Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY,

JALGAON (M.S.)

Third Year Bachelor of Engineering

in

Mechanical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology

कवयित्री बहिणाबाई चौधरी उत्तर महाराष्ट्र विद्यापीठ

अंतरी पेटवू ज्ञानज्योत

1990

'A' Grade

NAAC Re-Accredited

(4th Cycle)

SYLLABUS STRUCTURE

For Affiliated Colleges

Semester –V to VI

W.E.F. 2026 – 27

Syllabus Structure for Third Year Engineering (Semester – V, Level – 5.5) (Mechanical) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME-501	Computer Aided Design and Analysis	PCC	3			3	40	60			100	3
ME-502	Computer Aided Design and Analysis Lab	PCC			2	2			25	25 (PR)	50	1
ME-503	Heat Transfer & Thermal Machines	PCC	3			3	40	60			100	3
ME-504	Heat Transfer & Thermal Machines Lab	PCC			2	2			25	25 (PR)	50	1
ME-505	Modeling & Simulation Lab	PCC	3		4	7			50	25 (PR)	75	5
ME-506	Program Elective Course – I	PEC	3			3	40	60			100	3
ME-507	Program Elective Course – I Lab	PEC			2	2			25		25	1
ME-508	Mechanics of Material	MD M	2			2	40	60	25		125	2
OE-509	Open Elective – III	OE	2			2			25		25	2
			16		**10**	**26**	**160**	**240**	**175**	**75**	**650**	**21**

ISE: Internal Sessional Examination ESE: End Semester Examination ICA: Internal Continuous Assessment

CA: College Assessment UA: University Assessment

Program Elective Course – I		
Course Code		**Name of the Subject / Course**
ME-506	A	Tribology
ME-506	B	Kinematics & Dynamics of Machines
ME-506	C	Hydraulics and Pneumatics

Syllabus Structure for Third Year Engineering (Semester – VI, Level – 5.5) (Mechanical) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME-601	Mechatronics, Robotic and Control Systems	PCC	3			3	40	60			100	3
ME-602	Mechatronics, Robotic and Control Systems Lab	PCC			2	2			25	25 (PR)	50	1
ME-603	Machine Element & System Design	PCC	3			3	40	60			100	3
ME-604	Machine Element & System Design Lab	PCC			2	2			25	25 (OR)	50	1
ME-605	Program Elective Course – II Lab	PEC	3		4	7			50	25 (OR)	75	5
ME-606	Program Elective Course – III	PEC	3			3	40	60			100	3
ME-607	Program Elective Course – III Lab	PEC			2	2			25		25	1
ME-608	Engineering Data Analysis and Optimization Techniques	MD M	2			2	40	60	25		125	2
ME-609	Refrigeration and Air Conditioning Maintenance	VSEC	1		2	3			25		25	2
			15		**12**	**27**	**160**	**240**	**175**	**75**	**650**	**21**

ISE: Internal Sessional Examination ESE: End Semester Examination ICA: Internal Continuous Assessment
CA: College Assessment UA: University Assessment

Program Elective Course – II Lab			**Program Elective Course – III**		
Course Code		**Name of the Subject / Course**	**Course Code**		**Name of the Subject / Course**
ME-605	A	CAD/CAM Integration with Modeling Software Lab	ME-606	A	AI/ML for Mechanical Engineering
ME-605	B	Computational Fluid Dynamics Lab	ME-606	B	Programming for Mechatronics
ME-605	C	Die and Mold Design and Tool Engineering Lab	ME-606	C	Autonomous System Integration

EXIT COURSE FOR U. G. B. VOCATIONAL in Mechanical (DURATION 8 WEEKS)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME-610	Internship / Apprenticeship	OJT							125			4
ME-611	Mini Project	Project							25			4
									150			8

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Third Year Bachelor of Engineering
in
Mechanical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology



COURSE OUTLINE
For Affiliated Colleges
Semester – V
W.E.F. 2026 – 27

COMPUTER AIDED DESIGN & ANALYSIS (PCC)			
COURSE OUT LINE			
Course Title:	**COMPUTER AIDED DESIGN & ANALYSIS**	**Short Title: CADA**	**Course Code: ME-501**

Course description:

This course introduces the application of computers in mechanical engineering design and analysis. It covers fundamental concepts of Computer Aided Design (CAD), geometric modeling, transformations, curves and surfaces, and solid modeling techniques. The course also introduces engineering analysis using Finite Element Method (FEM), along with exposure to modern Computer Aided Engineering (CAE) tools used in industry. Emphasis is given to integrating design and analysis for real-world mechanical systems.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Engineering Graphics / Engineering Drawing, Engineering Mechanics, Strength of Materials,Basic Mathematics (Matrices and Linear Algebra),Fundamentals of Computer Programming (desirable)

Course objectives:

1. To understand the role of computers in mechanical design and manufacturing.
2. To learn geometric transformations and modeling techniques used in CAD.
3. To study curve, surface and solid modeling methods.
4. To introduce finite element analysis for solving engineering problems.
5. To familiarize students with modern CAD/CAE tools used in industry.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the role of computers in design, and explain the fundamentals of Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), and Computer Integrated Manufacturing (CIM).
2. Apply geometric transformations and modeling techniques for the representation of curves, surfaces, and solids in computer-aided design.
3. Analyze engineering problems using Finite Element Method (FEM) by developing element equations and interpreting results.
4. Apply basic concepts of Computational Fluid Dynamics (CFD) and heat transfer to analyze simple thermal and fluid flow systems.
5. Evaluate and optimize engineering designs using computer-aided design tools and optimization techniques.

COURSE CONTENT

		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction	**No. of Lectures: 09 Hours**	**Marks: 12**

Define CAD/CAM, Product Life Cycle & CAD/CAM, and Application of Computers for Design Process, Selection of a CAD system, Desirable relationship of CAD/CAM database, Benefits & Application of CAD. Computer communication, Principle of networking, Classification of network, Transmission media & interface, LAN system. Hardware in CAD

Unit–II: Transformations	**No. of Lectures: 09 Hours**	**Marks: 12**

Matrix representation of points, lines and planes; 2D transformation for translation, scaling, rotation, Mirror and reflection; Homogeneous representation & concatenation; Inverse coordinate transformation 3D transformations.

Unit–III: Curves and Surfaces	**No. of Lectures: 09 Hours**	**Marks: 12**

Representation of curves; Hermite curves, Bezier curves, Bspline curve; Surface modeling – parametric representation, planar surface, surface of revolution, Coons and bicubic patches, Cubic Spline, Bezier and B-spline surfaces. Requirement of Geometric Modeling, Geometric Model, Geometric Model Construction Method: Wire Frame Modeling, Surface Modeling

Unit–IV: Solid Modelling	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction, Geometry and Topology, Solid entities, Solid representation, Fundamentals of Solid modeling, Boundary representation (B-Rep), Constructive Solid Geometry (CSG), Sweep representation, Analytical solid modeling, Parametric solid modeling, feature based modeling, Graphics standards

Unit–V: Engineering Analysis	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to finite element method; Basic steps in finite element method; FE analysis of 1D element problems (spring, bar,); Development of element stiffness equation and their assembly; Plain strain and plain stress problems; Domain discretization, pre-processing and post-processing; Popular CAE software used in industry

Text Books:

1. Ibrahim Zeid, “Mastering CAD CAM,” Tata McGraw Hill Publishing Co. 2007.
2. C. McMohan and J. Browne, “CAD/CAM Principles,” Pearson Education, 2nd Edition, 1999.
3. Geometric Modeling, Michael E. Mortenson, Tata McGraw Hill, 2013.
4. CAD/Cam & Automation by R.B. Patil, Techmax Publication

Reference Books:

1. W. M. Neumann and R. F. Sproul, Principles of Computer Graphics, McGraw Hill, 1989.
2. D. Hearn and M. P. Baker, Computer Graphics, Prentice Hall Inc., 1992.
3. K. J. Bathe, Finite Element Procedures, Prentice Hall, 1996.
4. S. S. Rao, The Finite Element Method in Engineering, Butterworth-Heinemann.
5. J. N. Reddy, An Introduction to the Finite Element Method, McGraw Hill.

NPTEL Links

1. Computer Aided Design and Manufacturing – Prof. P.V.M. Rao – IIT Delhi – https://nptel.ac.in/courses/112/102/112102101/
2. Geometric Modeling – Prof. S. K. Saha – IIT Delhi – https://nptel.ac.in/courses/112/106/112106134/
3. Finite Element Analysis – Prof. K. M. Gupta – IIT Delhi – https://nptel.ac.in/courses/112/104/112104116/

4. Advanced Finite Element Analysis – Prof. S. Gopalakrishnan – IIT Madras – https://nptel.ac.in/courses/112/106/112106135/
5. Introduction to CFD – Prof. Suman Chakraborty – IIT Kharagpur – https://nptel.ac.in/courses/112/105/112105045/

<table>
<tr><th colspan="4">COMPUTER AIDED DESIGN & ANALYSIS LAB (ME-502)</th></tr>
<tr><th colspan="4">LAB COURSE CONTENT</th></tr>
<tr><td colspan="2"></td><td>Semester:</td><td>V</td></tr>
<tr><td colspan="2">Teaching Scheme:</td><td colspan="2">Examination scheme</td></tr>
<tr><td>Practical:</td><td>2 hours/week</td><td>Internal Continuous Assessment (ICA) CA:</td><td>25 marks</td></tr>
<tr><td></td><td></td><td>End semester exam (ESE) UA (PR):</td><td>25 marks</td></tr>
<tr><td colspan="4">Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.
1. 2D drawing using sketcher.
2. 3D modeling of mechanical components.
3. Assembly Modeling and drafting of components.
4. Surface Modeling techniques.
5. Geometric transformations using CAD tools (2D/3D transformations).
6. Curve Modeling (Bezier, B-spline, spline curves).
7. Solid Modeling using B-Rep and CSG techniques.
8. Finite Element Analysis (FEA) of simple components (1D/2D problems like bar, truss).
9. Basic CAE analysis (thermal/structural simulation using software tools).</td></tr>
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2. C. McMohan and J. Browne, “CAD/CAM Principles,” Pearson Education, 2nd Edition, 1999.
3. Geometric Modeling, Michael E. Mortenson, Tata McGraw Hill, 2013.
4. CAD/Cam & Automation by R.B. Patil, Techmax Publication</td></tr>
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3. K. J. Bathe, Finite Element Procedures, Prentice Hall, 1996.
4. S. S. Rao, The Finite Element Method in Engineering, Butterworth-Heinemann.
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HEAT TRANSFER & THERMAL MACHINES (PCC)			
COURSE OUT LINE			
Course Title:	**HEAT TRANSFER & THERMAL MACHINES**	**Short Title: HT**	**Course Code: ME-503**

Course description:

This course provides a comprehensive understanding of the principles of heat transfer and their engineering applications. The course introduces the three fundamental modes of heat transfer—conduction, convection, and radiation—and develops the governing equations and analytical techniques required to evaluate heat transfer in engineering systems. Students will learn to analyze steady and unsteady heat transfer processes, evaluate heat transfer coefficients using empirical correlations, and apply these concepts to the design and performance analysis of heat exchangers.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Engineering Thermodynamics, Engineering Mathematics, Basic Physics

Course objectives:

1. To understand and analyze the modes of heat transfer: conduction, convection, and radiation.
2. To formulate and solve heat transfer problems using analytical methods and correlations.
3. To analyze heat transfer in practical systems such as fins and insulation.
4. To study boiling and condensation heat transfer processes.
5. To understand the analysis and design of heat exchangers.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand and Analyze steady-state conduction in various geometries and evaluate fins and insulation performance.
2. Understand, apply boundary layer concepts and estimate heat transfer in forced and natural convection using dimensionless parameters and correlations..
3. Analyze radiation heat transfer using radiative properties and view factors for different enclosures and radiation heat exchange between grey surfaces.
4. Evaluate and design heat exchangers using LMTD and NTU methods considering performance factors.
5. Analyze phase change heat transfer in boiling and condensation processes and compare different regimes.

COURSE CONTENT

HEAT TRANSFER & THERMAL MACHINES		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**
Unit–I: Steady State Conductive Heat transfer:	**No. of Lectures: 09 Hours**	**Marks: 12**	

Steady 1D solution for conduction heat transfer in Cartesian, cylindrical and spherical geometry, Concept of conduction and film resistances, Critical insulation thickness, Types of fins, governing equation for pin fin for infinite long fin and fin with negligible heat loss, Fin performance, fin efficiency, fin effectiveness, overall fin effectiveness.

Unit–II: Convection Heat Transfer	**No. of Lectures: 09 Hours**	**Marks: 12**

Basic equations; Concept of Boundary layer for over plate and flow through pipe (Hydrodynamic & Thermal Boundary Layer), Forced convection heat transfer, significance of Dimensionless numbers, Natural convective heat transfer, Grashoff number (Gr), Estimating heat transfer rates in laminar and turbulent flow situations using appropriate correlations for free and forced convection.

Unit–III: Radiation Heat Transfer	**No. of Lectures: 09 Hours**	**Marks: 12**

Laws of radiation, Definitions of radiative properties, Concept of black body , Black and grey body radiation, Calculation of radiation heat transfer between surfaces using radiation properties, Radiation view factor, Properties of view factor, (numerical treatment on view factor on square cavity , triangular cavity , hemispherical cavity , concentric cylinder and sphere only) Radiation heat exchange between two diffuse gray parallel surface, radiation shields.

Unit–IV: Heat Exchanger	**No. of Lectures: 09 Hours**	**Marks: 12**

Classification of heat exchangers, temperature distribution in parallel, counter flow arrangement, condenser and evaporator, Overall heat transfer coefficient, fouling factor. Log-mean temperature difference method and NTU –effectiveness method of analysis for rating, and sizing of heat exchangers. Construction aspects in brief. For good heat exchanger, Design aspects of Condensers, Reboilers and Evaporators.

Unit–V: Boiling and Condensation heat transfer	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to Phase Change Heat Transfer. Pool Boiling – Fundamentals, Pool Boiling Curve & Regimes, Pool Boiling – Heat Transfer Analysis, Difference between pool vs flow boiling, Flow Boiling (Forced Convection Boiling), Introduction to Condensation, Film Condensation, Drop wise Condensation & Comparison.

Text Books:

1. R. K. Rajput, “Heat and Mass Transfer”, S. Chand & Company Ltd., New Delhi.
2. P. K. Nag “Heat Transfer” Tata McGraw Hill Publishing Company Ltd., New Delhi.
3. Arora S.C. & Domkundwar S., “A Course in Heat and Mass Transfer” (1994), Dhanpat Rai & Sons, IVth Edition.
4. Yunus A. Cengel, “Heat Transfer –A Practical Approach” (Tata McGraw Hill)
5. M. M. Rathore “Engineering Heat and Mass Transfer”, 2nd Edition, Laxmi Publications, New Delhi.

Reference Books:

1. J. P. Holman, “Heat Transfer” McGraw Hill, VII Edition.
2. P. Kothandaraman, “Fundamentals of Heat and Mass Transfer”.
3. D. S. Kumar “Heat and Mass Transfer” D.S. Kumar, S. K. Kataria & Sons, Delhi.
4. Sachdeva R.C., “Fundamentals of Heat and Mass Transfer” Wiley Eastern Limited, Third Edition.
5. Sukhatme S.P, “A Text Book on Heat Transfer” (1989), 3rd Edition, Orient Longmans Ltd., New Delhi.

6. Chapman A.J., "Heat Transfer" (1989), IVth Edition.
7. M. Thirumalseshwar,"Fundamentals of Heat and Mass Transfer" Pearson Education.
8. R. Rudramoorthy, K. Mayilsomy, "Heat Transfer", Pearson Education.

NPTEL Links:

1. Heat Transfer – Prof. Ganesh Viswanathan (IIT Bombay) https://onlinecourses.nptel.ac.in/noc22_ch09/preview
2. Heat Transfer – Prof. Sunando DasGupta (IIT Kharagpur) https://onlinecourses.nptel.ac.in/noc23_ch65/preview
3. Conduction and Convection Heat Transfer – Prof. Suman Chakraborty & Prof. S. K. Som (IIT Kharagpur) https://nptel.ac.in/courses/112105271
4. Heat Transfer – Prof. C. Balaji (IIT Madras) https://nptel.ac.in/courses/112106315
5. Heat and Mass Transfer – Prof. S. P. Sukhatme (IIT Bombay) https://nptel.ac.in/courses/112101097

NOTE: Steam table and Heat Transfer Data Book is permitted to use for solving the numerical .

HEAT TRANSFER & THERMAL MACHINES LAB (ME-504)			
LAB COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (PR):	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. Determination of thermal conductivity of metal rod / insulating powder / composite wall.
2. Determination of temperature distribution, fin efficiency, effectiveness in natural convection and forced convection.
3. Determination of heat transfer coefficient in natural convection.
4. Determination of heat transfer coefficient in Forced convection.
5. Determination of convective heat transfer coefficient for flow over a heated plate.
6. Determination of emissivity of a test surface.
7. Determination of Stefan Boltzmann constant.
8. Determination of LMTD, overall heat transfer coefficient and effectiveness of heat exchanger in parallel and counter flow arrangement and compare them.
9. Analytical Study of Boiling Curve and Heat Transfer in Pool Boiling phenomena

Text Books

1. R. K. Rajput, "Heat and Mass Transfer", S. Chand & Company Ltd., New Delhi.
2. P. K. Nag "Heat Transfer" Tata McGraw Hill Publishing Company Ltd., New Delhi.
3. Arora S.C. & Domkundwar S., "A Course in Heat and Mass Transfer" (1994), Dhanpat

Rai & Sons, IVth Edition.
4. Yunus A. Cengel, "Heat Transfer –A Practical Approach" (Tata McGraw Hill)
5. M. M. Rathore "Engineering Heat and Mass Transfer", 2nd Edition, Laxmi Publications, New Delhi.

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1. J. P. Holman, "Heat Transfer" McGraw Hill, VII Edition.
2. P. Kothandaraman, "Fundamentals of Heat and Mass Transfer".
3. D. S. Kumar "Heat and Mass Transfer" D.S. Kumar, S. K. Kataria & Sons, Delhi.
4. Sachdeva R.C., "Fundamentals of Heat and Mass Transfer" Wiley Eastern Limited, Third Edition.
5. Sukhatme S.P, "A Text Book on Heat Transfer" (1989), 3rd Edition, Orient Longmans Ltd., New Delhi.
6. Chapman A.J., "Heat Transfer" (1989), IVth Edition.
7. M. Thirumalseshwar,"Fundamentals of Heat and Mass Transfer" Pearson Education.
8. R. Rudramoorthy, K. Mayilsomy, "Heat Transfer", Pearson Education.

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Guidelines for ESE:

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MODELING & SIMULATION LAB			
COURSE OUT LINE			
Course Title:	**MODELING & SIMULATION LAB**	**Short Title: MSL**	**Course Code: ME-505**

Course description:

This course provides a comprehensive foundation in mathematical modeling, numerical simulation, and computer-aided engineering (CAE) of mechanical systems. Students learn to develop lumped and distributed parameter models, solve engineering problems using numerical methods, perform finite element and CFD simulations, analyze vibration and control systems, and interpret simulation outputs for design decisions. The syllabus is aligned with experiential and multidisciplinary learning, integrating Simulation, digital twins, and Industry 4.0 applications.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	05
Practical	04	15	60	

Prerequisite course(s):

Engineering Mathematics, Strength of Materials, Thermodynamics, Fluid Mechanics, Basic CAD knowledge

Course objectives:

1. To formulate mathematical models of mechanical systems.
2. To apply numerical and simulation techniques for engineering analysis.
3. To study FEM, CFD, and dynamic simulations.
4. To validate analytical and simulation results.
5. To develop CAE-based design optimization skills.

Course outcomes:

After successful completion of this course the student will be able to:

1. Develop mathematical models of mechanical, thermal, and fluid systems
2. Apply numerical methods for solving engineering simulation problems
3. Simulate structural, thermal, and flow problems
4. Analyze fluid flow and dynamic system behavior
5. Evaluate system-level simulation outputs and digital twin applications

COURSE CONTENT

MODELING & SIMULATION LAB		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**		

Unit–I: System Modeling & Physical Representation	**No. of Lectures: 09 Hours**	

Modeling concepts, Physical system abstraction, Lumped and distributed systems, Mechanical spring-mass-damper models, Thermal resistance network models, Fluid flow network models Mathematical assumptions, Model validation concepts

Unit–II: Numerical Simulation Techniques	**No. of Lectures: 09 Hours**	

Numerical solution methods, Interpolation and curve fitting, Numerical differentiation and integration, Root finding methods, ODE solving, Matrix methods, Simulation tool ink introduction

Unit–III: Structural and Thermal Simulation	**No. of Lectures: 09 Hours**	

Finite element modeling basics, Meshing strategies, Static structural analysis, Thermal simulation, Stress and deformation analysis, Contact and nonlinear basics, Introduction to Fatigue and life prediction.		
Unit–IV: Fluid Flow & Dynamic System Simulation	**No. of Lectures: 09 Hours**	
CFD fundamentals, Boundary conditions, Internal and External flow for Pipe, Dynamic system modeling , Modal analysis & natural frequencies		
Unit–V:System-Level Simulation & Digital Twin	**No. of Lectures: 09 Hours**	
System-level simulation concept, Manufacturing line simulation, Conveyor system modeling , and AGV simulation basic, Robot cell simulation basics , Digital twin concept , Predictive simulation & AI-based optimization , Industry 4.0 overview		

Text Books:

1. J. N. Reddy**,** An Introduction to the Finite Element Method**,** McGraw-Hill Education**,**
2. S. S. Rao**,** The Finite Element Method in Engineering**,** Butterworth-Heinemann (Elsevier)**.**
3. Steven C. Chapra**,** Applied Numerical Methods with MATLAB**,** McGraw-Hill Education**.**
4. MATLAB / ANSYS Manuals**,** MathWorks / ANSYS Inc.

Reference Books:

1. K. J. Bathe, Finite Element Procedures, Prentice Hall, 2nd Edition
2. Robert D. Cook et al., Concepts and Applications of Finite Element Analysis, Wiley, 4th Edition
3. H. K. Versteeg & W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson, 2nd Edition
4. Industry Simulation Workflow Papers, ASME / SAE International / Elsevier Journals, Latest Publications

NPTEL Links:

1. Finite Element Method, Prof. J.N. Reddy, Indian Institute of Technology Madras**,** https://nptel.ac.in/courses/112104116
2. Advanced Finite Element Analysis, Prof. S. S. Rao, Indian Institute of Technology Madras**,** https://nptel.ac.in/courses/112104115

MODELING & SIMULATION LAB			
COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Practical:	**4 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**50 marks**
		End semester exam (ESE) UA (PR):	**25 marks**

Concerned faculty member should suitably frame Six assignments / practicals from the following list.

1. To develop and simulate a spring–mass–damper system and analyze its response characteristics.
2. To solve ordinary differential equations using numerical solvers.

3. To perform modal analysis of a shaft to determine natural frequencies and mode shapes for vibration analysis.
4. To perform finite element analysis of a beam to determine stress, strain, and deformation under static loading conditions.
5. To simulate heat transfer in a fin using FEM/CAE tools and evaluate temperature distribution and heat dissipation performance.
6. To simulate fluid flow through a pipe and analyze velocity, pressure distribution, and flow characteristics.
7. To model and simulate a manufacturing conveyor system.
8. To study a digital twin model of an automated guided vehicle (AGV) system for simulation and performance evaluation.
9. To simulate the motion of a robotic arm and analyze kinematic behavior for automation applications.

Text Books:

1. J. J. N. Reddy, An Introduction to the Finite Element Method, McGraw-Hill Education,
2. S. S. Rao, The Finite Element Method in Engineering, Butterworth-Heinemann (Elsevier).
3. Steven C. Chapra, Applied Numerical Methods with MATLAB, McGraw-Hill Education.
4. MATLAB / ANSYS Manuals, MathWorks / ANSYS Inc.

Reference Books:

1. K. J. Bathe, Finite Element Procedures, Prentice Hall, 2nd Edition
2. Robert D. Cook et al., Concepts and Applications of Finite Element Analysis, Wiley, 4th Edition
3. H. K. Versteeg & W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson, 2nd Edition
4. Industry Simulation Workflow Papers, ASME / SAE International / Elsevier Journals, Latest Publications

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TRIBOLOGY (PEC – I)			
COURSE OUT LINE			
Course Title:	**TRIBOLOGY**	**Short Title: TRIBO**	**Course Code: ME-506A**

Course description:

The course aims of imparting the knowledge of Tribology. The background required includes knowledge of mathematics, chemistry, engineering materials, and fluid mechanics. The objective of the course is to understand the tribilogical concept, bearing design and its application, lubrication practices.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	4
Practical	02	15	30	

Prerequisite course(s):

Fundamental Knowledge of Physics, Chemistry, Engineering Maths, Engineering Mechanics, Fluid Mechanics, Machine Design and Engineering materials.

Course objectives:

1. To understand fundamentals of friction, wear, and lubrication
2. To analyze surface interactions and contact mechanics
3. To study lubrication mechanisms and lubricant properties
4. To design and evaluate Tribological components (bearings, gears, seals)
5. To apply tribology concepts in industrial applications and failure analysis

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain basic concepts of tribology and surface interactions
2. Analyze different types of friction and their mechanisms
3. Identify wear mechanisms and predict wear behavior
4. Understand lubrication regimes and lubricant properties
5. Apply Tribological principles in design of bearings, gears, etc.

COURSE CONTENT

TRIBOLOGY		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Tribology	**No. of Lectures: 09 Hours**	**Marks: 12**

Definition and scope of tribology, Historical development, Interdisciplinary nature, Economic importance of tribology, Surface topography and roughness, Contact between surfaces (real vs apparent contact), Basic contact mechanics.

Unit–II: Friction	**No. of Lectures: 09 Hours**	**Marks: 12**

Laws of friction (Coulomb friction), Types: Static, kinetic, rolling friction, Causes of friction, Adhesion theory, Abrasive theory, Junction growth theory, Friction instability and stick-slip phenomenon, Measurement of friction.

Unit–III: Wear	**No. of Lectures: 09 Hours**	**Marks: 12**
Definition and classification of wear, Wear mechanisms: Adhesive wear, Abrasive wear, Corrosive wear, Fretting wear. Wear models and Archard's equation, Surface fatigue, Wear testing and analysis, Wear prevention techniques		
Unit–IV: Lubrication & Lubricants	**No. of Lectures: 09 Hours**	**Marks: 12**
Functions of lubrication, Types of lubrication: Boundary lubrication, Mixed lubrication, Hydrodynamic lubrication, Elastohydrodynamic lubrication. Lubricants: Solid, semi-solid, liquid lubricants. Properties of lubricants: Viscosity, viscosity index, Flash point, pour point Additives and their functions, Selection of lubricants.		
Unit–V: Fluid Film Lubrication & Applications	**No. of Lectures: 09 Hours**	**Marks: 12**
Basics of fluid film lubrication, Reynolds equation (concept only), Hydrodynamic journal bearings, Hydrostatic bearings, Rolling contact bearings, Tribology of gears, Seals and gaskets, Industrial applications and case studies		

Text Books:

1. Prasanta Sahoo, (2009) Engineering Tribology, PHI Learning Private Limited.
2. Bharat Bhushan, (2002), Introduction to tribology, John Wiley and Sons.
3. T.A. Stolarski, Tribology in Machine Design , Industrial Press Inc
4. J. Halling (Editor), Principles of Tribology, Macmillan
5. Gwidon W. Stachowiak & Andrew W. Batchelor, Engineering Tribology, Butterworth-Heinemann
6. Ahmed Abdelbary & Li Chang, Principles of Engineering Tribology, Academic Press

Reference Books:

1. I.M. Hutchings, Tribology, Friction and Wear of Engineering Material, Edward Arnold
2. E. P. Bowden and Tabor. D., Friction and Lubrication, Heinemann Educational Books Ltd
3. A. Cameron, Basic Lubrication theory, Longman, U.K.., 1981.
4. M. J. Neale (Editor), Tribology Handbook, Newnes Butter worth, Heinemann, U.K.
5. Fuller D.D., (1999), Theory and practice of Lubrication for engineers, John Wiley sons.

NPTEL Links:

1. Dr. Harish Hirani, Tribology, https://nptel.ac.in/courses/112102014
2. Prof. B. V. Manoj Kumar , Prof. Bikramjit Basu, NOC: Friction and Wear of materials Principle and case studies, https://nptel.ac.in/courses/113108083
3. Prof. (HAG) Harish Hirani, NOC: Data-Enabled Tribological Engineering: From Experiments to Predictive Models, IIT Delhi, https://nptel.ac.in/courses/112102428

TRIBOLOGY LAB (ME-507A)			
LAB COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
Concerned faculty member should suitably frame any Six laboratory assignments / practicals			

from the following list.

1. To study the wear characteristics of materials under sliding conditions and determine the wear rate and coefficient of friction.
2. To determine the coefficient of static and kinetic friction between two surfaces using the inclined plane method.
3. To study the performance of hydrodynamic journal bearing and determine pressure distribution and frictional torque.
4. To determine the viscosity of lubricating oil using viscometer and study the effect of temperature on viscosity.
5. To analyze abrasive wear behaviour of different materials and compare their wear resistance.
6. To evaluate the anti-wear and extreme pressure properties of lubricants using four-ball test apparatus.
7. To measure surface roughness parameters (Ra, Rz) using surface profilometer.
8. To understand different lubrication regimes (boundary, mixed, hydrodynamic) and their effect on friction.
9. To determine the flash point and fire point of lubricating oil using standard apparatus.

Text Books

1. Prasanta Sahoo, (2009) Engineering Tribology, PHI Learning Private Limited.
2. Bharat Bhushan, (2002), Introduction to tribology, John Wiley and Sons.
3. T.A. Stolarski, Tribology in Machine Design , Industrial Press Inc
4. J. Halling (Editor), Principles of Tribology, Macmillan
5. Gwidon W. Stachowiak & Andrew W. Batchelor, Engineering Tribology, Butterworth-Heinemann
6. Ahmed Abdelbary & Li Chang, Principles of Engineering Tribology, Academic Press

Reference Books:

1. I.M. Hutchings, Tribology, Friction and Wear of Engineering Material, Edward Arnold
2. E. P. Bowden and Tabor. D., Friction and Lubrication, Heinemann Educational Books Ltd
3. A. Cameron, Basic Lubrication theory, Longman, U.K.., 1981.
4. M. J. Neale (Editor), Tribology Handbook, Newnes Butter worth, Heinemann, U.K.
5. Fuller D.D., (1999), Theory and practice of Lubrication for engineers, John Wiley sons.

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

KINEMATICS & DYNAMICS OF MACHINES
(PEC – I)

COURSE OUT LINE

Course Title:	**KINEMATICS & DYNAMICS OF MACHINES**	**Short Title: KDM**	**Course Code: ME-506B**

Course description:

This course will deal with kinematic analysis of mechanisms and machines. It will include motion and force transmission analysis of linkage mechanisms. It discusses the dynamic force analysis, Cams, Governor, Gyroscope and Balancing methods. The course will demonstrate various concepts by working out problems relevant to real life applications of mechanisms. The course is expected to help students in their basic understanding and use of kinematic analysis.

	Hours/week	**No. of weeks**	**No. of Lectures**	**Total Credits**
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Engineering Mechanic, Strength of Materials, Theory of Machines basics, Basic Mathematics (vector, dynamics)

Course objectives:

1. To understand the structure and motion of mechanisms.
2. To analyze velocity and acceleration of machine members.
3. To study cams, and governors.
4. To evaluate balancing and gyroscopic effects in machines.
5. To apply dynamic principles in machine design and vibration control.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand basic structure and elements of machines and identify functional characteristics of various machine elements
2. Determine position, velocity and acceleration of linkages in mechanism at any instant
3. Analyze the motion and the dynamical forces acting on mechanical systems composed of linkages.
4. Design cam for a given motion or a given input/output motion relationship and exemplify concepts of static and dynamic mass balancing.
5. Apply the principles of gyroscopic effects and stabilization on various transport vehicles and applications of various governors.

COURSE CONTENT

KINEMATICS & DYNAMICS OF MACHINES		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: MECHANISMS & MACHINES	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction, Constrained motion, Link, Kinematic pair, Types of Joints, Degree of Freedom, Classification of Kinematic pairs, Kinematic chain, Mechanism and structures, Equivalent Mechanisms, Simple mechanism, Compound mechanism, Planer mechanism, Spatial mechanism, Four Bar Mechanism, Mechanical Advantage, Transmission angle, Slider Crank Mechanism, Double Slider Crank Mechanism. Pantograph, Toggle Mechanism, Geneva Mechanism, Automobile steering Mechanism – Davis Steering Gear, Ackermann Gear, Hooks Joint, Double Hook Joint.

Unit–II: VELOCITY AND ACCELERATION ANALYSIS	**No. of Lectures: 09 Hours**	**Marks: 12**

Absolute and Relative Motions, motion of a link, Instantaneous centre, Kennedy's Theorem, Locating I-Centers of Four Bar Mechanism and Slider Crank mechanism, Space and Body Centrode, Relative Velocity of Four Bar Mechanism and Slider Crank mechanism, Rubbing Velocity, Acceleration, Radial and Tangential acceleration, Relative acceleration of Four Bar Mechanism and Slider Crank mechanism, Coriolis Acceleration

Unit–III: DYNAMIC FORCE ANALYSIS	**No. of Lectures: 09 Hours**	**Marks: 12**

D' Alembert's Principle, Inertia Force, Dynamic analysis of Four Bar Mechanism and Slider Crank mechanism, Engine force analysis, Simple and Compound Pendulum, Dynamically Equivalent System, Inertia of Connecting Rod

Unit–IV: CAMS and Balancing	**No. of Lectures: 09 Hours**	**Marks: 12**

CAMS: Types of Cams and Followers, Terminology, Motions of the Follower, Layout of Cam profiles, Specified Contour Cams, Circular and Tangent Cams, Pressure angle and Undercutting, Sizing of Cams. BALANCING: Need of Balancing, Static and Dynamic Balancing, balancing of several masses in different planes, Balancing of reciprocating masses.

Unit–V: Governor and Gyroscope	**No. of Lectures: 09 Hours**	**Marks: 12**

GOVERNORS: Introduction, Types of Governors, Watt Governor, Proell Governor, Wilson Hartnell Governor, Inertia Governor, Controlling Force, Sensitiveness, Hunting, Isochronism, Stability, Effort, Power of Governor. GYROSCOPE: Gyroscopic Principle, Gyroscopic Effect, Gyroscopic Effects on Aeroplanes, Naval ships, Stability of an Automobile, Stability of two wheels Vehicle.

Text Books:

1. Ratan S. S., Theory of Machines, 4th edition, Tata McGraw Hill, 2014.
2. Khurmi R. S, Theory of Machines, 14th edition, S. Chand & Co. Ltd., 2005.
3. Singh V. P., Theory of Machines, Dhanpat Rai & Co.
4. Bansal R. K., Theory of Machines, Laxmi Publications.
5. Singh Sadhu, Theory of Machines, Pearson Publication.

Reference Books:

1. Thomas Bevan, Theory of Machines, 3rd edition, CBS Publishers & Distributors, 2005.
2. Ghosh A. and Mallick A. K., Theory of Mechanisms and Machines, Affiliated East-West Pvt. Ltd, New Delhi, 1988.
3. Lal Jagdish, Theory of Mechanisms & Machines, Metropoliton Book Co.
4. Shingley J. E. and Uicker J. J., Theory of Machines and Mechanisms, McGraw Hill International Book Co.
5. Ballaney P. L., Theory of Machine, Khanna Publication.
6. Cleghorn W. L., Mechanisms of Machines, Oxford University Press, 2005.

7. Robert L. Norton, Kinematics and Dynamics of Machinery, Tata McGraw Hill, 2009.

NPTEL Links:

1. Kinematics of Mechanisms and Machines .Prof. Amitabha Ghosh, IIT Kanpur,| https://onlinecourses.nptel.ac.in/noc26_me55/preview
2. Kinematics of Machines, Prof. Amitabha Ghosh, IIT Kanpur , https://nptel.ac.in/courses/112104121
3. Dynamics of Machines, Prof. Amitabha Ghosh, IIT Kanpur https://nptel.ac.in/courses/112104114

KINEMATICS & DYNAMICS OF MACHINES LAB (ME-507B)			
COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Practical	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. To study the construction and working of basic mechanisms such as four-bar, slider-crank, crank-rocker, and oscillating cylinder mechanisms.

Drawing Sheets (Any three)

2. To determine the instantaneous centres of a four-bar mechanism and verify Kennedy's Theorem using graphical methods (Drawing sheet).
3. To determine the relative velocity of different links in a four-bar and slider-crank mechanism using graphical (velocity diagram) method (Drawing sheet).
4. To determine the acceleration of link in mechanisms and analyze radial, tangential, and Coriolis acceleration components (Drawing sheet).
5. To construct cam profiles for follower motions (Drawing sheet).
6. To determine the characteristics of Centrifugal Governor and Find its Sensitivity and Stability.
7. To verify the principle of working of gyroscope
8. To determine mass moment of inertia of compound pendulum.
9. To determine mass moment of inertia of Rigid body by using Bifilar suspension or Trifilar suspension

Text Books:

1. Ratan S. S., Theory of Machines, 4th edition, Tata McGraw Hill, 2014.
2. Khurmi R. S, Theory of Machines, 14th edition, S. Chand & Co. Ltd., 2005.
3. Singh V. P., Theory of Machines, Dhanpat Rai & Co.
4. Bansal R. K., Theory of Machines, Laxmi Publications.
5. Singh Sadhu, Theory of Machines, Pearson Publication.

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1. Thomas Bevan, Theory of Machines, 3rd edition, CBS Publishers & Distributors, 2005.
2. Ghosh A. and Mallick A. K., Theory of Mechanisms and Machines, Affiliated East-West Pvt. Ltd, New Delhi, 1988.
3. Lal Jagdish, Theory of Mechanisms & Machines, Metropoliton Book Co.
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5. Ballaney P. L., Theory of Machine, Khanna Publication.
6. Cleghorn W. L., Mechanisms of Machines, Oxford University Press, 2005.
7. Robert L. Norton, Kinematics and Dynamics of Machinery, Tata McGraw Hill, 2009.

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HYDRAULICS & PNEUMATICS (PEC – I)

COURSE OUT LINE

Course Title:	**HYDRAULICS & PNEUMATICS**	**Short Title: HP**	**Course Code: ME-506-C**

Course description:

This course provides a comprehensive understanding of fluid power systems, focusing on the principles and applications of hydraulics and pneumatics. The course includes the study of hydraulic and pneumatic components such as pumps, compressors, valves, actuators, and associated accessories, along with their construction and working. Students will learn to analyze and design basic hydraulic and pneumatic circuits, including electro-hydraulic and electro-pneumatic systems.

	Hours/week	**No. of weeks**	**No. of Lectures**	**Total Credits**
Theory	03	15	45	4
Practical	02	15	30	

Prerequisite course(s):

Engineering Thermodynamics, Engineering Mathematics, Basic Physics, Fluid Mechanics

Course objectives:

1. To understand the basic principles of fluid power systems and properties of hydraulic fluids and compressed air.
2. To study the construction and working of hydraulic and pneumatic components such as pumps, compressors, valves, and actuators.
3. To analyze and interpret hydraulic and pneumatic circuits for control of pressure, flow, and direction.
4. To develop skills to design simple fluid power circuits for industrial and automation applications.
5. To apply troubleshooting and maintenance techniques for efficient operation of hydraulic and pneumatic systems.

Course outcomes:

After completing this course, students will be able to:

1. Understand working principles of hydraulic and pneumatic systems
2. Identify and select appropriate components
3. Design basic hydraulic and pneumatic circuits
4. Analyze system performance and troubleshoot faults
5. Apply fluid power systems in industrial applications

COURSE CONTENT

HYDRAULICS & PNEUMATICS		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Fluid Power Systems:	**No. of Lectures: 09 Hours**	**Marks: 12**

Basics of fluid power, Difference between hydraulics and pneumatics, Properties of fluids (viscosity, density, pressure), Pascal's Law and its applications, Advantages and limitations of fluid power systems, Applications in industries (automation, manufacturing, robotics)

Unit–II: Hydraulic Systems	**No. of Lectures: 09 Hours**	**Marks: 12**

and Components		
Hydraulic fluids: types and properties, Hydraulic reservoirs and filters, Pumps: Types (gear, vane, piston), Working and applications, Hydraulic actuators: Cylinders (single acting, double acting), Hydraulic motors, Hydraulic circuits: basic layout and symbols		
Unit–III: Hydraulic Control Valves and Circuits	**No. of Lectures: 09 Hours**	**Marks: 12**
Types of valves: Direction control valves (DCV). Pressure control valves (relief, reducing, sequence valves), Flow control valves. Valve symbols and working principles, Regenerative circuits, Speed control circuits, Pressure intensifier and accumulator, Troubleshooting of hydraulic systems		
Unit–IV: Pneumatic Systems and Components	**No. of Lectures: 09 Hours**	**Marks: 12**
Properties of air and compressibility, Air compressors: types and working, Air preparation units (FRL: Filter, Regulator, Lubricator), Pneumatic actuators: Cylinders (single acting, double acting), Air motors, Pneumatic circuit symbols and layout.		
Unit–V: Pneumatic Control and Applications	**No. of Lectures: 09 Hours**	**Marks: 12**
Direction control valves in pneumatics. Flow and pressure control valves, Pneumatic circuits: Basic circuits, Speed control circuits, Sequential circuits, Electro-pneumatics (introduction) Applications in automation and industries, Maintenance and troubleshooting		

Text Books:

1. A.K. Upadhyay, “Hydraulics & Pneumatics”, 1st Edition, S.K. Kataria & Sons, New Delhi.
2. Jagadeesha T., “Hydraulics and Pneumatics”, 1st Edition, I.K. International Publishing House Pvt. Ltd., New Delhi.
3. Ilango S. & Soundararajan V., “Introduction to Hydraulics and Pneumatics”, 1st Edition, Prentice Hall of India Pvt. Ltd., New Delhi.
4. S.R. Majumdar, “Oil Hydraulic Systems: Principles and Maintenance”, 1st Edition, Tata McGraw Hill Education, New Delhi.
5. Dr. R.K. Rajput, “Hydraulics and Pneumatics”, 1st Edition, S. Chand & Company Ltd., New Delhi.

Reference Books:

1. Andrew Parr, “Hydraulics and Pneumatics”, 2nd Edition, Butterworth-Heinemann, Oxford.
2. Ian C. Turner, “Engineering Applications of Pneumatics and Hydraulics”, 2nd Edition, Routledge Publications.
3. Purushottam Pawar, “Industrial Hydraulics and Pneumatics”, 1st Edition, Sankalp Publication.
4. Md. Abdus Salam, “Fundamentals of Pneumatics and Hydraulics”, 1st Edition, Springer Publications.

NPTEL Links:

1. Oil Hydraulics and Pneumatics – Prof. Somashekhar S (IIT Madras) https://onlinecourses.nptel.ac.in/noc24_me55/preview
2. Fundamentals of Industrial Oil Hydraulics and Pneumatics – Prof. R. N. Maiti (IIT Kharagpur) https://nptel.ac.in/courses/112105047
3. Industrial Hydraulics and Automation – Prof. Niranjan Kumar & Prof. Ajit Kumar (IIT (ISM) Dhanbad) https://onlinecourses.nptel.ac.in/noc24_me69/preview
4. Fundamentals of Industrial Oil Hydraulics and Pneumatics (Archive Course) – IIT Kharagpur https://archive.nptel.ac.in/courses/112/105/112105047/

HYDRAULICS AND PNEUMATICS LAB (ME-507C)			
LAB COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. Study of hydraulic and pneumatic trainer kits, Identification of components: pumps, valves, actuators, compressors, Study of symbols and circuit diagrams
2. Operation of single acting and double acting hydraulic cylinders
3. Speed control of hydraulic actuator using flow control valve
4. Direction control using DC valves
5. Pressure control using relief valve
6. Operation of single acting and double acting pneumatic cylinders
7. Basic pneumatic circuits (AND, OR logic)
8. Sequential operation of pneumatic cylinders
9. Electro-pneumatic circuit using solenoid valves

Text Books

1. A.K. Upadhyay, “Hydraulics & Pneumatics”, 1st Edition, S.K. Kataria & Sons, New Delhi.
2. Jagadeesha T., “Hydraulics and Pneumatics”, 1st Edition, I.K. International Publishing House Pvt. Ltd., New Delhi.
3. Ilango S. & Soundararajan V., “Introduction to Hydraulics and Pneumatics”, 1st Edition, Prentice Hall of India Pvt. Ltd., New Delhi.
4. S.R. Majumdar, “Oil Hydraulic Systems: Principles and Maintenance”, 1st Edition, Tata McGraw Hill Education, New Delhi.
5. Dr. R.K. Rajput, “Hydraulics and Pneumatics”, 1st Edition, S. Chand & Company Ltd., New Delhi.

Reference Books:

1. Andrew Parr, “Hydraulics and Pneumatics”, 2nd Edition, Butterworth-Heinemann,

Oxford.
2. Ian C. Turner, “Engineering Applications of Pneumatics and Hydraulics”, 2nd Edition, Routledge Publications.
3. Purushottam Pawar, “Industrial Hydraulics and Pneumatics”, 1st Edition, Sankalp Publication.
4. Md. Abdus Salam, “Fundamentals of Pneumatics and Hydraulics”, 1st Edition, Springer Publications.

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MECHANICS OF MATERIAL (MDM)			
COURSE OUT LINE			
Course Title:	**Mechanics of Material**	**Short Title: MOM**	**Course Code: ME-508**

Course description:

This course develops fundamental understanding of stress, strain, and material behavior under different loading conditions, fostering analytical and problem-solving competencies in structural mechanics. It introduces key material properties such as elasticity, Poisson's ratio, and elastic constants, along with the analysis of combined stresses, principal stresses, and strains.

The course emphasizes application-driven learning through the study of beams and shafts, including shear force and bending moment analysis, bending and shear stresses, and torsional behavior of solid and hollow shafts. Learners are encouraged to connect theoretical concepts with real-world engineering applications, promoting critical thinking and design-oriented approaches.

In alignment with NEP 2020, the course supports outcome-based education, experiential learning, and skill development, enabling students to analyze, model, and evaluate structural elements while fostering interdisciplinary understanding and engineering judgment.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	02	15	30	2
Practical	--	--	--	

Prerequisite course(s):

Engineering Mechanics, Engineering Mathematics, and Basic Physics

Course objectives:

1. To understand behavior of materials under different types of loads
2. To analyze stress, strain, and deformation in engineering components
3. To study bending, torsion, and shear effects
4. To evaluate failure conditions and safety of structures
5. To apply concepts in design of machine elements

Course outcomes:

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

1. Explain the fundamental concepts of stress, strain, and mechanical properties of materials.
2. Analyze deformation in axially loaded members
3. Determine principal stresses, principal planes, and maximum shear stresses under different loading conditions.
4. Evaluate shear force, bending moment, and stresses in beams subjected to various loading conditions.
5. Analyze torsional behavior of solid and hollow shafts and apply concepts to solve engineering problems involving combined loading.

COURSE CONTENT

Mechanics of Material		**Semester:**	**V**
Teaching Scheme:		**Examination Scheme**	
Lectures:	**2 hours/week**	**End Semester Theory Exam (ESE) - UA:**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Theory Exam (ISE) -	**40 marks**

		CA:	
		Practical Internal Continuous Assessment (ICA) - CA	**25 marks**

Unit–I: Simple Stresses and Strains:	**No. of Lectures: 06 Hours**	**Marks: 12**
Concept of normal stress and strain, and shear stress in uniform and composite sections. Mechanical Properties, Hooke's Law and stress–strain relationship for axially loaded members. Poisson's ratio, volumetric strain, and elastic constants (E, G, K) with their interrelations.		
Unit–II: Axial Loading and Deformation	**No. of Lectures: 06 Hours**	**Marks: 12**
Deformation of bars under axial load, Bars of uniform and varying cross-section, Composite bars, Statically indeterminate problems (basic), Strain energy (introduction)		
Unit–III: Compound Stresses and Strain Analysis	**No. of Lectures: 06 Hours**	**Marks: 12**
Biaxial and triaxial stress systems. Stresses on inclined planes. Principal stresses, principal planes, and maximum shear stresses using analytical and graphical methods (Mohr's circle). Applications to combined loading conditions.		
Unit–IV: Bending of Beams (Shear Force and Bending Moment)	**No. of Lectures: 06 Hours**	**Marks: 12**
Types of beams and loading conditions. Determination and analysis of shear force and bending moment. Construction of shear force and bending moment diagrams. Relationship between load, shear force, and bending moment.		
Unit–V: Torsion of Circular Shafts	**No. of Lectures: 06 Hours**	**Marks: 12**
Theory of torsion for solid and hollow shafts. Torsion equation, shear stress, and angle of twist. Power transmission in shafts. Analysis of shafts under combined bending and torsion; determination of principal and maximum shear stresses.		

Text Books

1. Ramamrutham, S. & Narayanan, R. Strength of Materials, Dhanpat Rai Publishing Company (P) Ltd., New Delhi, 17th Edition, 2014.
2. Bansal, R.K. Strength of Materials, Laxmi Publications (P) Ltd., New Delhi, 6th Edition, 2018.
3. Jindal, U.C. Strength of Materials, Pearson Education India, 3rd Edition, 2010.
4. Singh, Sadhu. Strength of Materials, Khanna Publishers, New Delhi, 4th Edition, 2013.
5. Subramanian, R. Strength of Materials, Oxford University Press, New Delhi, 2nd Edition, 2010.

Reference Books:

1. Gere, J.M. & Timoshenko, S.P. Mechanics of Materials, CBS Publishers & Distributors / Cengage Learning, 2nd Edition (SI), 2011.
2. Beer, F.P., Johnston, E.R., DeWolf, J.T. & Mazurek, D.F. *Mechanics of Materials*, McGraw-Hill Education, 7th Edition (SI), 2015.
3. Popov, E.P. Engineering Mechanics of Solids, Pearson Education, 2nd Edition, 2009.
4. Boresi, A.P. & Schmidt, R.J. Advanced Mechanics of Materials, Wiley India Pvt. Ltd., 6th Edition, 2003.
5. Timoshenko, S.P. & Young, D.H. *Strength of Materials*, CBS Publishers & Distributors, 5th Edition, 2011.

NPTEL Links:

1. Prof. Bansal K. C. (IIT Roorkee), Stress–strain, bending, torsion, columns, Mohr's circle, https://nptel.ac.in/courses/112107147
2. Prof. Amitabha Ghosh, Fundamental concepts, elastic constants, stress analysis https://nptel.ac.in/courses/112104281
3. Prof. S. Ramesh, Beams, shear force, bending moment, torsion, https://nptel.ac.in/courses/112106065
4. Prof. K. Ramesh, Advanced stress analysis, strain energy, failure theories, https://nptel.ac.in/courses/112106241

Guidelines for ICA:

Students must submit ICA in the form of journal for Six Assignments based on above syllabus. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion of each assignment.

Kavayitri Bahinabai Chaudhari NORTH MAHARASHTRA UNIVERSITY, JALGAON (M.S.)

Third Year Bachelor of Engineering

in

(Common for all)

(As per NEP 2020 Guidelines)

Faculty of Science and Technology

'A' Grade
NAAC Re-Accredited
(4th Cycle)

COURSE OUTLINE FOR OPEN ELECTIVE - III

For Affiliated Colleges

Semester – V

W.E.F. 2026 – 27

Open Elective – III

A Student can opt for any one subject out of available institute wide subjects defined in the following list as Open Elective provided, he/she has not taken that particular subject in his/her Programme core, Programme elective, Multidisciplinary Minor, other Open elective and Vocational and Skill Enhancement courses etc. throughout his / her four years of UG Engineering Programme. The student must opt a subject that is compulsorily from faculty other than that of the Major discipline.

Course Code	Name of the Subject / Course	Faculty Offered by	Department Offered by
Open Elective - III (w.e.f. 2026 - 27 at Semester - V, Third Year Engineering)			
OE – 509 A	Legal Aspects of Business	Comm. & Mgmt.	Management
OE – 509 B	Modern Office Management	Comm. & Mgmt.	Commerce
OE – 509 C	Food Adulteration and Safety	Sci. & Tech.	Environment
OE – 509 D	Insurance Management	Comm. & Mgmt.	Commerce
OE – 509 E	Indian Social Problems	Humanities	Sociology
OE – 509 F	Disaster Management	Sci. & Tech.	Environment
OE – 509 G	Pharma Marketing Management	Sci. & Tech.	Pharmacy
OE – 509 H	Circular Economy	Humanities	Economics

LEGAL ASPECTS OF BUSINESS (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**LEGAL ASPECTS OF BUSINESS**	**Short Title:**	LAB	**Course Code:**	OE – 509 A

Course description:

This course provides a concise overview of the legal framework governing business in India, covering contracts, sale of goods, negotiable instruments, intellectual property rights, company law, and cyber law. It equips students with basic legal knowledge and practical understanding required for lawful, ethical, and effective business decision-making in a digital environment.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	02	15	30	02

Prerequisite course(s):

Basics of Law, Legal Environment of Business, Mercantile Law

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. To understand the basic concepts and rules of contracts as per the Indian Contract Act.
2. To learn the legal provisions related to sale of goods and negotiable instruments.
3. To know the importance and protection of intellectual property rights with reference to the Patents Act, Copyright Act, and Trade Marks Act.
4. To understand the basic structure and working of companies according to the Companies Act.
5. To understand digital laws, cybercrimes, and data protection as guided by the Information Technology Act.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand the basic principles and essentials of contracts under the Indian Contract Act.
2. Apply provisions of Sale of Goods and Negotiable Instruments laws in business transactions.
3. Explain the importance and protection of Intellectual Property Rights in business.
4. Understand the formation and legal framework of companies under company law.
5. Identify cyber laws, digital transactions, and data protection under the Information Technology Act.

COURSE CONTENT

LEGAL ASPECTS OF BUSINESS		Semester:	V
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	No. of Lectures: 06 Hours	

INDIAN CONTRACT ACT, 1872

Contract: Definition and meaning-Essentials of contract
Classification of Contracts, Offer and Acceptance
Consideration: Definition, Essentials of a Valid Consideration –Capacity to contract
Free Consent: Coercion, Undue influence, Fraud, Misrepresentation and Mistake

Unit–II:	No. of Lectures: 06 Hours	

SALES OF GOODS ACT, 1930 & Negotiable Instruments Act 1881

Sale of Goods Act 1930: Sale and agreement to sell, Conditions and warranties, Transfer of ownership, rights of unpaid seller.
Negotiable Instruments Act 1881: Meaning, type of negotiable instruments; promissory note, bill

of exchange, cheque. Endorsement and negotiation, Dishonour and legal remedies		
Unit–III:	**No. of Lectures: 06 Hours**	
INTELLECTUAL PROPERTY RIGHTS		
Intellectual Property Rights-Meaning, Need and Importance of Intellectual Property Patents Act, 1970 (2002): Definition, Objectives, Nature, and Types of Patents, Transfer of Patent Rights, Rights of Patentee. Copyright Act, 1957-Concept, Objectives, Nature, Criteria for protection, Ownership, Duration, and Copy Right in Computer Programmes. Trademark Act 1999 (Amendment Act 2010)- Concept, Registration, rights of registered proprietor, infringement and defenses.		
Unit–IV:	**No. of Lectures: 06 Hours**	
COMPANIES ACT, 1956 (Amended 2013)		
Meaning, Definition and characteristics and kinds of company. Memorandum of Association - Meaning, Purpose, Contents Doctrine of Ultra-Vires Articles of Association - Meaning Purpose, Content. Alternation, Constructive Notice		
Unit–V:	**No. of Lectures: 06 Hours**	
The Information Technology Act, 2000 (Amended 2008)		
Introduction, Digital Signatures and Electronic records, Electronic governance Cyber-crimes: hacking, phishing, identity theft, cyber fraud and remedies Data protection, privacy and digital compliance Important Provision of Information Technology Act 2000		
Text Books:		
1. Legal Aspects of Business (8th ed.). McGraw Hill Education. - Akhileshwar Pathak		
Reference Books:		
1. Legal Aspects of Business – David Albuquerque 2. Business Law – N.D.Kapoor 3. Mercantile Law – M. C. Kuchhal and Vivek Kuchhal		
NPTEL Links: • https://nptel.ac.in/courses/129106006 • https://onlinecourses.swayam2.ac.in/e-learning/preview/cec21_mg02 • https://onlinecourses.nptel.ac.in/noc26_mg30/preview		
Guidelines for ICA:		
Students must submit ICA in the form of journal. Concerned faculty member should suitably frame **FIVE** assignments based on the above syllabus. Faculty in charge will assess the assignments continuously, and grade or mark each assignment on completion date declared for each assignment.		

MODERN OFFICE MANAGEMENT (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**MODERN OFFICE MANAGEMENT**	**Short Title:**	MOM	**Course Code:**	OE – 509 B

Course description:
This course introduces the concepts and practices of modern office management in a technology-driven environment. It covers office structure, layout, communication, documentation, and record management, along with digital office tools and automation. The course also focuses on office personnel management, professional behaviour, productivity skills, and emerging trends preparing students to manage contemporary offices effectively.

Lecture	Hours/week	No. of weeks	Total hours	Semester credits
	02	15	30	02

Prerequisite course(s):

Fundamentals of Office Administration, Business Communication, Office Administration and Secretarial Practice

Course objectives:

The objective of this course is to impart knowledge so that the student will:

1. To understand basics of modern office management and emerging office trends.
2. To learn office layout, systems, and workplace environment management.
3. To develop skills in office communication, documentation, and services.
4. To understand records management, meetings, and office automation.
5. To build competencies in personnel management and productivity skills.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain concepts and modern trends of office management.
2. Apply office layout, systems, and environmental principles.
3. Demonstrate office communication, documentation, and services.
4. Analyze records management, meetings, and office automation.
5. Evaluate personnel management, productivity, and emerging trends.

COURSE CONTENT

MODERN OFFICE MANAGEMENT		Semester:	V
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	No. of Lectures: 06 Hours	

Introduction to Modern Office Management

Modern Office: Meaning, Definition, Characteristics, Functions and Past–Present–Future
Office Management: Meaning, Elements and Office as Service & Information Centre
Office Organisation: Office Manager- Functions, Duties, Responsibilities
Modern Trends in Office: Paperless Office and Virtual Office

Unit–II:	No. of Lectures: 06 Hours	

Office Layout and Environment

Office Systems: Objectives, Flow of Work, Planning and Scheduling
Office Layout: Meaning, Objectives, Principles, Types
Office Infrastructure & Facilities Management
Office Environment: Meaning, Factors & Importance Office Safety & Remedies

Unit–III:	No. of Lectures: 06 Hours	

Office Communication, Forms and Services		
Office Communication: Internal & External Communication, Digital Communication Business Documentation: Report Writing, Documentation and Office Correspondence Office Forms: Types, Control, Stationery- Standardisation and Issues Mail & Communication Services: Courier, Speed Post, Fax and E-mail Services		
Unit–IV:	**No. of Lectures: 06 Hours**	
Office Record Management		
Records Management: Meaning, Objectives and Organisation of Record Department Office Meetings - Meaning, Definition, Purpose, Types of meeting Filing & Retrieval Systems: Physical and Electronic Records, Retention and Disposal Digital Office & Automation: E-Office, Office Software Tools and Automation Systems		
Unit–V:	**No. of Lectures: 06 Hours**	
Office Personnel Management and Emerging Trends		
Office Personnel Management: Types, Qualities, Recruitment, and Training Professional Behaviour: Ethics, Discipline, Leadership and Team Coordination Productivity Skills: Time Management and Stress Management Emerging Trends in Office: Remote Work and Green Office Practices		
Text Books:		
• Office Management & Control – G.R.Terry		
Reference Books:		
1. Office Organization and Management – S. P. Arora, Vikas Publishing House Pvt. Ltd., New Delhi. 2. Office Organisation & Management – R.K. Chopada & Ankita Chopada, Himalaya Publishing House, Mumbai. 3. Office Management – I. M. Sahai, Kitab Mahal, Allahabad. 4. Office Management – P. K. Ghosh, Sultan Chand & Sons, New Delhi.		
NPTEL Links: • https://onlinecourses.swayam2.ac.in/e-learning/preview/nou23_mg05 • https://onlinecourses.swayam2.ac.in/e-learning/preview/cec21_mg24 • https://onlinecourses.swayam2.ac.in/e-learning/preview/imb24_mg54		
Guidelines for ICA:		
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FOOD ADULTERATION AND SAFETY (Open Elective – III)

COURSE OUTLINE

Course Title:	**FOOD ADULTERATION AND SAFETY**	**Short Title:**	FAS	**Course Code:**	**OE – 509 C**

Course description:
This course is designed to impart basic knowledge on identifying major types of food adulterants and contamination, food safety hazards using engineering and microbiological principles, Interpret food laws and regulatory standards relevant to engineering practice.
Also, to emphasize the roles of students in basic food safety management frameworks.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	02	15	30	02

Prerequisite course(s):

Course objectives:

The objective of this course is to:

1. To introduce the principles of food safety, food adulteration, and regulatory standards.
2. To explain types, sources, and detection of food adulterants using scientific and engineering approaches.
3. To familiarize students with national and international food safety regulations including FSSAI, Codex, ISO and HACCP.
4. To develop understanding of food contaminants, toxicants, and risk assessment methodologies.
5. To apply quality assurance and analytical techniques relevant to food safety monitoring.

Course outcomes:

Upon successful completion of this course the student will be able to:

1. Explain concepts of food safety, hazards, and adulteration mechanisms.
2. Identify and classify food adulterants and contaminants in different food matrices.
3. Apply analytical and instrumental techniques for detection of adulterants.
4. Interpret regulatory frameworks and food safety management systems.
5. Analyze risk assessment models and quality control measures in food systems.

COURSE CONTENT

FOOD ADULTERATION AND SAFETY		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	**No. of Lectures: 06 Hours**	

Fundamentals of Food Safety and Adulteration

- Concept and importance of food safety
- Definitions: Food safety, food quality, food security
- Types of food hazards: Biological, Chemical, Physical
- Concept of food adulteration
- Intentional and incidental adulteration
- Food contamination vs adulteration
- Food safety challenges in developing countries
- Overview of global food safety issues
- Role of regulatory bodies

- Food standards and their significance

Unit–II:	No. of Lectures: 06 Hours	

Food Adulterants and Contaminants

- Common food adulterants in cereals, pulses, milk, fats & oils, spices
- Chemical contaminants: Pesticide residues, heavy metals, industrial chemicals
- Natural toxins: Mycotoxins, plant toxins, marine toxins
- Veterinary drug residues
- Food additives and misuse
- Packaging contaminants
- Emerging contaminants
- Health effects of adulterants
- Case studies of major food adulteration incidents.

Unit–III:	No. of Lectures: 06 Hours	

Detection and Analytical Techniques

- Sampling methods and protocols
- Classical methods of detection
- Chromatographic techniques (HPLC, GC)
- Analytical Methods (UV-Vis, IR, NMR, Mass Spectrometry)
- Biosensors in food safety
- Molecular methods (PCR-based detection)
- Rapid detection kits
- Validation of analytical methods

Unit–IV:	No. of Lectures: 06 Hours	

Food Safety Regulations and Standards

- Codex Alimentarius Commission
- WTO agreements (SPS & TBT)
- Food Safety and Standards Act (India)
- FSSAI regulations
- ISO 22000 and Food Safety Management Systems
- HACCP principles and implementation
- Good Manufacturing Practices (GMP)
- Good Hygienic Practices (GHP)
- Risk analysis framework
- Traceability and recall systems.

Unit–V:	No. of Lectures: 06 Hours	

Risk Assessment and Quality Assurance

- Risk assessment framework
- Hazard identification
- Exposure assessment
- Dose-response assessment
- Risk characterization
- Quality control tools

- Statistical quality control in food industry
- Validation and verification
- Food safety auditing
- Emerging technologies in food safety monitoring.

Text Books:

1. Food Safety and Standards, K. Ramawat & J. Kumar, CRC Press / Springer
2. Food Safety & Quality Assurance: Principles and Practices, Sunetra Roday, Wiley
3. Food Safety and Standards in India, B. Srilakshmi, New Age International

Reference Books:

1. Food Analysis, S. Suzanne Nielsen, Springer
2. Principles of Food Toxicology, D. R. Heldman & D. B. Lund (Ed.), Springer / CRC Press

NPTEL Links:

- **Food Safety and Quality Management**
  https://nptel.ac.in/courses/126105011
- **Food Packaging Technology**
  https://nptel.ac.in/courses/126105010
- **Food Chemistry and Technology**
  https://nptel.ac.in/courses/126105013
- **Food Processing and Preservation**
  https://nptel.ac.in/courses/126105012

Guidelines for ICA:

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INSURANCE MANAGEMENT (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**INSURANCE MANAGEMENT**	**Short Title:**	IM	**Course Code:**	**OE – 509 D**

Course description:
This course provides a fundamental understanding of insurance concepts, principles, and practices. It covers life and general insurance products, legal and regulatory frameworks, underwriting and claims management, and the role of insurance in economic development. The course equips students with essential knowledge of insurance operations and industry practices, preparing them for opportunities in the insurance and financial services sector.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	02	15	30	02

Prerequisite course(s):

Basic knowledge of Commerce / Economics
Fundamental understanding of Financial Systems and Banking

Course objectives:

The objective of this course is:
1. To introduce students to the basic concepts, principles, and functions of insurance.
2. To provide knowledge of life and general insurance products and their features.
3. To familiarize students with the legal and regulatory framework of insurance in India.
4. To understand the role of insurance in economic development and financial stability.
5. To develop understanding of insurance operations including underwriting and claims management.

Course outcomes:

After successful completion of this course the student will be able to:
1. Explain the fundamental principles and functions of insurance.
2. Differentiate various life and general insurance products.
3. Describe the legal and regulatory framework governing insurance in India.
4. Analyze the contribution of insurance to economic development.
5. Understand underwriting, claims settlement, and operational practices in insurance companies.

COURSE CONTENT

INSURANCE MANAGEMENT		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	**No. of Lectures: 06 Hours**	

Fundamentals of Insurance

Meaning and definition of insurance Nature, scope and functions of insurance
Evolution and importance of insurance
Principles of insurance – Utmost Good Faith, Insurable Interest, Indemnity, Subrogation, Contribution, Proximate Cause
Types of insurance

Unit–II:	**No. of Lectures: 06 Hours**	

Life and General Insurance Products

Life Insurance – Term, Whole Life, Endowment, Annuities & Pension Plans
Basic concept of premium and mortality table
General Insurance – Fire, Marine, Motor and Health Insurance
Crop, Rural and Group Insurance

Maturity and Death Claims		
Unit–III:	**No. of Lectures: 06 Hours**	
Legal and Regulatory Framework of Insurance		
LIC Act, 1956 General Insurance Act, 1972 IRDA Act, 1999 and Functions of IRDA Actuaries Act, 2006 Regulatory and ethical practices in insurance		
Unit–IV:	**No. of Lectures: 06 Hours**	
Insurance and Economic Development		
Role of insurance in economic development Growth of life and general insurance in India Liberalization of insurance sector and its impact Issues, challenges and future potential of insurance industry		
Unit–V:	**No. of Lectures: 06 Hours**	
Insurance Operations and Governance		
Underwriting – Meaning and principles (Life & General Insurance) Claims Management – Life and General Insurance Insurance agents – Licensing, functions and code of conduct Consumer protection and grievance redressal mechanism		
Text Books:		
1. **Fundamentals of Insurance** – Dr. P.K. Gupta, Himalaya Publishing House		
Reference Books: 1. Insurance: Principles And Practice – M.N. Mishra & S B Mishra, S Chand Publishing 2. Principles of Insurance Management – Neelam C Gulati, Excel Books 3. **Principles and Practice of Insurance by P. Periasamy** A.K. Basu, Himalaya Publishing House		
ONLINE COURSES SWAYAM Links: https://onlinecourses.swayam2.ac.in/e-learning/preview/cec20_mg24		
Guidelines for ICA:		
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INDIAN SOCIAL PROBLEMS (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**INDIAN SOCIAL PROBLEMS**	**Short Title:**	ISP	**Course Code:**	**OE-509 E**

Course description:
This course introduces students to the sociological understanding of major social problems in India. The course includes the concept, characteristics, and approaches to the study of social problems and proceeds to examine key issues such as poverty, unemployment, population growth, and urbanization. It further explores violence against women, child labour, crime, and corruption as structural challenges affecting Indian society.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	02	15	30	02

Prerequisite course(s):

Course objectives:

The objective of this course is:
1. Understand the concept and approaches to social problems in the Indian context.
2. Analyze fundamental economic and demographic social issues in India.
3. Examine population growth and urbanization and their effects on society.
4. Understand gender and child-related social problems with sociological insight.
5. Identify and evaluate crime and corruption as structural social problems.

Course outcomes:

After successful completion of this course the student will be able to:
1. Explain the sociological concept and approaches to social problems.
2. Discuss poverty and unemployment with causes and consequences.
3. Analyze the issues of population growth and urbanization in India.
4. Describe violence against women and child labour with social impacts.
5. Explain crime and corruption as social problems and suggest measures.

COURSE CONTENT

INDIAN SOCIAL PROBLEMS		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	**No. of Lectures: 06 Hours**	

Social Problems: Meaning, Characteristics of Social Problems, Types of Social Problems, Approaches to the Study of Social Problems: Social Pathology Approach, Social Disorganization Approach, Value-Conflict Approach, Deviance Approach, Methods of Studying Social Problems

Unit–II:	**No. of Lectures: 06 Hours**	

Poverty: Meaning & Types, Causes of Poverty, Consequences of Poverty, Measures for Eradication
Unemployment: Meaning & Types, Causes, Consequences, Measures to Reduce Unemployment

Unit–III:	**No. of Lectures: 06 Hours**	

Population Growth: Growth of Population in India, Causes & Consequences, Population Control Measures
Urbanization: Meaning of Urbanization, Causes of Urbanization, Problems of Urbanization, Remedies for Urban Problems

Unit–IV:	**No. of Lectures: 06 Hours**	

Violence Against Women: Meaning & Forms, Causes & Consequences, Measures to Control
Child Labour & Child Abuse: Meaning & Causes, Problems of Child Labour & Abuse, Measures

to Eliminate		
Unit–V:	**No. of Lectures: 06 Hours**	
Crime and Criminals: Meaning of Crime, Types of Crime, Causes, Prevention & Control Corruption: Meaning of Corruption, Causes & Consequences, Measures to Control Corruption		
Text Books:		
1. Ahuja, Ram. *Social Problems in India*. 4th ed., Rawat Publications, 2021.		
Reference Books: 1. G. R. Madan – Indian Social Problems, Allied Publishers 2. C. N. Shankar Rao – Sociology of Indian Society, S. Chand Publications 3. Vidya Bhushan & D. R. Sachdeva – Introduction to Sociology, Kitab Mahal Publications 4. M. N. Srinivas – Social Change in Modern India, Orient Longman / Oxford University Press 5. R. Desai – Rural Sociology in India, Bombay Popular Prakashan		
NPTEL Links: 1. https://onlinecourses.swayam2.ac.in/cec25_hs92/preview 2. https://onlinecourses.nptel.ac.in/noc24_hs140/preview		
Guidelines for ICA:		
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DISASTER MANAGEMENT (Open Elective-III)					
COURSE OUTLINE					
Course Title:	**DISASTER MANAGEMENT**	**Short Title:**	**DM**	**Course Code:**	**OE – 509 F**

Course description:
The course aims to develop an understanding of disaster management concepts, disaster risk reduction, preparedness, response, and recovery, with emphasis on managing natural and man-made disasters effectively.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	**02**	**15**	**30**	**02**

Prerequisite course(s):

Course objectives:

The objective of this course is to:

1. Understand fundamental concepts of disasters, hazard, vulnerability, risk and their engineering relevance.
2. Identify and classify natural and anthropogenic disasters and their underlying causes.
3. Explain disaster management principles, phases of disaster cycle and mitigation strategies.
4. Describe institutional frameworks, stakeholders, tools, and technologies used in Disaster Management in India and globally.
5. Apply learned skills to analyze disaster case studies, ethical issues and engineering interventions for disaster risk reduction.

Course outcomes:

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

1. Define and explain key disaster concepts, types and impacts.
2. Distinguish between natural and man-made disasters and summaries control measures.
3. Illustrate stages of disaster management cycle and preparedness planning.
4. Evaluate roles of different stakeholders and tools in managing disaster events.
5. Analyze disaster case studies and articulate ethical, legal and policy issues.

COURSE CONTENT

DISASTER MANAGEMENT		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 Marks**

Unit–I:	**No. of Lectures: 06 Hours**	

Introduction & Disasters Fundamentals

Overview of Disaster Management: Definitions: Disaster, Hazard, Risk, Vulnerability, Capacity, Historical perspective & impacts (environment, society, economy)
Understanding Disasters: Nature, causes & classification of disasters, Concept of exposure, resilience, capacity

Unit–II:	**No. of Lectures: 06 Hours**	

Natural & Anthropogenic Disasters

Natural Disasters: Earthquakes, Tsunami, Volcanoes, Cyclones, Floods, Droughts, Landslides, Extreme weather events and climate change impacts.
Anthropogenic (Man-made) Disasters: Industrial accidents, fires, pollution events, Transportation failures, structural failures.

Unit–III:	**No. of Lectures: 06 Hours**	
Pandemics, Environmental Disasters & Management Principles		
Pandemics and Environmental Disasters: COVID-19 case insights and environmental disaster context. **Objectives & Principles of Disaster Management**: Prevention, preparedness, mitigation, response and recovery concepts. **Disaster Management Cycle**: Phases, actions and key engineering considerations		
Unit–IV:	**No. of Lectures: 06 Hours**	
Stakeholders & Institutional Framework		
Stakeholders in Disaster Management: Government agencies, NGOs, community groups, Technological tools (Early Warning Systems, GIS, Remote Sensing). **International Cooperation & Organizational Structures**: UN agencies, regional alliances and global frameworks **Disaster Management in India**: Institutional framework, NDMA, policy & legal context.		
Unit–V:	**No. of Lectures:06 Hours**	
Ethical Issues & Case Studies		
Ethical Issues in Disaster Management: Resource allocation, social equity and engineering ethics **Case Studies**: Natural and man-made disaster case analyses, Lessons learnt, best practices.		

Text Books:

1. R. Subramanian, Disaster Management, Vikas Publishing House.
2. S.C.Sharma, Disaster Management Khanna Publishing House, New Delhi.
3. G. K. Ghosh, Disaster Management, APH Publishing Corporation, New Delhi

Reference Books:

1. A.K. Singh, Disaster Management in India, New Royal Book Company, Lucknow
2. Anu Kapur Vulnerable India: A Geographical Study of Disasters, Sage Publications, New Delhi
3. Tushar Bhattacharya, Disaster Science and Management, McGraw-Hill Education (India)
4. Jagbir Singh (Ed.), Disaster Management: Future Challenges and Opportunities, Disaster, I.K. International Publishing House

Online Courses:

NIDM E-Learning Courses (National Institute of Disaster Management)
https://elearning.nidm.gov.in/local/home/index.php
SWAYAM & NPTEL MOOCs
https://archive.nptel.ac.in/courses/105/104/105104183/
iGOT Karmayogi (For Govt. Officials)
https://igotkarmayogi.gov.in/#/

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PHARMA MARKETING MANAGEMENT (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**PHARMA MARKETING MANAGEMENT**	**Short Title:**	PMM	**Course Code:**	OE – 509 G

Pharmaceutical Marketing Management focuses on the planning, implementation, and control of marketing strategies specific to the pharmaceutical industry, where ethical considerations, regulatory compliance, and patient safety play a critical role. It involves understanding healthcare markets, consumer and physician behavior, product life-cycle management, pricing strategies, distribution channels, and promotional activities such as medical detailing, digital marketing, and relationship management with healthcare professionals. The discipline integrates market research, brand management, and strategic decision-making to ensure effective product positioning while complying with national and international regulations. In an increasingly competitive and technology-driven environment, pharmaceutical marketing management emphasizes value-based marketing, patient-centric approaches, and sustainable growth.

	Hours/week	**No. of weeks**	**Total hours**	**Semester credits**
Theory	**02**	**15**	**30**	**02**

Course objectives:

The objective of this course is to:

1. To study the scope of marketing.
2. To study the quantitative and qualitative aspects of pharmaceutical market.
3. To study the products decision in product life cycle, product portfolios, packaging and labelling decisions.
4. To study the promotion of products.
5. To study marketing channels and management of logistics.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand and explain core marketing concepts and their application in the pharmaceutical industry.
2. Understand quantitative and qualitative aspects of pharmaceutical market.
3. Understand the product cycle, product portfolios.
4. Assess promotional tools including personal selling, advertising, digital marketing, and ethical promotion practices.
5. Understand the marketing channels and management of logistics.

COURSE CONTENT

PHARMA MARKETING MANAGEMENT		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA)CA:**	**25 marks**

Unit–I:	**No. of Lectures: 6 Hours**	

Marketing:

Definition, general concepts and scope of marketing; Distinction between marketing & selling; Marketing environment; Industry and competitive analysis; Analyzing consumer buying behavior; industrial buying behavior.

Pharmaceutical Market:

Quantitative and qualitative aspects; size and composition of the market; demographic descriptions and socio-psychological characteristics of the consumer; market segmentation &

targeting. Consumer profile; Motivation and prescribing habits of the physician; patients' choice of physician and retail pharmacist. Analyzing the Market; Role of market research.		
Unit–II:	**No. of Lectures: 6 Hours**	
Product Decision:		
Classification, product line and product mix decisions, product life cycle, product portfolio analysis; product positioning; New product decisions; Product branding, packaging and labeling decisions, Product management in pharmaceutical industry.		
Unit–III:	**No. of Lectures: 6 Hours**	
Promotion:		
Methods, determinants of promotional mix, promotional budget; An overview of personal selling, advertising, direct mail, journals, sampling, retailing, medical exhibition, public relations, online promotional techniques for OTC Products.		
Unit–IV:	**No. of Lectures: 6 Hours**	
Pharmaceutical Marketing Channels		
Designing channel, channel members, selecting the appropriate channel, conflict in channels, physical distribution management: Strategic importance, tasks in physical distribution management. **Management of Logistics:** Supply Chain, Cold Chain, Applications of IT & management information systems for efficient marketing, controlling expiry and returned goods.		
Unit–V:	**No. of Lectures: 6 Hours**	
Pricing:		
Meaning, importance, objectives, determinants of price; pricing methods and strategies, issues in price management in pharmaceutical industry. An overview of DPCO (Drug Price Control Order) and NPPA (National Pharmaceutical Pricing Authority). **Emerging concepts in marketing:** Vertical & Horizontal Marketing; Rural Marketing; Consumerism; Industrial Marketing; Global Marketing. **AI in Pharma Marketing:** Introduction to AI in Pharma Marketing: Role of AI in modern pharmaceutical marketing, Benefits, limitations, and future scope of AI in pharma, AI-driven market research and forecasting		
Text Books:		
1. Arun Kumar and N Menakshi: Marketing Management, Vikas Publishing, India. 2. Ramaswamy, U.S & Nanakamari, S: Marketing Management: Global Perspective, Indian Context, Macmilan India, New Delhi.		
Reference Books: 1. Philip Kotler and Kevin Lane Keller: Marketing Management, Prentice Hall of India New Delhi		
NPTEL Links: 1. https://youtu.be/iOZxUvq1JNE 2. https://nptel.ac.in/courses/110104068		
Guidelines for ICA:		
Students must submit ICA in the form of journal. Concerned faculty member should suitably frame **FIVE** assignments based on the above syllabus. Faculty in charge will assess the assignments continuously, and grade or mark each assignment on completion date declared for each assignment.		

CIRCULAR ECONOMY (Open Elective – III)					
COURSE OUTLINE					
Course Title:	**CIRCULAR ECONOMY**	**Short Title:**	**CE**	**Course Code:**	**OE-509 H**

Course description:
This course introduces the concept of Circular Economy, its principles, and its relevance in sustainable development. Students will learn about linear economy limitations, circular economy frameworks, business models, and its implementation in India.

	Hours/week	No. of weeks	Total hours	Semester credits
Theory	**02**	**15**	**30**	**02**

Prerequisite course(s):

Basic understanding of **Linear Economy and environmental sustainability concepts**.

Course objectives:

The objective of this course is:

1. To understand the basics of Circular Economy and its significance.
2. To familiarize students with circular economy frameworks, business models, and case studies.
3. To compare linear and circular economies, and understand traditional circular practices.
4. To understand the prospect of circular economy in India.
5. To analyze the role of government and benefits of circular economy.

Course outcomes:

After successful completion of this course the student will be able to:

1. Describe the principles and benefits of Circular Economy.
2. Apply circular economy frameworks and business models.
3. Compare and contrast linear and circular economies.
4. Identify opportunities for circular economy in India.
5. Understand the role of government and benefits of circular economy for various stakeholders.

COURSE CONTENT

CIRCULAR ECONOMY		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Unit–I:	**No. of Lectures: 06 Hours**	

Linear Economy and Circular Economy Basics

Linear Economy - Our Crumbling Planet: Law of Obsolescence, Disadvantages of Linear Economy,

Circular Economy: Think Ahead - Our Last Chance:- Elements of a Circular Economy, Why do we need to switch to a circular economy?

Unit–II:	**No. of Lectures: 06 Hours**	

Circular Economy Frameworks and Business Models

Fundamental Characteristics of Circular Economy - A Resource Multiplier: Innovation, Collaboration, Value optimization, Design out Waste, Renewable Energy, Closed and tighter loops, Business Models in a Circular Economy- Circular supply chain, Product as a service, Collaborations and sharing, Recovery and recycling, Product life extension, McKinsey Center for Business and Environment - the ReSOLVE framework

Unit–III:	**No. of Lectures: 06 Hours**	
Linear Vs. Circular Economy and Traditional Practices		
Linear Vs Circular Economy: Differential that whither the Planet and Us? - Material value preservation, Eco-effectiveness from eco-efficiency, Shift from Raw material to residual flows, Linear VS Circular economy, SWOT analysis of Circular Economy, Circular Economy - Old wine in new bottle: - Yoga – a circular alternate to gyms, Ayurveda – An old circular alternate to modern medicine, Earthen Pots – An old circular practice, Sun Drying – A circular alternate to laundry dryers		
Unit–IV:	**No. of Lectures: 06 Hours**	
Circular Economy in India		
India and Circularity - Showcasing Sustainable Future - Circularity in India, Prospect of Circular Economy in India, Role of Indian businesses, Invest in circular economy opportunities		
Unit–V:	**No. of Lectures: 06 Hours**	
Circular Economy Implementation and Benefits		
Role of Government -Set direction and show commitment, Enabling regulatory frameworks, Platforms for multi-stakeholder collaboration, Support circular models through public procurement and infrastructure Benefits of Circular Economy for India- Benefits for businesses and the Economy, Benefits for the environment, Benefits for citizens		
Text Books:		
Reference Books: Circular Economy: (Re)Emerging Movement by Shalini Goyal Bhalla		
NPTEL Links: SWAYAM https://onlinecourses.swayam2.ac.in/e-learning/preview/aic21_ge19		
Guidelines for ICA:		
Students must submit ICA in the form of journal. Concerned faculty member should suitably frame **FIVE** assignments based on the above syllabus. Faculty in charge will assess the assignments continuously, and grade or mark each assignment on completion date declared for each assignment.		

Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY,

JALGAON (M.S.)

Third Year Bachelor of Engineering

in

Mechanical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology



COURSE OUTLINE

For Affiliated Colleges

Semester – VI

W.E.F. 2026 – 27

MECHATRONICS, ROBOTIC AND CONTROL SYSTEMS (PCC)			
COURSE OUT LINE			
Course Title:	**MECHATRONICS, ROBOTIC AND CONTROL SYSTEMS**	**Short Title: MR&CS**	**Course Code: ME-601**

Course description:

This course integrates mechanical systems, sensors, actuators, control logic, embedded systems, industrial robotics, and intelligent automation into a unified mechatronic framework. Students learn the modeling, simulation, control, and robotic applications of modern manufacturing and smart machines, including PLCs, servo drives, machine vision, and Industry 4.0 concepts. The syllabus is aligned with AICTE NEP 2020 multidisciplinary and experiential learning philosophy, preparing students for careers in automation, robotics, CNC systems, digital manufacturing, autonomous systems, and smart factories.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Engineering Mechanics, Basic Electrical & Electronics Engineering, Fundamentals of Control Systems, Basics of Programming, Kinematics of Machines

Course objectives:

1. To understand integrated mechatronic system architecture.
2. To study sensors, actuators, controllers, and signal conditioning.
3. To develop mathematical models and control strategies.
4. To understand robot kinematics, end effectors, and industrial automation.
5. To apply PLC, embedded, and AI-enabled control in smart manufacturing.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain architecture of mechatronic and robotic systems
2. Select suitable sensors, actuators, and control elements
3. Analyze transfer functions and feedback control systems
4. Analyze transfer functions and feedback control systems
5. Design basic PLC / microcontroller-based control solutions

COURSE CONTENT

MECHATRONICS, ROBOTIC AND CONTROL SYSTEMS		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Fundamentals of Mechatronics	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to mechatronic systems, System integration concept, Mechanical, electrical, control, and computing interface, Sensors, Signal conditioning, Data acquisition systems, Smart sensors

Unit–II: Actuators and Embedded	**No. of Lectures: 09 Hours**	**Marks: 12**

Pneumatic and hydraulic actuators, DC, stepper and servo motors, Solenoids and piezo actuators, Motor drivers, Relay logic, Microcontrollers basics, Interfacing of sensors and actuators

Unit–III: Control Systems and Modeling	**No. of Lectures: 09 Hours**	**Marks: 12**

Mathematical modeling of mechanical systems, Transfer function, Block diagram reduction Feedback control systems, Time response analysis, Stability basics, PID controller, Closed loop speed / position control, CNC axis control examples

Unit–IV: Robotics and Automation	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to industrial robotics, Robot components and DOF, Robot joints and links, Forward kinematics basics, End effectors, Pick-and-place robots, Robot programming fundamentals, Industrial automation sequences, introduction to AGV and AMR, Applications in manufacturing

Unit–V: PLC, IoT and Smart Manufacturing	**No. of Lectures: 09 Hours**	**Marks: 12**

PLC architecture, Ladder logic basics, Timers and counters, Conveyor automation, Sensor-based sorting system, SCADA basics, IoT in machine monitoring, Predictive maintenance, AI in robotics and control, Industry 4.0 and digital twins

Text Books:

1. W. Bolton – Mechatronics: Electronic Control Systems in Mechanical Engineering
2. N.P. Mahalik – Mechatronics: Principles, Concepts and Applications
3. S.R. Deb – Robotics Technology and Flexible Automation
4. K. Ogata – Modern Control Engineering

Reference Books:

1. Devdas Shetty & Richard Kolk – Mechatronics System Design
2. Groover – Automation, Production Systems and CIM
3. Mikell Groover – Industrial Robotics
4. Bishop – Mechatronics Systems, Sensors and Actuators

NPTEL Links:

1. Introduction to Mechatronics – Prof. K.P. Ramachandran – IIT Madras – https://nptel.ac.in/courses/112/106/112106115/
2. Sensors and Actuators – Prof. Soumen Das – IIT Madras – https://nptel.ac.in/courses/108/106/108106165/
3. Control Engineering – Prof. S. Nagarajan – IIT Madras – https://nptel.ac.in/courses/108/106/108106098/
4. Introduction to Robotics – Prof. C. S. Shankar Ram – IIT Madras – https://nptel.ac.in/courses/112/106/112106155/
5. PLC Programming and Industrial Automation – Prof. S. K. Saha – IIT Delhi – https://nptel.ac.in/courses/108/102/108102045/
6. Introduction to Industry 4.0 and Industrial Internet of Things – Prof. Sudip Misra – IIT Kharagpur – https://nptel.ac.in/courses/106/105/106105213/

MECHATRONICS, ROBOTIC AND CONTROL SYSTEMS Lab (ME-602)			
COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (PR):	**25 marks**

Concerned faculty member should suitably frame Six assignments / practicals from the following list.

1. To study calibration of sensors and basic interfacing concepts for data acquisition.
2. To Study and evaluate stepper motor control for precise position control applications.
3. To control servo motor position using basic control signals.
4. To simulate PID control and analyze system response using software.
5. To study and simulate basic conveyor control using PLC ladder logic.
6. To simulate basic movement of a robot arm and study its degrees of freedom.
7. To study working of AGV systems and simulate basic navigation or path following.
8. To design a simple IoT dashboard for monitoring machine parameters.
9. To design and implement a small automation or autonomous-based system integrating sensors, control, and decision logic.

Text Books:

1. W. Bolton – Mechatronics: Electronic Control Systems in Mechanical Engineering
2. N.P. Mahalik – Mechatronics: Principles, Concepts and Applications
3. S.R. Deb – Robotics Technology and Flexible Automation
4. K. Ogata – Modern Control Engineering

Reference Books:

1. Devdas Shetty & Richard Kolk – Mechatronics System Design
2. Groover – Automation, Production Systems and CIM
3. Mikell Groover – Industrial Robotics
4. Bishop – Mechatronics Systems, Sensors and Actuators

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guidelines for ESE:

ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on the understanding and quality of lab work.

MACHINE ELEMENT & SYSTEM DESIGN (PCC)			
COURSE OUT LINE			
Course Title:	**MACHINE ELEMENT & SYSTEM DESIGN**	**Short Title: MESD**	**Course Code: ME-603**

Course description:

This course provides an in-depth understanding of the design principles of machine elements and practices involved in the design of various machine elements considering strength, stiffness, reliability, manufacturability, and safety essential for engineering applications. It integrates mechanical design theory with practical applications, covering components like shafts, gears, springs, bearings, and fasteners.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	4
Practical	02	15	30	

Prerequisite course(s):

Fundamental Knowledge of Physics, Engineering Maths, Engineering Mechanics, Theory of Machine and Engineering materials.

Course objectives:

1. To understand the fundamentals of machine design and failure theories.
2. To design machine elements under static and dynamic loading conditions.
3. To apply standard design procedures and codes for mechanical components.
4. To develop skills in selection of materials, manufacturing constraints, and safety considerations.
5. To introduce system design approach integrating multiple machine elements.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply design principles and failure theories in machine components.
2. Design shafts, joints, and fasteners under various loading conditions.
3. Analyze and design power transmission elements like gears and belts.
4. Select and design bearings, springs, and lubrication systems.
5. Develop integrated machine systems considering real-world constraints.

COURSE CONTENT

MACHINE ELEMENT & SYSTEM DESIGN		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Machine Element Design	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction of Machine Design, Basic procedure of Machine Design, Requisites of design engineer, Sources of design data, Design considerations, standardization, Selection of preferred sizes, Stress concentration - causes and remedies, Review of failure theories for static loading. Aesthetic and ergonomic considerations in design.

Shafts: - Material, Design on the basis of strength considering shaft subjected to, twisting moment only, bending moment only, combine twisting and bending moment, axial load in

addition to twisting and bending. Design on the basis of rigidity. A.S.M.E. code for shaft design.

Unit–II: Design of Joints and Springs	**No. of Lectures: 09 Hours**	**Marks: 12**

A. Threaded fasteners: Bolt design under static and dynamic loading, Eccentric loading in bolts

C. Spring: - Types, Applications and materials of springs, Stress and deflection equations for helical springs, Style of ends, Wahl's Stress Factor, Design of helical compression and tension springs, leaf spring, nipping, Shot peening.

Unit–III: Design of Spur Gear and Helical Gear	**No. of Lectures: 09 Hours**	**Marks: 12**

Gear types, terminology, and classifications. Gear tooth geometry, Type of gear tooth failure, Desirable properties and selection of gear material.

Spur Gears: Number of teeth and face width, Force analysis, Beam strength (Lewis) equation, Velocity factor, Service factor, Load concentration factor, Effective load on gear, Wear strength equation, Estimation of module based on beam and wear strengths, Estimation of dynamic tooth load by velocity factor and Buckingham's equation.

Helical Gears: Transverse and normal module, Virtual number of teeth, Force analysis, Beam and Wear strengths, Effective load on gear tooth, Estimation of dynamic load by velocity factor and Buckingham's equation, Design of helical gears.

Unit–IV: Design of Bearings	**No. of Lectures: 09 Hours**	**Marks: 12**

Rolling contact Bearings: Type of rolling contact bearing, Static and dynamic load carrying capacities, Striback's equation, Equivalent bearing load, Load-life relationship, Selection of bearing life, Selection of rolling contact bearings from manufacturer's catalogue. Design for cyclic loads and speed, bearing with probability of survival other than 90%.

Unit–V: Design for Fluctuating Loads	**No. of Lectures: 09 Hours**	**Marks: 12**

Design for Fluctuating Loads: Fluctuating stresses, Fatigue failure, Endurance limit, Notch sensitivity, Reversed stresses, Solderberg and Goodman diagrams, Fatigue design of components under combined stresses such as shafts, bolts and springs.

Design against static and dynamic load: Theories of static failure, Stress concentration etc. Overview of fatigue phenomena and its significance in engineering design, stress concentration factors, and notch sensitivity, S-N curves, Fluctuating stresses, Fatigue failure, Soderberg and Goodman criterion, Design of mechanical components subjected to dynamic loading for finite and infinite life.

Text Books:

1. Bhandari V.B., "Design of Machine elements", Tata McGraw Hill Pub. Co. ltd.
2. Farzdak Haideri, "Machine Design", Nirali Prakashan, Pune
3. R. B. Patil, "Mechanical System Design" Techmax publications; 4th edition (2018)
4. Data, Design. "Data Book of Engineers by PSG College." Kalaikathir Achchagam, Coimbatore.(PSG Design Data Book.)

Reference Books:

1. Shigley J.E., Mischke C.R., "Mechanical Engineering Design" McGraw Hill Pub. Co. Ltd.
2. Spott's M. F., Shoup T. E. "Design of Machine Elements", Prentice Hall International.
3. "Design Data", P.S.G. College of Technology, Coimbatore.

4. Juvinal R. C. "Fundamental of Machine Component Design", John Wiley and sons. 5. R. L. Norton, Mechanical Design – An Integrated Approach, Prentice Hall, 1998

NPTEL Links:

1. Prof. K. Gopinath, Prof. M.M. Mayuram, Machine Design, https://nptel.ac.in/courses/112106137
2. Prof. G. Chakraborty, Prof. S.K. Roychowdhury, Prof. B. Maiti, Design of Machine Elements I, https://nptel.ac.in/courses/112105125
3. Prof. Ramkumar, Design of Mechanical Transmission Systems, https://nptel.ac.in/courses/112106424

NOTE: PSG Design Data Book is permitted. Design of all components should include design for strength and rigidity apart from engineering performance requirements.

MACHINE ELEMENT & SYSTEM DESIGN LAB (ME-604)			
LAB COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End Semester Examination (ESE) UA OR:	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. To Comprehensive Study of Machine Design Principles and Shaft Design under Various Loading Conditions.
2. To Design and Analysis of Threaded Fasteners and Springs under Static and Dynamic Loading Conditions
3. To Design and Strength Analysis of Spur and Helical Gears.
4. To Comprehensive Study and Design of Rolling Contact Bearings under Static and Dynamic Loading Conditions
5. To study and understand the behavior of mechanical components under fluctuating and dynamic loading conditions.
6. Design and detailed assembly drawing project (computer aided drawing) of Leaf spring for the application of heavy vehicle.
7. Design and detailed assembly drawing project (computer aided drawing) of Compact Gearbox for Industrial Applications.
8. Design and detailed assembly drawing project (computer aided drawing) of a Shaft-Bearing System for Heavy Load Machinery
9. Course Project: Students in a group of two to four will be able to design and prepare working drawings (using any software) of any system having minimum 5 to 6 components by applying the knowledge gained during the course.

Text Books

1. Bhandari V.B., "Design of Machine elements", Tata McGraw Hill Pub. Co. ltd.
2. Farzdak Haideri, "Machine Design", Nirali Prakashan, Pune
3. R. B. Patil, "Mechanical System Design" Techmax publications; 4th edition (2018)

4. Data, Design. "Data Book of Engineers by PSG College." Kalaikathir Achchagam, Coimbatore.(PSG Design Data Book.)

Reference Books:

1. Shigley J.E., Mischke C.R., "Mechanical Engineering Design" McGraw Hill Pub. Co. Ltd.
2. Spott's M. F., Shoup T. E. "Design of Machine Elements", Prentice Hall International.
3. "Design Data", P.S.G. College of Technology, Coimbatore.
4. Juvinal R. C. "Fundamental of Machine Component Design", John Wiley and sons. 5. R. L. Norton, Mechanical Design – An Integrated Approach, Prentice Hall, 1998

Guidelines for ICA:

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Guidelines for ESE:

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CAD/CAM INTEGRATION WITH MODELING SOFTWARE LAB
(PEC – II)

COURSE OUT LINE

Course Title:	**CAD/CAM INTEGRATION WITH MODELING SOFTWARE LAB**	**Short Title: CCIMSL**	**Course Code: ME-605A**

Course description:

This course provides an integrated understanding of computer-aided design (CAD), computer-aided manufacturing (CAM), and digital modeling software workflows used in modern mechanical industries. Students learn parametric modeling, surface and assembly design, CAM toolpath planning, CNC post-processing, machining simulation, PLM concepts, and digital manufacturing integration using industry-standard tools. The course strongly aligns with experiential, skill-based, and multidisciplinary framework, enabling competency in smart manufacturing, digital twins, computer-integrated manufacturing, and Industry 4.0 environments.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	05
Practical	04	15	56	

Prerequisite course(s):

Engineering Graphics, CAD Modeling, Manufacturing Processes, CNC Programming Basics Computer Applications

Course objectives:

1. To develop parametric part, assembly, and surface models.
2. To integrate CAD models with CAM machining workflows.
3. To generate CNC programs and validate machining sequences.
4. To analyze digital manufacturing and PLM data flow.
5. To apply CAD/CAM integration in smart production systems.

Course outcomes:

After successful completion of this course the student will be able to:

1. Create parametric solid, assembly, and surface models
2. Generate CAM toolpaths for turning and milling
3. Analyze machining simulation and CNC code validation
4. Evaluate PLM and digital manufacturing workflows
5. Design an integrated CAD/CAM digital production solution

COURSE CONTENT

CAD/CAM INTEGRATION WITH MODELING SOFTWARE LAB		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**		

Unit–I: CAD Modeling Fundamentals	**No. of Lectures: 09 Hours**	

Parametric sketching, Solid feature modeling, Assembly constraints, Surface modeling, Sheet metal modeling, GD&T and drawing extraction, Design tables and configurations, Design automation basics

Unit–II: CAM Toolpath Planning	**No. of Lectures: 09 Hours**	

Introduction to CAM workflow, Tool library management, Cutting tool selection, 2D profile milling, Pocket milling, Drilling cycles, CNC turning operations		
Unit–III: CNC Code Generation and Simulation	**No. of Lectures: 09 Hours**	
Post-processing fundamentals, G-code and M-code generation, CNC milling simulation, Turning simulation, Collision detection, Toolpath verification, Cycle time estimation, multi-axis machining basics, CNC virtual machining		
Unit–IV: CAD/CAM Data Integration and PLM	**No. of Lectures: 09 Hours**	
CAD to CAM data transfer, Neutral file formats: IGES, STEP, STL, Revision control, Product lifecycle management, BOM integration, Toolpath revision workflow, Digital thread concept Manufacturing database systems		
Unit–V: Smart Manufacturing and Industry 4.0	**No. of Lectures: 09 Hours**	
Digital manufacturing workflow, CAD/CAM in CIM, CNC network integration, Digital twins in machining, Smart tool monitoring, Cloud CAM systems, AI-assisted toolpath optimization Additive + subtractive hybrid manufacturing, Industry case studies		
Text Books:		
1. P.N. Rao – CAD/CAM Principles and Applications 2. Ibrahim Zeid – CAD/CAM Theory and Practice 3. Mikell Groover – Automation, Production Systems and CIM 4. NX / Creo / SolidWorks CAM manuals		
Reference Books: 1. Chris McMahon – CAD/CAM: Principles, Practice and Manufacturing Management 2. Rao, Kundra & Tiwari – Computer Aided Manufacturing 3. CNC Programming manuals		
NPTEL Links		
1. Computer Aided Design and Manufacturing (CAD/CAM) – Prof. P. Venkataraman – Indian Institute of Technology Madras – https://nptel.ac.in/courses/112102101 2. Advanced CAD/CAM – Prof. K. K. Chawla – Indian Institute of Technology Roorkee – https://nptel.ac.in/courses/112104031 3. NPTEL Online Course Portal (All CAD/CAM Courses) – NPTEL Faculty (Multiple) – National Programme on Technology Enhanced Learning – https://onlinecourses.nptel.ac.in/		

CAD/CAM INTEGRATION WITH MODELING SOFTWARE LAB (ME-605A)			
COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**4 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**50 marks**
		End Semester Examination (ESE) UA OR:	**25 marks**

Concerned faculty member should suitably frame Six assignments / practicals from the following list.

1. Parametric part modeling
2. Assembly of gearbox / coupling
3. CAM profile milling
4. Pocket and drilling toolpath
5. CNC turning simulation / Performance
6. G-code validation
7. STEP / IGES data transfer
8. CNC cycle time optimization
9. Hybrid CAD-CAM + 3D print workflow

Text Books:

1. P.N. Rao – CAD/CAM Principles and Applications
2. Ibrahim Zeid – CAD/CAM Theory and Practice
3. Mikell Groover – Automation, Production Systems and CIM
4. NX / Creo / SolidWorks CAM manuals

Reference Books:

1. Chris McMahon – CAD/CAM: Principles, Practice and Manufacturing Management
2. Rao, Kundra & Tiwari – Computer Aided Manufacturing
3. CNC Programming manuals
4. Digital manufacturing research papers

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guidelines for ESE:

ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on the understanding and quality of lab work.

COMPUTATIONAL FLUID DYNAMICS LAB
(PEC – II)

COURSE OUT LINE

Course Title:	**COMPUTATIONAL FLUID DYNAMICS LAB**	**Short Title: CFD**	**Course Code: ME-605 B**

Course description:

This course introduces the fundamental principles and numerical techniques of Computational Fluid Dynamics (CFD**)** for analyzing fluid flow and heat transfer problems. It covers governing equations, discretization using Finite Difference (FDM) **and** Finite Volume (FVM) methods, and solution techniques. Key concepts such as stability, convergence, grid independence, flow modeling, and turbulence are included, along with the CFD workflow (pre-processing, solving, and post-processing). Applications in automobile, Aerospace, and energy systems are emphasized to link theory with practice.

	Hours/week	**No. of weeks**	**No. of Lectures**	**Total Credits**
Theory	03	15	45	05
Practical	04	15	60	

Prerequisite course(s):

Engineering Thermodynamics, Engineering Mathematics, Basic Physics

Course objectives:

1. To understand the fundamental governing equations of fluid flow and their physical significance.
2. To introduce numerical methods such as FDM and FVM for solving fluid flow problems.
3. To develop knowledge of discretization techniques, stability, and convergence criteria.
4. To apply numerical solution techniques for flow modeling including laminar and turbulent flows.
5. To familiarize students with CFD workflow and its applications in real engineering problems.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain governing equations and boundary conditions of fluid flow for engineering applications.
2. Apply numerical methods such as FDM and FVM for discretization of fluid flow problems.
3. Analyze diffusion and convection–diffusion problems using finite volume approach.
4. Apply solution techniques and turbulence models for solving fluid flow equations.
5. Use CFD tools to simulate and evaluate engineering applications like pipe flow and heat transfer.

COURSE CONTENT

COMPUTATIONAL FLUID DYNAMICS LAB	**Semester:**	**VI**
Teaching Scheme:	**Examination scheme**	
Lectures: **3 hours/week**		
Unit–I: Introduction & Governing Equations	**No. of Lectures: 09 Hours**	

Introduction to CFD and applications (automobile, aerospace, energy systems) ,Need of numerical methods (limitations of analytical solutions) , Conservation laws: Mass (Continuity equation) ,Momentum (Navier–Stokes equation) ,Energy equation ,Classification of Partial Differential Equations: Elliptic, Parabolic, Hyperbolic , Boundary and initial conditions		
Unit–II: Basics of Numerical Methods	**No. of Lectures: 09 Hours**	
Concept of discretization , Finite Difference Method (FDM) , Introduction to Finite Volume Method (FVM) , Taylor series approximation , Consistency, Stability, Convergence, Grid independence concept		
Unit–III: Finite Volume Method & Diffusion Problems	**No. of Lectures: 09 Hours**	
Control volume approach, 1-D steady state diffusion problems , Discretization of diffusion equation , Boundary condition implementation, Introduction to convection–diffusion problems Upwind and central difference schemes		
Unit–IV: Solution Techniques & Flow Modeling	**No. of Lectures: 09 Hours**	
Solution of linear algebraic equations: Direct methods ,Iterative methods (Gauss-Seidel) Discretization of Navier–Stokes equations, SIMPLE algorithm (basic idea) , Introduction to turbulence: Laminar vs Turbulent flow ,Basic turbulence models		
Unit–V: CFD Process & Applications	**No. of Lectures: 09 Hours**	
CFD workflow: Pre-processing (geometry, mesh) ,Solver ,Post-processing , Grid generation: Structured and unstructured mesh , Introduction to CFD software, Applications: Pipe flow ,Heat transfer ,Aerodynamics		
Text Books:		
1. S.V. Patankar – Numerical Heat Transfer and Fluid Flow, McGraw-Hill 2. H.K. Versteeg & W. Malalasekera – An Introduction to CFD: The Finite Volume Method, Pearson 3. John D. Anderson – Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill		
Reference Books:		
1. Ferziger & Perić – Computational Methods for Fluid Dynamics, Springer 2. T.J. Chung – Computational Fluid Dynamics, Cambridge University Press 3. Tannehill, Anderson & Pletcher – Computational Fluid Mechanics and Heat Transfer 4. C. Hirsch – Numerical Computation of Internal and External Flows		
NPTEL Links:		
1. Prof. Suman Chakraborty , Indian Institute of Technology (IIT) Kharagpur https://nptel.ac.in/courses/112105272 2. Prof. Sreenivas Jayanti , Indian Institute of Technology (IIT) Madras https://nptel.ac.in/courses/103106113 3. Introduction to Computational Fluid Dynamics (Supplementary).NPTEL Faculty https://nptel.ac.in/courses/112104030		

COMPUTATIONAL FLUID DYNAMICS LAB (ME-605B)			
LAB COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**4 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**50 marks**
		End semester exam (ESE) UA (OR):	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. To understand CFD fundamentals, workflow (pre-processing, solver, post-processing), and applications in engineering systems.
2. To create basic geometries (pipe/channel) and apply appropriate boundary conditions for CFD simulation..
3. To solve 1-D steady heat conduction problem using FDM and understand Taylor series approximation.
4. To generate mesh and analyze grid independence to solution accuracy.
5. To solve steady-state diffusion equation using control volume approach.
6. To simulate convection–diffusion problems and compare different discretization schemes.
7. To simulate laminar and turbulent flow in a pipe and compare velocity and pressure profiles.
8. To understand pressure-velocity coupling using SIMPLE algorithm in fluid flow problems.
9. To simulate heat transfer in pipe and external flow over airfoil (NACA 0012) and analyze results.

Text Books

1. S.V. Patankar – Numerical Heat Transfer and Fluid Flow, McGraw-Hill
2. H.K. Versteeg & W. Malalasekera – An Introduction to CFD: The Finite Volume Method, Pearson
3. John D. Anderson – Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill

Reference Books

1. Ferziger & Perić – Computational Methods for Fluid Dynamics, Springer
2. T.J. Chung – Computational Fluid Dynamics, Cambridge University Press
3. Tannehill, Anderson & Pletcher – Computational Fluid Mechanics and Heat Transfer
4. C. Hirsch – Numerical Computation of Internal and External Flows

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guidelines for ESE:

ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on the understanding and quality of lab work.

DIE AND MOLD DESIGN AND TOOL ENGINEERING LAB
(PEC – II)

COURSE OUT LINE

Course Title:	**DIE AND MOLD DESIGN AND TOOL ENGINEERING LAB**	**Short Title: DMT**	**Course Code: ME-605 C**

Course description:

This laboratory course provides practical exposure to the design, construction, and application of dies, molds, and various tooling systems used in manufacturing industries. The course focuses on understanding the working principles and components of press tools, jigs, fixtures, and injection molds through hands-on experiments and demonstrations.

	Hours/week	**No. of weeks**	**No. of Lectures**	**Total Credits**
Theory	03	15	45	05
Practical	04	15	60	

Prerequisite course(s):

Engg. Workshop, Manufacturing Processes, Manufacturing Technology

Course objectives:

1. To understand the fundamentals of die and mold design.
2. To develop skills in tool design, manufacturing, and inspection.
3. To gain practical exposure to press tools, jigs, fixtures, and molds.
4. To use CAD software for designing dies and molds
5. To study the construction and working of cutting tools.

Course outcomes:

After completing this course, students will be able to:

1. Identify and analyze different cutting tools, jigs, and fixtures.
2. Design basic tooling components used in manufacturing.
3. Use measuring instruments for inspection and quality control.
4. Understand and operate tool room machines safely.
5. Apply CAD tools for modeling and assembly of tooling systems.

COURSE CONTENT

DIE AND MOLD DESIGN AND TOOL ENGINEERING LAB	**Semester:**	**VI**
Teaching Scheme:	**Examination scheme**	
Lectures: **3 hours/week**		

Unit–I: Fundamentals of Tool Engineering:	**No. of Lectures: 09 Hours**	

Introduction to tool engineering and its importance in manufacturing, Classification of tools: cutting tools, forming tools, jigs and fixtures, Types of dies and molds, Tool materials: properties and selection (HSS, carbides, ceramics, composites), Heat treatment of tool steels, Tool life and wear mechanisms

Unit–II: Design of Cutting Tools	**No. of Lectures: 09 Hours**	

Single point cutting tool geometry, Design of turning, drilling, milling, and broaching tools, Cutting forces and power requirements, Tool failure and wear analysis, Indexable inserts and tool holders, Cutting tool materials and coatings.

Unit–III: Design of Press Tools (Dies)	**No. of Lectures: 09 Hours**	

Introduction to press working operations: blanking, piercing, bending, drawing, Types of dies: simple, compound, progressive, combination dies, Die components and terminology, Design of blanking and piercing dies, Strip layout and material utilization, Design of bending and drawing dies.		
Unit–IV: Design of Molds	**No. of Lectures: 09 Hours**	
Introduction to molding processes: injection, compression, transfer molding, Types of molds: injection mold, blow mold, compression mold, Mold components: cavity, core, runner, gate, ejector system, Mold materials and selection, Cooling system design and mold flow considerations, Defects in molded parts and remedies.		
Unit–V: Jigs, Fixtures and Advanced Tooling	**No. of Lectures: 09 Hours**	
Principles of jigs and fixtures, Types of jigs: drill jig, template jig, plate jig, Types of fixtures: milling, turning, welding fixtures, Location and clamping principles (3-2-1 principle), CNC tooling and modular fixtures, Introduction to CAD/CAM in tool design, Rapid tooling and additive manufacturing in tooling.		
Text Books:		
1. Production Technology, P.C. Sharma, S. Chand & Company Ltd., New Delhi. 2. Tool Engineering and Design, G.R. Nagpal, Khanna Publishers, New Delhi, 6th Edition 3. Basics of Mould Technology and Design, Dr. Kanwarjeet Singh, Dr. Gaurav Arora, Mahi Publication, India		
Reference Books:		
1. Tool Design, Cyril Donaldson, George H. LeCain, V.C. Goold, Joyjeet Ghose, Tata McGraw Hill / McGraw Hill Education (India), 5th Edition (2017) 2. Manufacturing Engineering and Technology, Serope Kalpakjian, Steven Schmid, Pearson Education 3. Jigs and Fixtures Design Manual, Erik K. Henriksen, Industrial Press Inc., 2nd Edition 4. Fundamentals of Tool Design, Society of Manufacturing Engineers (SME), Prentice Hall of India / SME		
NPTEL Links: 1. Product Design and Manufacturing – Prof. J. Ramkumar (IIT Kanpur) https://onlinecourses.nptel.ac.in/noc26_me49/preview 2. Fundamentals of Manufacturing Processes – Prof. D.K. Dwivedi (IIT Roorkee) https://onlinecourses.nptel.ac.in/noc24_me123/preview 3. Product Design and Development – NPTEL (IIT Faculty) https://onlinecourses-archive.nptel.ac.in/noc17_me16/preview		

DIE AND MOLD DESIGN AND TOOL ENGINEERING LAB (ME-605C)			
LAB COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**4 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**50 marks**
		End semester exam (ESE) UA (OR):	**25 marks**
Concerned faculty member should suitably frame Six laboratory assignments / practicals from			

the following list.

1. Study of different types of press tools (blanking, piercing, bending, forming).
2. Calculation of cutting force, clearance, and strip layout & Design of a simple blanking die.
3. Study and design of drilling jig.
4. Study and design of milling fixture.
5. Study of injection moulding machine and components.
6. Study of gating system, runners, and cooling system AND Design of a simple injection mold.
7. To study the construction, geometry, and angles of a drilling tool (twist drill).
8. To study the geometry, parts, and angles of a single point cutting tool.
9. Modeling of die/mold components using CAD software

Text Books

1. Production Technology, P.C. Sharma, S. Chand & Company Ltd., New Delhi.
2. Tool Engineering and Design, G.R. Nagpal, Khanna Publishers, New Delhi, 6th Edition
3. Basics of Mould Technology and Design, Dr. Kanwarjeet Singh, Dr. Gaurav Arora, Mahi Publication, India

Reference Books:

1. Tool Design, Cyril Donaldson, George H. LeCain, V.C. Goold, Joyjeet Ghose, Tata McGraw Hill / McGraw Hill Education (India), 5th Edition (2017)
2. Manufacturing Engineering and Technology, Serope Kalpakjian, Steven Schmid, Pearson Education
3. Jigs and Fixtures Design Manual, Erik K. Henriksen, Industrial Press Inc., 2nd Edition
4. Fundamentals of Tool Design, Society of Manufacturing Engineers (SME), Prentice Hall of India / SME

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guidelines for ESE:

ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on the understanding and quality of lab work.

AI/ML FOR MECHANICAL ENGINEERING
(PEC – III)

COURSE OUT LINE

Course Title:	**AI/ML FOR MECHANICAL ENGINEERING**	**Short Title: AI/ML**	**Course Code: ME-606 A**

Course description:

This course introduces the fundamentals of Artificial Intelligence and Machine Learning with a focus on applications in Mechanical Engineering. It covers basic concepts of data analysis, regression, and machine learning algorithms, along with their use in thermal systems, manufacturing, and engine performance prediction. The course emphasizes practical understanding using simple tools like Excel and Python, enabling students to apply AI techniques for prediction, optimization, and fault diagnosis in mechanical systems.

	Hours/week	**No. of weeks**	**No. of Lectures**	**Total Credits**
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Introduction to AI & ML, Python programming, Libraries, modules, coding basics

Course objectives:

1. To introduce AI/ML concepts for mechanical engineering.
2. To apply ML techniques in thermal and manufacturing systems.
3. To understand data-driven modeling of mechanical systems.
4. To use AI tools for prediction and optimization.
5. To apply AI for fault detection and diagnostics.

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand AI/ML concepts and their applications in mechanical engineering systems.
2. Analyze and preprocess mechanical engineering data using basic statistical tools.
3. Apply basic machine learning algorithms for prediction and classification problems.
4. Evaluate AI applications in thermal, manufacturing, and mechanical systems.
5. Develop simple AI-based models for solving real-world mechanical engineering problems.

COURSE CONTENT

AI/ML FOR MECHANICAL ENGINEERING		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to AI/ML	**No. of Lectures: 09 Hours**	**Marks: 12**

Basics of Artificial Intelligence and Machine Learning ,Types of Machine Learning: Supervised Learning ,Unsupervised Learning ,Reinforcement Learning ,Applications of AI in Mechanical Engineering: Predictive maintenance ,Smart manufacturing ,Thermal system optimization Introduction to datasets: Experimental data ,Sensor-based data

Unit–II: Mathematical Basics & Data Handling	**No. of Lectures: 09 Hours**	**Marks: 12**

Basics of Linear Regression , Fundamentals of Probability and Statistics: Mean, variance, correlation, Data preprocessing techniques: Normalization ,Handling missing data ,Data visualization: Graphs and plots for mechanical data.		
Unit–III: Machine Learning Algorithms	**No. of Lectures: 09 Hours**	**Marks: 12**
Supervised Learning Algorithms: Linear Regression (performance prediction) ,Decision Trees (fault diagnosis) , Unsupervised Learning: K-means clustering (pattern recognition) ,Model evaluation techniques: Error analysis ,Accuracy ,Over fitting and under fitting		
Unit–IV: AI Applications in Mechanical	**No. of Lectures: 09 Hours**	**Marks: 12**
AI applications in: Heat exchangers (prediction and optimization),IC engines (combustion and emission prediction), Manufacturing systems (tool wear, quality control) . Introduction to Digital Twin concept ,Case studies of AI applications in mechanical systems		
Unit–V: Introduction to AI Tools	**No. of Lectures: 09 Hours**	**Marks: 12**
Introduction to AI tools: Python (NumPy, Pandas – overview) , Excel-based ML tools , Basic ML workflow: Data collection , Model building , Prediction ,Mini Case study on: Engine performance prediction, Heat exchanger optimization ,Fault detection in mechanical systems		

Text Books:

1. Tom Taulli, Artificial Intelligence Basics, Apress, 1st Edition, 2019.
2. Tom M. Mitchell, Machine Learning, McGraw-Hill, 1st Edition, 1997.
3. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 4th Edition, 2020.
4. Steven L. Brunton and J. Nathan Kutz, Data-Driven Science and Engineering, Cambridge University Press, 1st Edition, 2019.
5. Wes McKinney, Python for Data Analysis, O'Reilly Media, 2nd Edition, 2017. (Latest Edition: 3rd Edition, 2022)

Reference Books:

1. Christopher M. Bishop, Pattern Recognition and Machine Learning, *Springer*, 1st Edition, 2006.
2. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, *Pearson, 3rd Edition, 2010.* (Latest: 4th Edition, 2021)
3. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani, An Introduction to Statistical Learning, Springer, 2nd Edition, 2021.
4. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow, O'Reilly Media, 2nd Edition, 2019.
5. Andrew Ng, Machine Learning Yearning, DeepLearning.AI, 1st Edition, 2018.

NPTEL Links:

1. Machine Learning (IIT Madras), Instructor: Prof. Balaraman Ravindran https://nptel.ac.in/courses/1061061392.
2. Artificial Intelligence (IIT Kharagpur), Instructor: Prof. P. P. Chakrabarti https://nptel.ac.in/courses/106105077.
3. Data Analytics with Python (IIT Roorkee) ,Instructor: Prof. Sanjeev Kumar https://nptel.ac.in/courses/106107220.
4. Introduction to Machine Learning (IIT Kharagpur) ,Instructor: Prof. Sudeshna Sarkar https://nptel.ac.in/courses/106105152.
5. Industry 4.0 and Industrial Internet of Things (IIT Kharagpur) , Instructor: Prof. Arun Kumar Samantaray https://nptel.ac.in/courses/106105198

AI/ML FOR MECHANICAL ENGINEERING LAB (ME-607A)			
LAB COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. To study basic concepts of AI/ML and identify their applications in mechanical engineering systems.
2. To collect and organize experimental/sensor data (e.g., engine or heat transfer data) in tabular form using Excel.
3. To calculate mean, variance, and correlation for given mechanical system data.
4. To perform data cleaning, normalization, and handling of missing values using Excel/Python.
5. To plot graphs for analysis of mechanical data.
6. To develop a simple linear regression model to predict performance parameters (At least 2 Cases) .
7. To classify machine conditions (normal/faulty) using a basic decision tree model.
8. To group mechanical system data into clusters based on operating conditions using K-means clustering.
9. To develop a simple AI-based model for prediction or optimization of a mechanical system (engine/heat exchanger/fault detection).

Text Books

1. Tom Taulli, Artificial Intelligence Basics, Apress, 1st Edition, 2019.
2. Tom M. Mitchell, Machine Learning, McGraw-Hill, 1st Edition, 1997.
3. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 4th Edition, 2020.
4. Steven L. Brunton and J. Nathan Kutz, Data-Driven Science and Engineering, Cambridge University Press, 1st Edition, 2019.
5. Wes McKinney, Python for Data Analysis, O'Reilly Media, 2nd Edition, 2017. (Latest Edition: 3rd Edition, 2022)

Reference Books:

1. Christopher M. Bishop, *Pattern Recognition and Machine Learning, Springer*, 1st Edition, 2006.
2. Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, Pearson, 3rd Edition, 2010. *(Latest: 4th Edition, 2021)*
3. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani, *An Introduction to Statistical Learning,* Springer, 2nd Edition, 2021.
4. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow,* O'Reilly Media, 2nd Edition, 2019.
5. Andrew Ng, *Machine Learning Yearning,* DeepLearning.AI, 1st Edition, 2018.

Guidelines for ICA:

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PROGRAMMING FOR MECHATRONICS
(PEC – III)

COURSE OUT LINE

Course Title:	**PROGRAMMING FOR MECHATRONICS**	**Short Title: PM**	**Course Code: ME-606-B**

Course description:

This course introduces the fundamental concepts of programming as applied to mechatronics systems. It focuses on developing skills in writing structured programs and applying them to control and automation tasks using microcontrollers. The course covers basic programming constructs, embedded system concepts, and interfacing of sensors and actuators.
Students will learn how to design and implement programs for real-time applications, including digital and analog input/output operations, motor control, and communication between devices. The course also provides an introduction to automation technologies such as PLC programming and IoT-based systems.

	Hours/week	**No. of weeks**	**No. of Lectures**	**Total Credits**
Theory	03	15	45	4
Practicals	02	15	30	

Prerequisite course(s):

Engineering Thermodynamics, Engineering Mathematics, Basic Physics

Course objectives:

1. To understand the fundamentals of programming concepts and their role in mechatronics and automation systems.
2. To develop programming skills using languages such as C/Embedded C or Arduino for control applications.
3. To study microcontroller architecture and programming for real-time embedded systems.
4. To interface sensors and actuators with microcontrollers for monitoring and control of physical systems.
5. To design and implement simple mechatronics and automation applications using programming and embedded systems.

Course outcomes:

After completion of the syllabus, students will be able to:

1. Write and execute programs for control applications
2. Interface sensors and actuators with microcontrollers
3. Develop embedded programs for automation systems
4. Implement basic communication between devices
5. Design simple mechatronics-based projects

COURSE CONTENT

PROGRAMMING FOR MECHATRONICS		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Programming &	**No. of Lectures: 09 Hours**	**Marks: 12**

Mechatronics Systems:		
Overview of mechatronics systems, Role of programming in automation and control, Basics of algorithms and flowcharts, Introduction to programming languages (C / Embedded C / Python) Structure of a program, Data types, variables, constants, and operators		
Unit–II: Control Structures and Functions	**No. of Lectures: 09 Hours**	**Marks: 12**
Decision-making statements (if, if-else, switch), Looping statements (for, while, do-while) Functions and modular programming, Arrays and strings, Basics of pointers (for C programming), Debugging techniques		
Unit–III: Microcontroller Programming	**No. of Lectures: 09 Hours**	**Marks: 12**
Introduction to microcontrollers (e.g., Arduino), Architecture and features, Programming using Embedded C / Arduino IDE, Digital input/output programming, Interfacing LEDs, switches, relays, Timing and delay functions		
Unit–IV: Sensors & Actuators Interfacing	**No. of Lectures: 09 Hours**	**Marks: 12**
Types of sensors (temperature, proximity, light, pressure), Signal conditioning basics, Analog and digital signals, ADC and DAC concepts, Interfacing sensors with microcontrollers Actuators: motors (DC, stepper, servo) and control		
Unit–V: Advanced Applications & Automation	**No. of Lectures: 09 Hours**	**Marks: 12**
Serial communication (UART basics), Introduction to PLC programming (ladder logic basics), Basics of robotics programming, Embedded system applications, IoT basics in mechatronics, Case studies of automation systems		

Text Books:

1. K. V. K. Prasad, “Embedded / Real-Time Systems: Concepts, Design and Programming”, 1st Edition, Dreamtech Press, New Delhi.
2. Nilesh B. Bahadure & Saurabh Chandrakar, “Microcontrollers and Embedded System Design”, 1st Edition, Tech-Max Publications, Pune.
3. J. G. Joshi, “Mechatronics”, 1st Edition, Khanna Book Publishing Pvt. Ltd., New Delhi.
4. Raj Kamal, “Embedded Systems: Architecture, Programming and Design”, 2nd Edition, Tata McGraw Hill Education, New Delhi.
5. Dr. K. K. Mehta, “Microprocessor and Microcontroller Systems”, 1st Edition, Khanna Publishers, New Delhi.

Reference Books:

1. Biswanath Samanta, “Introduction to Mechatronics: An Integrated Approach”, 1st Edition, Springer Publications.
2. Thomas Bräunl, “Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems”, 1st Edition, Springer Publications.
3. Peter Hintenaus, “Engineering Embedded Systems: Physics, Programs, Circuits”, 1st Edition, Springer Publications.
4. W. Bolton, “Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering”, 6th Edition, Pearson Education, London.
5. Michael Barr & Anthony Massa, “Programming Embedded Systems in C and C++”,

2nd Edition, O'Reilly Media, USA. Springer Publications.

NPTEL Links:

1. Introduction to Embedded System Design – Prof. Dhananjay V. Gadre (NSUT) & Prof. Badri Subudhi (IIT Jammu)
   https://onlinecourses.nptel.ac.in/noc24_cs43/preview
2. Embedded System Design with ARM – Prof. Indranil Sengupta (IIT Kharagpur)
   https://onlinecourses.nptel.ac.in/noc25_cs41/preview
3. Mechatronics – Prof. Pushparaj Mani Pathak (IIT Roorkee)
   https://onlinecourses.nptel.ac.in/noc25_me91/preview
4. Design of Mechatronic Systems – Prof. Prasanna Gandhi (IIT Bombay)
   https://onlinecourses.nptel.ac.in/noc24_me120/preview

PROGRAMMING FOR MECHATRONICS LAB (ME-607 B)			
LAB COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. Write and execute simple programs (input/output, arithmetic operations), Programs using decision-making statements (if, if-else, switch), Programs using loops (for, while, do-while), Programs using functions and arrays
2. Introduction to Arduino IDE and basic program structure, LED blinking program using microcontroller
3. Interfacing push button and controlling LED, Relay control using microcontroller
4. Interfacing temperature sensor and displaying output, Interfacing LDR (light sensor) for automatic light control
5. Interfacing proximity sensor, Analog input reading using ADC
6. Controlling DC motor using microcontroller
7. Interfacing and control of servo motor
8. Stepper motor control basics
9. Mini project: Automatic street light system

Text Books

1. K. V. K. Prasad, "Embedded / Real-Time Systems: Concepts, Design and Programming", 1st Edition, Dreamtech Press, New Delhi.
2. Nilesh B. Bahadure & Saurabh Chandrakar, "Microcontrollers and Embedded System Design", 1st Edition, Tech-Max Publications, Pune.
3. J. G. Joshi, "Mechatronics", 1st Edition, Khanna Book Publishing Pvt. Ltd., New Delhi.
4. Raj Kamal, "Embedded Systems: Architecture, Programming and Design", 2nd Edition, Tata McGraw Hill Education, New Delhi.
5. Dr. K. K. Mehta, "Microprocessor and Microcontroller Systems", 1st Edition, Khanna

Publishers, New Delhi.

Reference Books:

1. Biswanath Samanta, “Introduction to Mechatronics: An Integrated Approach”, 1st Edition, Springer Publications.
2. Thomas Bräunl, “Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems”, 1st Edition, Springer Publications.
3. Peter Hintenaus, “Engineering Embedded Systems: Physics, Programs, Circuits”, 1st Edition, Springer Publications.
4. W. Bolton, “Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering”, 6th Edition, Pearson Education, London.
5. Michael Barr & Anthony Massa, “Programming Embedded Systems in C and C++”, 2nd Edition, O’Reilly Media, USA. Springer Publications.

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

AUTONOMOUS SYSTEM INTEGRATION
(PEC – III)

COURSE OUT LINE

Course Title:	**AUTONOMOUS SYSTEM INTEGRATION**	**Short Title: ASI**	**Course Code: ME-606-C**

Course description:

This course focuses on the design and integration of autonomous systems with emphasis on system-level intelligence rather than basic mechatronics components. It covers the architecture of autonomous systems, including perception, localization, planning, and decision-making. The course introduces modern concepts such as sensor fusion, SLAM, and intelligent navigation algorithms. It also highlights integration frameworks and real-world applications such as autonomous vehicles, drones, and mobile robots. The course enables students to understand how multiple subsystems work together to achieve autonomy in engineering applications.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	4
Practical	02	15	30	

Prerequisite course(s):

Engineering Mathematics , Basic Electronics & Instrumentation (Sensors and Signals) , Fundamentals of Mechatronics / Embedded Systems , Basics of Programming (C / Python – desirable)

Course objectives:

1. To understand architecture and working of autonomous systems
2. To develop knowledge of perception, localization, and decision-making
3. To study intelligent navigation and path planning techniques
4. To learn integration of AI, IoT, and real-time systems in autonomy
5. To analyze real-world autonomous applications

Course outcomes:

After completion of the syllabus, students will be able to:

1. Understand mechatronics and autonomous system architecture
2. Apply perception and sensor fusion concepts
3. Analyze localization and mapping techniques
4. Implement basic path planning and decision-making algorithms
5. Integrate intelligent modules for real-world autonomous applications

COURSE CONTENT

AUTONOMOUS SYSTEM INTEGRATION		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Architecture of Autonomous Systems	**No. of Lectures: 09 Hours**	**Marks: 12**

Definition and characteristics of autonomous systems , Levels of autonomy (human-assisted to fully autonomous) , Functional architecture: perception–planning–control pipeline ,Hardware-software co-design in autonomous systems , Real-time systems and computational

requirements Safety, redundancy, and fault tolerance in autonomous systems

Unit–II: Perception and Sensor Fusion	**No. of Lectures: 09 Hours**	**Marks: 12**

Environment perception concepts , Sensor fusion principles (multi-sensor data integration) , Vision-based perception (camera systems, basics of image processing) , LiDAR and RADAR concepts (working and applications) , Object detection and classification basics . Introduction to AI/ML in perception systems.

Unit–III: Localization and Mapping	**No. of Lectures: 09 Hours**	**Marks: 12**

Concept of localization in autonomous systems , Coordinate frames and transformations , GPS and inertial navigation systems (INS) , Introduction to SLAM (Simultaneous Localization and Mapping) , Mapping techniques: grid mapping, feature-based mapping , Localization challenges in dynamic environments

Unit–IV: Path Planning and Decision Making	**No. of Lectures: 09 Hours**	**Marks: 12**

Motion planning concepts , Path planning algorithms: Dijkstra algorithm ,A* algorithm ,Rapidly Exploring Random Trees (RRT) , Obstacle avoidance strategies , Decision-making in dynamic environments , Behavior-based and rule-based control , Introduction to reinforcement learning in autonomous systems

Unit–V: System Integration and Applications	**No. of Lectures: 09 Hours**	**Marks: 12**

Integration of perception, planning, and control modules , Middleware frameworks (ROS – Robot Operating System basics , etc.) , Communication in autonomous systems (V2V, V2X concepts) , Cloud and edge computing in autonomy , Case studies: Autonomous vehicles, Drones (UAV systems) ,Smart agriculture and surveillance systems

Text Books:

1. Autonomous Mobile Robots, *Roland* Siegwart, Illah Nourbakhsh & Davide Scaramuzza, MIT Press.
2. Learning Robotics using Python, Lentin Joseph, Packt Publishing.
3. Autonomous and Robotics Systems Design, V. R. Niveditha, A. Sinduja, I. S. Beschi et al., Leilani Katie Publication and Press (India).
4. Robotics and Smart Autonomous Systems: Technology and Applications, Prabhu Jyot Singh et al., CRC Press / Taylor & Francis.

Reference Books:

1. Robotics: Modelling, Planning and Control, Bruno Siciliano et al., Springer.
2. Artificial Intelligence: A Modern Approach, Stuart Russell & Peter Norvig, Pearson Education.
3. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer.
4. Introduction to Robotics, S. K. Saha, McGraw Hill Education (India).
5. Practical Robotics in C++: Build and Program Real Autonomous Robots Using Raspberry Pi, Lloyd Brombach, BPB Publications (India).
6. Intelligent Autonomous Systems: Foundations and Applications, D. K. Pratihar et al., Springer
7. Probabilistic Robotics, Sebastian Thrun, Wolfram Burgard & Dieter Fox, MIT Press.

NPTEL Links:

1. *Autonomous Mobile Robots*, Prof. D. K. Pratihar, IIT Kharagpur, https://onlinecourses.nptel.ac.in/noc21_me32/preview

2. *Artificial Intelligence*, Prof. Sudeshna Sarkar, IIT Kharagpur, https://onlinecourses.nptel.ac.in/noc22_cs97/preview
3. *Computer Vision*, Prof. P. J. Narayanan, IIT Hyderabad, https://onlinecourses.nptel.ac.in/noc22_cs36/preview
4. *Introduction to Robotics*, Prof. D. K. Pratihar, IIT Kharagpur, https://onlinecourses.nptel.ac.in/noc21_me32/preview

AUTONOMOUS SYSTEM INTEGRATION LAB (ME-607C)			
LAB COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. To study functional architecture (Perception–Planning–Control) of autonomous systems using block diagrams and case studies.
2. To simulate basic sensor fusion (e.g., combining distance and position data) using software tools like Python etc..
3. To perform basic image processing operations (edge detection, object identification) using Python/OpenCV etc.
4. To analyze position estimation using sample GPS datasets and plot trajectories.
5. To study and simulate basic SLAM concept using available tools (ROS/Gazebo).
6. To implement Dijkstra algorithm for shortest path finding in a grid environment using Python.
7. To implement A* algorithm and compare with Dijkstra in terms of efficiency.
8. To simulate obstacle detection and avoidance strategy using virtual environment (ROS/Gazebo or any simulator).
9. To design and demonstrate a simple autonomous system (hardware-based) such as: Autonomous mobile robot / Smart navigation system.

Text Books

1. Autonomous Mobile Robots, *Roland* Siegwart, Illah Nourbakhsh & Davide Scaramuzza, MIT Press.
2. Learning Robotics using Python, Lentin Joseph, Packt Publishing.
3. Autonomous and Robotics Systems Design, V. R. Niveditha, A. Sinduja, I. S. Beschi et al., Leilani Katie Publication and Press (India).
4. Robotics and Smart Autonomous Systems: Technology and Applications, Prabhu Jyot Singh et al., CRC Press / Taylor & Francis.

Reference Books:

1. Robotics: Modelling, Planning and Control, Bruno Siciliano et al., Springer.
2. Artificial Intelligence: A Modern Approach, Stuart Russell & Peter Norvig, Pearson Education.

3. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer.
4. Introduction to Robotics, S. K. Saha, McGraw Hill Education (India).
5. Practical Robotics in C++: Build and Program Real Autonomous Robots Using Raspberry Pi, Lloyd Brombach, BPB Publications (India).
6. Intelligent Autonomous Systems: Foundations and Applications, D. K. Pratihar et al., Springer
7. Probabilistic Robotics, Sebastian Thrun, Wolfram Burgard & Dieter Fox, MIT Press.

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

ENGINEERING DATA ANALYSIS AND OPTIMIZATION TECHNIQUES (MDM)

COURSE OUT LINE

Course Title:	**ENGINEERING DATA ANALYSIS AND OPTIMIZATION TECHNIQUES**	**Short Title: EDAOT**	**Course Code: ME-608**

Course description:

This course introduces fundamental concepts of data analysis, statistical methods, and optimization techniques used in engineering applications. It covers descriptive statistics, design of experiments (DOE), Taguchi methods, Response Surface Methodology (RSM), and basic exposure to statistical software tools. The course also provides an introductory understanding of modern techniques like Artificial Neural Networks for engineering optimization.

	Hours/week	**No. of weeks**	**No. of Lectures**	**Total Credits**
Theory	02	15	30	02

Prerequisite course(s):

Engineering Mathematics (Probability, Statistics, Linear Algebra basics), Engineering Thermodynamics, Fluid Mechanics / Heat Transfer (basic understanding of engineering systems), Manufacturing Processes / Production Engineering, Basic Computer Programming

Course objectives:

1. To introduce fundamental concepts of data analysis and statistical methods.
2. To develop understanding of Design of Experiments (DOE) and optimization techniques.
3. To apply Taguchi and RSM methods for engineering problem-solving.
4. To provide exposure to statistical software tools for data analysis.
5. To introduce modern optimization approaches including AI-based techniques.

Course outcomes:

After successful completion of this course the student will be able to:

1. Apply statistical **tools** for analysis and interpretation of engineering data.
2. Design and analyze experiments using Design of Experiments (DOE) principles and ANOVA..
3. Implement Taguchi method for parameter design and optimization of engineering systems.
4. Develop mathematical models and optimize responses using Response Surface Methodology.
5. Study and understand basics of Artificial Neural Networks for data analysis and modern optimization techniques.

COURSE CONTENT

ENGINEERING DATA ANALYSIS AND OPTIMIZATION TECHNIQUES		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**2 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

		Internal Continuous Assessment (ICA) CA:	**25 marks**
Unit–I: Fundamentals of Data Analysis and Statistics	**No. of Lectures: 06 Hours**	**Marks: 12**	
Types of data (qualitative & quantitative) , Data collection and pre-processing , Measures of central tendency and dispersion , Probability basics and distributions (normal, binomial) , Correlation and simple regression.			
Unit–II: Design of Experiments (DOE)	**No. of Lectures: 06 Hours**	**Marks: 12**	
Introduction to Design of Experiments , Principles of DOE (randomization, replication, blocking) , Full factorial design (2-level) , Fractional factorial design (basic concept), Introduction to ANOVA (analysis of variance).			
Unit–III: Taguchi Method for Robust Design	**No. of Lectures: 06 Hours**	**Marks: 12**	
Concept of robust design and quality engineering , Signal-to-noise (S/N) ratio and its types , Orthogonal arrays (L9, L16 – basic understanding) , Taguchi experimental design procedure , Analysis of results and optimization using Taguchi method			
Unit–IV: Response Surface Methodology (RSM)	**No. of Lectures: 06 Hours**	**Marks: 12**	
Concept of optimization and modeling , First-order and second-order models , Central Composite Design (CCD) and Box–Behnken design , Contour plots and surface plots ,Applications in engineering optimization.			
Unit–V: Software Tools and Modern Techniques	**No. of Lectures: 06 Hours**	**Marks: 12**	
Introduction to statistical software for data analysis , Regression and ANOVA using software tools , Introduction to Artificial Neural Networks , Overview of optimization using AI techniques , Case studies in engineering applications.			
Text Books:			
1. Introduction to Probability and Statistics for Engineers and Scientists – Jay L. Devore, Cengage Learning, 9th Edition, 2015. 2. Engineering Optimization: Theory and Practice – Singiresu S. Rao, Wiley, 4th Edition, 2009.			
Reference Books:			
1. Probability and Statistics – T Veerarajan, McGraw Hill Education (India), 2nd Edition, 2008. 2. Design and Analysis of Experiments – Ranjit K. Roy, Wiley, 2nd Edition, 2001. 3. Optimization Techniques – Kalyanmoy Deb, Wiley, 1st Edition, 2005. 4. Applied Statistics and Probability for Engineers – Douglas C. Montgomery, Wiley, 7th Edition, 2018. 5. Response Surface Methodology – Raymond H. Myers, Wiley, 4th Edition, 2016.			
NPTEL Links:			

1. Design and Analysis of Experiments – Prof. G. Srinivasan, Indian Institute of Technology Madras, https://nptel.ac.in/courses/110105087
2. Analysis of Variance and Design of Experiments – I – Prof. S. K. Mishra, Indian Institute of Technology Kanpur , https://nptel.ac.in/courses/111104075
3. Quality Design and Control – Prof. K. K. Aggarwal, Indian Institute of Technology Kanpur , https://nptel.ac.in/courses/110105088

ENGINEERING DATA ANALYSIS AND OPTIMIZATION TECHNIQUES			
COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
		Internal Continuous Assessment (ICA) CA:	**25 marks**

Concerned faculty member should suitably frame Six assignments / practicals from the following list.

1. To analyze real-life engineering data using statistical measures and graphical representation.
2. To apply probability distributions (normal and binomial) for solving engineering-related numerical problems.
3. To establish relationships between variables using correlation and regression analysis.
4. To design and analyze a 2-level factorial experiment for studying factor effects.
5. To evaluate the significance of factors using analysis of variance (ANOVA).
6. To optimize process parameters using Taguchi method and S/N ratio analysis.
7. To develop predictive models and optimize responses using Response Surface Methodology.
8. To perform statistical analysis such as regression and ANOVA using statistical software.
9. To apply DOE, Taguchi, and RSM techniques for solving real-world engineering optimization problems.

Text Books

1. Introduction to Probability and Statistics for Engineers and Scientists – Jay L. Devore, Cengage Learning, 9th Edition, 2015.
2. Engineering Optimization: Theory and Practice – Singiresu S. Rao, Wiley, 4th Edition, 2009.

Reference Books

1. Probability and Statistics – T Veerarajan, McGraw Hill Education (India), 2nd Edition, 2008.
2. Design and Analysis of Experiments – Ranjit K. Roy, Wiley, 2nd Edition, 2001.
3. Optimization Techniques – Kalyanmoy Deb, Wiley, 1st Edition, 2005.
4. Applied Statistics and Probability for Engineers – Douglas C. Montgomery, Wiley, 7th Edition, 2018.
5. Response Surface Methodology – Raymond H. Myers, Wiley, 4th Edition, 2016.

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REFRIGERATION AND AIR CONDITIONING MAINTENANCE (VSEC)			
COURSE OUT LINE			
Course Title:	**REFRIGERATION AIR CONDITIONING MAINTENANCE**	**Short Title: RACM**	**Course Code: ME -609**

Course description:

This course focuses on **the** maintenance, servicing, and troubleshooting of refrigeration and air conditioning systems used in domestic and automotive applications. It emphasizes hands-on skills, fault diagnosis, refrigerant handling, and safety practices aligned with industry requirements. Students will develop the ability to inspect, maintain, and repair refrigeration and AC systems**,** including split air conditioners and car air conditioning systems, using modern tools and eco-friendly refrigerants.

	Hours/week	**No. of weeks**	**No. of Lectures**	**Total Credits**
Theory	01	15	15	02
Practical	02	15	30	

Prerequisite course(s):

Basic Thermodynamics, Basic Electrical Engineering, Fundamentals of Heat Transfer

Course objectives:

1. To develop understanding of refrigeration and air conditioning systems from a maintenance and servicing perspective
2. To impart skills in fault diagnosis, troubleshooting, and preventive maintenance
3. To train students in handling refrigerants, charging, evacuation, and leak detection
4. To familiarize students with domestic refrigerators, split AC, and automotive AC systems
5. To promote awareness of environmental regulations and eco-friendly refrigerants

Course outcomes:

After successful completion of this course the student will be able to:

1. Understand and explain the working of refrigeration and air conditioning systems, including the Vapour Compression Refrigeration Cycle, from a maintenance perspective.
2. Perform inspection, preventive maintenance, and servicing of domestic refrigeration systems.
3. Diagnose faults and carry out troubleshooting and repair of refrigeration and air conditioning systems.
4. Handle refrigerants safely and perform charging, evacuation, and leak detection using standard tools and practices.
5. Service split air conditioners and Car Air Conditioning System, and apply safety and environmental guidelines including Kigali Amendment.

COURSE CONTENT

REFRIGERATION AND AIR CONDITIONING MAINTENANCE		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**1 hours/week**		
	No. of Lectures: 15 Hours		

Fundamentals of Refrigeration and Domestic Systems

1. Basic principles of refrigeration , Concept of Vapour Compression Refrigeration Cycle (VCR cycle), electrical components, wiring basics.
2. Types of domestic refrigerators (Direct cool, Frost-free) , Functional understanding of Vapour Compression Refrigeration Cycle from servicing perspective, cleaning, defrosting, gasket inspection
3. Refrigerants: Properties, classification, environmental impact (ODP, GWP)
4. Introduction to eco-friendly refrigerants (R134a, R600a, R290). Overview of Kigali Amendment and its impact on refrigerants
5. Common faults: no cooling, compressor failure, gas leakage, Electrical faults: thermostat, relay, overload protector, servicing and preventive maintenance of domestic refrigeration systems.

Air Conditioning Systems and Maintenance Practices

1. Basics of air conditioning: Psychometric properties and comfort Air conditioning.
2. Construction and servicing practices split AC and Central AC
3. Introduction to Car Air Conditioning System and its components as Compressors, condensers, evaporators, expansion devices , Routine servicing and performance issues in vehicles.
4. Leak detection, refrigerant charging, evacuation process and manifold gauge.
5. Safety practices and tools used in AC maintenance.

Text Books:

1. C. P. Arora, Refrigeration and Air Conditioning, Tata McGraw-Hill
2. R. S. Khurmi & J. K. Gupta, Refrigeration and Air Conditioning, S. Chand
3. P. L. Ballaney, Refrigeration and Air Conditioning, Khanna Publishers

Reference Books:

1. ASHRAE Handbook Refrigeration
2. Refrigeration and Air Conditioning Technology – Bill Whitman, Bill Johnson, John Tomczyk
3. Bureau of Energy Efficiency Manuals on HVAC systems
4. ISHRAE Guidelines for HVAC Maintenance

NPTEL Links:

1. Refrigeration and Air Conditioning – Prof. S. C. Kaushik, Indian Institute of Technology Delhi, https://nptel.ac.in/courses/112105128.
2. RAC Product Design – NPTEL, Prof. Sanjeev Jain & Prof. Bhupinder Godara, IIT Delhi, https://onlinecourses.nptel.ac.in/noc21_me106/preview.

REFRIGERATION AND AIR CONDITIONING MAINTENANCE LAB (ME- 609)			
LAB COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. To study the preventive maintenance of a domestic refrigerator.
2. Study / Evaluate the COP of a domestic refrigerator.
3. To study electrical components and perform basic wiring of a domestic refrigerator.
4. To perform cleaning, defrosting, cleaning and gasket inspection domestic refrigerator.
5. To perform servicing of split Air Conditioning systems.
6. To study components and servicing aspects of automobile air conditioning systems.
7. To perform refrigerant charging, evacuation of Air Conditioning systems.
8. To study refrigerant properties, classification, and environmental impact.
9. To test and service electrical components of split Air Conditioning systems.

Text Books

1. C. P. Arora, Refrigeration and Air Conditioning, Tata McGraw-Hill
2. R. S. Khurmi & J. K. Gupta, Refrigeration and Air Conditioning, S. Chand
3. P. L. Ballaney, Refrigeration and Air Conditioning, Khanna Publishers

Reference Books:

1. ASHRAE Handbook Refrigeration
2. Refrigeration and Air Conditioning Technology – Bill Whitman, Bill Johnson, John Tomczyk
3. Bureau of Energy Efficiency Manuals on HVAC systems
4. ISHRAE Guidelines for HVAC Maintenance

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Honors offered by Mechanical for students of the same Branch of Engineering

In addition to 168 credits of UG Engineering Programmes (Bachelor of Engineering) i.e. Major in which the student has taken admission, a student may opt for Honors in the same Engg. / Tech. discipline / branch / Emerging Areas.

A student is required to study additional 20 credits in the same Engg. / Tech. discipline/ branch / Emerging Areas for Honors distributed over semesters III to VIII.

The total number of credits required for completion of the Honors in the same Engg./ Tech. discipline/ Emerging Areas is 20 credits, in addition to 168 credits in Major.

Students will have to compulsorily choose Honors from the same Engg. / Tech. discipline / branch.

Honors Degree in the Bachelor of Engineering programme shall be awarded to students earning additional total credits of all six semesters from second year to final year, i.e., 20 Credits, in addition to 168 credits or 126 credits respectively. The student admitted in first year must earn 168 credits and 126 credits admitted in lateral entry (admitted after Diploma or B.Sc.) at second year.

Honors offered by Mechanical are as follows.

A. Robotics
B. 3D Printing
C. Energy Engineering

The detail syllabus structure for the same is as follows.

Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY,

JALGAON (M.S.)

Bachelor of Engineering – Honors

In

Robotics

for Third Year Bachelor of Engineering

offered by

Mechanical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology

'A' Grade
NAAC Re-Accredited
(4th Cycle)

SYLLABUS STRUCTURE & COURSE OUTLINE

For Affiliated Colleges

Semester – V & VI

W.E.F. 2026 – 27

Honors in Robotics

Syllabus Structure for Honors in Robotics: Additional Credit (Semester – V) (w.e.f. 2026 – 27)
(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 510A	Robotics Instrumentation	PCC	3			3	40	60			100	3
ME - 511A	Robotics Instrumentation lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for Honors in Robotics: Additional Credit (Semester – VI) (w.e.f. 2026 – 27)
(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 612A	Mechatronics and Embedded Systems	PCC	3			3	40	60			100	3
ME - 613A	Mechatronics and Embedded Systems Lab.	PCC			2	2			25	25 (OR)	50	1

ROBOTICS INSTRUMENTATION (PCC)			
COURSE OUT LINE			
Course Title:	**ROBOTICS INSTRUMENTATION**	**Short Title: RI**	**Course Code: ME-510A**

Course description:

This course introduces the basic concepts of robotic systems and the instrumentation used in robotics. The course covers sensors, actuators, robot control, and programming techniques. It also focuses on the application of robots in industrial automation and modern manufacturing systems

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Engineering Mathematics, Basic Physics ,Electronics, Programming Basics

Course objectives:

1. To introduce the basic concepts and structure of robotic systems.
2. To understand sensors and instrumentation used in robotics.
3. To study actuators, drive systems, and robot control techniques.
4. To learn robot programming methods and automation applications.
5. To understand industrial robotics and modern trends in robotic instrumentation.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain the basic concepts and components of robotic systems.
2. Identify and analyze sensors and instrumentation used in robotics.
3. Understand actuators and drive systems used in robotic mechanisms.
4. Apply robot control techniques and programming methods.
5. Analyze industrial applications and safety aspects of robotic systems.

COURSE CONTENT

ROBOTICS INSTRUMENTATION		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Robotics:	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to robotics, History and evolution of robots, Components of robotic systems, Classification of robots, Robot anatomy and degrees of freedom, Applications of robotics in industrial automation and instrumentation.

Unit–II: Sensors and Instrumentation in Robotics	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to sensors in robotics ,Position and displacement sensors ,Proximity sensors, Force and torque sensors ,Vision sensors and cameras ,Signal conditioning and data acquisition systems .

Unit–III: Actuators and Drive Systems	**No. of Lectures: 09 Hours**	**Marks: 12**
Introduction to actuators, Electric actuators (DC motors, stepper motors, servo motors) ,Hydraulic actuators ,Pneumatic actuators, Robot drive systems ,Power transmission systems in robots .		
Unit–IV: Robot Control and Programming	**No. of Lectures: 09 Hours**	**Marks: 12**
Robot control systems ,Open loop and closed loop control ,Robot programming methods ,Teach pendant programming ,Offline programming ,Introduction to robot simulation tools .		
Unit–V: Industrial Robotics and Applications	**No. of Lectures: 09 Hours**	**Marks: 12**
Industrial robotic systems, Robotic automation in manufacturing, Robotic assembly systems, Robotic inspection and quality control, Safety in robotic systems, Future trends in robotics and intelligent instrumentation.		
Text Books:		
1. Introduction to Robotics: Mechanics and Control – John J. Craig 2. Robotics: Control, Sensing, Vision, and Intelligence – K. S. Fu, R. C. Gonzalez, C. S. G. Lee		
Reference Books:		
1. Industrial Robotics: Technology, Programming and Applications – Mikell P. Groover 2. Robot Modeling and Control – Mark W. Spong 3. Robotics Engineering: An Integrated Approach – Richard D. Klafter		
NPTEL Links: 1. Robotics – Prof. D. K. Pratihar (IIT Kharagpur) https://onlinecourses.nptel.ac.in/noc25_me166 **2.** Robotics and Control – Prof. N. Sukavanam (IIT Roorkee) https://onlinecourses.nptel.ac.in/noc24_me18 **3.** Control Engineering for Robotics – Prof. Chayan Bhawal (IIT Guwahati) https://onlinecourses.nptel.ac.in/noc26_ee02		

ROBOTICS INSTRUMENTATION LAB (ME-511A)			
LAB COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**
Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list. 1. To study the basic components and structure of a robotic system. 2. To understand the different joints and degrees of freedom in a robotic arm. 3. To study various sensors used for measurement and control in robotic systems.			

4. To interface and test the operation of a proximity sensor with a robotic controller
5. To study the position control of a servo motor used in robotic systems.
6. To study the operation and control of a stepper motor used in robotic
7. To learn basic robot programming and movement control using a teach pendant.
8. To perform pick and place operation using a robotic arm.
9. To study and implement robot simulation using suitable software and analyze robot motion and task execution.

Text Books

1. Introduction to Robotics: Mechanics and Control – John J. Craig
2. Robotics: Control, Sensing, Vision, and Intelligence – K. S. Fu, R. C. Gonzalez, C. S. G. Lee

Reference Books:

1. Industrial Robotics: Technology, Programming and Applications – Mikell P. Groover
2. Robot Modeling and Control – Mark W. Spong
3. Robotics Engineering: An Integrated Approach – Richard D. Klafter

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guidelines for ESE:

ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on the understanding and quality of lab work.

MECHATRONICS AND EMBEDDED SYSTEMS (PCC)			
COURSE OUT LINE			
Course Title:	**MECHATRONICS AND EMBEDDED SYSTEMS**	**Short Title: M&ES**	**Course Code: ME-612A**

Course description:

This course integrates mechanical engineering systems with sensors, actuators, microcontrollers, embedded processors, PLCs, communication interfaces, and intelligent control algorithms. It focuses on the design and integration of smart mechatronic products, embedded control units, machine monitoring systems, robotic modules, and IoT-enabled manufacturing devices. Students develop competency in real-time interfacing, signal acquisition, firmware logic, feedback control, and cyber-physical machine systems, aligned with AICTE NEP 2020 experiential and interdisciplinary learning principles.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
	02	15	30	

Prerequisite course(s):

Basic Electrical & Electronics, Kinematics and Dynamics of Machines, Instrumentation and Control, C Programming / Arduino Basics, CAD / MATLAB Fundamentals

Course objectives:

1. To understand integrated mechatronic and embedded system architecture.
2. To study sensors, actuators, signal conditioning, and microcontroller interfacing.
3. To develop embedded control logic for mechanical systems.
4. To analyze feedback control, communication, and real-time data acquisition.
5. To apply IoT and smart monitoring in mechanical automation systems.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain architecture of mechatronic and embedded systems
2. Interface sensors and actuators with microcontrollers
3. Analyze embedded control logic and communication protocols
4. Evaluate real-time feedback and monitoring systems
5. Design smart embedded solutions for mechanical applications

COURSE CONTENT

MECHATRONICS AND EMBEDDED SYSTEMS		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Fundamentals of Mechatronics and Embedded Systems	**No. of Lectures: 09 Hours**	**Marks: 12**

Mechatronic system architecture, Mechanical–electronic integration, Embedded system fundamentals, Real-time systems basics, Sensors, Signal conditioning, Data acquisition, Smart machine examples

Unit–II: Sensors, Actuators and Microcontroller	**No. of Lectures: 09 Hours**	**Marks: 12**

Interfacing		
DC motor, stepper motor, servo motor, Solenoids and relays, Pneumatic and electro-pneumatic actuators, ADC / DAC basics,, Arduino / ESP32 / ARM Cortex basics, Sensor interfacing, Motor driver circuits, Embedded safety logic		
Unit–III: Embedded Programming and Communication	**No. of Lectures: 09 Hours**	**Marks: 12**
Embedded C fundamentals, State machine logic, Timers and counters, Serial communication, CAN bus basics, PLC–microcontroller integration, Edge devices in smart machines, Real-time debugging and testing		
Unit–IV: Control Systems and Mechatronic Applications	**No. of Lectures: 09 Hours**	**Marks: 12**
Open-loop and closed-loop systems, PID control basics, Speed and position control, CNC axis control, Servo control systems, Robotic joint actuation, Pick-and-place automation, Smart conveyor systems, Mechatronic product case studies		
Unit–V: IoT, Industry 4.0 and Smart Manufacturing	**No. of Lectures: 09 Hours**	**Marks: 12**
IoT-enabled machine monitoring, MQTT and cloud dashboards, Predictive maintenance, Edge analytics basics, PLC + SCADA integration, Embedded vision basics, Digital twin introduction, Smart factory architecture, AI-enabled machine diagnostics		
Text Books:		
1. W. Bolton – Mechatronics 2. N.P. Mahalik – Mechatronics: Principles, Concepts and Applications 3. Raj Kamal – Embedded Systems 4. K. Ogata – Modern Control Engineering		
Reference Books: 1. Devdas Shetty – Mechatronics System Design 2. Frank Vahid – Embedded System Design 3. Bishop – Sensors and Actuators in Mechatronics 4. ARM / Arduino official documentation		
NPTEL		
1. Introduction to Mechatronics – Prof. D. K. Pratihar, Indian Institute of Technology Kharagpur – https://nptel.ac.in/courses/112105268		

MECHATRONICS AND EMBEDDED SYSTEMS LAB (ME-613A)			
COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**
Concerned faculty member should suitably frame Six assignments / practicals from the following list. 1. Temperature sensor interfacing with Arduino 2. Stepper motor control using driver module			

3. Servo motor position control 4. PID motor speed control simulation 5. UART communication experiment 6. CAN / RS485 machine node communication 7. IoT dashboard for machine monitoring 8. PLC + sensor conveyor automation 9. ESP32 wireless machine data logger
Text Books:
1. W. Bolton – Mechatronics 2. N.P. Mahalik – Mechatronics: Principles, Concepts and Applications 3. Raj Kamal – Embedded Systems 4. K. Ogata – Modern Control Engineering
Reference Books:
1. Devdas Shetty – Mechatronics System Design 2. Frank Vahid – Embedded System Design 3. Bishop – Sensors and Actuators in Mechatronics 4. ARM / Arduino official documentation
Guidelines for ICA:
Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.
Guidelines for ESE:
ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on the understanding and quality of lab work.

Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY,

JALGAON (M.S.)

Bachelor of Engineering – Honors

In

3D Printing

for Third Year Bachelor of Engineering

offered by

Mechanical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology

'A' Grade
NAAC Re-Accredited
(4th Cycle)

SYLLABUS STRUCTURE & COURSE OUTLINE

For Affiliated Colleges

Semester – V & VI

W.E.F. 2026 – 27

Honors in 3D Printing

Syllabus Structure for Honors in 3D Printing: Additional Credit (Semester – V) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 510B	Material characterization Techniques in 3D printing	PCC	3			3	40	60			100	3
ME - 511B	Material characterization Techniques in 3D printing lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for Honors in 3D Printing: Additional Credit (Semester – VI) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 612B	Rapid tooling and industrial processes	PCC	3			3	40	60			100	3
ME - 613B	Rapid tooling and industrial processes lab	PCC			2	2			25	25 (OR)	50	1

MATERIAL CHARACTERIZATION TECHNIQUES IN 3D PRINTING (PCC)			
COURSE OUT LINE			
Course Title:	**MATERIAL CHARACTERIZATION TECHNIQUES IN 3D PRINTING**	**Short Title: MCT3DP**	**Course Code: ME-510B**

Course description:

This course is introduced to bridge the gap between manufacturing processes and material performance evaluation, enabling students to gain expertise in modern characterization tools and quality assurance practices. Strengthening student competency in advanced manufacturing, materials engineering, failure analysis, and AI-assisted inspection systems. The course is highly relevant for Industry 4.0, digital manufacturing, smart factories, and research in sustainable materials for additive manufacturing.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Engineering Materials, Manufacturing Processes, Basics of 3D Printing / Additive Manufacturing, Materials Science

Course objectives:

1. Understand the need for characterization of 3D printed materials.
2. Study microstructural, mechanical, thermal and surface characterization methods.
3. Analyze defects, porosity, anisotropy and layer bonding in AM parts.
4. Correlate material properties with process parameters.
5. Develop skills for quality validation of polymer, metal and composite AM parts.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain characterization requirements in additive manufacturing.
2. Use microscopy and spectroscopy techniques for AM materials.
3. Evaluate thermal and mechanical behavior of printed components.
4. Analyze defects and failure in 3D printed structures.
5. Select suitable characterization techniques for polymers, metals and composites.

COURSE CONTENT

MATERIAL CHARACTERIZATION TECHNIQUES IN 3D PRINTING		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Material Characterization in 3D Printing	**No. of Lectures: 09 Hours**	**Marks: 12**

Importance of characterization in additive manufacturing, Relationship between process–structure–property, Material forms used in 3D printing, Characterization needs, Print defects, Standards overview.

Unit–II: Microstructural	**No. of Lectures: 09 Hours**	**Marks: 12**

Characterization Techniques		
Optical microscopy, Stereo microscopy, Metallographic sample preparation, Grain structure analysis, Phase identification, Porosity analysis, Crack detection, SEM (Scanning Electron Microscopy), EDS / EDX elemental analysis, TEM basics		
Unit–III: Thermal and Chemical Characterization	**No. of Lectures: 09 Hours**	**Marks: 12**
DSC (Differential Scanning Calorimetry), TGA (Thermogravimetric Analysis), DMA of printed polymers, Thermal degradation study, Glass transition temperature, Melting and crystallization behavior, FTIR spectroscopy, Raman spectroscopy, XRD for phase identification, Residual stress measurement basics		
Unit–IV: Mechanical Characterization of 3D Printed Parts	**No. of Lectures: 09 Hours**	**Marks: 12**
Tensile testing as per ASTM, Compression testing, Flexural testing, Impact testing, Hardness testing, Creep behavior, Anisotropic property evaluation		
Unit–V: Surface and Dimensional Characterization	**No. of Lectures: 09 Hours**	**Marks: 12**
Surface roughness measurement, Profilometer, AFM basics, Surface waviness, Layer height effect, Dimensional accuracy, Coordinate Measuring Machine (CMM), 3D scanning, CT scan for internal defect analysis, Tolerance verification, Geometrical deviation analysis, Print accuracy benchmarking		

Text Books:

1. Ian Gibson, David Rosen, Brent Stucker – Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer.
2. Chee Kai Chua, Kah Fai Leong – 3D Printing and Additive Manufacturing: Principles and Applications, World Scientific.
3. Andreas Gebhardt, Jan-Steffen Hötter – Additive Manufacturing: 3D Printing for Prototyping and Manufacturing, Hanser / Springer.

Reference Books:

1. S. Kumar, J. P. Davim – Materials Forming, Machining and Characterization, Elsevier.
2. Elsevier – Characterization Techniques for Advanced Polymer Composite Materials (useful for polymer AM and composite filaments).
3. ASTM / ISO Standards on Additive Manufacturing testing, specimen preparation, and process qualification.
4. Research papers on SEM, XRD, DSC, CT scan, and porosity analysis of 3D printed materials for advanced study.
5. ASM Handbook, Volume on Materials Characterization and failure analysis methods for metals, polymers, and composites.

NPTEL Links:

1. Fundamentals of Additive Manufacturing Technologies – Prof. Suryakumar S, Indian Institute of Technology Madras – https://nptel.ac.in/courses/112106348
2. Advances in Additive Manufacturing of Materials – Prof. B.S. Murty, Indian Institute of Technology Madras – https://nptel.ac.in/courses/113106092
3. Metal Additive Manufacturing – Prof. DebRoy Tarasankar, Pennsylvania State University– https://nptel.ac.in/courses/112104265

4. Characterization of Materials – Prof. S. Sampath Kumar, Indian Institute of Science Bangalore – https://nptel.ac.in/courses/113106031
5. Navigating the Latest Trends in Additive Manufacturing Landscape – Prof. Suryakumar S, Indian Institute of Technology Madras – https://nptel.ac.in/courses/112106363

MATERIAL CHARACTERIZATION TECHNIQUES IN 3D PRINTING (ME-511B)			
COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Practical	**2 Hours / week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**

Concerned faculty member should suitably frame Six assignments / practicals from the following list.

1. Tensile test on PLA and ABS printed specimens
2. Surface roughness measurement of FDM parts
3. SEM image analysis of layer bonding
4. DSC analysis of PLA printed sample
5. TGA of recycled filament
6. XRD analysis of metal printed specimen
7. CT scan defect study of lattice structure
8. Dimensional inspection using Vernier/CMM
9. Failure analysis of broken tensile specimen

Text Books:

1. Ian Gibson, David Rosen, Brent Stucker – Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer.
2. Chee Kai Chua, Kah Fai Leong – 3D Printing and Additive Manufacturing: Principles and Applications, World Scientific.
3. Andreas Gebhardt, Jan-Steffen Hötter – Additive Manufacturing: 3D Printing for Prototyping and Manufacturing, Hanser / Springer.

Reference Books:

1. S. Kumar, J. P. Davim – Materials Forming, Machining and Characterization, Elsevier.
2. Elsevier – Characterization Techniques for Advanced Polymer Composite Materials
3. ASM Handbook, Volume on Materials Characterization and failure analysis methods for metals, polymers, and composites. (useful for polymer AM and composite filaments).
4. ASTM / ISO Standards on Additive Manufacturing testing, specimen preparation, and process qualification.

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guidelines for ESE:

ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on the understanding and quality of lab work.

RAPID TOOLING AND INDUSTRIAL PROCESSES (PCC)			
COURSE OUT LINE			
Course Title:	**RAPID TOOLING AND INDUSTRIAL PROCESSES**	**Short Title: RT&IP**	**Course Code: ME-612B**

Course description:

This course introduces the fundamentals of rapid tooling and its role in modern industrial manufacturing. It covers techniques used to quickly develop molds, dies, and tools using advanced methods such as additive manufacturing and CAD/CAM. The course also provides an overview of key industrial processes like casting, machining, forming, and injection molding, with focus on reducing production time, cost, and improving product quality. This course aligns with NEP 2020 by promoting skill-based and multidisciplinary learning in advanced manufacturing technologies. It emphasizes experiential learning through practical exposure to rapid tooling and industrial processes. The course supports industry relevance and employability by integrating modern tools such as CAD/CAM and additive manufacturing. It also encourages innovation, problem-solving and critical thinking, preparing students for emerging trends in Industry 4.0 and sustainable manufacturing.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Manufacturing Processes, Engineering Materials / Material Science, Basics of CAD/CAM (preferred).

Course objectives:

1. To understand the concept and importance of rapid tooling in industry
2. To study different rapid tooling techniques and their applications
3. To gain knowledge of various industrial manufacturing processes
4. To analyse material selection, cost, and quality considerations
5. To develop the ability to select suitable processes for manufacturing applications

Course outcomes:

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

1. Explain fundamentals of rapid tooling, prototyping, and CAD/CAM integration.
2. Describe rapid tooling techniques, materials, and design considerations.
3. Apply additive manufacturing processes in tooling applications.
4. Apply and analyse industrial manufacturing processes and defects.
5. Analyze process planning, cost, quality, and Industry 4.0 concepts.

COURSE CONTENT

RAPID TOOLING AND INDUSTRIAL PROCESSES		**Semester:**	**VI**
Teaching Scheme:		**Examination Scheme**	
Lectures	**3 hours/week**	**End Semester Theory Exam (ESE) - UA:**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Theory Exam (ISE) - CA:	**40 marks**

:		**Practical Internal Continuous Assessment (ICA) - CA**	**25 marks**
Unit–I: Introduction to Rapid Tooling and Industrial Processes		**No. of Lectures: 09 Hours**	**Marks: 12**
Overview of manufacturing and need for rapid tooling, Concept of rapid prototyping and its role in product development, Definition and classification of rapid tooling (Direct and Indirect tooling),Advantages and limitations of rapid tooling, Comparison between conventional tooling and rapid tooling, Introduction to CAD/CAM integration in tooling design, Overview of additive manufacturing processes used in tooling, Applications of rapid tooling in automotive, aerospace, and consumer industries			
Unit–II: Rapid Tooling Techniques		**No. of Lectures: 09 Hours**	**Marks: 12**
Direct rapid tooling methods (SLS, SLA, DMLS, etc.),Indirect rapid tooling methods (pattern-based techniques),Soft tooling and bridge tooling concepts, Materials used in rapid tooling, Tool design considerations for rapid tooling, Accuracy, surface finish, and limitations, Case studies of rapid tooling applications			
Unit–III: Additive Manufacturing in Tooling		**No. of Lectures: 09 Hours**	**Marks: 12**
. Fundamentals of additive manufacturing (AM),Types of AM processes (FDM, SLA, SLS, Binder Jetting, etc.),Role of AM in mold and die making, Hybrid manufacturing processes Design for additive manufacturing, Post-processing techniques, Applications and industrial examples			
Unit–IV: Industrial Manufacturing Processes		**No. of Lectures: 09 Hours**	**Marks: 12**
Overview of casting processes (sand casting, die casting),Machining processes (turning, milling, drilling), Forming processes (forging, rolling, extrusion),Injection molding and plastic processing, Process selection criteria, Process parameters and quality control, Defects and their remedies			
Unit–V: Process Planning, Economics and Applications		**No. of Lectures: 09 Hours**	**Marks: 12**
Process planning for rapid tooling, Cost analysis and time estimation, Quality assurance and inspection techniques, Integration of CAD/CAM in manufacturing, Industry 4.0 concepts in tooling and manufacturing, Sustainability and eco-friendly manufacturing, Industrial case studies and recent trends			
Text Books			
1. Shiva, S., & Shukla, A. K. (2024). Additive manufacturing technologies. Wiley India. 2. Kumar, L. J., Pandey, P. M., & Wimpenny, D. I. (2019). 3D printing and additive manufacturing technologies. Springer. 3. Babbar, A., Sharma, A., & Jain, V. (Eds.). (2023). Additive manufacturing processes in biomedical engineering. CRC Press. 4. Gebhardt, A. (2012). Understanding additive manufacturing: Rapid prototyping, rapid tooling, rapid manufacturing. Hanser Publications.			
Reference Books:			

1. Kumar, S. (2022). Additive manufacturing solutions. Springer.
2. Kumar, S. (2025). A concise encyclopedia of additive manufacturing. Springer.
3. Paul, C. P., & Jinoop, A. N. (2021). Additive manufacturing: Principles, technologies and applications. McGraw Hill Education.
4. Rathee, S., Srivastava, M., & Davim, J. P. (Eds.). (2026). Metal additive manufacturing: Methods, materials and applications. Springer.
5. Gibson, I., Rosen, D. W., & Stucker, B. (2015). Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing (2nd ed.).
6. Gibson, I., Rosen, D. W., & Stucker, B. (2021). Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing (3rd ed.). Springer

NPTEL Links:

1. Rapid prototyping, rapid tooling, additive manufacturing, CAD/CAM integration, reverse engineering – J. Ramkumar – Indian Institute of Technology Kanpur – https://nptel.ac.in/courses/112104306
2. Additive manufacturing processes (FDM, SLA, SLS), materials, design, industrial applications – Sajan Kapil – Indian Institute of Technology Guwahati – https://nptel.ac.in/courses/112103306

RAPID TOOLING AND INDUSTRIAL PROCESSES LAB (ME-613B)			
LAB COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical	**2 hours / week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. To study different rapid prototyping and rapid tooling processes (SLA, SLS, FDM).
2. To create a basic CAD model of a simple component.
3. To perform slicing of an STL file using 3D printing software.
4. To fabricate a simple component using 3D printing.
5. To study and demonstrate indirect rapid tooling techniques.
6. To measure and compare dimensional accuracy and surface finish of printed parts.
7. To observe CNC machine operations.
8. To measure dimensions of a printed part using a vernier calliper.
9. To study mold and die components through demonstration.

Text Books

1. Shiva, S., & Shukla, A. K. (2024). Additive manufacturing technologies. Wiley India.
2. Kumar, L. J., Pandey, P. M., & Wimpenny, D. I. (2019). 3D printing and additive manufacturing technologies. Springer.
3. Babbar, A., Sharma, A., & Jain, V. (Eds.). (2023). Additive manufacturing processes in biomedical engineering. CRC Press.
4. Gebhardt, A. (2012). Understanding additive manufacturing: Rapid prototyping, rapid tooling, rapid manufacturing. Hanser Publications.

Reference Books:

1. Kumar, S. (2022). Additive manufacturing solutions. Springer.
2. Kumar, S. (2025). A concise encyclopedia of additive manufacturing. Springer.
3. Paul, C. P., & Jinoop, A. N. (2021). Additive manufacturing: Principles, technologies and applications. McGraw Hill Education.
4. Rathee, S., Srivastava, M., & Davim, J. P. (Eds.). (2026). Metal additive manufacturing: Methods, materials and applications. Springer.
5. Gibson, I., Rosen, D. W., & Stucker, B. (2015). Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing (2nd ed.).
6. Gibson, I., Rosen, D. W., & Stucker, B. (2021). Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing (3rd ed.). Springer.

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guidelines for ESE:

ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on the understanding and quality of lab work.

Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY,

JALGAON (M.S.)

Bachelor of Engineering – Honors

In

Energy Engineering

for Third Year Bachelor of Engineering

offered by

Mechanical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology



SYLLABUS STRUCTURE & COURSE OUTLINE

For Affiliated Colleges

Semester – V & VI

W.E.F. 2026 – 27

Honors in Energy Engineering

Syllabus Structure for Honors in Energy Engineering: Additional Credit (Semester – V) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 510C	Energy Conservation, Audit and Management	PCC	3			3	40	60			100	3
ME - 511C	Energy Conservation, Audit and Management lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for Honors in Energy Engineering: Additional Credit (Semester – VI) (w.e.f. 2026 – 27)

(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 612C	Energy Environment and Impact Analysis	PCC	3			3	40	60			100	3
ME - 613C	Energy Environment and Impact Analysis lab	PCC			2	2			25	25 (OR)	50	1

ENERGY CONSERVATION, AUDIT AND MANAGEMENT (PCC)			
COURSE OUT LINE			
Course Title:	**ENERGY CONSERVATION, AUDIT AND MANAGEMENT**	**Short Title: ECAM**	**Course Code: ME-510C**

Course description:

This course focuses on the principles of energy conservation, energy auditing, and efficient energy management practices in industrial and commercial sectors. It introduces students to energy resources, consumption patterns, and the need for energy efficiency. The course covers energy audit methodologies, electrical and thermal energy conservation techniques, and economic evaluation of energy-saving measures. It also emphasizes practical approaches for identifying, analyzing, and implementing energy conservation opportunities in real-world systems.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Engineering Thermodynamics, Engineering Mathematics, Basic Physics

Course objectives:

1. To understand energy resources, energy demand, and the need for conservation.
2. To learn energy audit principles, procedures, and measurement techniques.
3. To analyze electrical and thermal systems for improving energy efficiency.
4. To evaluate energy conservation opportunities using economic methods.
5. To develop skills for implementing effective energy management practices in industries.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain energy concepts, sources, and conservation principles in real-world context.
2. Apply energy audit methodologies and use basic instruments for data collection and analysis.
3. Analyze electrical systems and suggest methods for improving energy efficiency.
4. Evaluate thermal systems for energy conservation and waste heat recovery.
5. Apply energy management techniques and economic analysis for energy-saving decisions.

COURSE CONTENT

ENERGY CONSERVATION, AUDIT AND MANAGEMENT		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Energy and Conservation	**No. of Lectures: 09 Hours**	**Marks: 12**

Definition and forms of energy , Units and conversions of energy , Global and Indian energy scenario , Energy demand and supply gap , Renewable and non-renewable energy sources, Need and importance of energy conservation , Basic concepts of energy efficiency, Energy intensity and benchmarking in industries, Overview of national energy policies and **Bureau of Energy Efficiency** initiatives

Unit–II: Energy Audit Fundamentals	**No. of Lectures: 09 Hours**	**Marks: 12**
Definition and objectives of energy audit ,Types: Preliminary and Detailed energy audit ,Energy audit methodology , Data collection and analysis , Instruments used in energy audit, Preparation of energy audit report and recommendation techniques, Introduction to energy audit software tools		
Unit–III: Electrical Energy Conservation	**No. of Lectures: 09 Hours**	**Marks: 12**
Electrical load management ,Energy efficient motors and transformers ,Power factor improvement ,Lighting systems (LED vs conventional) ,Energy saving using Variable Frequency Drives (VFD) , Energy efficiency in pumps, fans and compressors, harmonics in electrical systems		
Unit–IV: Thermal Energy Conservation	**No. of Lectures: 09 Hours**	**Marks: 12**
Boilers and efficiency improvement , Steam system management , Furnaces and waste heat recovery , Insulation and heat loss reduction , Cogeneration and combined heat & power (CHP), Energy efficiency in HVAC and refrigeration systems, Thermic fluid heaters.		
Unit–V:Energy Management & Economics	**No. of Lectures: 09 Hours**	**Marks: 12**
Energy management system (EMS) , Energy policies and standards (ISO 50001 basics), Demand-side management , Energy economics: Payback period, ROI, Life Cycle Costing (LCC) , Energy conservation opportunities, Application of IoT, AI, and data analytics in energy management, Case studies of energy conservation in industries.		

Text Books:

1. Energy Management, Audit and Conservation , Barun Kumar De, Vrinda Publications.
2. Handbook on Energy Audit and Environment Management, Y. P. Abbi,, TERI, India
3. Energy Management , Dr. Sanjeev Singh, Umesh Rathore , S.K. Kataria & Sons

Reference Books:

1. Industrial Energy Conservation Techniques ,S. C. Tripathy, New Age International
2. Energy Management Handbook , Wayne C. Turner , John Wiley & Sons
3. Handbook of Energy Audits, Albert Thumann , Fairmont Press
4. Guide to Energy Management ,Barney L. Capehart , CRC Press
5. Energy Management and Conservation Handbook , Frank Kreith, D. Yogi Goswami ,CRC Press
6. Energy Audit and Management: Concept, Methodologies, Procedures and Case Studies , L. Ashok Kumar, Gokul Ganesan , CRC Press.

NPTEL Links:

1. Energy Conservation & Management: Prof. L. Umanand ,Indian Institute of Science https://nptel.ac.in/courses/108108067
2. Energy Management & Audit Concepts: Prof. A. K. Singh , Indian Institute of Technology Delhi https://nptel.ac.in/courses/112102018
3. Electrical Energy Systems : Electrical Energy Systems , Prof. D. P. Kothari , Indian Institute of Technology Delhi https://nptel.ac.in/courses/108102047

ENERGY CONSERVATION, AUDIT AND MANAGEMENT LAB (ME-511 C)			
LAB COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. To analyze energy consumption data (electricity bills/load data) and understand energy usage pattern, demand variation, and scope for energy conservation.
2. To measure voltage, current, power, and power factor using electrical instruments and understand their role in energy audit.
3. o compare energy consumption and efficiency of different lighting systems (LED, CFL, incandescent) and evaluate energy saving potential.
4. To study the effect of low power factor and determine improvement using capacitor bank with basic calculations.
5. To determine the efficiency of an electric motor under different loading conditions and identify energy saving opportunities.
6. To study the efficiency of a boiler/heating system using standard methods and understand thermal energy losses.
7. To study heat loss in a system and evaluate the effectiveness of insulation materials in reducing energy loss.
8. To analyse energy savings achieved by using Variable Frequency Drive (VFD) in pumps or fans under varying load conditions.
9. To conduct a basic energy audit of a laboratory/building, identify energy conservation opportunities, and estimate potential energy and cost savings.

Text Books

1. Energy Management, Audit and Conservation , Barun Kumar De, Vrinda Publications.
2. Handbook on Energy Audit and Environment Management, Y. P. Abbi,, TERI, India

Reference Books:

1. Energy Management , Dr. Sanjeev Singh, Umesh Rathore , S.K. Kataria & Sons
2. Energy Audit and Management: Concept, Methodologies, Procedures and Case Studies , L. Ashok Kumar, Gokul Ganesan , CRC Press.

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guidelines for ESE:

ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on the understanding and quality of lab work.

ENERGY ENVIRONMENT AND IMPACT ANALYSIS (PCC)			
COURSE OUT LINE			
Course Title:	**ENERGY ENVIRONMENT AND IMPACT ANALYSIS**	**Short Title: EEIA**	**Course Code: ME-612C**

Course description:

This course focuses on evaluating the environmental impacts associated with various energy systems, including fossil fuels, nuclear, and renewable energy sources. It introduces analytical tools, sustainability concepts, and policy frameworks used to assess and mitigate environmental effects.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Engineering Thermodynamics, Engineering Mathematics, Basic Physics

Course objectives:

1. Understand various energy resources and their environmental implications
2. Analyze the impact of energy production and consumption
3. Apply tools for environmental and impact assessment
4. Evaluate sustainable energy solutions

Course outcomes:

After successful completion of this course the student will be able to:

1. Assess environmental impacts of different energy systems
2. Apply EIA and LCA methodologies
3. Propose sustainable and eco-friendly energy solutions
4. Understand environmental regulations and policies

COURSE CONTENT

ENERGY ENVIRONMENT AND IMPACT ANALYSIS		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Energy Systems:	**No. of Lectures: 09 Hours**	**Marks: 12**

Definition and classification of energy, Primary vs secondary energy, Energy demand and supply trends (global & national), Energy conversion processes, Energy efficiency and conservation principles

Unit–II Conventional Energy Resources	**No. of Lectures: 09 Hours**	**Marks: 12**

Fossil fuels: coal, oil, natural gas, Thermal power plants – working and efficiency, nuclear energy: principles, advantages, risks, Environmental issues: Air pollution, Greenhouse gas emissions, Resource depletion

Unit–III: Renewable Energy Resources	**No. of Lectures: 09 Hours**	**Marks: 12**

Solar energy (PV and thermal systems), Wind energy systems, Hydropower, Biomass and bioenergy, Geothermal and tidal energy, Comparison: renewable vs conventional energy

Unit–IV: Energy and Environment	**No. of Lectures: 09 Hours**	**Marks: 12**
Energy–environment relationship, Ecosystem impacts of energy projects, Climate change and global warming, Carbon footprint and energy use, Concepts of sustainability and sustainable development		
Unit–V Energy Economics and Policy	**No. of Lectures: 09 Hours**	**Marks: 12**
Energy pricing and market structures, Cost-benefit analysis, Energy policies and regulations International agreements (e.g., Paris Agreement), Government initiatives for sustainable energy		

Text Books:

1. Environmental Impact Assessment, Author: Larry W. Canter, Publisher: McGraw-Hill, New York
2. Energy and Environment Authors: Robert A. Hinrichs, Merlin Kleinbach, William D. Reisner Publisher: Cengage Learning
3. Energy Systems Evaluation: Sustainability Assessment Authors: Francisca Morgado-Dias et al. Publisher: Springer
4. Environmental Impact Assessment Editor: Judith Rosales Publisher: Delve Publishing
5. Sustainable Energy Systems Engineering Author: W. G. J. H. M. van Sark (and others depending on edition) Publisher: Academic Press / Elsevier

Reference Books:

1. Environmental Energy Impact Analysis Authors: S. Krishna Shukla, P. Rajeev Srivastava Publisher: Commonwealth Publishers
2. A Handbook of Environment Impact Assessment Authors: V. S. Kulkarni, S. N. Kaul, R. K. Trivedi Publisher: Scientific Publishers, India
3. Sustainable Energy and the Environment: A Clean Technology Approach Authors: N. D. Kaushika, K. S. Reddy, Kshitij Kaushik Publisher: Springer (Cham)

NPTEL Links:

1. Environmental Impact Assessment (EIA) Prof. Harshit Sosan Lakra (IIT Roorkee) https://onlinecourses.nptel.ac.in/noc26_ar13/preview?utm_
2. Energy Resources, Economics and Environment Prof. Rangan Banerjee IIT Bombay https://elearn.nptel.ac.in/shop/nptel/energy-resources-economics-and-environment/?utm
3. Energy Resources, Economics, and Sustainability Prof. Pratham Arora | https://onlinecourses.nptel.ac.in/noc25_hs86/preview?utm
4. Environmental Planning and Management Prof. Sonal K. Thengane | IIT Roorkee https://onlinecourses.nptel.ac.in/noc26_ge08/preview?utm

ENERGY ENVIRONMENT AND IMPACT ANALYSIS LAB (ME-613C)			
LAB COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**

Concerned faculty member should suitably frame FOUR laboratory assignments / practicals from the following list.

1. Energy Audit of a Building
   Objective: To evaluate energy consumption in a residential/commercial building
   a. Collect electricity usage data (bills, appliances)
   b. Identify major energy-consuming devices
   c. Calculate total energy consumption (kWh)
   d. Suggest energy-saving measures
2. Solar Panel Performance Analysis
   Objective: To study efficiency of a solar PV system
   a. Measure solar irradiance
   b. Record voltage and current output
   c. Calculate efficiency
3. Carbon Footprint Calculation
   Objective: To estimate institutional carbon emissions
   a. Collect data on energy use, transport, waste
   b. Apply emission factors
   c. Calculate CO_2 equivalent emission
4. Air Quality Monitoring
   Objective: To measure ambient air quality parameters
   a. Measure PM, SO_2, NOx levels using sensors
   b. Compare with permissible standards
5. Environmental Impact Assessment (Mini Project)
   Objective: To conduct a basic Environmental Impact Assessment for a small project
   a. Select a project (road, plant, building)
   b. Identify impacts using checklist/matrix and Suggest mitigation measures
6. To study the Energy Systems and Emission Estimation , study the Comparative Analysis: Coal vs Gas vs Renewable.
7. Study of Electrostatic Precipitator / Cyclone Separator (Model)
   Efficiency evaluation.
8. To study the Air Quality issues due to of particulate matter (PM2.5/PM10) CO_2 and SO_2 a case study.
9. To study the methods to measure Calorific Value of Fuels and Compare of CV of different fuels

Text Books

1. Environmental Impact Assessment, Author: Larry W. Canter, Publisher: McGraw-Hill, New York
2. Energy and Environment Authors: Robert A. Hinrichs, Merlin Kleinbach, William D. Reisner Publisher: Cengage Learning
3. Energy Systems Evaluation: Sustainability Assessment Authors: Francisca Morgado-Dias et al. Publisher: Springer
4. Environmental Impact Assessment Editor: Judith Rosales Publisher: Delve Publishing
5. Sustainable Energy Systems Engineering Author: W. G. J. H. M. van Sark (and others depending on edition) Publisher: Academic Press / Elsevier

Reference Books:

1. Environmental Energy Impact Analysis Authors: S. Krishna Shukla, P. Rajeev Srivastava Publisher: Commonwealth Publishers
2. A Handbook of Environment Impact Assessment Authors: V. S. Kulkarni, S. N. Kaul, R. K. Trivedi Publisher: Scientific Publishers, India
3. Sustainable Energy and the Environment: A Clean Technology Approach Authors: N. D. Kaushika, K. S. Reddy, Kshitij Kaushik Publisher: Springer (Cham)

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

Guidelines for ESE:

ESE will be based on the laboratory assignments submitted by the students in the form of journal. Evaluation will be based on the understanding and quality of lab work.

Specialization Minor offered by Mechanical for students of other Branch of Engineering

In addition to 168 credits of UG Engineering Programmes (Bachelor of Engineering) i.e. Major in which the student has taken admission, a student may opt for Specialization Minor in another Engg. / Tech. discipline / branch / Emerging Areas, not in Major Engg. / Tech. discipline / branch.

A student is required to study additional 20 credits in another Engg. / Tech. discipline/ branch / Emerging Areas for Specialization Minor distributed over semesters III to VIII.

The total number of credits required for completion of the Specialization Minor in another Engg./ Tech. discipline/ Emerging Areas is 20 credits, in addition to 168 credits in Major.

Students will have to compulsorily choose Specialization Minor from other Engg. / Tech. discipline / branch, not from Major Engg. / Tech. discipline / branch.

Specialized Minor Degree in the Bachelor of Engineering programme shall be awarded to students earning additional total credits of all six semesters from second year to final year, i.e., 20 Credits, in addition to 168 credits or 126 credits respectively. The student admitted in first year must earn 168 credits and 126 credits admitted in lateral entry (admitted after Diploma or B.Sc.) at second year.

Specialization Minors offered by Mechanical are as follows.

A. Robotics
B. 3D Printing
C. Energy Engineering

The detail syllabus structure for the same is as follows.

Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY,

JALGAON (M.S.)

Bachelor of Engineering – Minor
In
Robotics
for Third Year Bachelor of Engineering
offered by
Mechanical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology



SYLLABUS STRUCTURE & COURSE OUTLINE
For Affiliated Colleges
Semester – V & VI
W.E.F. 2026 – 27

Specialization Minor in Robotics

Syllabus Structure for specialization minor in Robotics: Additional Credit (Semester – V) (w.e.f. 2026 – 27)
(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 512A	Robotics sensors and Control system	PCC	3			3	40	60			100	3
ME - 513A	Robotics sensors and Control system lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for specialization minor in Robotics: Additional Credit (Semester – VI) (w.e.f. 2026 – 27)
(As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 614A	Applied Robotics	PCC	3			3	40	60			100	3
ME - 615A	Applied Robotics Lab	PCC			2	2			25	25 (OR)	50	1

ROBOTICS SENSORS AND CONTROL SYSTEM (PCC)			
COURSE OUT LINE			
Course Title:	**ROBOTICS SENSORS & CONTROL SYSTEM**	**Short Title: RSCS**	**Course Code: ME-512A**

Course description:

This course introduces the basic concepts of sensors and control systems used in robotics. It covers types of robotic sensors, signal processing, sensor interfacing, and control techniques such as open loop and closed loop control. The course helps students understand how sensors and controllers work together to monitor and control robotic systems in industrial applications.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Engineering Mathematics, Basic Physics ,Electronics, Programming Basics

Course objectives:

1. To understand the fundamentals of robotics and the role of sensors in robotic systems
2. To study different types of sensors used for sensing position, motion, and environment in robots.
3. To understand signal conditioning and interfacing of sensors with controllers.
4. To learn the basic control techniques used in robotic systems.
5. To introduce advanced robotic control methods and applications.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain basic robotics concepts and identify different sensors used in robots.
2. Classify robotic sensors and describe their working principles
3. Interface sensors with microcontrollers and analyze sensor signals.
4. Explain open loop and closed loop control systems used in robotics.
5. Describe modern robotic control systems and applications.

COURSE CONTENT

ROBOTICS SENSORS & CONTROL SYSTEM		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Robotics and Sensors	**No. of Lectures: 09 Hours**	**Marks: 12**

Introduction to Robotics ,Components of a Robot, Classification of Robots, Robot applications in industry ,Introduction to sensors and transducers ,Sensor characteristics (range, accuracy, sensitivity, resolution) ,Types of sensors used in robots.

Unit–II: Types of Robotic Sensors	**No. of Lectures: 09 Hours**	**Marks: 12**

Position sensors (encoders, potentiometers) ,Velocity and acceleration sensors ,Proximity sensors (inductive, capacitive, optical) ,Force and torque sensors ,Vision sensors and cameras ,Tactile sensors .		
Unit–III: Signal Processing and Sensor Integration	**No. of Lectures: 09 Hours**	**Marks: 12**
Sensor signal conditioning ,Analog and digital signals ,Filtering and amplification ,Data acquisition systems, Sensor interfacing with microcontrollers ,Noise reduction techniques		
Unit–IV: Control Systems in Robotics	**No. of Lectures: 09 Hours**	**Marks: 12**
Introduction to control systems ,Open loop and closed loop control systems ,Feedback control concept ,PID control in robotics ,Motion control of robotic systems ,Stability and accuracy in control systems.		
Unit–V: Advanced Robotic Control and Applications	**No. of Lectures: 09 Hours**	**Marks: 12**
Intelligent control techniques, AI in robotic control, Sensor fusion, Autonomous robots, Industrial robot control systems, Future trends in robotic sensing and control.		

Text Books:

1. Control in Robotics and Automation: Sensor Based Integration – B. Siciliano & K. P. Valavanis
2. Introduction to Robotics: Mechanics and Control – John J. Craig
3. Robotics: Control, Sensing, Vision and Intelligence – K. S. Fu, R. C. Gonzalez, C. S. G. Lee

Reference Books:

1. Robotics Engineering: An Integrated Approach – Richard D. Klafter
2. Industrial Robotics – Mikell P. Groover
3. Sensors and Transducers – D. Patranabis
4. Modern Control Engineering – Katsuhiko Ogata

NPTEL Links:

1. Sensors and Actuators - Prof. Hardik J. Pandya (IISc Bangalore) https://onlinecourses.nptel.ac.in/noc25_ee76/preview
2. Control Engineering for Robotics – Prof. Chayan Bhawal (IIT Guwahati) https://onlinecourses.nptel.ac.in/noc26_ee02/preview
3. Intelligent Control of Robotic Systems – Prof. M. Felix Orlando (IIT Roorkee) https://onlinecourses.nptel.ac.in/noc25_ee89/preview

ROBOTICS SENSORS AND CONTROL SYSTEM LAB (ME-513A)			
LAB COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**
Concerned faculty member should suitably frame Six laboratory assignments / practicals from			

the following list.

1. To study different sensors used in robotics.
2. To interface an IR sensor with a microcontroller/Arduino.
3. To measure distance using an ultrasonic sensor.
4. To study the working of an encoder for measuring position.
5. To control DC motor speed using Pulse Width Modulation (PWM).
6. To study open loop and closed loop control system.
7. To design and test a simple line follower robot.
8. To detect obstacles and control robot motion.

Text Books

1. Control in Robotics and Automation: Sensor Based Integration – B. Siciliano & K. P. Valavanis
2. Introduction to Robotics: Mechanics and Control – John J. Craig
3. Robotics: Control, Sensing, Vision and Intelligence – K. S. Fu, R. C. Gonzalez, C. S. G. Lee

Reference Books:

1. Robotics Engineering: An Integrated Approach – Richard D. Klafter
2. Industrial Robotics – Mikell P. Groover
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Guidelines for ESE:

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APPLIED ROBOTICS (PCC)			
COURSE OUT LINE			
Course Title:	**APPLIED ROBOTICS**	**Short Title: AR**	**Course Code: ME-614A**

Course description:

This Course focuses on the practical implementation of robotic systems in industrial and service applications. The course introduces robot components, kinematics, sensors, actuators, control systems, programming, and industrial applications. Students will understand how robots are designed, controlled, and applied in automation, manufacturing, and modern industries.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Engineering Mechanics, Basic Electronics, Control Systems, Sensors and Instrumentation, Programming Fundamentals.

Course objectives:

1. To introduce students to the basic concepts, structure, and classifications of robotic systems
2. To understand the mathematical and motion principles involved in robot movement.
3. To understand sensing and actuation mechanisms used in robotic systems.
4. To introduce different control strategies and programming methods used in robotics.
5. To understand real-world applications of robotics in various industries.

Course outcomes:

After successful completion of this course the student will be able to:

1. Identify robot components and classify different types of industrial robots.
2. Analyze robot motion and basic kinematic relationships
3. Select appropriate sensors and actuators for robotic applications
4. Explain robot control techniques and basic programming methods.
5. Describe different industrial and service applications of robots.

COURSE CONTENT

Applied Robotics		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Robotics	**No. of Lectures: 09 Hours**	**Marks: 12**

Definition and history of robotics, Components of robot system, Robot configurations (Cartesian, Cylindrical, Spherical, SCARA, Articulated), Robot anatomy and terminology, Degrees of Freedom (DOF), Robot work envelope and payload capacity.

Unit–II: Robot Kinematics and Motion.	**No. of Lectures: 09 Hours**	**Marks: 12**

Coordinate systems and frames, Forward kinematics, Inverse kinematics, Robot joint movements, Trajectory planning, Speed and acceleration control in robots.		
Unit–III: Sensors and Actuators in Robotics	**No. of Lectures: 09 Hours**	**Marks: 12**
Role of sensors in robotics ,Types of sensors: Position sensors ,Proximity sensors ,Vision sensors, Force and torque sensors ,Actuators: Electric motors, Hydraulic actuators, Pneumatic actuators ,End effectors and grippers		
Unit–IV: Robot Control and Programming	**No. of Lectures: 09 Hours**	**Marks: 12**
Robot control systems, Open loop and closed loop control, Robot programming methods: Lead-through programming, Teach pendant programming, Offline programming, Robot programming languages, Safety considerations in robot operation.		
Unit–V: Applications of Robotics	**No. of Lectures: 09 Hours**	**Marks: 12**
Industrial applications of robots: Welding, Assembly, Material handling, Painting, Service robots, Medical robots, Agricultural robots, Future trends in robotics and automation.		

Text Books:

1. Industrial Robotics: Technology, Programming and Applications – Mikell P. Groover, McGraw Hill.
2. Robotics: Control, Sensing, Vision and Intelligence – K. S. Fu, R. C. Gonzalez, C. S. G. Lee, McGraw Hill.

Reference Books:

1. Introduction to Robotics: Mechanics and Control – John J. Craig, Pearson.
2. Robotics Engineering: An Integrated Approach – Richard D. Klafter, Thomas A. Chmielewski, Michael Negin.
3. Fundamentals of Robotics: Analysis and Control – Robert J. Schilling.

NPTEL Links:

1. Robotics – Prof. D. K. Pratihar, (IIT Kharagpur) https://onlinecourses.nptel.ac.in/noc25_me166
2. Robotics : Basics and selected advance topics– Prof. Ashitava Ghosal ,(IISc, Banglore) https://nptel.ac.in/courses/112108298

APPLIED ROBOTICS LAB (ME-615A)			
LAB COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**
Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list. 1. To study different components and configurations of an industrial robot. 2. To identify the degrees of freedom in different robot configurations.			

3. To program a robot for pick-and-place operation.
4. To study different types of robot grippers and their working.
5. To interface sensors with robotic control system.
6. To control DC motor speed and direction for robotic joint movement.
7. To program robot movement along a predefined trajectory.
8. To simulate robot motion using robotics simulation software.
9. To understand and analyze open-loop and closed-loop control systems used in robotics.

Text Books

1. Industrial Robotics: Technology, Programming and Applications – Mikell P. Groover, McGraw Hill.
2. Robotics: Control, Sensing, Vision and Intelligence – K. S. Fu, R. C. Gonzalez, C. S. G. Lee, McGraw Hill.

Reference Books:

1. Introduction to Robotics: Mechanics and Control – John J. Craig, Pearson.
2. Robotics Engineering: An Integrated Approach – Richard D. Klafter, Thomas A. Chmielewski, Michael Negin.
3. Fundamentals of Robotics: Analysis and Control – Robert J. Schilling.

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Kavayitri Bahinabai Chaudhari
NORTH MAHARASHTRA UNIVERSITY,
JALGAON (M.S.)

Bachelor of Engineering – Minor
In
3D Printing
for Third Year Bachelor of Engineering
offered by
Mechanical
(As per NEP 2020 Guidelines)

Faculty of Science and Technology

'A' Grade
NAAC Re-Accredited
(4th Cycle)

SYLLABUS STRUCTURE & COURSE OUTLINE
For Affiliated Colleges
Semester – V & VI
W.E.F. 2026 – 27

Specialization Minor in 3D Printing

Syllabus Structure for specialization minor in 3D Printing: Additional Credit (Semester – V) (w.e.f. 2026 – 27) (As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 512B	Materials in 3D printing and Sustainability	PCC	3			3	40	60			100	3
ME - 513B	Materials in 3D printing and Sustainability lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for specialization minor in 3D Printing: Additional Credit (Semester – VI) (w.e.f. 2026 – 27) (As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 614B	Industrial applications of 3D Printing	PCC	3			3	40	60			100	3
ME - 615B	Industrial applications of 3D Printing lab	PCC			2	2			25	25 (OR)	50	1

MATERIALS IN 3D PRINTING AND SUSTAINABILITY

COURSE OUT LINE

Course Title:	MATERIALS IN 3D PRINTING AND SUSTAINABILITY	Short Title: M3DPS	Course Code: ME-512B

Course description:

This course focuses on materials used in 3D printing with a sustainability perspective, covering polymers, metals, ceramics, composites, bio-materials, recycled feedstock, and eco-friendly filament development. Students study the relationship between material selection, printability, mechanical performance, recyclability, energy consumption, and environmental impact. The course also introduces life cycle assessment (LCA), circular economy, sustainable design for additive manufacturing, waste minimization, and green manufacturing practices, aligned with AICTE NEP 2020 experiential, multidisciplinary, and innovation-driven curriculum design.

	Hours/week	No. of weeks		
Theory	03	15	45	04
	02	15	30	

Prerequisite course(s):

Engineering Materials, Manufacturing Processes, CAD / 3D Modeling, Basics of Additive Manufacturing, Environmental Studies

Course objectives:

1. To understand materials used in polymer, metal, and composite 3D printing.
2. To study sustainable feedstock and recycled filament technologies.
3. To analyze environmental impact and life cycle of AM materials.
4. To evaluate material performance, biodegradability, and reuse strategies.
5. To develop sustainable additive manufacturing solutions for mechanical applications.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain classes of materials used in additive manufacturing
2. Select suitable sustainable materials for 3D printing applications
3. Analyze printability, recyclability, and energy implications
4. Evaluate life cycle and circular economy approaches in AM
5. Design sustainable material strategies for 3D printed products

COURSE CONTENT

MATERIALS IN 3D PRINTING AND SUSTAINABILITY		Semester:	V
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Materials for 3D Printing	No. of Lectures: 09 Hours	Marks: 12

Introduction to AM materials, Polymer materials, Metal powders, Ceramic and bio-materials Composite filaments, Material selection criteria, Printability and compatibility

Unit–II: Sustainable and Recycled AM Materials	No. of Lectures: 09 Hours	Marks: 12

Recycled PLA and ABS, PET bottle to filament conversion, Waste plastic reuse in AM Bio-based polymers, Biodegradable filaments, Natural fiber reinforced filaments, Circular material flow, Re-manufacturing using AM, Sustainable material sourcing		
Unit–III: Material Characterization and Performance	**No. of Lectures: 09 Hours**	**Marks: 12**
Mechanical testing of printed materials, Thermal behavior, Rheology and melt flow index, Layer adhesion and anisotropy, Moisture absorption effects, Aging and degradation, Recycled material performance comparison, Durability vs sustainability trade-off		
Unit–IV: Sustainability Assessment in Additive Manufacturing	**No. of Lectures: 09 Hours**	**Marks: 12**
Life Cycle Assessment (LCA) basics, Carbon footprint of AM materials, Energy consumption in FDM / SLA / SLS, Material utilization efficiency, Waste minimization strategies, Design for sustainability, Eco-design principles, Environmental standards and reporting		
Unit–V: Circular Economy and Green Manufacturing Applications	**No. of Lectures: 09 Hours**	**Marks: 12**
Circular economy in additive manufacturing, Distributed manufacturing, Repair and remanufacturing by AM, Lightweight sustainable structures, Sustainable lattice design, Green tooling and jigs, Biomedical sustainable printing, Smart sustainable production case studies, Industry 4.0 and digital sustainability		

Text Books:

1. Ian Gibson – Additive Manufacturing Technologies
2. Andreas Gebhardt – Understanding Additive Manufacturing
3. Chua & Leong – 3D Printing and Additive Manufacturing
4. Ashby – Materials and the Environment: Eco-informed Material Choice

Reference Books:

1. ASM Handbook – Materials Characterization and Sustainability
2. David Dornfeld – Green Manufacturing
3. ASTM standards on AM materials
4. Recent research papers on sustainable 3D printing materials

NPTEL Links

1. Introduction to Additive Manufacturing **,** Dr. P. M. Pandey**,** Indian Institute of Technology Delhi**,**https://onlinecourses.nptel.ac.in/noc22_me65/preview
2. Advanced Materials and Processes**,**Prof. S. K. Sinha**,** Indian Institute of Technology Kanpur**,** https://onlinecourses.nptel.ac.in/noc22_me82/preview
3. Sustainable Manufacturing**,** Prof. Shankar Narayanan**,** Indian Institute of Technology Madras**,**https://onlinecourses.nptel.ac.in/noc22_mg74/preview
4. Product Design and Manufacturing**,** Prof. Amaresh Chakrabarti**,** Indian Institute of Science Bangalore**,**https://onlinecourses.nptel.ac.in/noc22_me54/preview
5. Manufacturing Processes I **,**Prof. B. S. Murty, Indian Institute of Technology Madras **,**https://onlinecourses.nptel.ac.in/noc22_me01/preview

MATERIALS IN 3D PRINTING AND SUSTAINABILITY LAB (ME-513B)			
COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
		Internal Continuous Assessment (ICA) CA:	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**

Concerned faculty member should suitably frame Six assignments / practicals from the following list.

1. Tensile test of virgin vs recycled PLA specimen
2. Moisture effect on filament strength
3. PET bottle recycling to filament demo
4. Power consumption measurement of FDM printer
5. LCA mini study of printed part
6. Infill optimization for material saving
7. Biodegradable filament print study
8. Carbon footprint calculation of AM part
9. Sustainable lattice design mini project

Text Books:

1. Ian Gibson – Additive Manufacturing Technologies
2. Andreas Gebhardt – Understanding Additive Manufacturing
3. Chua & Leong – 3D Printing and Additive Manufacturing
4. Ashby – Materials and the Environment: Eco-informed Material Choice

Reference Books:

1. ASM Handbook – Materials Characterization and Sustainability
2. David Dornfeld – Green Manufacturing
3. ASTM standards on AM materials
4. Recent research papers on sustainable 3D printing materials

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INDUSTRIAL APPLICATIONS OF 3D PRINTING			
COURSE OUT LINE			
Course Title:	**INDUSTRIAL APPLICATIONS OF 3D PRINTING**	**Short Title: IA3DP**	**Course Code: ME-614B**

Course description:

This course introduces the principles and industrial applications of 3D printing (additive manufacturing) in modern manufacturing. It focuses on the use of 3D printing technologies in sectors such as automotive, aerospace, biomedical, and consumer products. The course covers various additive manufacturing processes, materials, design considerations, and post-processing techniques. Emphasis is given to real-world applications, product development, and the role of 3D printing in Industry 4.0 and sustainable manufacturing. This course aligns with NEP 2020 by promoting skill-based, multidisciplinary, and industry-oriented learning in emerging technologies like 3D printing. It emphasizes experiential and hands-on learning, enhancing students' practical skills and employability. The course fosters innovation, design thinking, and problem-solving abilities, preparing students for Industry 4.0 and sustainable manufacturing practices.

	Hours/week	**No. of weeks**	**No. of Lectures**	**Total Credits**
Theory	03	15	**45**	04
Practical	02	15	**30**	

Prerequisite course(s):

Manufacturing Processes, Engineering Materials / Material Science, Basics of CAD/CAM (preferred).

Course objectives:

1. To understand the fundamentals of 3D printing and additive manufacturing technologies
2. To study different 3D printing processes and materials used in industry
3. To explore industrial applications in various sectors such as automotive, aerospace, and biomedical
4. To Analyze design considerations and process parameters for 3D printing
5. To develop knowledge of post-processing techniques and quality aspects.

Course outcomes:

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

1. Understand the fundamentals of 3D printing and additive manufacturing technologies.
2. Explain different 3D printing processes and materials used in industry.
3. Apply design principles for developing components using 3D printing.
4. Analyze industrial applications of 3D printing in various sectors.
5. Evaluate process parameters, quality, and performance of 3D printed parts.

COURSE CONTENT

Industrial Applications of 3D Printing		**Semester:**	**VI**
Teaching Scheme:		**Examination Scheme**	
Lectures:	**3 hours/week**	**End Semester Theory Exam (ESE) - UA:**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Theory Exam (ISE) - CA:	**40 marks**
		Practical Internal Continuous Assessment (ICA) - CA	**25 marks**
Unit–I: Introduction to		**No. of Lectures: 09 Hours**	**Marks: 12**

3D Printing		
Overview of additive manufacturing (AM), Evolution and importance of 3D printing, Comparison with conventional manufacturing, Types of 3D printing technologies (FDM, SLA, SLS, etc.), Advantages and limitations of 3D printing, Applications overview in industry		
Unit–II: 3D Printing Processes and Materials	**No. of Lectures: 09 Hours**	**Marks: 12**
Detailed study of AM processes (FDM, SLA, SLS, DMLS, Binder Jetting), Materials used in 3D printing (polymers, metals, ceramics), Material properties and selection, Process parameters and their effects, Defects and limitations		
Unit–III: Design for Additive Manufacturing (DfAM)	**No. of Lectures: 09 Hours**	**Marks: 12**
Design principles for 3D printing, CAD modeling for AM, STL file generation and slicing Support structures and optimization. Topology optimization basics, Case studies.		
Unit–IV: Industrial Applications of 3D Printing	**No. of Lectures: 09 Hours**	**Marks: 12**
Applications in automotive industry, Applications in aerospace industry, Applications in biomedical field (implants, prosthetics), Applications in tooling and rapid prototyping, Applications in consumer products, Case studies of real industrial use.		
Unit–V: Post-Processing, Quality and Future Trends	**No. of Lectures: 09 Hours**	**Marks: 12**
Post-processing techniques (finishing, heat treatment, surface treatment), Inspection and quality control methods, Cost analysis and economic considerations, Industry 4.0 and digital manufacturing, Sustainability and environmental aspects, Future trends in 3D printing.		

Text Books

1. Gibson, I., Rosen, D. W., & Stucker, B. (2021). Additive manufacturing technologies (3rd ed.). Springer.
2. (Comprehensive coverage of AM processes, design, and industrial applications)
3. Kumar, L. J., Pandey, P. M., & Wimpenny, D. I. (2019). 3D printing and additive manufacturing technologies. Springer.
4. Chua, C. K., & Leong, K. F. (2019). Rapid prototyping, 3D printing and additive manufacturing: Principles and applications (5th ed.). World Scientific.
5. Gebhardt, A. (2012). Understanding additive manufacturing: Rapid prototyping, rapid tooling, rapid manufacturing. Hanser Publications.
6. Noorani, R. (2006). Rapid prototyping: Principles and applications. Wiley / Oxford University Press.

Reference Books:

1. Kalpakjian, S., & Schmid, S. R. (2020). Manufacturing engineering and technology (8th ed.). Pearson.
2. Wimpenny, D. I., Pandey, P. M., & Kumar, L. J. (Eds.). (2017). Advances in 3D printing & additive manufacturing technologies. Springer.
3. Liou, F. W. (2019). Rapid prototyping and engineering applications: A toolbox for prototype development (2nd ed.). CRC Press.
4. Kumar, S. (2025). A concise encyclopedia of additive manufacturing. Springer.
5. Kamrani, A. K., & Nasr, E. A. (2006). Rapid prototyping: Theory and practice. Springer.

NPTEL Links:
1. Fundamentals of Additive Manufacturing Technologies – by Prof. Sajan Kapil (IIT Guwahati) 2. https://nptel.ac.in/courses/112103306 3. Navigating the Latest Trends in Additive Manufacturing Landscape – by Prof. Alankar & Prof. Akshatha Hulmani (IIT Bombay) 4. https://nptel.ac.in/courses/112101623 5. Additive Manufacturing Technologies for Practising Engineers – by IIT Madras Faculty 6. https://elearn.nptel.ac.in/shop/executive-workshops/execedu-ongoing/additive-manufacturing-technologies-for-practising-engineers-cohort-3/

INDUSTRIAL APPLICATIONS OF 3D PRINTING LAB (ME-615B)			
LAB COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. Study of different 3D printing processes
2. Basic CAD model creation
3. Conversion of CAD file to STL
4. Slicing using 3D printing software
5. 3D printing of simple object
6. Measurement and comparison of printed part
7. Study of defects in printed parts
8. Demonstration of post-processing techniques
9. Mini project: Design and print a simple product

Text Books

1. Chua, C. K., Leong, K. F., & Lim, C. S. (2010). Rapid prototyping: Principles and applications (3rd ed.). World Scientific.
2. Noorani, R. (2006). Rapid prototyping: Principles and applications. Wiley.
3. Liou, F. W. (2019). Rapid prototyping and engineering applications: A toolbox for prototype development (2nd ed.). CRC Press.
4. Gibson, I., Rosen, D. W., & Stucker, B. (2021). Additive manufacturing technologies (3rd ed.). Springer.
5. Gebhardt, A. (2012). Understanding additive manufacturing: Rapid prototyping, rapid tooling, rapid manufacturing. Hanser Publications.

Reference Books:

1. Kamrani, A. K., & Nasr, E. A. (2006). Rapid prototyping: Theory and practice. Springer.
2. Kalpakjian, S., & Schmid, S. R. (2020). Manufacturing engineering and technology

(8th ed.). Pearson.
3. Wimpenny, D. I., Pandey, P. M., & Kumar, L. J. (Eds.). (2017). Advances in 3D printing & additive manufacturing technologies. Springer.
4. Kumar, S. (2022). Additive manufacturing solutions. Springer.
5. Chua, C. K., & Leong, K. F. (2019). Rapid prototyping, 3D printing and additive manufacturing: Principles and applications (5th ed.). World Scientific.

Guidelines for ICA:

Students must submit ICA in the form of journal. Each assignment should be well documented. Faculty in Charge will assess the assignments continuously and grade or mark each assignment on completion date declared for each assignment.

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Kavayitri Bahinabai Chaudhari

NORTH MAHARASHTRA UNIVERSITY,

JALGAON (M.S.)

Bachelor of Engineering – Minor
In
Energy Engineering
for Third Year Bachelor of Engineering
offered by
Mechanical

(As per NEP 2020 Guidelines)

Faculty of Science and Technology

'A' Grade
NAAC Re-Accredited
(4th Cycle)

SYLLABUS STRUCTURE & COURSE OUTLINE

For Affiliated Colleges

Semester – V & VI

W.E.F. 2026 – 27

Specialization Minor in Energy Engineering

Syllabus Structure for specialization minor in Energy Engineering: Additional Credit (Semester – V) (w.e.f. 2026 – 27) (As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 512C	Energy Efficiency &Management	PCC	3			3	40	60			100	3
ME - 513C	Energy Efficiency &Management lab	PCC			2	2			25	25 (OR)	50	1

Syllabus Structure for specialization minor in Energy Engineering: Additional Credit (Semester – VI) (w.e.f. 2026 – 27) (As per NEP 2020 Guidelines)

Course Code	Name of the Course	Category	Teaching Scheme				Evaluation Scheme					Credits
							Theory		Practical		Total	
			Theory Hrs / week	Tutorial Hrs / week	Practical Hrs / week	Total	ISE (CA)	ESE (UA)	ICA (CA)	ESE (UA)		
ME - 614C	Environmental Impact Analysis of Energy System	PCC	3			3	40	60			100	3
ME - 615C	Environmental Impact Analysis of Energy System lab.	PCC			2	2			25	25 (OR)	50	1

ENERGY EFFICIENCY & MANAGEMENT (PCC)			
COURSE OUT LINE			
Course Title:	**ENERGY EFFICIENCY & MANAGEMENT**	**Short Title: EEM**	**Course Code: ME-512C**

Course description:

This course introduces the principles of energy efficiency, conservation techniques, and energy management practices in industrial and commercial systems. It covers energy audit methodologies, electrical and thermal energy conservation techniques, and economic analysis of energy-saving measures. The course also emphasizes practical approaches for identifying and implementing energy conservation opportunities in real-world applications.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Basic Thermodynamics , Fundamentals of Electrical Engineering , Heat Transfer

Course objectives:

1. To understand different forms of energy, energy resources, and conservation principles.
2. To learn energy audit procedures and measurement techniques.
3. To analyze energy efficiency in electrical and thermal systems.
4. To evaluate energy-saving opportunities using economic analysis.
5. To develop skills for effective energy management in industrial applications.

Course outcomes:

After successful completion of this course the student will be able to:

1. Explain energy concepts, sources, and conservation principles.
2. Perform basic energy audit and analyze energy consumption data.
3. Evaluate energy efficiency of electrical systems and suggest improvements.
4. Analyze thermal systems for energy conservation and waste heat recovery.
5. Apply energy management techniques and economic analysis for decision making.

COURSE CONTENT

ENERGY EFFICIENCY & MANAGEMENT		**Semester:**	**V**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Energy and Conservation	**No. of Lectures: 09 Hours**	**Marks: 12**

Definition and forms of energy , Units and conversions of energy , Global and Indian energy scenario , Energy demand and supply gap , Renewable and non-renewable energy sources, Need and importance of energy conservation , Basic concepts of energy efficiency

Unit–II: Energy Audit Fundamentals	**No. of Lectures: 09 Hours**	**Marks: 12**

Definition and objectives of energy audit ,Types: Preliminary and Detailed energy audit ,Energy audit methodology , Data collection and analysis , Instruments used in energy audit

Unit–III: Electrical Energy Conservation	**No. of Lectures: 09 Hours**	**Marks: 12**
Electrical load management ,Energy efficient motors and transformers ,Power factor improvement ,Lighting systems (LED vs conventional) ,Energy saving using Variable Frequency Drives (VFD)		
Unit–IV: **Thermal Energy Conservation**	**No. of Lectures: 09 Hours**	**Marks: 12**
Boilers and efficiency improvement , Steam system management , Furnaces and waste heat recovery , Insulation and heat loss reduction , Cogeneration and combined heat & power (CHP).		
Unit–V:Energy Management & Economics	**No. of Lectures: 09 Hours**	**Marks: 12**
Energy management system (EMS) , Energy policies and standards (ISO 50001 basics), Demand-side management , Energy economics: Payback period, ROI, Life Cycle Costing (LCC) , Energy conservation opportunities		

Text Books:

1. Energy Management, Audit and Conservation , Barun Kumar De, Vrinda Publications.
2. Handbook on Energy Audit and Environment Management, Y. P. Abbi,, TERI, India
3. Energy Management , Dr. Sanjeev Singh, Umesh Rathore , S.K. Kataria & Sons

Reference Books:

1. Industrial Energy Conservation Techniques ,S. C. Tripathy, New Age International
2. Energy Management Handbook , Wayne C. Turner , John Wiley & Sons
3. Handbook of Energy Audits, Albert Thumann , Fairmont Press
4. Guide to Energy Management ,Barney L. Capehart , CRC Press
5. Energy Management and Conservation Handbook , Frank Kreith, D. Yogi Goswami ,CRC Press
6. Energy Audit and Management: Concept, Methodologies, Procedures and Case Studies , L. Ashok Kumar, Gokul Ganesan , CRC Press.

NPTEL Links:

1. Energy Conservation & Management: Prof. L. Umanand ,Indian Institute of Science https://nptel.ac.in/courses/108108067
2. Energy Management & Audit Concepts: Prof. A. K. Singh , Indian Institute of Technology Delhi
    a. https://nptel.ac.in/courses/112102018
3. Electrical Energy Systems : Electrical Energy Systems , Prof. D. P. Kothari , Indian Institute of Technology Delhi
    a. https://nptel.ac.in/courses/108102047

ENERGY EFFICIENCY & MANAGEMENT LAB (ME-513 C)			
LAB COURSE CONTENT			
		Semester:	**V**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**

Concerned faculty member should suitably frame Six laboratory assignments / practicals from the following list.

1. To analyze energy consumption data (electricity bills/load data) and understand energy usage pattern, demand variation, and scope for energy conservation.
2. To measure voltage, current, power, and power factor using electrical instruments and understand their role in energy audit.
3. o compare energy consumption and efficiency of different lighting systems (LED, CFL, incandescent) and evaluate energy saving potential.
4. To study the effect of low power factor and determine improvement using capacitor bank with basic calculations.
5. To determine the efficiency of an electric motor under different loading conditions and identify energy saving opportunities.
6. To study the efficiency of a boiler/heating system using standard methods and understand thermal energy losses.
7. To study heat loss in a system and evaluate the effectiveness of insulation materials in reducing energy loss.
8. To analyse energy savings achieved by using Variable Frequency Drive (VFD) in pumps or fans under varying load conditions.
9. To conduct a basic energy audit of a laboratory/building, identify energy conservation opportunities, and estimate potential energy and cost savings.

Text Books

1. Energy Management, Audit and Conservation , Barun Kumar De, Vrinda Publications.
2. Handbook on Energy Audit and Environment Management, Y. P. Abbi,, TERI (The Energy and Resources Institute), India
3. Energy Management , Dr. Sanjeev Singh, Umesh Rathore , S.K. Kataria & Sons (Popular Indian engineering publisher)
4. Energy Audit and Management: Concept, Methodologies, Procedures and Case Studies L. Ashok Kumar, Gokul Ganesan , CRC Press.

Reference Books:

1. Industrial Energy Conservation Techniques ,S. C. Tripathy, New Age International
2. Energy Management Handbook , Wayne C. Turner , John Wiley & Sons
3. Handbook of Energy Audits, Albert Thumann , Fairmont Press
4. Guide to Energy Management ,Barney L. Capehart , CRC Press
5. Energy Management and Conservation Handbook , Frank Kreith, D. Yogi Goswami ,CRC Press

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ENVIRONMENTAL IMPACT ANALYSIS OF ENERGY SYSTEMS (PCC)			
COURSE OUT LINE			
Course Title:	**ENVIRONMENTAL IMPACT ANALYSIS OF ENERGY SYSTEMS**	**Short Title: EIAES**	**Course Code: ME-614C**

Course description:

This course focuses on evaluating the environmental impacts associated with various energy systems, including fossil fuels, nuclear, and renewable energy sources. It introduces analytical tools, sustainability concepts, and policy frameworks used to assess and mitigate environmental effects.

	Hours/week	No. of weeks	No. of Lectures	Total Credits
Theory	03	15	45	04
Practical	02	15	30	

Prerequisite course(s):

Engineering Thermodynamics, Engineering Mathematics, Basic Physics

Course objectives:

1. Understand different energy systems and their environmental impacts
2. Learn methods for environmental impact assessment (EIA)
3. Analyze lifecycle impacts of energy production and consumption
4. Evaluate mitigation strategies and sustainable energy solutions
5. Develop critical thinking on energy policy and environmental management.

Course outcomes:

After successful completion of this course the student will be able to:

1. Assess environmental impacts of different energy systems
2. Assess environmental impacts of conventional energy systems.
3. Propose sustainable and eco-friendly energy solutions
4. Apply EIA methodologies and prepare EMP.
5. Understand environmental regulations and policies

COURSE CONTENT

ENVIRONMENTAL IMPACT ANALYSIS OF ENERGY SYSTEMS		**Semester:**	**VI**
Teaching Scheme:		**Examination scheme**	
Lectures:	**3 hours/week**	**End semester exam (ESE):**	**60 marks**
		Duration of ESE:	**03 hours**
		Internal Sessional Exam (ISE):	**40 marks**

Unit–I: Introduction to Energy Systems:	**No. of Lectures: 09 Hours**	**Marks: 12**

Global energy scenario and trends, Classification of energy sources (renewable & non-renewable), Energy conversion processes, Energy demand and supply dynamics

Unit–II: Environmental Impacts of Conventional Energy	**No. of Lectures: 09 Hours**	**Marks: 12**

Fossil fuels (coal, oil, natural gas) and emissions, Air pollution and greenhouse gases
Global Warming and climate change, Water pollution and thermal pollution, Impacts of nuclear energy (radiation, waste disposal)

Unit–III: Environmental Impacts of Renewable Energy Systems	**No. of Lectures: 09 Hours**	**Marks: 12**
Solar energy systems and land use impact, Wind energy and ecological concerns, Hydropower and aquatic ecosystems, Biomass energy and emissions, Geothermal energy and environmental risks		
Unit–IV: Environmental Impact Assessment (EIA)	**No. of Lectures: 09 Hours**	**Marks: 12**
Concept and objectives of EIA, EIA process and methodologies, Screening, scoping, and baseline data collection, Impact prediction and evaluation, Environmental management plans (EMP)		
Unit–Environmental Policies and Regulations	**No. of Lectures: 09 Hours**	**Marks: 12**
National environmental policies (India & global context), International agreements (e.g., Paris Agreement), Environmental laws related to energy projects, Regulatory bodies and compliance		

Text Books:

1. Environmental Impact Assessment, Author: Larry W. Canter, Publisher: McGraw-Hill, New York
2. Energy and Environment Authors: Robert A. Hinrichs, Merlin Kleinbach, William D. Reisner Publisher: Cengage Learning
3. Energy Systems Evaluation: Sustainability Assessment Authors: Francisca Morgado-Dias et al. Publisher: Springer
4. Environmental Impact Assessment Editor: Judith Rosales Publisher: Delve Publishing
5. Sustainable Energy Systems Engineering Author: W. G. J. H. M. van Sark (and others depending on edition) Publisher: Academic Press / Elsevier

Reference Books:

1. Environmental Energy Impact Analysis Authors: S. Krishna Shukla, P. Rajeev Srivastava Publisher: Commonwealth Publishers
2. A Handbook of Environment Impact Assessment Authors: V. S. Kulkarni, S. N. Kaul, R. K. Trivedi Publisher: Scientific Publishers, India
3. Sustainable Energy and the Environment: A Clean Technology Approach Authors: N. D. Kaushika, K. S. Reddy, Kshitij Kaushik Publisher: Springer (Cham)

NPTEL Links:

1. Environmental Impact Assessment (EIA) Prof. Harshit Sosan Lakra (IIT Roorkee) https://onlinecourses.nptel.ac.in/noc26_ar13/preview?utm_
2. Energy Resources, Economics and Environment Prof. Rangan Banerjee,IIT Bombay https://elearn.nptel.ac.in/shop/nptel/energy-resources-economics-and-environment/?utm
3. Energy Resources, Economics, and Sustainability Prof. Pratham Arora | https://onlinecourses.nptel.ac.in/noc25_hs86/preview?utm
4. Environmental Planning and Management Prof. Sonal K. Thengane | IIT Roorkee https://onlinecourses.nptel.ac.in/noc26_ge08/preview?utm

ENVIRONMENTAL IMPACT ANALYSIS OF ENERGY SYSTEMS LAB (ME-615C)			
LAB COURSE CONTENT			
		Semester:	**VI**
Teaching Scheme:		**Examination scheme**	
Practical:	**2 hours/week**	**Internal Continuous Assessment (ICA) CA:**	**25 marks**
		End semester exam (ESE) UA (OR):	**25 marks**

Concerned faculty member should suitably frame six laboratory assignments / practicals from the following list.

1. Introduction to Environmental Impact Assessment (EIA)
   Lab Activities:
   - Familiarization with EIA frameworks and standards
   - Case study review of energy projects (thermal, hydro, solar)
   - Screening and scoping exercises
2. To study Energy Systems and estimate Emission.
   Lab Activities:
   - Calculation of emissions from fossil fuel-based power plants
   - Comparative analysis: coal vs gas vs renewables.Use of emission factors
3. To measure Air Pollution content and prepare Model.
   Lab Activities:
   - Dispersion modeling of pollutants (SO_2, NOx, PM)
   - Stack height and plume rise calculations
   - Scenario analysis for urban vs rural settings
4. To study and Assess Life Cycle (LCA) of Energy Systems
   Lab Activities:
   - Conduct LCA for solar PV, wind, and coal power plants
   - Inventory analysis (inputs/outputs)
5. To perform Water and Soil Impact Analysis
   Lab Activities:
   - Assessment of thermal pollution in water bodies
   - Analysis of soil contamination from energy projects
6. To study the Renewable Energy Impact Assessment
   Lab Activities:
   - Environmental assessment of solar farms and wind turbines
   - Land use and biodiversity impact analysis
7. To study Sustainability & Mitigation
   Lab Activities:
   - Carbon capture and storage (CCS) study.
   - Waste-to-energy system environmental analysis.
8. To perform Analytical & Computational Techniques for LCA
   Lab Activities:
   - Life Cycle Assessment (LCA) of an energy system using software tools.

- Energy audit and environmental impact estimation of a facility.

9. TO Study Renewable Energy Systems
   Lab Activities:
   - Environmental impact assessment of solar PV systems.
   - Wind energy system impact analysis (noise, land use).

Text Books

1. Environmental Impact Assessment, Author: Larry W. Canter, Publisher: McGraw-Hill, New York
2. Energy and Environment Authors: Robert A. Hinrichs, Merlin Kleinbach, William D. Reisner Publisher: Cengage Learning
3. Energy Systems Evaluation: Sustainability Assessment Authors: Francisca Morgado-Dias et al. Publisher: Springer
4. Environmental Impact Assessment Editor: Judith Rosales Publisher: Delve Publishing
5. Sustainable Energy Systems Engineering Author: W. G. J. H. M. van Sark (and others depending on edition) Publisher: Academic Press / Elsevier

Reference Books:

1. Environmental Energy Impact Analysis Authors: S. Krishna Shukla, P. Rajeev Srivastava Publisher: Commonwealth Publishers
2. A Handbook of Environment Impact Assessment Authors: V. S. Kulkarni, S. N. Kaul, R. K. Trivedi Publisher: Scientific Publishers, India
3. Sustainable Energy and the Environment: A Clean Technology Approach Authors: N. D. Kaushika, K. S. Reddy, Kshitij Kaushik Publisher: Springer (Cham)

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