Government College of Engineering, Chhatrapati Sambhajinagar
(An Autonomous Institute of Government of Maharashtra)

Tentative Teaching and Evaluation Scheme from Academic Year 2026-27 as per NEP - 2020
Final Year B. Tech. Program in Mechanical Engineering

Semester – VII

Sr. No	Categ o ry	Course Code	Course Title	Teaching Scheme			Credits	Continuous Evaluation in terms of Marks				
				L	T	P		ISE I	ISE II	ISE III	ESE	Total
1.	PCC	MEPCC4001	Heating, Ventilation, Air Conditioning and Refrigeration	3	0	0	**3**	15	15	10	60	**100**
2.	PCC	MEPCC4002	Lab Heating, Ventilation, Air Conditioning and Refrigeration	0	0	2	**1**	-	-	25	25	**50**
3.	PCC	MEPCC4003	CAD/ CAM	2	0	0	**2**	10	10	-	30	**50**
4.	PCC	MEPCC4004	Lab CAD/ CAM	0	0	2	**1**	-	-	25	25	**50**
5.	PCC	MEPCC4005	Metrology and Quality Control	2	0	0	**2**	10	10	-	30	**50**
6.	PCC	MEPCC4006	Lab Metrology and Quality Control	0	0	2	**1**	-	-	25	25	**50**
7.	PEC		Program Elective - IV	3	0	0	**3**	15	15	10	60	**100**
8.	PEC		Lab Program Elective - IV	0	0	2	**1**	-	-	25	25	**50**
9.	PEC		Program Elective - V	3	0	0	**3**	15	15	10	60	**100**
10.	PEC		Lab Program Elective – V	0	0	2	**1**	-	-	25	25	**50**
11.	PEC		Program Elective – VI	2	0	0	**2**	10	10	-	30	**50**
12.	ELC	MEPRJ4001	Project	0	0	8	**4**	-	-	100	100	**200**
13.	ELC	MERMC4002	Research Methodology	2	0	0	**2**	10	10	-	30	**50**
Total without Honor				**17**	**0**	**18**	**26**	**85**	**85**	**255**	**525**	**950**
13	*HNC	MEHNC7003/ MEHNC7008/ MEHNC7013/ MEHNC7018	Additive Manufacturing Design/ Industrial Automation / Industrial Safety and Fire Audit/ Product Design	4	0	0	**4**	15	15	10	60	**100**
Total with Honor				**21**	**0**	**18**	**30**	**100**	**100**	**265**	**585**	**1050**

Program Elective - IV MEPEC4001 Advanced Welding Technology MEPEC4002 Lab Advanced Welding Technology MEPEC4003 Finite Element Analysis MEPEC4004 Lab Finite Element Analysis MEPEC4005 Fuel Cells and Hydrogen MEPEC4006 Lab Fuel Cells and Hydrogen MEPEC4007 Artificial Intelligence and Machine Learning MEPEC4008 Lab Artificial Intelligence and Machine Learning MEPEC4021 Turbomachinery MEPEC4022 Lab Turbomachinery	**Program Elective – V** MEPEC4009 Advanced Manufacturing Technology MEPEC4010 Lab Advanced Manufacturing Technology MEPEC4011 Tool Design MEPEC4012 Lab Tool Design MEPEC4013 Computational Fluid Dynamics MEPEC4014 Lab Computational Fluid Dynamics MEPEC4015 Automobile Engineering MEPEC4016 Lab Automobile Engineering
Program Elective - VI MEPEC4017 Lean Manufacturing MEPEC4018 Optimization Techniques MEPEC4019 Introduction to Nuclear Engineering MEPEC4020 Electrical Vehicle Design	

Semester – VIII

Sr. No	Category	Course Code	Course Title	Teaching Scheme L	T	P	Credits	Continuous Evaluation in terms of Marks ISE I	ISE II	ISE III	ESE	Total
1.	OJT	MEINT 4001	Internship	0	0	24	**12**	-	-	150	150	**300**
Total without Honor				**0**	**0**	**24**	**12**	**-**	**-**	**150**	**150**	**300**
2.	*HNC	MEHNC7004/ MEHNC7009/ MEHNC7014/ MEHNC7019/	3D Printing and Application/ /Artificial Intelligence in Robotics/ Heat Exchanger Design/ Computer Aided Analysis	4	0	0	**4**	15	15	10	60	**100**
3.	*HNC	MEHNC7005/ MEHNC7010/ MEHNC7015/ MEHNC7020	Mini Project (Additive Manufacturing)/ Mini Project (Robotics & Automation)/ Mini Project (Energy Systems)/ Mini Project (Mechanical Design)	0	0	4	**2**	-	-	30	30	**60**
Total with Honor				**4**	**0**	**28**	**18**	**15**	**15**	**190**	**240**	**460**

*** Equivalent online courses (NPTEL/SWAYAM/MOOC/COURSERA/OTHERS) will be approved by BoS Chairman**

MEPCC4001: Heating, Ventilation , Air Conditioning and Refrigeration		
Teaching Scheme	**Examination Scheme**	
Lectures: 03 Hrs. / Week	**ISEI**	**15 Marks**
Credits: 03	**ISEII**	**15 Marks**
	ISE III	**10 Marks**
	ESE	**60 Marks**

Course Outcomes:

After completing the course students will able to

Course Outcomes	
CO1	Explain refrigeration cycles and psychometric processes
CO2	Analyze performance of vapor compression and absorption systems
CO3	Perform cooling load calculations and design air conditioning systems
CO4	Evaluate HVAC equipment and ducting systems
CO5	Apply AI/ML tools for performance prediction and optimization in HVAC systems

Detailed Syllabus:

Unit 1	**Fundamentals of Refrigeration** Basic concepts: Refrigeration, Heat pump, Reversed Carnot cycle, Vapour Compression Refrigeration System (VCRS),Refrigerants: Types, properties, environmental impact (ODP, GWP) Multi-stage and cascade systems
Unit 2	**Vapour Absorption & Advanced Systems** Vapour Absorption Refrigeration System (VARS), Aqua-ammonia and LiBr-water systems, Comparison: VCRS vs VARS, Cryogenics and LNG refrigeration basics
Unit 3	**Psychometric & Air Conditioning Processes** Psychometric properties, Psychometric chart, Air conditioning processes: Sensible heating/cooling, Humidification/dehumidification, Human comfort and comfort indices
Unit 4	**Cooling Load & HVAC Design** Heat load estimation: Sensible & latent heat, CLTD/CLF method, Air distribution systems, Duct design (equal friction method), Ventilation standards (ASHRAE basics)
Unit 5	**HVAC Equipment & AI Applications** Compressors, condensers, evaporators, Cooling towers, fans, air handling units (AHU), Energy efficiency and green HVAC systems **AI/ML applications:** Prediction of COP, Fault detection, Smart HVAC systems, Optimization of heat exchangers

Text and Reference Books

1. ASHRAE. (2021). *Principles of Heating, Ventilating, and Air Conditioning* (10th ed.). Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
2. McQuiston, F. C., Parker, J. D., & Spitler, J. D. (2005). *Heating, Ventilating, and Air Conditioning: Analysis and Design* (6th ed.). John Wiley & Sons.
3. Whitman, B., Johnson, B., Tomczyk, J., & Silberstein, E. (2020). *Refrigeration and Air Conditioning Technology* (9th ed.). Cengage Learning.

4. Althouse, A. D., Turnquist, C. H., Bracciano, A. F., & Bracciano, D. A. (2015). *Modern Refrigeration and Air Conditioning* (20th ed.). Goodheart-Willcox Publishers.
5. Arora, C. P. (2010). *Refrigeration and Air Conditioning* (3rd ed.). McGraw Hill Education (India).
6. Ballaney, P. L. (2015). *Refrigeration and Air Conditioning*. Khanna Publishers.
7. Khurmi, R. S., & Gupta, J. K. (2014). *A Textbook of Refrigeration and Air Conditioning*. S. Chand Publishing.
8. ASHRAE. (2021). *ASHRAE Handbook—Fundamentals*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.
9. ASHRAE. (2020). *ASHRAE Handbook—HVAC Systems and Equipment*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.
10. ASHRAE. (2019). *ASHRAE Handbook—HVAC Applications*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.
11. ASHRAE. (2022). *ASHRAE Handbook—Refrigeration*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.
12. Carrier Air Conditioning Company. (1965, revised editions available). *Carrier System Design Manual*. Carrier Corporation.

Program Outcomes

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

MEPCC4002: Lab – Heating, Ventilation , Air Conditioning and Refrigeration		
Teaching Scheme	**Examination Scheme**	
Practical:02Hrs. /Week	**ISEIII**	**25Marks**
Credit:01	**ESE**	**25Marks**

Course Outcomes:

After completing the course students will able to

Course Outcomes	
CO1	Demonstrate operation of VCRS and VARS systems
CO2	Evaluate COP and system performance experimentally
CO3	Analyze psychometric processes using charts/instruments
CO4	Perform cooling load estimation for real spaces

List of the Experiments:

The student shall perform following experiments:

Sr. No.	Title of the Experiments
1	Study of Vapor Compression Refrigeration System (VCRS)
2	Performance Evaluation of VCRS test rig
3	Study and performance evaluation of pilot Ice Plant
4	Study of Vapor Absorption Refrigeration System (VARS): Industrial Visit
5	Study of throttling devices used in VCRS
6	Study of refrigerant compressors
7	Psychometric Properties Measurement
8	Cooling Load Estimation of a Room
9	Study of HVAC Equipment (AHU / Cooling Tower)
10	AI-Based COP Prediction (Mini Experiment)

Program Outcomes

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

1 – high 2 – Medium 3 - Low

Assessment:
ISE II- Continuous Assessment of individual student in a batch during each experiment Maximum **Marks-25**

Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**ISE II**
S1	Implementation	04
S2	Manipulation	07
S3	Precision	14
S4	Articulation	00
S5	Naturalization	00
Total Marks		25

MEPCC4003: CAD/CAM		
Teaching Scheme	**Examination Scheme**	
Lectures: 02 hrs./ week	**ISE I**	**10Marks**
Tutorial: 00 hrs./ week	**ISE II**	**10 Marks**
Credits :02	**ESE**	**30 Marks**

Course Outcomes:

After completing the course, students will be able to:

	Course Outcomes
CO1	Recognize the proper computer graphics techniques for geometric modeling and transform object using various transformation methods.
CO2	Use analytical and synthetic curves and surfaces techniques in part modeling
CO3	Understand various rapid manufacturing techniques & generate tool path for part for CNC

Detailed Syllabus:

Unit 1	**Introduction**: Fundamentals of CAD, CAM, Automation, design process, Application of computers for design, Benefits of CAD, Computer configuration for CAD applications, Computer peripherals for CAD, Design workstation, Graphic terminal, CAD software. **Geometric Modeling:** Introduction, Wire frame modelling: Definition, advantages, dis-advantages, wire frame entities.
Unit 2	**Surface modelling:** Definition, advantages, disadvantages, surface entities-analytic entities and synthetic entities. **Solid Modelling:** Definition, Curve representation: Implicit and explicit forms of straight line, circle, ellipse, cubic spline and bezier curve, differences between bezier curve and, cubic spline curve.
Unit 3	**Computer Aided Manufacturing (CAM)** Introduction to automation. Need and future of NC, CN and CAM. Introduction to Part programming, G and M Codes APT (Automatically Programmed Tool) Part programming, Problems on Programming For Drilling Turning and Milling **Additive Manufacturing Processes**: Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies of following: Solid-based Rapid Prototyping Systems

Text and Reference Books

1) Ibrahim Zeid and R. Sivasubramanian - CAD/CAM - Theory and Practice Tata McGraw Hill Publishing Co. 2009

2) S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.

3) Kundra T. K., Rao P. N. and Tewari M. K., “Numerical Control and Computer Aided Manufact uring”, Tata McGraw Hill, 1990.

4) Groover M.P. and Zimmers E.W., “Computer Aided Design and Manufacturing ”, Prentice Hall India, 1997.

5) Rao P N., “CAD/CAM Principles and Applications ”, Tata McGraw Hill, 2006

6) Adithan, M. , Pabla, B.S. ,” CNC Machines”, New Age International (P) Ltd

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes3 – High 2 – Medium 1 - Low

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

Assessment:
ISE I: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/Presentations/ Course Projects.
ISE II: Shall be based on class test.
ISE III: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/Presentations/ Course Projects

Assessment Pattern:

Assessment Pattern LevelNo.	Knowledge Level	ISE I	ISE II	ISE III	End Semester Examination
K1	Remember	5	03		7
K2	Understand	5	07		7
K3	Apply				8
K4	Analyze				8
K5	Evaluate				
K6	Create				
Total Marks 100		10	10		30

Assessment table:

Assessment Tool	**K1 and K2**	**K2 and K3**	**K2 and K3**
	CO1	CO2	CO3
ISE I (10 Marks)	5	5	
ISE II (10Marks)		5	5
ESE Assessment (60Marks)	10	10	10
Total Marks 50	15	20	15

MEPCC4004 : Lab - CAD/CAM		
Teaching Scheme	**Examination Scheme**	
Practical:02Hrs. /Week	**ISEIII**	**25Marks**
Credit:01	**ESE**	**25Marks**

Course Outcomes:

As an outcome of completing the Laboratory course, students will able to

	Course Outcomes
CO1	Use 3d Modelling features to develop different types of curves, surfaces and solids
CO2	Use feature and Boolean based modeling to develop surface model
CO3	Analyze different views, neutral file and find mass properties of geometric models
CO4	Use CAM software to simulate and generate part program for various machining operations

Sr.No	**List of Experiment**
1.	Industrial visit to study the following CNC systems or Automation Industry and write detail Report.
2.	Hands on training of 3D modelling software, Sketch Based Features, Dress Up features- Part Drawings
3.	Create a 3-D solid model and convert into orthographic, isometric and sectional views and find their mass properties
4.	Surface modeling using sketch based features
5.	Generate IGES and STEP files for given 3-D solid model and perform reflection, transmission and loopback test
6.	Demonstration of MASTERCAM software, basic geometries & Simulation
7.	Simulation and generation of NC part program for drilling & Milling operation
8.	Perform plane and step turning operation on CNC lathe
9.	Perform taper and circular turning operation on CNC lathe.

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes

3 – High 2 – Medium 1 - Low

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

Assessment:
ISE I

The ISE I will consist of submitting a file for all the experiments with neatly written records of the study and diagrams. The term work will be assessed by the course coordinator

End Semester Evaluation
The End Semester Evaluation will comprise of viva voce on the conducted practical's.The End Semester Evaluation will be done by two examiners, one will be the course coordinator and other will be examiner appointed by DSB

Assessment Pattern:

Assessment Pattern LevelNo.	**Knowledg eLevel**	**ISE I**	**End Semester Examination**
K1	Remember	05	05
K2	Understand	05	05
K3	Apply	05	05
K4	Analyze	05	05
K5	Evaluate	05	05
K6	Create		
Total Marks		25	25

Assessment Pattern LevelNo.	**Knowledg eLevel**	**ISE I**	**End Semester Examination**
S1	Imitation	05	05
S2	Manipulation	05	05
S3	Precision	05	05
S4	Articulation	05	05
S5	Naturalization	05	05
Total Marks		25	25

special Instructions if any: Nil

MEPCC4005: Metrology and Quality Control		
Teaching Scheme	**Examination Scheme**	
Lectures: 02 hrs./ week	**ISE I**	**10Marks**
Tutorial: 00 hrs./ week	**ISE II**	**10 Marks**
Credits :02	**ESE**	**30 Marks**

Course Outcomes:

After completing the course, students will be able to:

	Course Outcomes
CO1	Explain standards, limits, fits, gauges and dimensional measurement systems used in manufacturing.
CO2	Apply measurement techniques using comparators, angular measuring instruments, gear measurement, surface finish and coordinate measuring machines.
CO3	Demonstrate the fundamentals of quality control, statistical process control, ISO standards and acceptance sampling for manufacturing quality assurance.

Detailed Syllabus:

Unit 1	**Engineering Metrology:** Definition and concept of metrology, standardization, standards of linear measurement, line standard, end standard and wavelength standard, traceability and reliability. **Limits, Fits and Gauges:** Tolerances, methods of expressing accumulation of tolerances, relationship between tolerance and cost, interchangeability, selective assembly, maximum and minimum metal conditions, Indian Standard (IS 919). Terminology of limits and fits, types of fits, hole basis and shaft basis systems, selection of fits. Plain gauges, ring gauges, snap gauges, adjustable gap gauges, Taylor's principle, gauge maker's tolerance, wear allowance, numerical on gauge design and industrial applications of limits, fits and gauges.
Unit 2	**Comparators:** Introduction, construction, working principle and applications of mechanical, optical, electrical and pneumatic comparators. **Angular Measurement:** Vernier bevel protractor, universal bevel protractor, sine bar, angle gauges, etc.. **Measurement of Gears:** Sources of errors in manufacturing gears, gear measurement and gear rolling tests. **Measurement by Light Wave Interference:** Principle of interference, light source for interferometry **Measuring Machines:** Construction, working and applications of Coordinate Measuring Machines (CMM) and laser viewers for profile inspection.
Unit 3	**Quality Control:** Concept of quality, quality characteristics, quality of design, quality of conformance, quality assurance, quality control and inspection, inspection stages, ISO 9000 series, concept and need of ISO 9000 certification. **Statistical Quality Control:** Meaning and importance of SQC, sources of variation, variable and attribute measurements, control charts ($\bar{X}$–R and P charts), process capability and process capability indices (Cp and Cpk).

Text and Reference Books.

1. **Jain, R. K.**, *Engineering Metrology*, **21st Edition**, Khanna Publishers, New Delhi, **2022**.
2. **Mahajan, M.**, *A Textbook of Metrology*, **3rd Edition**, Dhanpat Rai Publications, New Delhi, **2019**.
3. **Montgomery, D. C.**, *Introduction to Statistical Quality Control*, **8th Edition**, John Wiley & Sons, **2020**.
4. **Juran, J. M. and De Feo, J. A.**, *Juran's Quality Handbook: The Complete Guide to Performance Excellence*, **7th Edition**, McGraw-Hill Education, **2017**.

Reference Books

1. **Beckwith, T. G., Marangoni, R. D. and Lienhard, J. H.**, *Mechanical Measurements*, **6th Edition**, Pearson Education, **2007**.
2. **Besterfield, D. H.**, *Quality Control*, **9th Edition**, Pearson Education, **2013**.
3. **Groover, M. P.**, *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, **7th Edition**, John Wiley & Sons, **2020**.
4. **Bureau of Indian Standards (BIS)**, *IS 919: Limits, Fits and Tolerances*, **Latest Revision**, Bureau of Indian Standards, New Delhi.

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes3 – High 2 – Medium 1 – Low

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

Assessment:

ISE I: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/Presentations/ Course Projects.

ISE II: Shall be based on class test.

ISE III: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/ Presentations / Course Projects

Assessment Pattern:

Assessment Pattern LevelNo.	KnowledgeLevel	ISE I	ISE II	ISE III	End Semester Examination
K1	Remember	5	03		7
K2	Understand	5	07		7
K3	Apply				8
K4	Analyze				8
K5	Evaluate				
K6	Create				
Total Marks 100		10	10		30

Assessment table:

Assessment Tool	**K1 and K2**	**K2 and K3**	**K2 and K3**
	CO1	CO2	CO3
ISE I (10 Marks)	5	5	
ISE II (10Marks)		5	5
ESE Assessment (60Marks)	10	10	10
Total Marks 50	15	20	15

MEPCC4006: Lab-Metrology and Quality Control		
Teaching Scheme	**Examination Scheme**	
Practical: 02 hrs./ week	**ISE III**	**25Marks**
Tutorial: 00 hrs./ week		
Credits :01	**ESE**	**25 Marks**

Course Outcomes:

After completing the course, students will be able to:

CO	Course Outcomes
CO1	To apply knowledge of appropriate measuring instruments, gauges or comparators used to determine geometry and dimensions of components in engineering applications.
CO2	To perform experiments and analyze and interpret data used for quality control.
CO3	Analyze the measurement of the surface roughness.
CO4	To understand the advances in Metrology such as use of CMM, Laser, Machine Vision System for Metrology etc.
CO5	To understand Quality Control Techniques and its applications in engineering industries.

Detailed Syllabus: Conduct any 8 Experiments and 3 Assignments

Expt. No	Title of the Experiments
1	Demonstration and measurements by linear measuring instruments for linear measurements.
2	Demonstration and measurements by limit gauges for gauging tolerances.
3	Demonstration and measurements by different types of comparators like mechanical, optical, electronic and pneumatic.
4	Demonstration and measurements by different types of angular measuring instruments such as Vernier bevel protector, universal bevel protector, sine bar, sine centre, angle gauges, optical instruments like auto collimator, angle dekkor.
5	Testing of gears by gear rolling tester.
6	Demonstration and measurements of surface roughness by surface roughness measuring instrument.
7	Demonstration and measurements of screw thread parameters by using one wire, two and three wire methods.
8	Demonstration of interferometry applied to flatness, concave and convex testing.
9	Industrial visit to understand the use of CMM and Laser Viewers for profile checks.
10	Demonstration and construction of control charts for variables and attributes.

Assessment:
ISE III
The ISE III will consist of submitting a file for all the experiments with neatly written records of the study and diagrams. The term work will be assessed by the course coordinator.

End Semester Evaluation (ESE)
The End Semester Evaluation will comprise of viva voce on the conducted practical's. The End Semester Evaluation will be done by two examiners, one will be the course coordinator and the other will be
examiner appointed by DSB.

Mapping of Course Outcomes 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	
CO2	2						2						
CO3										2			2
CO4			2										
CO5	2					3						3	

Mapping Scale: 3 – High, 2 – Medium, 1 – Low.

Assessment Pattern (Knowledge Level)

Assessment Pattern Level No.	Knowledge Level	ISE I	End Semester Examination
K1	Remember	5	6
K2	Understand	5	6
K3	Apply	5	6
K4	Analyze	6	6
K5	Evaluate	4	4
K6	Create	-	-
Total Marks		**25**	**25**

Assessment Pattern (Skill Level)

Assessment Pattern Level No.	Knowledge Level	ISE I	End Semester Examination
S1	Imitation	6	6
S2	Manipulation	6	6
S3	Precision	6	6
S4	Articulation	6	6
S5	Naturalization	7	7
Total Marks		**25**	**25**

MEPEC 4001: Advanced Welding Technology		
Teaching Scheme	**Examination Scheme**	**Marks**
Lectures: 03 Hrs/Week	**ISE I**	**15**
	ISE II	**15**
	ISE III	**10**
Credits: 03	**ESE**	**60**

Course outcomes

After completing the course students should be able to -

CO1	Implement advanced and modern welding processes by configuring operational parameters for specific production tasks.
CO2	Apply metallurgical principles and weldability data to select the correct filler metals and pre-heating cycles for diverse engineering materials.
CO3	Utilize standard non-destructive testing (NDT) techniques to locate welding defects and employ specific clamp/sequence methods to control distortion.
CO4	Demonstrate the integration of robotics, automation sensors, and emerging tool paths within automated welding workcells.
CO5	Employ industrial selection matrices and engineering standards to choose the most cost-effective and structurally sound welding process for a given application.

Detailed Syllabus:

Unit 1	**Fundamentals of Advanced Welding Processes** Review of conventional welding processes (SMAW, GMAW, GTAW), Heat source characteristics and power density, Classification of advanced welding processes, Physics of welding arc, metal transfer modes, Shielding gases and their influence, Underwater welding techniques
Unit 2	**High Energy Beam Welding** Laser Beam Welding (LBW): principle, types of lasers, applications, Electron Beam, Welding (EBW): equipment, working, advantages, Plasma Arc Welding (PAW), Comparison of beam welding processes
Unit 3	**Solid-State Welding Processes** Friction Welding and Friction Stir Welding (FSW), Ultrasonic Welding, Diffusion Welding, Explosion Welding, Cold Welding, Applications in aerospace and automotive industries
Unit 4	**Welding Metallurgy and Weldability**

	Heat Affected Zone (HAZ) transformations, Solidification of weld metal, Weldability of ferrous and non-ferrous metals, Welding of stainless steels, aluminum alloys, titanium alloys, Hydrogen-induced cracking, hot cracking
Unit 5	**Welding Defects, Residual Stresses and Distortion & Industrial applications** Types and causes of welding defects, Non-Destructive Testing (NDT): UT, RT, PT, MT, Residual stresses: causes and measurement, Distortion types and control techniques, Post-weld heat treatment (PWHT), Introduction to WPS and Welder qualification/certification requirements, Mechanized/automated/robotic welding

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.

Mapping of Course outcome with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1		2							1	1
CO2	3	3	2	1	2							1	2
CO3	2	3	3	2	2							1	1
CO4	2	2	3	3	3	1						1	2
CO5	1	2	2	2	3	2	1					1	2

3- High, 2- Medium, 1- Low

Assessment pattern:

Assessment pattern level	**Knowledge levels**	**ISE I (CO1 & 2)**	**ISE II (CO3 & 4)**	**ISE III (CO5)**	**ESE (CO1 to 5)**
K1	Remember	3	3		17
K2	Understand	3	3	2	17
K3	Apply	3	3	2	10
K4	Analyze	3	3	3	8
K5	Evaluate	3	3	3	8
Total Marks: 100		15	15	10	60

MEPEC4001: Lab –Advanced Welding Technology		
Teaching Scheme	**Examination Scheme**	**Marks**
Practical: 02 Hrs/Week	**ISE**	**25**
Credits: 01	**ESE**	**25**

Course outcomes:

After completing the course students should be able to -

CO1	Study advanced welding processes such as GTAW, GMAW, and SAW with appropriate parameter selection.
CO2	Study weld bead geometry and identify defects using standard inspection methods.
CO3	Demonstrate the use of automated and robotic welding systems.
CO4	Study weld quality using non-destructive testing (NDT) techniques.
CO5	Explain standard industrial welding codes and prepare a routine Welding Procedure Specification (WPS) sheet for a joint.

List of Experiments

Any 8 of the following –

Sr. No.	Title of the Experiment
1	**Study and demonstration of advanced welding equipment** (GTAW, GMAW, SAW, Plasma Arc Welding setup)
2	**Gas Tungsten Arc Welding (GTAW/TIG)** - Bead-on-plate and butt joint, Effect of current and shielding gas
3	**Gas Metal Arc Welding (GMAW/MIG)** - Welding of thin sheets, Study of transfer modes
4	**Submerged Arc Welding (SAW)** - Bead geometry analysis, Flux handling and recovery
5	**Plasma Arc Welding (PAW) / Laser Beam Welding (Demo/Simulation)** - Process parameters and applications OR Industrial visit to company where such technology is in use
6	**Resistance Welding (Spot/Seam Welding)** - Welding of sheet metals, Nugget formation study OR Industrial visit to company where such technology is in use
7	**Friction Stir Welding (FSW) / Friction Welding (Demo)** - Solid-state welding concept OR Industrial visit to company where such technology is in use
8	**Robotic Welding / CNC Welding Simulation** - Programming basics and path control
9	**Weld Defects Identification** - Visual inspection of defective samples
10	**Non-Destructive Testing (NDT)** - Dye Penetrant Test (DPT), Ultrasonic Testing (UT) / Radiography (Demo)

11	**Destructive Testing of Welds** - Tensile test / Bend test / Hardness test
12	**Preparation of Welding Procedure Specification (WPS)** - Documentation as per ASME/AWS standards

Assessment:
ISEIII: Shall be on the basis of assessment of term work.
ESE: ESE will base on oral exam conducted by course coordinator and external examination.

Mapping of Course outcome with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PS O2
CO1	3	2	1		2							1	
CO2	3	3	2	2	2							1	
CO3	3	3	3	2	2							1	
CO4	3	2	3	3	3	2						1	
CO5	3	2	2	2	3	2	2					1	2

3-

High, 2- Medium, 1- Low

Assessment pattern:

Assessment pattern level	Knowledge levels	ISE I (CO1 & 2)	ESE (CO1 to 5)
K1	Remember	5	5
K2	Understand	8	8
K3	Apply	8	8
K4	Analyze	2	2
K5	Evaluate	2	2
Total Marks: 50		**25**	**25**

Text and Reference Books:
1. Kou, S. – "Welding Metallurgy", Wiley
2. Cary, H.B. & Helzer, S.C. – "Modern Welding Technology", Pearson
3. AWS Handbook – American Welding Society
4. Messler, R.W. – "Principles of Welding", Wiley
5. Deb Roy & David – "Welding Metallurgy and Weldability"
6. Steen & Mazumder – "Laser Material Processing"

Professional Elective IV MEPEC4003 : Finite Element Analysis			
Teaching Scheme		**Examination Scheme**	
Lectures:	03 Hrs. / Week	**ISE I**	15 Marks
Tutorial:	00 hrs/week	**ISE II**	15 Marks
Credits:	03	**ESE**	60 Marks

Course Outcomes:

Upon successful completion of the course, students will be able to:

CO No.	Course Outcome Statement
CO1	Understand the fundamentals of FEA, governing principles, and the variational and weighted residual approaches.
CO2	Apply the Finite Element Method (FEM) to formulate and solve 1D structural, thermal, and truss problems.
CO3	Solve 2D plane stress, plane strain, and axisymmetric problems using appropriate element formulations.
CO4	Analyze structural dynamics problems including free vibration and transient response using FEM.
CO5	Demonstrate knowledge of isoparametric formulation, numerical integration, and applications in non-linear and practical problems.

Detailed Syllabus:

Unit	Content
Unit 1	**Introduction to Finite Element Analysis** Concept of Finite Element Analysis (FEA), historical background and engineering applications; overview of the FEA process (pre-processing, solving, and post-processing); comparison with analytical and numerical methods; mathematical preliminaries including matrix algebra and boundary value problems; variational methods (Principle of Minimum Potential Energy and Rayleigh–Ritz method); weighted residual methods (Galerkin, Collocation, and Least Squares); concepts of discretization, nodes, elements, degrees of freedom, shape functions, global stiffness matrix and load vector assembly, and application of boundary conditions using elimination and penalty methods.
Unit 2	**FEA for 1D Problems** Finite element formulation for 1D bar, rod, truss, and beam elements; stiffness matrix, coordinate transformation, and assembly procedures; 1D steady-state heat conduction and fluid flow problems; application of boundary conditions; numerical solutions for bars, trusses, beams, and fins; concepts of error estimation, convergence, h-refinement, and p-refinement.
Unit 3	**FEA for 2D Problems**

	Fundamentals of 2D elasticity, plane stress and plane strain conditions; Constant Strain Triangle (CST), Linear Strain Triangle (LST), and bilinear quadrilateral (Q4) elements; shape functions, strain-displacement relations, stiffness matrix formulation, and assembly; application of boundary conditions and solution techniques.
Unit 4	**Advanced Two-Dimensional Elements and Applications:** Isoparametric formulation, Jacobian matrix, Gauss numerical integration, axisymmetric finite element formulation, 2D steady-state and transient heat conduction, and introduction to plate and shell elements.
Unit 5	**Mesh Generation, Convergence & Applications** Structured and unstructured mesh generation; mesh quality (aspect ratio, skewness, and Jacobian); adaptive mesh refinement (h-, p-, and hp-refinement), convergence criteria, patch test, reduced integration, and hourglass control; substructuring and super-elements; introduction to commercial FEA software, pre-processing (geometry, material properties, and meshing), post-processing (stress, deformation, and factor of safety), and engineering applications in structural, thermal, biomechanical, and automotive analyses.

Text and Reference Books

1. O. C. Zienkiewicz, R. L. Taylor, and J. Z. Zhu, The Finite Element Method: Its Basis and Fundamentals, 7th ed. Oxford, UK: Butterworth-Heinemann, 2013.
2. R. D. Cook, D. S. Malkus, M. E. Plesha, and R. J. Witt, Concepts and Applications of Finite Element Analysis, 4th ed. Hoboken, USA: John Wiley & Sons, 2002.
3. J. N. Reddy, An Introduction to the Finite Element Method, 3rd ed. New York, USA: McGraw-Hill, 2006.
4. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, 4th ed. Upper Saddle River, USA: Pearson Prentice Hall, 2011.
5. K. J. Bathe, Finite Element Procedures. Englewood Cliffs, USA: Prentice Hall, 1996.
6. S. S. Rao, The Finite Element Method in Engineering, 6th ed. Oxford, UK: Butterworth-Heinemann, 2017.
7. D. L. Logan, A First Course in the Finite Element Method, 6th ed. Stamford, USA: Cengage Learning, 2016.

NPTEL Courses

1. Finite Element Method (IIT Kharagpur): https://nptel.ac.in/courses/105105041
2. Introduction to Finite Element Method (IIT Madras): https://nptel.ac.in/courses/105106051
3. Finite Element Analysis (IIT Bombay): https://nptel.ac.in/courses/105101085
4. Non-Linear Finite Element Analysis (IIT Kanpur): https://nptel.ac.in/courses/105104073

Online Courses

1. A Hands-on Introduction to Engineering Simulations (Coursera – Cornell): https://www.coursera.org/learn/simulation

2. Finite Element Analysis (Udemy): https://www.udemy.com/topic/finite-element-analysis/
3. SimScale FEA Learning Resources: https://www.simscale.com/blog/what-is-finite-element-analysis/

Websites / Learning Platforms

1. ANSYS Learning Hub: https://www.ansys.com/training-center
2. ABAQUS/Simulia Documentation: https://www.3ds.com/products-services/simulia/products/abaqus/
3. FEA for All (Community Blog): https://feaforall.com/
4. SkyCiv Structural Engineering Software: https://skyciv.com/

Assessment:

ISE I: Based on assignments, quizzes, and presentations on Units 1 and 2.

ISE II: Class test focusing on Units 3 and 4.

ESE: Comprehensive examination covering all units.

Mapping of Course Outcome with Program Outcomes and Program Specific Outcomes

3 – High 2 – Medium 1 – Low

CO \ PO/PEO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1	PEO 1	PEO 2
CO1	3	2	–	–	–	–	–	–	–	–	1	2	1
CO2	2	3	–	2	3	–	–	–	–	–	–	3	–
CO3	2	3	2	3	2	–	–	–	–	–	–	3	–
CO4	2	2	3	3	3	–	–	–	2	–	–	3	2
CO5	–	2	–	2	3	–	–	–	–	–	3	2	3

Assessment Pattern:

Assessment Pattern Level No.	Knowledge Levels	ISE I	ISE II	ISE III	ESE
K1	Remember	4	4	-	18
K2	Understand	4	4	-	18
K3	Apply	4	4	-	12
K4	Analyze	3	3	-	12
K5	Evaluate	-	-	-	-
K6	Create	Nil	Nil	-	Nil
	Total Marks	**15**	**15**		**60**

Assessment Table:

Assessment Tool	**K1, K2**	**K1, K3**	**K1, K4**	**K1,K3,K4**	**K1,K2,K3**
	CO1	**CO2**	**CO3**	**CO4**	**CO5**
ISE I (15 Marks)	8	7			
ISE II (15 Marks)			8	7	
ESE (60 Marks)	12	14	12	14	18
Total Marks 100	**20**	**21**	**20**	**21**	**18**

Special Instructions if any:

Nil

LAB Professional Elective IV MEPEC4004 : LAB - Finite Element Analysis			
Teaching Scheme		**Examination Scheme**	
Practical:	02 Hrs. / Week / Batch	**ISE-III**	25 Marks
Credits:	01	**ESE**	25 Marks

Course Outcomes

After completion of this course, students will be able to:

CO No.	Course Outcome Statement
CO1	Understand the formulation and setup of FEA problems including element selection and boundary conditions.
CO2	Perform simulations of 1D bar, truss, beam, and thermal problems using FEA.
CO3	Analyze 2D plane stress, plane strain, and axisymmetric problems using FEA software.
CO4	Apply FEA software tools for modeling, meshing, simulation, and visualization of engineering components.
CO5	Evaluate the effects of mesh refinement, element type, and turbulence/material models on simulation accuracy.

List of Experiments

Students are required to perform the following practical using any suitable Finite Element Analysis (FEA) software or programming tools such as ANSYS, MATLAB etc. The experiments are designed to develop a comprehensive understanding of FEA problem formulation, simulation, and analysis.

No.	Title of the Experiment	Objective
1	Bar Element (1D Axial Loading)	Simulate and analyze a 1D bar under axial load; determine displacements and stresses.
2	2D Truss Analysis	Analyze 2D truss structures under static loading; compute member forces and reactions.
3	Beam Element Analysis	Simulate a cantilever and simply supported beam; evaluate deflection and bending moment.
4	Plane Stress / Plane Strain Analysis	Analyze a 2D plate under static loading using CST or Q4 elements; plot stress contours.
5	Axisymmetric Problem	Simulate a thick-walled cylinder or pressure vessel using axisymmetric FEA formulation.

6	1D Steady-State Heat Conduction	Simulate and analyze 1D thermal conduction with Dirichlet and Neumann boundary conditions.
7	2D Heat Conduction	Analyze 2D steady-state heat transfer in a plate; plot temperature contours.
8	Mesh Generation & Grid Independence	Generate structured and unstructured meshes; study the effect of mesh refinement on accuracy.
9	Free Vibration Analysis	Determine natural frequencies and mode shapes of a beam or plate structure.
10	Post-Processing & Visualization	Visualize FEA results including deformation, stress contours, and reaction forces using FEA software. add real life based project in live with the practical

End Semester Evaluation

The End Semester Evaluation will include a viva voce to assess understanding of practical concepts and applications.

Assessment Pattern:

Assessment Pattern Level No.	Knowledge Level	ISE I	End Semester Examination
K1	Remember		5
K2	Understand		10
K3	Apply		10
K4	Analyze	-	
K5	Evaluate	-	
K6	Create	-	
	Total Marks		**25**

Mapping of Course Outcome with Program Outcomes and Program Specific Outcomes

CO-PO/ PEO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PEO1	PEO2
CO1	2	1	–	–	–	–	–	–	–	–	–	2	–
CO2	2	3	–	2	2	–	–	–	–	–	–	3	–
CO3	–	2	2	2	3	–	–	–	–	–	–	3	–

CO4	2	2	3	3	3	–	–	–	2	–	–	3	2
CO5	–	2	–	2	3	–	–	–	–	–	2	2	3

Special Instructions:

- Nil

MEPEC 4005: Fuel Cells & Hydrogen Energy		
Teaching Scheme	**Examination Scheme**	**Marks**
Lectures: 03 Hrs/Week	**ISE I**	**15**
	ISE II	**15**
	ISE III	**10**
Credits: 03	**ESE**	**60**

Course outcomes

After completing the course students will be able to -

CO1	Explain hydrogen value chain and its role in the future energy scenario.
CO2	Understand different technologies for hydrogen production.
CO3	Study different hydrogen production, storage, and transportation methods.
CO4	. Apply principles of fuel cell operations to calculate system efficiency and use characteristic curve metrics to solve mass transport and ohmic performance issues.
CO5	Employ the strategic guidelines of the National Hydrogen Mission and Indian regulatory frameworks to solve implementation challenges in real-world hydrogen applications.

Detailed Syllabus:

Unit 1	**Introduction to the Hydrogen Energy** Global and Indian energy scenario, Need for renewable and clean energy sources, Hydrogen as an energy carrier: Properties, advantages, limitations, Hydrogen economy, value chain: Concept, benefits, and challenges, Safety aspects in hydrogen handling.
Unit 2	**Hydrogen Production Technologies** Conventional methods: Steam methane reforming, partial oxidation, Electrolysis of water: Alkaline and PEM electrolysis, Thermochemical and photochemical methods, Biological hydrogen production, Green hydrogen: Renewable pathways, cost and efficiency analysis.
Unit 3	**Hydrogen Storage and Transportation** Compressed and liquefied hydrogen storage, Material-based storage: Metal hydrides, chemical storage systems, Hydrogen transportation: Pipelines, storage tanks, and carriers, Safety, leakage, and environmental considerations, Challenges and recent developments.
Unit 4	**Fuel Cell Fundamentals, Types, Performance** Introduction to fuel cells: Working principle and thermodynamics, Electrochemical reactions and Nernst equation, Types of fuel cells: Proton Exchange Membrane Fuel Cell (PEMFC), Solid Oxide Fuel Cell (SOFC), Molten Carbonate Fuel Cell (MCFC), Alkaline Fuel Cell (AFC), Construction and materials used. Fuel Cell Performance**:** Performance parameters- Efficiency, polarization characteristics, Losses in fuel cells (activation, ohmic, concentration losses). Fuel cell system design and integration.

Unit 5	**Applications, Issues, future trends & NHM** Applications of Fuel Cells: Transportation, stationary, portable power, Issues in applications & commercialization, environmental impact & future trends:, National Hydrogen Mission (NHM) – Introduction, promotional schemes for a green hydrogen economy in India, the relevant regulatory framework in India.

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.

Mapping of Course outcome with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1		2							1	
CO2	3	3	2	1	2							1	
CO3	2	3	3	2	2							1	
CO4	2	2	3	3	3	1						1	
CO5	1	2	2	2	3	2	1					1	2

3- High, 2- Medium, 1- Low

Assessment pattern:

Assessment pattern level	Knowledge levels	ISE I (CO1 & 2)	ISE II (CO3 & 4)	ISE III (CO5)	ESE (CO1 to 5)
K1	Remember	3	3		17
K2	Understand	3	3	2	17
K3	Apply	3	3	2	10
K4	Analyze	3	3	3	8
K5	Evaluate	3	3	3	8
Total Marks: 100		**15**	**15**	**10**	**60**

Textbooks:

1. O’Hayre, R., Cha, S.W., Colella, W., Prinz, F.B., Fuel Cell Fundamentals, Wiley, 3rd Edition.
2. Larminie, J., Dicks, A., Fuel Cell Systems Explained, Wiley, 2nd Edition.
3. Sørensen – Hydrogen Energy Systems
4. Ball & Wietschel – The Hydrogen Economy
5. Darren P. Broom – *Hydrogen Storage Materials: The Characterisation of Their Storage Properties*
6. Lennie Klebanoff (Ed.) – *Hydrogen Storage Technology: Materials and Applications*

Reference Books:

7. Revankar, S.T., Majumdar, P., *Fuel Cells: Principles, Design and Analysis*, CRC Press.
8. Sørensen, B., *Hydrogen and Fuel Cells: Emerging Technologies and Applications*, Elsevier.
9. Singhal, S.C., Kendall, K., *Electrochemical Energy Systems*, McGraw-Hill.
10. Ball, M., Wietschel, M., *The Hydrogen Economy*, Cambridge University Press.
11. Zhang, J., *PEM Fuel Cell Electrocatalysts and Catalyst Layers*, Springer.
12. Fuel Cell Systems Explained" – James Larminie & Andrew Dicks

MEPEC4006: Lab –Fuel Cells & Hydrogen Energy		
Teaching Scheme	**Examination Scheme**	**Marks**
Practical: 02 Hrs/Week	**ISEIII**	**25**
Credits: 01	**ESE**	**25**
	Total	**50**

Course outcomes

After completing the course students should be able to -

CO1	. Understand basic working and safety aspects of hydrogen systems and fuel cells
CO2	Perform experiments related to hydrogen production and fuel cell operation
CO3	Analyze performance characteristics of different fuel cell systems
CO4	. Evaluate hydrogen storage methods and system efficiency
CO5	Develop small-scale hydrogen energy system models or simulations

List of Experiments

Sr.No.	List of Experiments
1.	Study of hydrogen properties and safety protocols
2.	Demonstration of hydrogen leakage detection techniques
3.	Study of components of a fuel cell system (PEMFC kit)
4.	Electrolysis of water – performance analysis (voltage vs hydrogen output)
5.	Efficiency calculation of electrolyzer
6.	Green hydrogen production by electro-oxidation of a low-value biomass feedstock
7.	V-I characteristics of PEM fuel cell
8.	Power output and efficiency calculation of fuel cell
9.	Effect of temperature and pressure on fuel cell performance
10.	Industrial visit to nearby HPCL plant.
11.	Study of hydrogen storage methods (compressed, hydride – demo/simulation)
12.	Energy balance of hydrogen storage system
13.	Simulation of fuel cell system (MATLAB/Simulink or any open-source tool)
14.	Mini Project: Design of hydrogen-based energy system (e.g., fuel cell vehicle model, backup power system)

Assessment:

ISEIII: Shall be on the basis of assessment of term work.

ESE: ESE will base on oral exam conducted by course coordinator and external examination.

Mapping of Course outcome with Program Outcomes:

CO\PO	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO 8	PO 9	PO1 0	PO 11	PSO 01	PSO0 2
CO1	3	2	1		2							1	
CO2	3	3	2	2	2							1	
CO3	3	3	3	2	2							1	
CO4	3	2	3	3	3	2						1	2

3- High, 2- Medium, 1- Low

Assessment pattern:

Assessment pattern level	Knowledge levels	ISE I (CO1 & 2)	ESE (CO1 to 5)
K1	Remember	5	5
K2	Understand	6	6
K3	Apply	6	6
K4	Analyze	4	4
K5	Evaluate	4	4
Total Marks: 50		**25**	**25**

Text and Reference books -

1. O'Hayre et al., Fuel Cell Fundamentals, Wiley
2. Larminie & Dicks, Fuel Cell Systems Explained, Wiley
3. Sørensen, Hydrogen and Fuel Cells, Elsevier
4. Klebanoff, Hydrogen Storage Technology, CRC Press

MEPEC4007: Artificial Intelligence and Machine Learning		
Teaching Scheme	**Examination Scheme**	
Lectures: 03 Hrs. / Week	**ISEI**	**15 Marks**
Tutorial: 00 hrs/week	**ISEII**	**15 Marks**
	ISEIII	**10 Marks**
Credits: 03	**ESE**	**60 Marks**

Course Outcomes: Upon successful completion of the course, students will be able to:

CO No.	Course Outcome
CO1	Illustrate core AI and ML concepts by coding basic script examples that mimic human logic decision-making loops.
CO2	Implement standard feature extraction and dimensionality reduction techniques using programming libraries to clean and prepare raw datasets.
CO3	Execute standard ML algorithms to solve practical classification and regression problems on structured engineering datasets.
CO4	Deploy a machine learning model by following a systematic, step-by-step programming workflow from data ingestion to validation output.
CO5	Utilize pre-trained deep learning networks and reinforcement learning environments to run basic predictive and agent-based simulation tasks.

Detailed Syllabus:

Unit 1	**Introduction to Artificial Intelligence & Machine Learning**: History and evolution of Artificial Intelligence (AI), comparison of AI with Data Science, need and applications of AI in Mechanical Engineering, introduction to Machine Learning (ML) and its role in engineering applications. Fundamental concepts of AI including reasoning, problem solving, knowledge representation, planning, learning, perception, and motion and manipulation. Approaches to AI such as cybernetics and brain simulation, symbolic, sub-symbolic and statistical approaches. Approaches to Machine Learning including supervised learning, unsupervised learning, and reinforcement learning.
Unit 2	**Feature Extraction and Selection**: Introduction to feature extraction including statistical features and Principal Component Analysis (PCA). Feature selection techniques such as ranking methods, decision tree concepts including entropy reduction and information gain, exhaustive search, best-first search, and greedy methods like forward selection and backward elimination. Applications of feature extraction and selection techniques in Mechanical Engineering.
Unit 3	**Classification and Regression** Introduction to classification techniques including decision tree, random forest, Naive Bayes, and support vector machine (SVM). Regression methods such as logistic regression and support vector regression (SVR), along with regression trees using decision tree and random forest, and clustering and instance-based methods like K-means and K-nearest neighbor

	(KNN). Applications of classification and regression algorithms in Mechanical Engineering.
Unit 4	**Development of Machine Learning Model** Introduction to identifying machine learning problems such as classification, clustering, regression, and ranking. Overview of the complete machine learning workflow including data collection and data preprocessing. Selection of appropriate models and training methods using training, testing, and K-fold cross-validation techniques. Evaluation of model performance using confusion matrix and performance metrics such as accuracy, precision, recall, true positives, and false positives. Introduction to hyperparameter tuning and making predictions using trained models.
Unit 5	**Reinforcement and Deep Learning** Introduction to reinforcement learning including its characteristics and types of algorithms such as value-based, policy-based, and model-based methods. Understanding positive and negative reinforcement concepts along with models like Markov Decision Process (MDP) and Q-learning. Overview of deep learning fundamentals including characteristics, artificial neural networks (ANN), and convolutional neural networks (CNN). Applications of reinforcement and deep learning techniques in Mechanical Engineering

Text and Reference Books

1. S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 3rd ed. Upper Saddle River, NJ, USA: Pearson, 2003.
2. M. Deisenroth, A. A. Faisal, and C. S. Ong, *Mathematics for Machine Learning*. Cambridge, U.K.: Cambridge University Press, 2020. ,
3. S. Kumar, D. Zindani, and J. P. Davim, *Artificial Intelligence in Mechanical and Industrial Engineering*. Boca Raton, FL, USA: CRC Press, 2021.
4. Z. Nagy, *Artificial Intelligence and Machine Learning Fundamentals*. New York, NY, USA: Apress, 2018.

Online Links

5. NPTEL, "Artificial Intelligence Course," http://nptel.ac.in/courses/111101003/
6. NPTEL, "Machine Learning Course," https://nptel.ac.in/courses/106/106/106106202/
7. NPTEL, "Deep Learning / AI Course," Available: https://nptel.ac.in/courses/112/103/112103280/
8. Analytics Vidhya, "Machine Learning and Data Science Resources," https://www.analyticsvidhya.com/
9. **AI For Everyone – DeepLearning.AI** https://www.coursera.org/learn/ai-for-everyone
10. **Introduction to Artificial Intelligence – IBM** https://www.coursera.org/learn/introduction-to-ai
11. **Machine Learning Specialization – Andrew Ng** https://www.coursera.org/specializations/machine-learning-introduction
12. **Google AI Professional Certificate – Google** https://www.coursera.org/professional-certificates/google-ai
13. **Machine Learning with Python: From Linear Models to Deep Learning – Massachusetts Institute of Technology** https://www.edx.org/learn/machine-learning

14. **Machine Learning Crash Course – Google**
https://developers.google.com/machine-learning/crash-course

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.

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes
3- High 2- Medium 1 – Low

CO \ PO/PEO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 10	PO1 11	PSO1	PSO2
CO1	3	2	–	–	1	–	–	–	–	–	1	2	1
CO2	2	3	–	2	3	–	–	–	–	–	–	3	–
CO3	2	3	2	3	3	–	–	–	–	–	–	3	–
CO4	2	2	3	3	3	–	–	–	2	–	–	3	2
CO5	2	2	–	2	3	–	–	–	–	–	3	2	3

Assessment pattern:

Assessment pattern levels no.	Knowledge levels	ISE I	ISE II	ISE II	ESE
K1	Remember	4	4	-	18
K2	Understand	4	4	-	18
K3	Apply	4	4	-	12
K4	Analyze	3	3	-	12
K5	Evaluate				
K6	Create	Nil	Nil	-	Nil
Total Marks 50		15	15		60

Assessment table:

Assessment Tool	K1, K2	K1,K3	K1,K4	K1.K3,K4	K1,K2,K3
	CO1	CO2	CO3	CO4	CO5
ISE I (15 Marks)	8	7			
ISE II (15Marks)			8	7	
ESE (60 Marks)	12	14	12	14	18

Total Marks 100	20	21	20	21	18

Special Instruction if any: Nil

MEPEC4008: Lab-Artificial Intelligence and Machine Learning		
Teaching Scheme	**Examination Scheme**	
Practical: 02 Hrs. / Week /Batch	**ISE-III**	**25 Marks**
Credits: 01	**ESE**	**25 Marks**

Course Outcomes

After completion of this course, students will be able to:

CO No.	Course Outcome
CO1	Understand AI/ML learning approaches
CO2	Study and preprocess datasets
CO3	Perform feature extraction and selection
CO4	Develop classification and regression models

List of Experiments

Sr. No.	Title of the Experiment
1	Introduction to AI/ML Learning Paradigms
2	Data Acquisition and Visualization
3	Feature Extraction and Dataset Preparation
4	Feature Selection / PCA
5	Classification Model Development
6	Regression Model Development
7	Markov Process Modeling
8	Reinforcement Learning Application
9	Genetic Algorithm Optimization
10	Neural Network Application

Assessment:

ISEIII: Shall be on the basis of assessment of term work.

ESE: ESE will base on oral exam conducted by course coordinator and external examination.

Assessment Pattern:

Assessment Pattern Level No.	Knowledge Level	ISE I	End Semester Examination
K1	Remember		5
K2	Understand		10
K3	Apply		10
K4	Analyze		-
K5	Evaluate		-
K6	Create		-
Total Marks			25

Mapping of Course Outcome with Program Outcomes and Program Specific Outcomes

CO -PO/PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	–	–	–	–	–	–	–	–	–	2	–
CO2	2	3	–	2	2	–	–	–	–	–	–	3	–
CO3	–	2	2	2	3	–	–	–	–	–	–	3	–
CO4	2	2	3	3	3	–	–	–	2	–	–	3	2
CO5	–	2	–	2	3	–	–	–	–	–	2	2	3

Special Instructions:

- Nil

MEPEC4021: Turbo Machinery		
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs / week	**ISE I**	**15 Marks**
Credits: 03	**ISE II**	**15 Marks**
	ISE III	**10 Marks**
	ESE	**60 Marks**

Course Outcomes:

	Course Outcomes
CO1	Apply thermodynamic principles and velocity diagrams to analyze the performance of steam turbines.
CO2	Analyze jet and rocket propulsion systems and evaluate thrust and propulsive efficiency.
CO3	Analyze impulse type hydraulic turbines using the impulse-momentum principle.
CO4	Apply governing equations and velocity diagrams to evaluate work transfer and efficiency in reaction turbines and fluid machines.
CO5	Use experimental data, unit quantities and performance curves to assess the behaviour of fluid machinery under varying operating conditions.
CO6	Explain the construction, working and applications of rotary compressors.

Detailed Syllabus:

Unit 1.	**Steam Turbines** Classification of steam turbines, impulse and reaction turbines: construction and working, velocity diagrams for impulse turbine stages, work done, blade efficiency, stage efficiency and condition for maximum blade efficiency, degree of reaction, velocity diagrams for reaction (Parson's) turbine and optimum operating condition, need for compounding: pressure, velocity and pressure-velocity compounding, losses in steam turbines and reheat factor (concept), governing of steam turbines: throttle, nozzle and by-pass governing, common applications of steam turbines in power generation and process industries.
Unit 2.	**Jet Propulsion** Principle of jet propulsion and classification of air-breathing engines, thrust, thrust power, propulsive, thermal and overall efficiencies, turbojet engine: construction, working cycle and performance parameters, turboprop and turbofan engines: bypass ratio and comparative merits, pulse jet and ramjet engines: working principle and limitations, common applications of various jet engines in civil and military aviation, concept of rocket propulsion: thrust equation, specific impulse, solid and liquid propellant rockets.
Unit 3.	**Introduction and Hydraulic Turbines Impulse Type** Impulse-momentum principle, force exerted by a jet on fixed and moving flat plates, inclined plates, curved vanes and a series of plates and vanes, velocity triangles, work done and efficiency calculations, layout of a hydroelectric power plant, gross head

	and net head, hydraulic, mechanical, volumetric and overall efficiencies of hydraulic turbines, Pelton wheel turbine: main components and constructional features, velocity diagrams and work done, condition for maximum hydraulic efficiency, design parameters: calculation of number of jets, number of buckets, speed ratio and jet ratio, governing of Pelton wheel turbine.
Unit 4.	**Hydraulic Turbines Reaction Type** Reaction turbines: main components and constructional features, types of reaction turbines (Francis, Kaplan and propeller), velocity diagrams, work done and efficiency calculations, draft tube: functions, types and draft-tube efficiency, phenomenon of cavitation, its effects on performance and life of turbine, Thoma's cavitation factor and preventive measures, unit quantities, specific speed, model testing and characteristic curves, governing mechanisms for reaction turbines, selection of suitable turbine based on head, discharge and specific speed.
Unit 5.	**Rotary Compressor** Introduction to compressors, classification of compressors into positive displacement and dynamic types, comparison between reciprocating and rotary compressors, rotary vane compressor: construction, working and applications, Roots blower (lobe compressor): construction, working and characteristics, screw compressor: construction, working and advantages, centrifugal compressor: construction, basic principle, working and velocity diagram, work input and isentropic efficiency, phenomena of surging and choking, industrial applications and selection of rotary compressors.

Reference and Text Books

1 Fluid Mechanics and Hydraulic Machines, R.K. Bansal, 9th Edition, Laxmi Publications (P) Ltd., New Delhi, 2014.
2 Hydraulics and Fluid Mechanics including Hydraulic Machines, P.N. Modi and S.M. Seth, 19th Edition, Standard Book House, 2012.
3 Fluid Mechanics: Fundamentals and Applications, Y.A. Cengel and J.M. Cimbala, 3rd Edition, Tata McGraw-Hill, 2019.
4 Fluid Mechanics, Frank M. White, 7th Edition, Tata McGraw-Hill, 2011.
5 Turbines, Compressors and Fans, S.M. Yahya, 4th Edition, McGraw-Hill Education, 2011.
6 Steam and Gas Turbines and Power Plant Engineering, R. Yadav, Central Publishing House, Allahabad, 2010.
7 Gas Turbine Theory, H.I.H. Saravanamuttoo, G.F.C. Rogers and H. Cohen, 7th Edition, Pearson Education, 2017.
8 Fundamentals of Fluid Mechanics, B.R. Munson, T.H. Okiishi, W.W. Huebsch and A.P. Rothmayer, 7th Edition, John Wiley & Sons, 2004.
1. Fluid Mechanics and Thermodynamics of Turbomachinery, S.L. Dixon and C.A. Hall, 7th Edition, Elsevier, 2014.

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 and fifth units.
ISE III: Shall be on the basis of Class Tests/ Assignments/ Quizzes/ Field visits/Presentations.

Mapping of Course outcome with Program Outcomes and Program
Specific Outcomes 3 – High 2 – Medium 1 - Low

Course Outcome	PO 1	PO2	PO3	PO4	PO 5	PO6	PO7	PO8	PO 9	PO10	PO11	PO 1 2	PS01	PSO 2
CO1	1	2											1	
CO2	1	2	2										1	
CO3		3	2										2	
CO4	2	3	2										1	
CO5	1	2	3										2	

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

Special Instructions if any: Nil

MEPEC4022: Lab –Turbomachinery		
Teaching Scheme	**Examination Scheme**	
Practical: 2 Hrs/Week	**ISEIII**	**25 Marks**
Credits: 1	**ESE**	**25 Marks**

Course Outcome

As an outcome of completing the Laboratory course, students will able to:

	Course Outcomes
CO1	Conduct trials on Pelton, Francis and Kaplan turbines and evaluate their performance characteristics.
CO2	Demonstrate the constructional and operational features of steam turbines, rotary compressors and jet engines.
CO3	Prepare technical reports on experiments and industrial visits with neatly recorded observations and analysis.

Minimum Eight experiments shall be performed to cover entire curriculum of the course Turbo Machinery.

List of Experiments

Sr.No	Details
1.	Trial on Pelton wheel
2.	Trial on Francis reaction turbine
3.	Trial on Kaplan turbine
4.	Study of Steam Turbines
5.	Study of rotary compressors
6.	Study of Jet Engines
7.	Industrial visit to hydraulic power station
8.	Industrial visit to Gas turbine station

Term work

The term work will consist of submitting a file for all the experiments with neatly written records of the study and diagrams. The term work will be assessed by the course coordinator

Practical Examination

The Practical Examination will comprise of viva voce on the syllabus

The practical will be assessed by two examiners, one will be the course coordinator and other will be examiner appointed by BOS

Mapping of Course outcome with Program Outcomes and Program

Course Outcome	PO 1	PO2	PO3	PO4	PO 5	PO6	PO7	PO 8	PO 9	PO10	PO11	PO1 2	PS01	PSO2
CO1	**1**	**2**											**1**	
CO2		1	**2**										**1**	
CO3		**1**	**2**										**2**	

MEPEC4009: Advanced Manufacturing Technology		
Teaching Scheme	**Examination Scheme**	
Lectures: 3Hrs. / Week	**ISEI**	**15 Marks**
Tutorial: 00 hrs/week	**ISEII**	**15 Marks**
Credits: 3	**ISEIII**	**10 Marks**
	ESE	**60 Marks**

Course Outcomes

CO No.	Course Outcomes
CO1	Calculate process parameters and select material requirements to execute Squeeze, Centrifugal, and Continuous casting processes.
CO2	Demonstrate the operation of EDM and Wire-EDM (WEDM) systems by configuring equipment and spark generation circuits for specific machining tasks.
CO3	Employ diverse shaping techniques—such as pressing, extruding, and hot pressing—to meet specific component density and structural requirements.
CO4	Apply thermal and electrical power parameters to solve mathematical expressions for predicting Material Removal Rate (MRR).
CO5	Implement specific packaging technologies, bonding methods, and Surface Mount Technology (SMT) protocols to ensure PCB assembly reliability.

Detail Syllabus

	Syllabus
Unit 1	**Advances in Casting Process:** V-process, flask less moulding, evaporative casting, plaster mould casting, Vacuum Mould Casting, Squeeze Casting, Centrifugal Casting, Continuous Casting, Evaporative Pattern Casting. design for plaster mould casting quality accuracy, uniformity and other considerations in casting and moulding. Recent developments in pattern and casting designing.
Unit 2	**Non-Traditional Machining:** Introduction, need, AJM, Parametric Analysis, Process capabilities, USM – Mechanics of cutting, models, Parametric Analysis, WJM –principle, equipment, process characteristics, performance, EDM – principles, equipment, generators, Abrasive water jet machining (AWJM)- principle, process characteristics, Electrochemical machining (ECM) principle, process characteristics, MRR, Surface finish, WEDM.
Unit 3	**Powder Metallurgy and Surface Coating:** Powder Metallurgy: process, different methods of producing powders, different techniques to form the shape viz. pressing, extruding, sintering, and hot pressing. advantages, disadvantages of powder metallurgy. Surface Coating: Scope, Cleaners, Methods of cleaning, Surface coating types, and ceramic and organic methods of coating, economics of coating. Electro forming, Chemical vapour deposition, thermal spraying, Ion implantation, diffusion coating, Diamond coating and cladding.

Unit 4	**Laser Beam Machining:** Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Plasma Arc Machining – Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Electron Beam Machining - Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Electro Chemical Machining – Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications.
Unit 5	**Fabrication of Microelectronic devices** Crystal growth and wafer preparation, Film Deposition oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, computer aided design in microelectronics, surface mount technology, Integrated circuit economics. E-Manufacturing, nanotechnology, micromachining and High-speed Machining, basic principles, working, applications, advantages.

References:

1. Modern Manufacturing process engineering, Benjamin W. Niebel, Allen B Draper, Richard A. Wysk, 2nd edition, McGraw Hill, New Delhi, 2001.
2. Non Traditional Manufacturing Processes, Garry F. Benedict- Marcel Dekker, by CRC Press New York.2014.
3. Production Technology, HMT,Hand Book”,TMH.
4. Metal Casting, Hayane and Rosanthal, Indian edition, McGraw Hill, New delhi, 2001.
5. Non-traditional manufacturing process, Derban Michigan, 5th edition, E.J. Weller Society of Manufacturing Engineers, 2012.

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.

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes
3- High 2- Medium 1 – Low

Course outcome	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO11	PSO1	PSO2
CO1	3	2	2	1	2	1	1	-	-	-	-	2	3
CO2	3	3	2	2	2	-	-	-	-	-	-	2	3
CO3	3	2	2	1	1	1	2	-	-	-	-	2	2
CO4	3	2	3	2	2	-	-	-	-	-	1	2	2
CO5	2	2	1	-	2	1	2	-	1	1	3	2	2

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, K2	K1,K3	K1,K4	K1.K3,K4	K1,K2,K3
	CO1	**CO2**	**CO3**	**CO4**	**CO5**
ISE I (15 Marks)	8	7			
ISE II (15Marks)			8	7	
ESE (60 Marks)	12	14	12	14	18
Total Marks 100	20	21	20	21	18

Special Instruction if any: Nil

MEPEC 4010 : Lab - Advanced Manufacturing Technology		
Teaching Scheme	**Examination Scheme**	
Practical: 02 Hrs. / Week /Batch	**ISE-III**	**25 Marks**
Credits: 01	**ESE**	**25 Marks**

Course Outcomes:

After completion of this Lab course students will be able to:

	Course Outcomes
CO1	Understand the various advanced manufacturing methods
CO2	Demonstrate the operation of EDM and Wire-EDM (WEDM) systems by configuring equipment and spark generation circuits for specific machining tasks.
CO3	Implement specific packaging technologies, bonding methods, and Surface Mount Technology (SMT) protocols to ensure PCB assembly reliability.
CO4	Employ diverse shaping techniques—such as pressing, extruding, and hot pressing—to meet specific component density and structural requirements.

List of the Experiments List of Experiments (Any Eight)

The student shall perform any six experiments.

Sr. No.	**Title of the Experiments**
1	Study and demonstration of Modern Casting Methods (Continuous & Centrifugal Casting)
2	Study of Parametric Analysis of Ultrasonic Machining (USM) Mechanics
3	Study of Water Jet Machining (WJM)
4	Study of Abrasive Jet (AJM)
5	Study of Advanced Thermal Machining (PAM & EBM)
6	Comparative Study of Shape Forming in Powder Metallurgy
7	Study of Semiconductor Lithography & PCB Surface Mount Technology (SMT)
8	Industrial visit based on advanced manufacturing techniques.
9	Study and demonstration of laser beam machining.

Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**ISE-III**	**End Semester Examination**
K1	Remember		5
K2	Understand		10
K3	Apply		10
K4	Analyze		

Total Marks	25	25

Assessment Pattern Level No.	Knowledge Level		End Semester Examination
S1	Imitation	Data / Information	5
S2	Manipulation	Planning/ Layout	5
S3	Precision	Detailing	5
S4	Articulation	Presentation/ Viva-Voce	10
S5	Naturalization	-	
Total Marks			25

Assessment:
ISEIII: Shall be on the basis of assessment of term work.
ESE: ESE will base on oral exam conducted by course coordinator and external examination.

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PO 11	PS O1	PS O2
CO1	3	2	1	2	1	-	1	-	2	2	-	3	1
CO2	3	3	2	3	2	-	-	-	2	2	-	3	2
CO3	3	3	2	3	3	-	-	-	2	2	-	3	1
CO4	3	2	3	2	2	2	2	-	2	2	1	2	3

MEPEC4011: Tool Design		
Teaching Scheme	**Examination Scheme**	
Lecture: 3 Hrs. / Week	**ISE I**	**15 Marks**
Credit: 3	**ISE II**	**15 Marks**
	ISE III	**10 Marks**
	End Semester Examination	**60 Marks**

Course Outcomes: After completing the course student will be able to

Course Outcomes	
CO 1	Define and explain the fundamental terminology, geometry, and basic principles of cutting tools and machining operations.
CO 2	Select cost-effective cutting tools and machining parameters for executing specific manufacturing operations.
CO 3	Utilize the principles of 3-2-1 location and clamping to select appropriate locators, jigs, and fixtures for a specific machined component.
CO 4	Calculate cutting forces and clearance values to implement fundamental design principles for blanking and piercing dies.
CO 5	Execute the design of bending and drawing dies by operating standard CAD software.

Detailed Syllabus:

Unit 1	**Theory of Metal Cutting:** Mechanics of chip formation, Single point cutting tool, designation of cutting tool, method of machining, types of chips, determination of shear angle, determination of unreformed chip thickness, force analysis, energy consideration, oblique cutting, tool wear and tool life, economics of metal cutting, machinability, surface roughness, Cutting fluids types and characteristics, Types of Inserts
Unit 2	**Multipoint cutting tools:** types of cutting tool, classification, nomenclature, geometry, force and power consumption, tooth form and cutting angle for (milling cutters, broach, drills, reamers, Taps and Hobs)
Unit 3	**Jigs & fixtures:** Principle of location, locating devices, Principle of clamping & clamping devices, force calculation, Types of bushes & their applications, Definition of drill jig, types of drill jig, chip formation in drill jig, general consideration in design of drill jigs, method of construction, indexing drill jig, drill jig and modern manufacturing method. Definition of fixture, fixture and economics, types of fixtures, milling fixture, turning fixtures, indexing fixture .
Unit 4	**Press tool design:** Press Operations, press tool components, press working terminology, working of cutting die, types of dies, principle of metal cutting (strip layout, clearance, land, straight, angular clearance) theory of metal cutting, cutting forces, energy, methods of reducing cutting forces, blanking and piercing die consideration.
Unit 5	**Design of Drawing Die:** Number of draws, stage wise achievement of drawn component, stage wise components drawing, re-draw and inverted die, drawing radii & clearance, drawing force. **Design of Bending Die:** bending principle, bending methods, Estimation of bend radius, bend allowance, developed length, bending pressure, bottoming force, spring back effect in bending operation, spanking. Use of CAD in Die design.

Text and Reference Books :

1. Amitabh Bhattacharyya, “Metal Cutting Theory and Practice”, Central Book Publication, Calcutta
2. Cyril Donaldson, “Tool Design”, Tata McGraw-Hill Publishing Co. Ltd, New Delhi
3. Kempster, “Introduction to Jig and Tool Design”, M. H. A. English Language Book Society
4. P.H. Joshi, “Jigs and Fixtures”, Tata McGraw-Hill Publishing Co. Ltd, New Delhi
5. “Production Engineering”, H.M.T. Hand-Book, Tata McGraw-Hill Publishing Co. Ltd, New Delhi
6. Wilson (Edited), “Fundamentals of Tool Design”, A.S.T.M.E.
7. P.C. Sharma “Production Engineering”, S. Chand Company Ltd New Delhi
8. S K Basu and S N Mukherjee, “Fundamentals of tool engineering design”, Oxford and IBH publication Co. Pvt. Ltd Bombay
9. P. H. Joshi “Press Tools Design and Construction” Wheeler Publishing

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PS01	PS02
CO1	2	1	2		2	1						2	2
CO2	1		1			1						1	1
CO3	2	2	2	2	2	1						2	2
CO4	2	2	2	2	2	1						2	2
CO5	2	2	2	2	2	1						2	2

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 Number	Knowledge Level	ISE I Marks	ISE II Marks	ISE III/ TA Marks	End Semester Examination
K1	Remember	5	5	2	10
K2	Understand	5	5	3	20
K3	Apply	5	5	5	30

MEPEC4012 : Lab - Tool Design		
Teaching Scheme	**Examination Scheme**	
Practical: 02 Hrs. / Week /Batch	**ISE-III**	**25 Marks**
Credits: 01	**ESE**	**25 Marks**

Course Outcomes:

After completion of this Lab course students will be able to:

	Course Outcomes
CO1	Understand the geometry of single point and multipoint cutting tools and analyze tool life calculation
CO2	Participate to develop locating and clamping devices and analyze minimum force required for clamping
CO3	Design jigs for drilling and fixtures for turning and milling for particular industrial product
CO4	Select, design and draw standard dies for Piercing and Blanking operations

List of the Experiments List of Experiments (Any Eight)

The student shall perform CAD-based design and drawing of jigs and fixtures across any six selected experiments.

Sr. No.	Title of the Experiments
1	Locating Devices: Drawing and Designing of various Locating systems/devices for Jigs/Fixtures
2	Clamping Devices and Drill Bushes: Drawing and Designing of various Clamping system/devices (mechanical/hydraulic/pneumatic) for Jigs/Fixtures and Drill bushes
3	Design of Drilling Jig: Design and Drawing of Drilling Jig for the given component
4	Design of Milling: Design and Drawing of Milling for the job given.
5	Design and Turning Fixture: Design and Drawing of Turning fixture for the job given.
6	Design of Press Tool: Piercing press tool for the given components.
7	Design and Drawing of Blanking for the given components.
8	Multipoint Cutting Tool: Drawing of various Multipoint cutting tools e.g drill, milling cutters, reamers, broaches, taps, hobs
9	Journal Assignment on a) Tooling Materials: Tool materials and its characteristics and classification b) Single point Cutting Tool: Geometry, Tool signature, Significance of various angles, Merchant theory, factors affecting Tool life, Tool wear c) Press Working: Working, operations, classification, types of dies etc
10	Models: Preparing a model of Single Point Cutting Tool from soft/wood

Assessment Pattern:

Assessment Pattern Level No.	**Knowledge Level**	**ISE-III**	**End Semester Examination**
K1	Remember		5
K2	Understand		10
K3	Apply		10
K4	Analyze		
Total Marks		25	25

Assessment Pattern Level No.	**Knowledge Level**		**End Semester Examination**
S1	Imitation	Data / Information	5
S2	Manipulation	Planning/ Layout	5
S3	Precision	Detailing	5
S4	Articulation	Presentation/ Viva-Voce	10
S5	Naturalization	-	
Total Marks			25

Assessment:
ISEIII: Shall be on the basis of assessment of term work.
ESE: ESE will base on oral exam conducted by course coordinator and external examination.

Assessment Table:

Assessment Tool	**S1**	**S2**	**S3**	**S4**
	CO1	**CO2**	**CO3**	**CO4**
Practical Examination	**5**	**5**	**5**	**10**

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes

Course outcome	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PS O1**	**PS O2**
CO1	3	2	1	2	1	-	1	-	2	2	-	3	1
CO2	3	3	2	3	2	-	-	-	2	2	-	3	2
CO3	3	3	2	3	3	-	-	-	2	2	-	3	1
CO4	3	2	3	2	2	2	2	-	2	2	1	2	3

Professional Elective V MEPEC4013 : Computational Fluid Dynamics		
Teaching Scheme	**Examination Scheme**	
Lectures: 03 Hrs. / Week	**ISEI**	**15 Marks**
Tutorial: 00 hrs/week	**ISEII**	**15 Marks**
	ISEIII	**10 Marks**
Credits: 03	**ESE**	**60 Marks**

Course Outcomes: Upon successful completion of the course, students will be able to:

CO No.	Course Outcome Statement
CO1	Understand the fundamentals of CFD, governing equations, and their physical significance.
CO2	Apply numerical methods such as FDM and FVM for discretization of governing equations.
CO3	Solve diffusion and convection-diffusion problems using appropriate numerical schemes.
CO4	Analyze flow fields using pressure–velocity coupling methods such as SIMPLE algorithm.
CO5	Demonstrate knowledge of mesh generation and turbulence modeling for practical CFD applications.

Detailed Syllabus:

Unit 1	**Introduction to CFD** Introduction to CFD, Applications in Engineering, CFD Framework: Pre- processor, Solver, Post-processor, Governing Equations: Continuity, Momentum, Energy, Navier–Stokes Equations (Conservative & Non-conservative forms), Physical interpretation
Unit 2	**Numerical Methods for CFD** Finite Difference Method (FDM) and Finite Volume Method (FVM), Taylor Series Expansion, Forward Backward and Central Difference Schemes, Numerical Error Analysis, Gauss-Seidel Method and TDMA
Unit 3	**FVM for Diffusion Problems** 1D steady-state heat conduction, Boundary conditions: Dirichlet, Neumann, Robin, 2D and 3D diffusion problems, Unsteady diffusion using Explicit and Implicit schemes
Unit 4	**FVM for Convection–Diffusion Problems & Flow Field Calculation** 1D steady convection-diffusion, CDS UDS Exponential Hybrid and Power Law schemes, Incompressibility and pressure–velocity coupling, Staggered and Co-located grids, SIMPLE and SIMPLER algorithms

Unit 5	**Mesh Generation & Turbulence Modelling** Structured and Unstructured meshes, Grid generation basics, Turbulence modelling: RANS and k–ε model, Post-processing and visualization

Text and Reference Books

1. H. K. Versteeg and W. Malalasekera, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, 2nd ed. Harlow, UK: Pearson Education, 2007.
2. J. D. Anderson, *Computational Fluid Dynamics: The Basics with Applications*. New York, USA: McGraw-Hill, 1995.
3. S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*. Boca Raton, USA: CRC Press, 1980.
4. J. H. Ferziger, M. Perić, and R. L. Street, *Computational Methods for Fluid Dynamics*, 4th ed. Berlin, Germany: Springer, 2020.
5. J. Blazek, *Computational Fluid Dynamics: Principles and Applications*, 3rd ed. Oxford, UK: Elsevier, 2015.
6. D. A. Anderson, J. C. Tannehill, and R. H. Pletcher, *Computational Fluid Mechanics and Heat Transfer*, 2nd ed. Washington, USA: Taylor & Francis, 1997.

7. NPTEL Courses
   - Computational Fluid Dynamics (IIT Kharagpur)
     https://onlinecourses.nptel.ac.in/noc21_me126/preview
   - Computational Fluid Dynamics
     https://nptel.ac.in/courses/103106119
   - Introduction to Computational Fluid Dynamics
     https://nptel.ac.in/courses/112105045
   - Foundation of Computational Fluid Dynamics (IIT Madras)
     https://onlinecourses.nptel.ac.in/noc20_me64/preview
   - Computational Fluid Dynamics for Incompressible Flows (IIT Guwahati)
     https://onlinecourses.nptel.ac.in/noc25_me10/preview
   - Applied Computational Fluid Dynamics (IIT Kanpur)
     https://onlinecourses.nptel.ac.in/noc25_ae22/preview
   - Introduction to CFD (NPTEL Course)
     https://onlinecourses.nptel.ac.in/noc20_ae11/preview

8. Online Courses

- Applied Computational Fluid Dynamics (Coursera)
  https://www.coursera.org/learn/applied-computational-fluid-dynamics
- Computational Fluid Dynamics (NPTEL)
  https://onlinecourses.nptel.ac.in/noc21_me126/preview
- Computational Fluid Dynamics Courses (Udemy)
  https://www.udemy.com/topic/computational-fluid-dynamics/
- Masters in CFD (Skill-Lync)
  https://skill-lync.com/mechanical-engineering-courses/masters-cfd
- CFD Courses (Flowthermolab)
  https://www.flowthermolab.com/courses/

9. Websites / Learning Platforms

- SimScale CFD Learning Resources
  https://www.simscale.com/blog/cfd-analysis-for-beginners/
- CFD Online Forum & Resources
  https://www.cfd-online.com/
- OpenFOAM Official Website
  https://www.openfoam.com/

- Class Central CFD Courses
  https://www.classcentral.com/subject/computational-fluid-dynamics
- MR CFD Academy Courses
  https://portal.mr-cfd.com/courses

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.

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes
3- High 2- Medium 1 – Low

CO \ PO/PEO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 10	PO1 11	PSO1	PSO2
CO1	3	2	–	–	–	–	–	–	–	–	1	2	1
CO2	2	3	–	2	3	–	–	–	–	–	–	3	–
CO3	2	3	2	3	2	–	–	–	–	–	–	3	–
CO4	2	2	3	3	3	–	–	–	2	–	–	3	2
CO5	–	2	–	2	3	–	–	–	–	–	3	2	3

Assessment pattern:

Assessment pattern levels no.	Knowledge levels	ISE I	ISE II	ISE II	ESE
K1	Remember	4	4	-	18
K2	Understand	4	4	-	18
K3	Apply	4	4	-	12
K4	Analyze	3	3	-	12
K5	Evaluate				
K6	Create	Nil	Nil	-	Nil
Total Marks 50		15	15		60

Assessment table:

Assessment Tool	K1, K2	K1,K3	K1,K4	K1.K3,K4	K1,K2,K3
	CO1	**CO2**	**CO3**	**CO4**	**CO5**

ISE I (15 Marks)	8	7			
ISE II (15Marks)			8	7	
ESE (60 Marks)	12	14	12	14	18
Total Marks 100	20	21	20	21	18

Special Instruction if any: Nil

LAB Professional Elective V MEPEC4014 : Lab - Computational Fluid Dynamics		
Teaching Scheme	**Examination Scheme**	
Practical: 02 Hrs. / Week /Batch	**ISE-III**	**25 Marks**
Credits: 01	**ESE**	**25 Marks**

Course Outcomes

After completion of this course, students will be able to:

CO No.	Course Outcome
CO1	Understand the formulation and setup of CFD problems including boundary conditions
CO2	Perform simulations of steady and transient heat transfer problems
CO3	Analyze fluid flow and convection–diffusion phenomena using CFD techniques
CO4	Apply CFD software tools for modeling, simulation, and visualization

List of Experiments

Students are required to perform the following practicals using any suitable computational fluid dynamics (CFD) software or programming tools such as ANSYS Fluent, OpenFOAM etc . The experiments are designed to develop a comprehensive understanding of CFD problem formulation, simulation, and analysis.

Sr. No.	Title of the Experiment
1	1D Steady-State Heat Conduction
2	1D Transient Heat Conduction
3	1D Convection–Diffusion Problem
4	2D Incompressible Flow (Driven Cavity)
5	External Flow over Cylinder
6	Laminar Flow in Pipe
7	Mesh Generation & Grid Independence Study
8	Turbulent Flow Simulation (k–ε Model)
9	Post-Processing & Visualization

Assessment:
ISEIII: Shall be on the basis of assessment of term work.
ESE: ESE will base on oral exam conducted by course coordinator and external examination.

Assessment Pattern:

Assessment Pattern Level No.	Knowledge Level	ISE III	End Semester Examination
K1	Remember	5	5
K2	Understand	10	10
K3	Apply	10	10
K4	Analyze		-
K5	Evaluate		-
K6	Create		-
Total Marks		25	25

Mapping of Course Outcome with Program Outcomes and Program Specific Outcomes

CO -PO/ PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	–	–	–	–	–	–	–	–	–	2	–
CO2	2	3	–	2	2	–	–	–	–	–	–	3	–
CO3	–	2	2	2	3	–	–	–	–	–	–	3	–
CO4	2	2	3	3	3	–	–	–	2	–	–	3	2

Special Instructions:

- Nil

MEPEC4015 : Automobile Engineering		
Teaching Scheme	**Examination Scheme**	
Lectures: 03 Hrs. / Week	**ISEI**	**15 Marks**
	ISEII	**15 Marks**
Credits: 03	**ISE III**	**10 Marks**
	ESE	**60 Marks**

Course Outcomes

CO No.	Course Outcomes
CO1	Understand the construction, working and other details about Internal Combustion Engine used in Automobiles.
CO2	Description of working principles of transmission system with detailed information of gear boxes.
CO3	Demonstrate the working operations of braking and suspension systems by troubleshooting their components and calculating stopping distances or spring stiffness values.
CO4	Infer the role of electrical system in vehicles having the information about the safety and maintenance
CO5	Compare the Modern technology and safety measures used in Automotive Vehicles.

Detailed Syllabus

	Syllabus
Unit 1	**Introduction to Automobile Engineering**: Classification of automobiles, chassis and Frames: Types of Chassis layout and various types of frames and their constructional details, layout types, Sub-systems of automobile Power Unit: -Functions and locations power for propulsion, Engine parts-types, construction and functions, multiple cylinder engines. General considerations of engine balance vibration, firing order road performance curves.
Unit 2	**Transmission system:-** Construction, transmission, requirements of single plate friction clutch and multi plate clutch, clutch adjustments, clutch troubles and remedies, fluid flywheel and torque convertor. **Gear Boxes: -** Sliding mesh, constant mesh and synchromesh gear box, function of over drives, trouble shooting and remedies. Propeller shaft, Hotchkiss drive torque tube drive, differential, Final drive Types of rear axles
Unit 3	**Braking system and Suspension System: -** Mechanical, hydraulic brakes, power brakes, air brakes and vacuum brakes Fault finding and maintenance of brakes, Steering system: - Function, types of linkages, steering gears, steering gear ratio. Wheel alignment, steering geometry, & their effects, Introduction of power steering. Suspension system: Types of Rigid, axle and independent suspension system, shock Absorbers.
Unit 4	**Electrical System and Vehicle safety and maintenance**: Bendix drive, over running clutch drive, Solenoid switch; solenoids switch. Ignition system: - Battery coil and magneto ignition system, Ignition timing and its effect on engine performance, Ignition advance mechanisms, electronic ignition system. Characteristics of batteries, rating capacity and

	efficiency of batteries, introduction to lithium batteries.
Unit 5	**Modern technology in Automobile Vehicles**: Electric vehicles and Hybrid electric vehicles: Concept and environmental importance of Electric vehicles and Hybrid Electric vehicles, Layout, Construction and working of EVs and HEVs, Hybridization factor and fuel efficiency analysis.

Text and Reference Books

- Kirpal Singh, "Automobile Engineering", Vol I & II, Standard publishers Distributors, Delhi
- Ramalingum K. K., "Automobile Engineering", Scitech publications", Chennai
- Srinivasan S. "Automotive Engines", Tata McGraw Hill
- Crouse W. H. "Automotive Mechanics", Tata McGraw Hill
- Joseph Heitner, "Automotive Mechanics", East-West press Pvt. Ltd
- T. R. Banga&Nathu Singh, "The Automobile Engineering", Khanna Publishers
- R. K. Rajput, "Automobile Engineering", Laxmi Publication
- K. K. Jain & R.B. Asthana. "Automobile Engineering", Tata McGraw Hill
- S. Srinivasan, "Automotive Mechanics", Tata McGraw Hill
- R.K. Mohanty, "Automobile Engineering", Standard Book House
- Chris Mi, M .AbulMasrur, Hybrid Electric Vehicles: Principles and Applications withPractical Perspectives, ,Willey.
- Ehsani, YiminGao, Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles,Standards media

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.

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes
3- High 2- Medium 1 – Low

Course outcome	PO 1	PO 2	PO 3	PO 4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1			2		1	2	1	2	1
CO2	3	3	2	2			2		1	2	1	3	2
CO3	3	3	3	2			3		2	2	2	3	3
CO4	3	3	3	3			3		2	2	2	3	3
CO5	3	2	3	2			3		2	2	2	3	3

Assessment pattern:

Assessment pattern levels no.	Knowledge levels	ISE I	ISE II	ESE
K1	Remember	8		10
K2	Understand	7		10
K3	Apply		7	15
K4	Analyze		8	25

K5	Evaluate	Nil	Nil	Nil
K6	Create	Nil	Nil	Nil
Total Marks		15	15	60

Assessment table:

Assessment Tool	**K1**	**K2,**	**K3**	**K4**	**K4**
	CO1	**CO2**	**CO3**	**CO4**	**CO5**
ISE I	8	7			
ISE II			5	5	5
ISE III	2	2	2	2	2
ESE	10	10	15	12	13
Total Marks 100	20	19	22	19	20

Special Instruction if any: Nil

MEPEC4016: Lab - Automobile Engineering		
Teaching Scheme	**Examination Scheme**	
Practical: 02 Hrs. / Week	**ISEIII**	**25 Marks**
Credits: 01	**ESE**	**25 Marks**

Course Outcomes

CO No.	Course Outcome
CO1	Understand the various Chassis and construction of an Automobile.
CO2	To Know the working and constructions of transmission systems in an Automobile
CO3	Infer the working and constructions of steering, braking systems in an Automobile
CO4	Classify the working and constructions of Suspension systems in an Automobile
CO5	Summarize regarding the modern E – vehicles

List of Experiments (Any Eight)

Experiment No.	List of Experiment
1	Study of construction and working of various types of Chassis and types of an automobile
2	Study of construction and working of various types of braking systems
3	Study of construction and working of various types of Gear boxes and transmission systems in an automobile
4	Study of construction and working of various types of Suspension & its systems used in an automobile
5	Study of construction and working of various types of Cooling and lubrication systems in an automobile
6	Study of construction and working of various types of Starting systems in an automobile
7	Study of construction and working of various steering systems and steeing geometry and steering Gear boxes
08	Introduction of Latest trends in automobile engineering like EV, Hydrogen Vehicle etc
09	Industrial visit to any two industries related to Automobile vehicle Manufacturing vehicle components, manufacturing

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes
3- High 2- Medium 1 – Low

Course outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	3									1	
CO2	1	2		3									2	
CO3	1							2	3				2	
CO4								1						
CO5	3	2			2							2		

Assessment:
ISEIII: Shall be on the basis of assessment of term work.
ESE: ESE will base on oral exam conducted by course coordinator and external examination.

Assessment pattern:

Assessment pattern levels no.	Knowledge levels	ISE I	ESE
S1	Imitation	05	05
S2	Manipulation	10	10
S3	Precision	10	10
S4	Articulation	00	00
S5	Naturalization	00	00
Total Marks		25	25

Preparation (S1)	5	5
Conduct of Experiment (S2)	5	5
Observation and Analysis of Results (S3)	5	5
Record (S2)	5	5
Presentation/ Viva-Voce (S3)	5	5
Total	**25**	**25**

Assessment table:

Assessment Tool	S1	S2	S3	S4
	CO1	**CO2**	**CO3**	**CO4**
Term Work (25 Marks)	05	10	05	05
Practical Examination & Viva Voce (25 Marks)	05	10	05	05

MEPEC4017: Lean Manufacturing		
Teaching Scheme	**Examination Scheme**	
Lectures: 03 Hrs. / Week	**ISEI**	**15 Marks**
	ISEII	**15 Marks**
Credits: 03	**ISE III**	**10 Marks**
	ESE	**60 Marks**

Course Outcomes:

CO	Course Outcomes
CO1	Identify lean principles and waste
CO2	Apply lean tools
CO3	Recognize mapping and flow systems
CO4	Explain lean implementation
CO5	Illustrate lean applications

Detailed Syllabus:

	Syllabus
Unit 1	Introduction to Lean Manufacturing: Evolution of lean, Toyota Production System, principles of lean, identification of value-added and non-value-added activities, classification of waste (Muda, Mura, Muri), benefits and limitations of lean systems.
Unit 2	Lean Tools and Techniques: 5S methodology, Kaizen philosophy, Poka-Yoke techniques, visual management, root cause analysis using fishbone diagram and 5 Why method, Value Stream Mapping (current and future state), process cycle efficiency.
Unit 3	Flow and Pull Systems: Continuous flow manufacturing, takt time calculation, line balancing techniques, cellular manufacturing concepts, Just-in-Time (JIT) production, Kanban system design, push vs pull production systems, inventory control.
Unit 4	Lean Implementation: Implementation strategies, lean layout design, SMED (Single Minute Exchange of Die), Total Productive Maintenance (TPM), supplier integration, lean supply chain management, challenges in lean implementation.
Unit 5	Advanced Lean Applications: Lean Six Sigma concepts, performance measurement metrics, benchmarking, lean in service industries, case studies in automotive and manufacturing sectors, sustainability and green manufacturing practices.

Text and Reference Books:

1. Ohno, Taiichi, *Toyota Production System: Beyond Large-Scale Production*, Productivity Press.
2. Womack, James P. and Jones, Daniel T., *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, Simon & Schuster.
3. Shingo, Shigeo, *A Study of the Toyota Production System from an Industrial Engineering Viewpoint*, Productivity Press.

4. Rother, Mike and Shook, John, *Learning to See: Value Stream Mapping to Add Value and Eliminate Muda*, Lean Enterprise Institute.

5. Liker, Jeffrey K., *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*, McGraw-Hill.

Mapping of Course Outcomes with Program Outcomes:

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

1 – Low, 2 – Medium, 3 – High

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:

Level	Knowledge	ISE1	ISE2	ISE3	End Semester
K1	Remember	5	5		20
K2	Understand	5	5	5	20
K3	Apply	5	5	5	20
K4	Analyze				
K5	Evaluate				
K6	Create				

Total Marks: 100

MEPEC4018: Optimization Techniques		
Teaching Scheme	**Examination Scheme**	
Lectures: 2 Hrs. / Week	**ISEI**	**10 Marks**
Tutorial: 00 hrs/week	**ISEII**	**10 Marks**
Credits: 2	**ESE**	**30 Marks**

Course Outcomes

CO	Course Outcomes
CO1	Explain optimization fundamentals, formulate engineering optimization problems, and classify optimization techniques involving constrained, unconstrained, linear, nonlinear, single-variable, and multivariable systems.
CO2	Apply linear programming methods such as Graphical Method, Simplex Method, Big M Method, and Dual Simplex Method to solve engineering optimization problems.
CO3	Develop and analyze project schedules using network techniques, Critical Path Method (CPM), and Program Evaluation and Review Technique (PERT) for project planning and optimization.

Detail Syllabus

Unit No	Syllabus
1	**Fundamentals of Optimization:** Introduction to Optimization, Mathematical Fundamentals for Optimization, Engineering Applications of Optimization, Optimal Problem Formulation, Classification of Optimization Problems, Constrained and Unconstrained Optimization, Linear and Nonlinear Optimization, Single Variable and Multivariable Optimization
2	**Linear Programming and Optimization Methods:** Introduction to Linear Programming Problems (LPP), Formulation of Linear Programming Models, Graphical Method, Simplex Method, Big M Method, Dual Simplex Method
3	**Project Planning and Optimization Techniques:** (a) Introduction to Project Scheduling - Project Planning Concepts, Activities and Events, Network Representation and Construction Rules (b) Critical Path Method (CPM) - Network Diagram Formation, Earliest and Latest Event Times, Float and Slack, Critical Path Identification (c) Program Evaluation and Review Technique (PERT) - Three-Time Estimates (Optimistic, Most Likely, Pessimistic), Expected Project Duration, Probability of Project Completion, Comparison between CPM and PERT

Reference books:

1 Rao, S. S., *Engineering Optimization: Theory and Practice*, 5th Edition, Wiley India.
2 Deb, Kalyanmoy, *Optimization for Engineering Design: Algorithms and Examples*, PHI Learning.
3 Taha, H. A., *Operations Research: An Introduction*, Pearson Education.
4 Kalyanmoy Deb, *Multi-Objective Optimization Using Evolutionary Algorithms*, Wiley.
5 Arora, J. S., *Introduction to Optimum Design*, McGraw Hill.
6 Edwin K. P. Chong and Stanislaw H. Zak, *An Introduction to Optimization*, Wiley.
7 Ravindran, Phillips and Solberg, *Operations Research: Principles and Practice*, Wiley.
8 Hillier, F. S. and Lieberman, G. J., *Introduction to Operations Research*, McGraw Hill.

9	Ravindran, A., Phillips, D. T., and Solberg, J. J., *Operations Research: Principles and Practice*, Wiley.
10	Sharma, J. K., *Operations Research: Theory and Applications*, Macmillan India.
11	Panneerselvam, R., *Operations Research*, PHI Learning.
12	Gupta, P. K. and Hira, D. S., *Operations Research*, S. Chand Publications.

Assessment:
ISE 1: Shall be on the basis of Class Tests on First unit.
ISE II: Shall be on the basis of Class Tests on Second unit.

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes
3- High 2- Medium 1 – Low

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	1	1	–	–	–	–	–	–	1	2	1
CO2	3	3	2	2	1	–	–	–	–	–	2	3	2
CO3	2	3	2	2	1	–	–	–	1	1	3	2	3

Assessment pattern:

Assessment pattern levels no.	Knowledge levels	ISE I	ISE II	ESE
K1	Remember	-	-	-
K2	Understand	5	5	5
K3	Apply	5	5	10
K4	Analyze	-	-	10
K5	Evaluate	-	-	5
K6	Create	-	-	-
Total Marks		10	10	30

Assessment table:

Assessment Tool	K1	K2	K3	K4	K5
	CO1, CO2	CO1, CO2	CO2, CO3	CO2, CO3	CO3
ISE I	–	5	5	–	–
ISE II	–	5	5	–	–
ISE III	–	–	–	–	–
ESE	–	5	10	10	5
Total Marks 50	–	15	20	10	5

MEPEC4019: Nuclear Engineering		
Teaching Scheme	**Examination Scheme**	
Lectures: 02 Hrs. / Week	**ISEI**	**10Marks**
Credits: 02	**ISEII**	**10Marks**
	EndSemesterExamination	**30Marks**

Course Outcomes:
After completing the course students will able to

Course Outcomes	
CO1	Explain nuclear physics principles, reactions, and reactor fundamentals.
CO2	Analyze nuclear power plant systems, safety, and radiation effects.
CO3	Apply basic AI/ML concepts for monitoring, prediction, and optimization in nuclear systems.

Detailed Syllabus:

Unit 1	**Basics of Nuclear Physics** Atomic structure, nuclear binding energy, Radioactivity: alpha, beta, gamma decay, Nuclear reactions and cross-section, Chain reaction and criticality
Unit 2	**Nuclear Reactor Engineering** Types of reactors: PWR, BWR, PHWR, FBR, Moderator, coolant, control rods, reflectors Neutron life cycle and multiplication factor, Reactor kinetics (introductory)
Unit 3	**Nuclear Power Plants** Layout of nuclear power plant, Working of PWR, BWR, PHWR systems, Steam cycle integration, Waste disposal and fuel reprocessing basics
Unit 4	**Radiation, Safety, and Environmental Impact** Radiation units and measurement, Biological effects of radiation, Shielding and protection Nuclear safety and regulatory framework (IAEA guidelines)
Unit 5	**AI Applications in Nuclear Engineering** *(NEP Skill Integration)* Introduction to AI/ML in thermal systems, Predictive modeling of heat transfers and reactor parameters, Fault detection and anomaly detection in reactors, Digital twins for nuclear plants, Case studies: AI in reactor safety and maintenance

Text and Reference Books

1. John R. Lamarsh, Anthony Baratta, *" Introduction to Nuclear Engineering (Addison-Wesley Series in Nuclear Science and Engineering)", Person college division, 3rd edition , 2001*
2. Glasstone & Sesonske," *Nuclear Reactor Engineering* Reactor Design Basics Vol 1 4th edition, CBS publication, 2004
3. Approaches to Operating Nuclear Power Plants to Mitigate Production Losses Caused by Climate Change and Environmental Hazards, International Atomic Energy Agency publications, https://doi.org/10.61092/iaea.shex-l4r2, 2026
4. U.S. Nuclear Regulatory Commission safety guidelines
5. Vaidyanathan G, Nuclear Reactor Engineering (Principle and Concepts), S Chand & Company publication, 2013
6. AI/ML for Energy Systems – Research papers (IEEE, Elsevier)

Program Outcomes

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

1 – High 2 – Medium 3 - Low

Assessment: ISEI, II (Class Test, TA) & ESE

TA: Students will perform one or more of the following activities

1. Surprise Test
2. Assignment
3. Quiz
4. Any other activity suggested by the course coordinator.

MEPEC4020 : Electrical Vehicle Design		
Teaching Scheme	**Examination Scheme**	
Lectures: 03 Hrs. / Week	**ISEI**	**15 Marks**
	ISEII	**15 Marks**
Credits: 03	**ISE III**	**10 Marks**
	ESE	**60 Marks**

Course Outcomes

CO No.	Course Outcome
CO1	Identify EV concepts, EV configurations and various EV parameters for better understanding of the EV technology
CO2	Analyse the EV propulsion system and electric motors for vehicular applications & power electronics converters required for their control
CO3	Understand the axillaries and Chassis electrical systems in EV
CO4	Understand various Energy storage devices including the Hybridization.
CO5	Apply Energy management system strategies to solve problems

Detailed Syllabus

	Syllabus
Unit 1	**Introduction to EV & HEV** Past, Present & Future of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine. EV System: EV Configuration: Fixed & variable gearing, single & multiple motor drive, In-wheel drives EV Parameters: Weight, size, force, energy & performance parameters
Unit 2	**Introduction Electric Propulsion unit**: - Electric Vehicle Dynamics Introduction to electric components used in electric vehicles. Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives. Configuration and control of Switch Reluctance Motor drives drive system efficiency.
Unit 3	**Energy Storage :-** Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its modelling, SOC, Different Types of Batteries, Super Capacitor based energy storage and its analysis, Hybridization of different energy storage devices
Unit 4	**Chassis Electrical Systems** Anti-lock brakes, Active suspension, Traction control , Automatic transmission, Other chassis electrical systems, Case studies, Diagnosing chassis electrical system faults, Advanced chassis systems technology, New developments in chassis electrical systems
Unit 5	**Energy Management Strategies & Charging Infrastructure: -** Introduction to energy management strategies used in electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies, Types of EV charging Infrastructure & Standardized Communication protocols for EV charging.

Text and Reference Books:

1. Fuel Cell Vehicles: Fundamentals, Theory and Design",CRC Press, 2nd Edition, 2017 (Unit-I, II)
2. Ali Emadi,"Advanced Electric Drive Vehicles (Energy, Power Electronics, and Machines)", CRC Press, 2015. (Unit-III)
3. John G. Hayes and A. Goodarzi, "Electric Powertrain - Energy Systems, Power electronics and drives for Hybrid, electric and fuel cell vehicles", Wiley, 2018. (Unit-IV & V)
4. James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley,2nd Edition 2012.
5. Mehrdad Ehsani, Yimi Gao, Sebastian Longo, Kambiz Ebrahimi, "Modern Electric, Hybrid Electric and Fuel Cell
6. Vehicles: Fundamentals, Theory and Design", CRC Press, Third edition.
7. James Larminie, John Lowry, "Electric Vehicle Technology" Wiley, Second ediion.2012.
8. Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2001
9. Jack Erjavec, Jeff Arias, "Hybrid, Electric and Fuel-cell Vehicles", Cengage Learning India Pvt Ltd. New Delhi. R1
10. C. Mi, M. A. Masrur and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011. R2
11. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015. R3
12. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.R4
13. T. Denton, "Electric and Hybrid Vehicles", Routledge.R5
14. Iqbal Hussein, "Electric and Hybrid Vehicles Design Fundamentals", CRC Press R6
15. A.K. Babu, Electric & Hybrid Vehicle
16. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001

Online Resources

Sr. No	Web Link
1	https://nptel.ac.in/courses/108/103/108103009/
2	https://nptel.ac.in/courses/108/106/108106170
3	https://www.youtube.com/watch?v=V004WUdpHeA&list=PL8qPObng38fHB4nP oBOA4l1ujmriiq_1E
4	https://www.youtube.com/watch?v=3E1SXG7VkQk&list=PLyqSpQzTE6M9spod-

	UH7Q69wQ3uRm5thr&index=2
5	https://www.sciencedirect.com/science/article/pii/S2095756420300647
6	How does an Electric Car work? | Tesla Model S https://www.youtube.com/watch?v=3SAxXUIre28
7	Tesla Model 3's motor - The Brilliant Engineering behind it https://www.youtube.com/watch?v=esUb7Zy5Oio
8	Understanding the Honda Hybrid E-Drive https://www.youtube.com/watch?v=QLUIExAnNcE
9	Toyota Hybrid System https://www.youtube.com/watch?v=jNuixuVhc5E
10	BMW Electric Drive HOW IT'S MADE - Interior BATTERY CELLS Production Assembly Line https://www.youtube.com/watch?v=xvaQMTcckSg

Mapping of Course outcome with Program Outcomes and Program Specific Outcomes
3- High 2- Medium 1 – Low

Course outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1			2		1	2	1	2	1
CO2	3	3	2	2			2		1	2	1	3	2
CO3	3	3	3	2			3		2	2	2	3	3
CO4	3	3	3	3			3		2	2	2	3	3
CO5	3	2	3	2			3		2	2	2	3	3

Assessment pattern:

Assessment pattern levels no.	Knowledge levels	ISE I	ISE II	ESE
K1	Remember	8		20
K2	Understand	7	8	15
K3	Apply		7	25
K4	Analyze			
K5	Evaluate	Nil	Nil	Nil
K6	Create	Nil	Nil	Nil
Total Marks		15	15	60

Assessment table:

Assessment Tool	K1	K2,	K3	K4	K4
	CO1	**CO2**	**CO3**	**CO4**	**CO5**
ISE I	8	7			
ISE II			5	5	5
ISE III	2	2	2	2	2

ESE	10	10	15	12	13
Total Marks 100	20	19	22	19	20

Special Instruction if any: Nil

MEPRJ4001: Project						
Teaching Scheme	**L**	**T**	**P**	**ISE III**	**ESE**	**Total**
Credits: 04	0	0	8 Hrs / Week	100	100	**200**

Course Outcomes:

After completing this course, students will be able to:

CO No.	Course Outcome Statement (NEP 2020 Aligned)
CO1	Identify an engineering problem in advanced areas of Mechanical Engineering by reviewing literature, current trends, and industrial/societal needs.
CO2	Review existing literature to identify research gaps, define clear objectives, and establish the scope and methodology of the project.
CO3	Design, fabricate, or simulate an innovative solution that addresses the identified problem and demonstrates social or industrial benefit.
CO4	Analyse experimental / simulation results critically, draw valid engineering conclusions, and compare with existing work.
CO5	Present findings professionally and explore the possibility of publication in peer-reviewed journals or conference proceedings.

NEP 2020 Alignment

This project course is designed in direct alignment with the National Education Policy (NEP) 2020, emphasizing experiential, multidisciplinary, skill-oriented, and research-driven learning:

NEP 2020 Principle	Implementation in Project Course
Experiential Learning	Students undertake hands-on design / fabrication / simulation projects rather than passive coursework.
Multidisciplinary Approach	Projects may integrate mechanical, electrical, computational, and socio-economic dimensions for holistic solutions.
Skill Integration	Develops cognitive (analysis, design), practical (fabrication, simulation), and affective (teamwork, ethics) skill sets.
Innovation & Entrepreneurship	Students may pursue start-ups, IP generation, product design, or MSME-linked industry projects.
Industry–Academia Linkage	Projects can be conducted at Industry / Govt. Organizations / MSME / Research Institutes with industry supervisors.
Research & Inquiry	Literature survey, gap identification, methodology design, and result validation cultivate research temperament.
Communication &	Regular project diary, mid-term reviews, final report, and viva voce

Documentation	develop professional communication competency.

Project Guidelines

Project Identification Process

1. Students must conduct a literature survey, industry visit, or current-trend analysis to identify a meaningful engineering problem.
2. The identified topic must be finalized in consultation with the assigned Guide/Supervisor before the end of Week 2.
3. The project must be relevant to Mechanical Engineering with clear engineering analysis / performance evaluation / societal impact.
4. Where applicable, industry or research organization projects are encouraged to bridge the academia–industry gap (NEP 2020 Clause 16.6).

Eligibility and Selection Criteria for External Projects

- The guide shall ensure compatibility of the student's skill set with the proposed industry project.
- A minimum of three relevant technical skill sets must be demonstrable by the student before project assignment at an external organization.
- External projects must be approved by the Department Project Committee before commencement.
- For industry / MSME projects, an MOU or formal project sanction letter is required.

Project Categories and Types

Cat.	Project Type	Description
A	Design & Fabrication	Design, fabrication, and performance testing of a product / experimental setup / apparatus / small equipment with engineering analysis.
B	Experimental Investigation	Experimental verification of principles used in Mechanical Engineering; includes data collection, analysis, and validation against theory.
C	Simulation / Computational	Computational modelling using CFD, FEA, or other numerical tools with valid database, algorithm design, and output reports.
D	Industry / Research Project	Project executed at Industry / Govt. Organization / MSME / Research Institute under external supervisor; aligned to industrial problem-solving.
E	Innovation / Entrepreneurship	Start-up idea, IP generation, product innovation, or market-ready prototype with business feasibility analysis; aligned with NEP 2020 entrepreneurship thrust.
F	Social / Community	Projects addressing community challenges, sustainable

	Impact	development goals (SDGs), rural engineering, or assistive technologies.

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 Timeline and Phase Plan (20-Week Semester)

Phase	Duration	Activity	Deliverables / Milestones
I	Weeks 1 – 4	Problem Identification & Literature Review	Problem statement, literature review (min. 15 references), objectives and scope document, project proposal — Review 1.
II	Weeks 5 – 8	Methodology Design & Resource Planning	Detailed methodology, CAD models / experimental plan / simulation setup, Bill of Materials, Gantt chart — Review 2.
III	Weeks 9 – 12	Implementation & Experimentation / Simulation	Prototype / simulation model / experimental data; progress report with preliminary results — ISE II Mid-Review.
IV	Weeks 13 – 16	Result Analysis & Validation	Result analysis, validation, error estimation, comparison with literature — ISE II Final Review.
V	Weeks 17 – 20	Report Writing & Publication	Final project report (standard format), paper draft for journal / conference, Project Diary submission — ESE Viva Voce.

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 and Evaluation Scheme

The project is evaluated continuously through two Internal Semester Examinations (ISE I and ISE II) and one End Semester Examination (ESE) comprising the final report and viva voce. The breakdown is as follows:

Assessment Component	**Criteria**	**ISE III(50)**	**ESE (100)**
Problem Identification & Literature Review	Quality of problem statement, relevance, depth of literature survey, gap identification.	15	–
Methodology & Planning	Soundness of methodology, experimental / simulation plan, Gantt chart, resource planning.	15	–
Project Diary / Workbook	Regularity, completeness, day-to-day observations, supervisor signatures.	10	–
Implementation & Execution	Quality and completeness of prototype / simulation / experimental execution; innovation demonstrated.	10	–
Results, Analysis & Validation	Correctness of results, depth of analysis, validation with theory / literature, error analysis.	10	–
Final Report	Completeness, standard format, language quality, figures, references (IEEE / ASME style).	20	40
Viva Voce & Presentation	Clarity of presentation, depth of understanding, ability to defend methodology and results, Q&A.	10	40
Publication / IP / Innovation	Paper draft / accepted paper / patent application / prototype demonstrated (bonus criteria).	10	20
TOTAL		**100**	**100**

Skill / Knowledge Level Pattern (Bloom's Taxonomy – NEP 2020)

Level	Bloom's / Skill	NEP Domain	ISE III (100)	ESE (100)
S1	K1–K2 Recall / Understand	Cognitive – Foundation	–	10
S2	K3 Apply	Practical / Skill	40	20
S3	K4 Analyse	Critical Thinking	40	30
S4	K5 Evaluate	Research / Innovation	20	30
S5	K6 Create	Entrepreneurship / IP	–	10 (Bonus)
	Total		**50**	**100**

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

3 – High 2 – Medium 1 – Low

CO \ PO/PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1	1	2	2	2	–	–	1	–	–	2	1
CO2	2	1	2	1	1	2	–	–	1	1	–	2	1
CO3	2	2	2	2	1	–	1	–	2	1	–	2	–
CO4	2	1	–	2	2	1	–	–	1	1	–	1	1
CO5	2	2	1	–	1	1	–	1	3	2	1	1	1

CO–Assessment Tool Mapping

Assessment Tool	CO1	CO2	CO3	CO4	CO5
ISE I – Review 1 (Proposal)	✓	✓	–	–	–
ISE I – Review 2 (Methodology)	✓	✓	✓	–	–
ISE II – Mid Review (Progress)	–	✓	✓	✓	–
ISE II – Final Review (Results)	–	–	✓	✓	✓

ESE – Report + Viva Voce	✓	✓	✓	✓	✓
Project Diary / Workbook	✓	✓	✓	✓	–

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.

MERMC4002: Research Methodology		
Teaching Scheme	**Examination Scheme**	
Lectures: 02 Hrs. / Week	**ISEI**	**10Marks**
Credits: 02	**ISEII**	**10Marks**
	ESE	**30Marks**

Course Outcomes:

After completing the course students will able to

	Course Outcomes
CO1	Formulate a research problem and design a structured methodology for engineering investigations.
CO2	Analyze experimental data using statistical methods and regression techniques.
CO3	Prepare technical reports and research papers while adhering to ethical guidelines and IPR protocols.

Detailed Syllabus:

Unit 1	**Introduction to Research and Research Design:** Meaning, objectives, and types of research. Research process. Defining the research problem in Mechanical Engineering. Research design: features of a good research design. Sampling design. Measurement and scaling techniques. Methods of data collection: Experimental and Survey methods.
Unit 2	**Data Analysis and Optimization Techniques:** Data analysis and statistical methods. Hypothesis testing. T-test and Analysis of Variance (ANOVA). Correlation and Regression analysis. Introduction to statistical tools (MATLAB/Excel) for data analysis. Introduction to optimization techniques. Taguchi Method. Basics of Response Surface Methodology (RSM) for thermal and manufacturing engineering problems.
Unit 3	**Technical Writing, Research Ethics, and Intellectual Property Rights:** Structure of technical reports, thesis, and research papers. Technical writing and documentation. Referencing styles (IEEE). Plagiarism and plagiarism detection. Ethics in engineering research. Intellectual Property Rights (IPR): Copyrights, Patents, Trademarks, and Industrial Designs. Basics of patent drafting and filing process.

Text and Reference Books

7. C.R. Kothari and Gaurav Garg, "Research Methodology: Methods and Techniques,**'** New Age International Publishers, 2019
8. Douglas C. Montgomery," Design and Analysis of Experiments', John Wiley & Sons, 2012
9. Ronald E. Walpole," Probability and Statistics for Engineers and Scientists", Macmillan USA, 1993
10. Madhav Phadke," Quality Engineering Using Robust Design", UDVELI books publication, 2021
11. George C. Runger,' Applied Statistics and Probability for Engineers", John Wiley & Sons Inc, 2013
12. Douglas C. Montgomery,' Introduction to Linear Regression Analysis", Wiley India Pvt Ltd, 2006
13. Robert A. Day," How to Write and Publish a Scientific Paper", Cambridge University Press, 7th edition, 2024

14. P. Neeraj and S. Khusdeep," Intellectual Property Rights: Text and Cases', PHI learning EEE edition, 2020
15. Kalyanmoy Deb," Optimization for Engineering Design: Algorithms and Examples", PHI, 2012
16. Steven Chapra," Numerical Methods for Engineers," Mc Graw Hill publication, 2000
17. Michael Alley," The Craft of Scientific Writing," Springer, 4th version, 2018

Online resources:

- **https://onlinecourses.nptel.ac.in/noc21_ge03/preview**
- **https://www.mendeley.com/guides/citation-guides/**
- https://www.mathworks.com/products/statistics.html
- https://www.wipo.int/edocs/pubdocs/en/wipo-pub-1081-1-en-introduction-to-the-international-intellectual-property-legal-framework.pdf
- https://www.youtube.com/watch?v=XMdek3z-z9M

Program Outcomes

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PSO 1	PSO 2
CO1	1	1	2	1	-	-	-	-	-	-	3	1	-
CO2	1	1	3	1	1	-	-	-	-	-	-	1	-
CO3	3	-	-	1	-	-	-	1	-	1	2	1	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 unit

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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	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

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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	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

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
CO1	3	3	2	-	2	3	2	2	-	1	-	3	1
CO2	2	2	3	-	3	3	2	2	-	1	-	3	1
CO3	3	3	2	1	2	3	3	2	1	1	-	3	2
CO4	3	3	2	2	3	2	2	2	1	2	1	2	2
CO5	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

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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	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

Semester VII

MEINT 4001: Internship		
Teaching Scheme	**Examination Scheme**	
Lectures: 24 Hrs. / Week	**ISE III**	**150 Marks**
Credits: 12	**ESE**	**150 Marks**

Course Outcomes:

After completing the course students will able to

Course Outcomes	
CO1	Demonstrate professional competence through industry Internships.
CO2	Choose appropriate technology and tools to solve given problem.
CO3	Identify methods and materials to carry out experiments/develop code
CO4	Analyze and discuss the results to draw valid conclusions

Guidelines:

Engineering internships are intended to provide students with an opportunity to apply conceptual knowledge from academics to the realities of the field work/training. The following guidelines are proposed to give academic credit for the internship undergone as a part of the Final Year B. Tech. (Mechanical Engineering) curriculum. Students should visit industry / Research organization / Research Centre and identify the internship area and finalize in consultation with Guide.

Duration:

The internship shall have 08 credits, minimum 16 hours per week interaction.

Internship work Identification:

Student may choose to undergo Internship at industry / Research organization / Research Centre. Student may choose either to work on innovation or entrepreneurial activities resulting in start-up or undergo internship with industry / Research organization / Research centre to make themselves ready for the industry.

Student shall take guided internship in a strict supervision of Academic Guide (Preferably Mentor of Teacher Guardian Scheme) and Industrial Supervisor. The internship shall inculcate skills to the incumbent which will facilitate earning livelihood. These skill sets shall be close to vocational education level. Before assigning particular industry/research organization guide shall ensure compatibility of students, availability of internship in the proposed organization expected minimum three skill sets.

Internship work identification process should be initiated before the end of VIIth semester of Final Year B. Tech. program in coordination with training and placement cell / industry institute cell / internship cell. This will help students to start their internship work on time.

Internship Diary/ Internship Workbook:
Students must maintain Internship Diary / Internship Workbook. The main purpose of maintaining diary / workbook is to cultivate the habit of documenting. The students should record in the daily training diary the day-to-day account of the observations, impressions, information gathered and suggestions given, if any. The training diary/workbook should be signed every day by the supervisor.
Internship Diary/workbook and Internship Report should be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.

Internship Work Evaluation:
Every student is required to prepare and maintain documentary proofs of the activities done by him as internship diary or as workbook. The evaluation of these activities will be done by Program Head / Cell In-charge / Project Head / faculty mentor or Industry Supervisor based on- Overall compilation of internship activities, sub-activities, the level of achievement expected, evidence needed to assign the points and the duration for certain activities.
Assessment and Evaluation is to be done in consultation with internship supervisor (Internal and External – a supervisor from place of internship). Recommended evaluation parameters-Post Internship Internal Evaluation -100 Marks + Internship Diary/Workbook and Internship Report -100 Marks.

Feedback from internship supervisor (External and Internal)
Post internship, faculty coordinator should collect feedback about student with recommended parameters include as- Technical knowledge, Discipline, Punctuality, Commitment, Willingness to do the work, Communication skill, individual work, Team work, Leadership.

Mapping of Course outcomes with Program outcomes and Program Specific Outcomes:

Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PS O1	PS O2
CO1	3	1	1	2					2	2			
CO2	2		1	2	1				1	2	1		
CO3	3	1		2		2	2		1			2	
CO4	3		2			1		2		2	1		1

1 – Low, 2 – Medium, 3 – High

Assessment:
ISE I, ISEII- Continuous Assessment of individual student Maximum Marks-50
ISEIII - Continuous Assessment of individual student Maximum Marks-100
ESE -Viva Voce based on presentation and report Maximum Marks-100

Assessment Pattern:

Assessment Pattern Level No.	Knowledge Level	ISE III	ESE
S1	Implementation	50	50
S2	Manipulation	20	20

S3	Precision	60	60
S4	Articulation	20	20
S5	Naturalization	00	00
Total Marks		**150**	**150**

Knowledge Level	**ISE III**	**ESE**
Preparation S1	25	25
Articulation of problem S4	20	20
Observation S3	40	40
Record S2	25	25
Mini project/ Presentation/Viva Voce S3	40	40
Total Marks	**150**	**150**

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

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

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

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**	**PO 10**	**PO 11**	**PSO1**	**PSO2**
CO1	3	1	1	2	2	2	–	–	1	–	–	3	1
CO2	2	1	1	2	1	2	–	–	1	1	–	2	1
CO3	2	2	3	2	2	–	1	–	1	1	–	2	3
CO4	2	2	3	1	2	–	–	–	2	1	–	2	3
CO5	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
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 & 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	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	1	1	2	2	2	–	–	1	–	–	3	1
CO2	2	1	1	2	1	2	–	–	1	1	–	2	1
CO3	2	2	3	2	2	–	1	–	1	1	–	2	3
CO4	2	2	3	1	2	–	–	–	2	1	–	2	3
CO5	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).
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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.
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5. Incomplete or poorly maintained diaries will attract deduction in the ISE continuous assessment marks.

Project Report Format

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1	Introduction	Background, motivation, problem statement, objectives, scope, and organization of the report.
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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, 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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1	1	2	2	2	–	–	1	–	–	3	1
CO2	2	1	1	2	1	2	–	–	1	1	–	2	1
CO3	2	2	3	2	2	–	1	–	1	1	–	2	3
CO4	2	2	3	1	2	–	–	–	2	1	–	2	3
CO5	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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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.
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, 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

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**	**PSO1**	**PSO2**
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).
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