable: Problem statement, literature survey (min. 10 references), project proposal

System Concept & Energy Analysis

- Thermodynamic analysis: first and second law, exergy evaluation
- Load analysis and demand forecasting for the chosen system
- System component sizing: solar panels, wind turbines, boilers, heat exchangers, compressors
- Energy audit: energy consumption pattern, loss quantification, baseline establishment
- Concept selection using energy payback period, LCOE, or COP-based criteria
- Deliverable: System concept, load analysis, component sizing, energy audit report

Simulation & Modelling

- System simulation using MATLAB/Simulink, HOMER Pro, EES, or TRNSYS
- Solar energy modelling: PV system sizing, irradiation data, output prediction
- Thermal system modelling: heat exchanger effectiveness, cycle efficiency analysis
- CFD modelling for thermal analysis (ANSYS Fluent / OpenFOAM) where applicable
- Sensitivity analysis for key system parameters
- Deliverable: Simulation model, performance output plots, sensitivity analysis report

Prototype/Experimental Setup Development

- Design and fabrication of small-scale experimental setup or physical model
- Instrumentation: thermocouples, flow meters, pyranometers, power analyzers
- Data acquisition system setup (DAQ / Arduino / Raspberry Pi)
- Experimental plan: test matrix, measurement protocol, safety measures
- Conducting energy performance experiments and data recording
- Deliverable: Experimental setup, instrumentation plan, data recording sheets

Performance Evaluation & Optimization

- Experimental data analysis: thermal efficiency, COP, energy savings potential
- Validation of experimental/simulation results against standard benchmarks
- Optimization: parametric study, insulation improvement, control strategy refinement
- Economic analysis: cost-benefit, payback period, carbon emission reduction
- Comparison with existing systems or literature values
- Deliverable: Performance evaluation report, optimization recommendations

Report Writing & Presentation

- Comprehensive documentation of all project phases
- Technical report: motivation, system design, simulation, experiments, results, conclusions
- Data visualization: performance curves, energy flow diagrams, comparison charts
- Final project presentation and viva voce
- Submission of Project Diary / Workbook
- Deliverable: Final project report, presentation, project diary

Project Diary / Project Workbook

1. Each student must maintain a personal Project Diary / Workbook throughout the semester.
2. The diary must record day-to-day observations, impressions, data collected, calculations, supervisor suggestions, and decisions taken.
3. The diary must be signed by the internal supervisor at every practical session and by the external supervisor (if applicable) weekly.
4. The Project Diary must be submitted to the guide immediately after the completion of the project.
5. Incomplete or poorly maintained diaries will attract deduction in the ISE continuous assessment marks.

Project Report Format

Students must submit a final report following the standard technical report format given below. The report must be word-processed (font: Times New Roman 12 pt, line spacing 1.5, A4 paper) and bound.

Ch.	Title	Contents
1	Introduction	Background, motivation, problem statement, objectives, scope, and organization of the report.
2	Literature Review	Critical survey of at least 15 recent papers/patents; identification of research gaps; research questions.
3	Methodology	Design/experimental/simulation methodology; materials, tools, equipment; flow chart of work; mathematical modelling if applicable.

4	Results & Discussion	Presentation of results (graphs, tables, figures); comparison with theoretical/literature values; discussion and engineering interpretation.
5	Conclusions & Future Scope	Summary of key findings; conclusions mapped to objectives; limitations; recommended future work.
Ref	References	IEEE or ASME citation format; minimum 15 references including recent journal articles, conference papers, and standards.
App	Appendices	Raw data, design drawings, simulation files, code snippets, sample calculations, ethics/consent forms if applicable.

Assessment Scheme

Total Marks: 60 | Distribution across two reviews and final evaluation:

Assessment Component	**Marks ISE II**	**Marks ESE II**
Problem Identification, Audit & Literature Review	3	3
System Concept, Load Analysis & Sizing (Review 1)	3	3
Simulation / Modelling Output	4	4
Experimental Setup & Data Collection	4	4
Performance Evaluation & Optimization Report (Review 2)	3	3
Final Project Report	3	3
Final Presentation & Viva Voce	3	3
Total	30	30

Note: A minimum of two formal reviews are conducted — two in the first half and two in the second half of the semester. Each review is assessed by the project guide and an internal reviewer.

CO–PO–PSO Mapping

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO 1**	**PSO 2**
CO 1	3	1	1	2	2	2	–	–	1	–	–	3	1
CO 2	2	1	1	2	1	2	–	–	1	1	–	2	1
CO 3	2	2	3	2	2	–	1	–	1	1	–	2	3
CO 4	2	2	3	1	2	–	–	–	2	1	–	2	3
CO 5	2	3	1	2	2	1	–	–	1	1	–	2	2

3 – High 2 – Medium 1 – Low– No Correlation

Ethics, Integrity and Intellectual Property

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Special Instructions

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2. A student/ group of student may opt for Innovation / Entrepreneurship activities resulting in a start-up or a demonstrable prototype as the project deliverable.
3. Students are encouraged to collaborate with MSME, Govt. R&D labs, startups, and NGOs for socially impactful projects.
4. The Department Project Committee will review all projects at the end of each phase and may provide corrective guidance.

MEHNC7020: Mini Project (Mechanical Design)						
Teaching Scheme	**L**	**T**	**P**	**ISE III**	**ESE**	**Total**
Credits: 02	0	0	4 Hrs / Week	**30**	**30**	**60**

Course Outcomes:
After completing the course students will able to

Course Outcomes	
CO1	Identify product design problems or improvement opportunities through reverse engineering, market analysis, or literature review.
CO2	Review literature on design methodologies, standards, and existing products to define project objectives and design specifications.
CO3	Develop conceptual and detailed CAD models applying GD&T, design standards, and manufacturing feasibility constraints.
CO4	Perform FEA/CAE analysis to evaluate structural, thermal, or dynamic behaviour of the designed component or assembly.
CO5	Identify product design problems or improvement opportunities through reverse engineering, market analysis, or literature review.

Project Guidelines

Problem Identification & Literature Review

- Introduction to product design process: market needs, design specifications, product life cycle
- Reverse engineering methodology: scan-to-CAD, dimensional inspection, functional analysis
- Literature survey on existing product designs, patents, and design standards
- Problem identification: design deficiency, weight reduction, ergonomic improvement, or new product need
- Preparing Product Design Specification (PDS) and project proposal
- Deliverable: Problem statement, PDS document, literature survey (min. 10 references)

Concept Development & Design Methodology

- Design methods: QFD (House of Quality), Pugh Matrix, TRIZ, morphological chart
- Concept generation: at least three alternative design concepts
- Design for Manufacturability (DfM) and Design for Assembly (DfA) considerations
- DFMEA (Design Failure Mode and Effect Analysis) for critical components
- Concept selection and detailed design specification
- Deliverable: Concept sketches, QFD matrix, DFMEA table, selected concept with rationale

CAD Modelling & Engineering Analysis

- Detailed parametric CAD modelling: parts, assemblies, sub-assemblies
- Application of GD&T (Geometric Dimensioning and Tolerancing)
- Engineering drawing generation: part drawings, assembly drawings, BOM
- Finite Element Analysis: mesh generation, boundary conditions, loading, result interpretation

- Topology/shape optimization using FEA-based tools
- Deliverable: Complete CAD model with drawings, FEA simulation report

Prototype Development / Physical Model

- Prototype fabrication: conventional machining, AM (3D printing), or sheet metal work
- Assembly and fitting verification
- Dimensional inspection using CMM, Vernier, or 3D scan
- Functional mock-up for ergonomics, assembly, and serviceability review
- Cost estimation and material procurement planning
- Deliverable: Physical prototype / functional model with dimensional inspection report

Design Validation & Optimization

- Experimental testing: structural (tensile, bending, fatigue), functional, or thermal as applicable
- Comparison of experimental results with FEA/CAE predictions
- Design optimization: geometric refinement, weight reduction, material substitution
- Reliability evaluation: factor of safety, failure mode analysis, design margin
- Finalization of design with validated performance data
- Deliverable: Validation test reports, optimized design with performance summary

Report Writing & Presentation

- Comprehensive documentation of design process from problem to solution
- Technical report: PDS, concept development, CAD/CAE, prototype, validation, conclusions
- Engineering drawing package as appendix (ISO/ASME standards)
- Final project presentation and viva voce
- Submission of Project Diary / Workbook
- Deliverable: Final project report, drawing package, presentation, project diary

Project Diary / Project Workbook

1. Each student must maintain a personal Project Diary / Workbook throughout the semester.
2. The diary must record day-to-day observations, impressions, data collected, calculations, supervisor suggestions, and decisions taken.
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App	Appendices	Raw data, design drawings, simulation files, code snippets, sample calculations, ethics/consent forms if applicable.

Assessment Scheme

Total Marks: 60 | Distribution across two reviews and final evaluation:

Assessment Component	**Marks ISE II**	**Marks ESE II**
Problem Identification, PDS & Literature Review	3	3
Concept Development & Design Methodology (Review 1)	3	3
CAD Model, Drawings & FEA Report	4	4
Prototype Fabrication & Dimensional Inspection	4	4
Design Validation & Optimization Report (Review 2)	3	3
Final Project Report with Drawing Package	3	3
Final Presentation & Viva Voce	3	3
Total	30	30

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CO–PO–PSO Mapping

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CO 3	2	2	3	2	2	–	1	–	1	1	–	2	3
CO 4	2	2	3	1	2	–	–	–	2	1	–	2	3
CO 5	2	3	1	2	2	1	–	–	1	1	–	2	2

3 – High 2 – Medium 1 – Low– No Correlation

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