

T. Y. B. Tech : Mechanical Engineering
[Level 5.5, UG] Semester -V

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC		Heat Transfer	3	0	2	1	4	30	20	50	50	50
02	PCC		Dynamics of Machine	3	0	2	0	4	30	20	50	50	50
03	PCC		Metrology & Measurement	2	0	2	1	3	30	20	50	50	50
04	PEC		Program Elective Course - I (Specify List) *	3	0	0	1	3	30	20	50	-	-
05	MDM		Multidisciplinary Minor II	3	1	0	0	4	30	20	50	-	-
06	RM		Open Elective Course III	2	0	0	2	2	30	20	50	-	-
07	ELC		Internship 1#	0	0	0	0	1	-	-	-	CIE-100	
08	ELC		Project-I	0	0	4	0	2	-	-	-	CIE-100	
Total Credit								23					

Summer Internship (Industry /R&D / Academic Institute) after IV semester during summer vacation and evaluation will be done at the start of V semester. Duration minimum One and a maximum Two months.

*Program Elective Course I – Discipline-wise List			
Design Engineering	Thermal Engineering/Fluid Science	Manufacturing Science and Engineering	Interdisciplinary
Finite Element Methods (FEM)	Fluid Dynamics	Advanced Manufacturing Technology	Fundamentals of Green Hydrogen Technology
Experimental Stress Analysis	Modern IC Engines	Operations Research	Machine Learning
	Steam and Gas Turbine		Renewable Energy Resources

V-1 : Heat Transfer

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Heat Transfer	3	0	2	1	4	30	20	50	50	50

Course Outcomes:

Students who successfully complete this course will have demonstrated an ability to:

- CO 1:** Understand the fundamental modes of heat transfer and apply governing equations to solve related problems.
- CO 2:** Analyze steady and transient heat conduction in various geometries.
- CO 3:** Evaluate convective heat transfer in internal and external flows.
- CO 4:** Design and analyze heat exchangers using effectiveness and NTU methods.
- CO 5:** Apply radiation heat transfer principles to engineering systems.

Syllabus:

Unit	Contents	Hrs
1	One dimensional steady state heat conduction: Introduction, derivation of Generalized heat conduction equation in Cartesian coordinates, Fourier, Laplace and Poission's equation. Generalized heat conduction equation in cylindrical and spherical coordinates. (no derivation). Heat conduction through a composite slab, cylinder and sphere, effect of variable thermal conductivity, critical radius of insulation, thermal contact resistance. Conduction with heat generation for plane wall, cylinder and sphere.	8
2	Extended surfaces and unsteady state heat conduction: Types and applications of fins, heat transfer through extended surfaces, derivation of temperature distribution equations and heat transfer through fins of constant cross-sectional area. Effectiveness and efficiency of a fin, overall efficiency of fin array. Errors in the measurement of temperature in a thermowell. System with negligible internal thermal resistance, Biot and Fourier numbers. Lumped heat capacity method, use of Heisler charts.	8
3	Two dimensional steady state heat conduction: Introduction to analytical method two dimensional steady state heat conduction in rectangular plates , two dimensional steady state heat conduction in semi-infinite plates. Numerical solutions of steady 2D conduction, conduction shape factors for common geometries.	6

4	<p>Convective Heat Transfer: Local and average convective coefficient, hydrodynamic and thermal boundary layer. Laminar and turbulent flow over a flat plate and through a duct, friction factor, drag and drag co-efficient. Dimensional analysis in free and forced convection, physical significance of the dimensionless numbers related to free and forced convection. Empirical correlations for free and forced convection for heat transfer in laminar and turbulent flow over a flat plate and through a duct.</p> <p>Introduction to condensation and boiling, pool boiling, critical heat flux, burnout point, forced boiling. Film and drop wise condensation (No numerical treatment)</p>	7
5	<p>Radiation: Fundamental concepts, black body radiation, Planck's distribution law, Wien's displacement law and the Stefan-Boltzmann law. Transmissivity, absorptivity, reflectivity, the grey, black and real surface. Radiation shape factor, use of shape factor charts, Kirchhoff's law, Lambert's cosine law. Heat exchange between non-black bodies, heat exchange between two infinitely parallel planes and cylinders, Radiation shields, heat exchange by radiation, between two finite black/gray surfaces. Gas radiation (elementary treatment only). Solar radiation, irradiation, radiation potential, electrical network method of solving radiation problems.</p>	7
6	<p>Heat exchangers: Heat exchangers classification, overall heat transfer coefficient, heat exchanger analysis, use of log mean temperature difference (LMTD) for parallel and counter flow heat exchangers, LMTD correction factor, fouling factor. The effectiveness-NTU method for parallel and counter flow heat exchangers. Design considerations of heat exchanger.</p>	6

Laboratory Course Work:

Students have to perform any eight of the following experiments, make a report, and submit it as Term work for evaluation

List of Experiments:

1. Determination of thermal conductivity of a metal rod
2. Determination of thermal conductivity of insulating powder.
3. Determination of thermal conductivity of a given liquid.
4. Determination of thermal resistance of composite slab
5. Determination of Time required to Heat/Cool a body (Unsteady State Heat Conduction)
6. Determination of heat transfer coefficient in natural convection
7. Determination of heat transfer coefficient in forced convection for flow through cylinder
8. Determination of critical heat flux
9. Determination of emissivity of given surface
10. Determination of Stefan Boltzmann constant
11. Determination of effectiveness of heat exchanger (shell and tube type, cross flow type and plate type)

Suggested learning resources:

Text Books

1. S.C.Arora, V. M. Domkundwar, A.V.Domkundwar, A course in Heat and Mass Transfer, Dhanpat Rai and Co. Pvt. Ltd, New Delhi

2. S. P Sukhatme, A Text Book of Heat Transfer, University Press, 4th Edition, 2005
3. R.K.Rajput, Heat and Mass Transfer, S. Chand and Co. Pvt. Ltd, New Delhi.

Reference Books

1. Incropera and Dewitt: Fundamentals of Heat and Mass Transfer, John Wiley and Sons, NY.
2. P.K.Nag, Heat and Mass Transfer, Tata McGraw-Hill, 2011
3. Yunus A. Cengel, Heat Transfer: A Practical Approach, McGraw-Hill Higher Education, 2002
4. J.P. Holman: Heat Transfer; McGraw-Hill, 1996
5. C.P. Kothandaraman, S. Subramanyam, Heat and Mass Transfer Data Book, New Age International Publishers, Mumbai.

Weblinks:

<https://archive.nptel.ac.in/courses/112/108/112108149/>

CO–PO Mapping Table

CO	Mapped POs	Descriptions & Justifications
CO1: Understand modes of heat transfer and governing laws	PO1, PO2	Requires foundational knowledge of thermodynamics and mathematics to analyze conduction, convection, and radiation problems.
CO2: Analyze conduction problems in various geometries	PO2, PO3, PO4	Involves problem formulation, solution design, and use of mathematical models for transient and steady-state conduction.
CO3: Evaluate convective heat transfer in flows	PO1, PO5	Applies engineering principles and modern tools to internal/external flow analysis.
CO4: Design and analyze heat exchangers	PO3, PO11	Requires system-level design thinking and understanding of project management principles.
CO5: Apply radiation principles to engineering systems	PO7, PO8	Encourages sustainable design and ethical considerations in thermal systems.

CO–PO–PSO Mapping Matrix

Mapped Levels:

3: Strong correlation, 2: Moderate correlation, 1: Low correlation, 0: No significant correlation

CO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	0	0	0	0	0	0	0	0	2	2	1
CO2	2	2	3	2	1	0	0	0	0	1	0	3	3	1
CO3	3	1	2	1	2	0	0	0	0	0	0	2	3	1
CO4	1	1	3	2	1	0	0	0	0	2	0	3	2	1
CO5	1	0	1	0	1	2	2	0	0	0	0	1	1	2

V-2 : Dynamics of Machine

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Dynamics of Machine	3	0	2	0	4	30	20	50	50	50

Course outcomes:

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

- CO1:** Analyze dynamic forces in mechanisms and machines.
- CO2:** Evaluate balancing of rotating and reciprocating masses.
- CO3:** Study vibrations in mechanical systems and apply mitigation techniques.
- CO4:** Use analytical and simulation tools for dynamic analysis.
- CO5:** Apply concepts to real-world machine dynamics problems.

Syllabus:

Unit	Contents	Hrs.
1	Gears II: Helical gear, spiral gear, bevel gear and worm gear. Gear trains	7
2	Belt Drives: Introduction, Velocity ratio, Belt length, limiting ratio, power transmitted, centrifugal tensions, condition for maximum power transmission.	5
	Clutches and Brakes: Clutches and Brakes: types, power and torque transmission, and absorption derivations.	8
3	Balancing: Static and dynamic balance, balancing of revolving several masses on several planes, balancing of reciprocating masses in single and multi cylinder engines, balancing machines.	8
4	Gyroscope: Introduction, Gyroscopic couple, Gyroscopic effects, Gyroscopic ship stabilization.	6
5	Mechanical vibrations: Fundamentals, undamped and damped free vibrations of single degree freedom system, forced vibration of single degree of freedom system, critical speed of shafts.	8

Laboratory Course work:

List of Experiments:

1. Determination of torque for epicyclic gear train.
2. Determinations of torque and power transmitted by various friction drives.
3. Determination of unbalanced forces in rotating masses.
4. Determination of unbalanced forces in reciprocation engines.
5. Determination of Gyroscopic couple.
6. Determination of natural frequency of transverse vibrations of a bar.
7. Determination of damping coefficient of torsional vibrations.
8. Determination of node point of two rotor system.
9. Determination of critical speed of shaft of single rotor.

Suggested learning resources:

Textbooks:

- John Hannah and Stephens, R. C., “Mechanics of Machines: Advanced Theory and Examples”, 1970, Hodder; Student international edition ISBN 0713132329 Edward Arnold London
- Ballaney, P., “Theory of Machines and Mechanisms”, 2005, ISBN 9788174091222 Khanna Publications
- Bansal, R. K., “Theory of machines”, Laxmi Publications Pvt. Ltd, New Delhi

Reference Books:

- Bevan Thomas, “The Theory of Machines”, 3rd edition, CBS publishing
- Uicker Jr, J. J., Penock G. R. and Shigley, J. E., “Theory of Machines and Mechanisms’ 2003, Tata McGraw Hill
- Ramamurthy, V., “Mechanisms of Machines”, 3rd edition, ISBN 978-1842654569, Narosa Publishing House

Weblinks:

<https://archive.nptel.ac.in/courses/112/105/112105125/>
<https://archive.nptel.ac.in/courses/112/106/112106137/>

CO–PO Mapping Table

CO	Mapped POs	Descriptions & Justifications
CO1: Analyze dynamic forces in mechanisms	PO1, PO2	Involves applying physics and mechanics to understand machine behavior.
CO2: Evaluate balancing of masses	PO3, PO4	Requires design and modeling of rotating/reciprocating systems with constraints.
CO3: Study vibrations and mitigation techniques	PO5, PO9	Uses simulation tools and collaborative problem-solving in team settings.
CO4: Use analytical and simulation tools	PO5, PO10	Involves modern software tools and effective communication of results.
CO5: Apply concepts to real-world problems	PO6, PO12	Encourages contextual reasoning and lifelong learning in machine dynamics.

CO–PO–PSO Mapping Matrix

Mapped Levels:

3: Strong correlation, 2: Moderate correlation, 1: Low correlation, 0: No significant correlation

CO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	0	0	0	0	0	0	0	0	0	2	2	1
CO2	2	2	3	2	1	0	0	0	0	0	0	0	3	3	1
CO3	1	1	2	1	3	0	0	0	2	0	0	1	2	3	2
CO4	1	1	2	2	3	0	0	0	1	2	0	1	2	3	2
CO5	1	0	1	0	1	2	0	0	1	1	0	3	2	2	3

V-3 : Metrology and Measurements

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
<tbid>	Metrology and Measurements						MSE	TA	ESE	ISE	ESE
		2	0	2	1	3	30	20	50	50	50

Course Outcomes:

Students will be able to:

CO 1: Understand principles of measurement systems and metrology.

CO 2: Apply standards and calibration techniques in engineering practice.

CO 3: Use precision instruments for dimensional and geometric measurements.

CO 4: Analyze measurement data and assess uncertainty.

CO 5: Integrate metrology in quality control and manufacturing systems.

Syllabus:

Unit	Contents	Hrs
1	<p>Linear and Angular Measurements, Interferometry, Measurement System:</p> <p>Introduction: Meaning of Metrology, Precision, Accuracy, Methods and Errors in Measurement, Calibration.</p> <p>Linear Measurement: Standards, Line Standards, End Standard, Wavelength Standard, Classification of Standards, Precision and Non - Precision Measuring instruments and their characteristics, Slip Gauges.</p> <p>Interferometry: Introduction, Flatness testing by interferometry, NPL Flatness Interferometer. Study of Measuring Machines, Recent Trends in Engineering Metrology, use of interferometers for length, angle and surface roughness measurement</p> <p>Angle Measurement: Sine bars, Sine Centers, Uses of sine bars, angle gauges, Autocollimator Angle Dekkor, Constant deviation prism.</p> <p>Measurement System Analysis: Introduction, Influence of temperature, operator skills and the instrument errors etc.</p>	6
2	<p>Design of gauges, Interferometers and Comparators, Measuring Machines:</p> <p>Limits, Fits and Tolerances: Meaning of Limit, Fits and Tolerance, Cost – Tolerance relationship, concept of Interchangeability, Indian Standard System.</p> <p>Design of limits Gauges: Types, Uses, Taylor’s Principle, Design of Limit Gauges.</p> <p>Inspection of Geometric parameters: Straightness, Flatness, Parallelism, Concentricity, Squareness, and Circularity.</p> <p>Comparators: Uses, Types, Advantages and Disadvantages of various types of Comparators.</p> <p>Measuring Machines: Theory of Coordinate Metrology, Universal Measuring Machines, Coordinate Measuring Machines (CMM), different</p>	7

	configurations of CMM, Principle, Error involved, calibration, Probing system, automated inspection system.	
3	<p>Surface Finish Measurement, Screw Thread Metrology, Gear Metrology:</p> <p>Surface Finish Measurement: Surface Texture, Meaning of RMS and CLA values, Roughness Measuring Instruments, Tactile and Non-tactile measuring instruments, difference between waviness and roughness, Grades of Roughness, Specifications, Assessment of surface roughness as per IS, Relationship between surface roughness and Manufacturing Processes.</p> <p>Screw Thread Metrology: External Screw Thread Terminology, Floating Carriage Instruments, Pitch and flank Measurement of External Screw Thread, Application of Tool Maker's Microscope, Use of Profile Projector.</p> <p>Gear Metrology: Spur Gear Parameters, Gear Tooth Thickness Measurement: Gear Tooth Vernier Calliper, Constant Chord Method.</p>	8
4	<p>Introduction to Mechanical Measurements:</p> <p>Importance of Measurements, Classification of measuring instruments, generalized measurement system, types of inputs for measurements. Concepts such as Linearity, Sensitivity, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc. Errors in Measurements, Classification of errors in measurements, First order instruments and its response to step, ramp, sinusoidal and impulse inputs.</p>	5
5	<p>Measurement Methods and Devices:</p> <p>Displacement Measurement: Transducers for displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder), Nozzle Flapper Transducer.</p> <p>Velocity Measurement: Tachometers, Tacho generators, Digital tachometers and Stroboscope.</p> <p>Acceleration Measurement: theory of accelerometer and vibrometers, strain gauge based and piezoelectric accelerometers.</p> <p>Strain Measurement: Theory of Strain Gauges, gauge factor, temperature Compensation, Bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors.</p>	5
6	<p>Measurement – Methods and Devices:</p> <p>Pressure Measurement: Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors, High Pressure Measurements, Bridge man gauge, Vacuum gauges viz. McLeod gauge, Ionization and Thermal Conductivity gauges.</p> <p>Temperature Measurement: Thermocouple, Resistance thermometers, Thermistors, Pyrometers. Liquid in glass Thermometers, Bimetallic strip.</p> <p>Flow measurement: Venturimeter, Orifice meter, Rotameter.</p>	5

Laboratory Course Work:

List of Experiments:

The term work shall consist of the conduction of any eight experiments from the list given below.

1. Determination of Linear dimensions of a part using Precision and non-precision measuring Instruments.
2. Precision angular measurement using a setup of Sine Bar and Slip Gauges
3. Measurement of straightness, circularity, run out, and total run out.
4. Measurement of screw thread parameters using Floating Carriage Micrometer.
5. Surface Finish measurement using a suitable instrument.
6. Interferometry: Measurement of surface flatness using an optical flat.

7. Study and Measurement of Parameters Using Profile Projector.
8. Exercise on Design of Limit Gauges using Taylor's Principles.
9. Demonstration of Digital Comparator and Pneumatic Comparator
10. Demonstration of CMM and Vision Measurement Machine
11. Measurement of temperature using RTD
12. Measurement of flow using a flowmeter

Assignments:

1. Exercise on Design of Limit Gauges using Taylor's Principles.
2. Develop a Matlab-Simulink model for First order instruments for various inputs.

Suggested learning resources:

Text Books:

- R. K. Jain, A Text book of Engineering Metrology, Khanna Publications Pvt. Ltd. 18th Edition, 2002
- I.C. Gupta, A Text book of Engineering Metrology, Dhanpat Rai Publications Pvt. Ltd. 6th Edition, 2004
- B.C.Nakra, K.K. Choudhry, Instrumentation, Measurement and Analysis, McGraw Hill Education (India) Private Limited, 2017.
- Anand Bewoor, Vinay Kulkarni, Metrology and Measurement, Tata McGraw-Hill, first edition 2009.
- N. V. Raghavendra, L. Krishnamurthy, Engineering Metrology and Measurements, Oxford University Press, 1st edition 2013
- R. K. Rajput, A textbook of measurement and metrology, S.K. Kataria & Sons, 2013.
- R. K. Jain, Mechanical and Industrial Measurements, Khanna Publishers, 1995
- A. K. Sawhney, Mechanical Measurement and Control, Dhanpat Rai & Co. (P) Limited, 2017

Reference Books

- G.M.S. De Silva, Basic Metrology for ISO 9000 Certification Elsevier Publications, 3rd Edition 2002.
- Ernest Doebelin and Manik, Measurement Systems, McGraw-Hill, 6th Edition, 2017.

CO–PO Mapping Table

CO	Mapped POs	Descriptions & Justifications
CO1: Understand principles of measurement systems	PO1, PO2	Builds foundational knowledge and analytical skills in precision engineering.
CO2: Apply standards and calibration techniques	PO3, PO8	Involves ethical practices and design of accurate measurement systems.
CO3: Use precision instruments for measurements	PO5, PO10	Requires hands-on tool usage and clear documentation/reporting.
CO4: Analyze data and assess uncertainty	PO4, PO11	Focuses on data interpretation and project-level decision-making.
CO5: Integrate metrology in quality control	PO6, PO7	Applies engineering solutions to societal and environmental contexts.

CO–PO–PSO Mapping Matrix

Mapped Levels:

3: Strong correlation, **2:** Moderate correlation, **1:** Low correlation, **0:** No significant correlation

CO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	0	0	0	0	0	0	0	0	0	2	2	1
CO2	2	1	3	0	0	0	0	2	0	0	0	0	3	2	2
CO3	1	1	2	0	3	0	0	0	0	2	0	0	3	3	2
CO4	1	1	2	3	2	0	0	0	0	1	2	0	2	3	2
CO5	1	0	1	0	1	2	2	1	0	1	1	0	2	2	3

PEC-4.1 : Finite Element Method

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MS E	TA	ESE	ISE	ESE
ME-xxxx	Finite Element Analysis	3	0	0	1	3	30	20	50	--	

Course outcomes:

Students who successfully complete this course will have demonstrated an ability to:

- CO1:** Understand the mathematical foundations and formulation techniques of FEM.
- CO2:** Apply FEM to solve 1D and 2D problems in structural, thermal, and fluid domains.
- CO3:** Develop and analyze finite element models using shape functions and interpolation.
- CO4:** Implement FEM algorithms using software tools (e.g., ANSYS, MATLAB, Python).
- CO5:** Interpret simulation results to assess physical behavior and validate models.

Syllabus:

Unit	Contents	Hrs.
1	Introduction: <ul style="list-style-type: none"> • Overview of engineering problems and solution methods, illustrated through an example: physical system - physical model - mathematical model (Governing differential equation) - solution methods - final solution. Emphasizes the need for numerical methods and types of engineering analysis. • Concepts of shape functions, approximation functions, local and global coordinates. • Initial Value Problems, Boundary value problems and solution methods, Direct approach – example, advantage and limitations. • Introduction to steps of FEM for the generic problems. 	4
2	Variational Methods in FEM: <ul style="list-style-type: none"> • Elements of calculus of variation, Strong form and weak form, equivalence between strong and weak forms, Rayleigh-Ritz method, Principle of Minimum Potential Energy . Euler -Lagrange Equations from a Functional . • Method of weighted residuals – Galerkin and Petrov-Galerkin approach; Least Squares . Examples - Axially loaded bar, Heat Conduction/Convection Pin-Fin for 1-D Problems, governing equations, discretization, derivation of element equation, assembly, imposition of boundary condition and solution, examples. 	6
3	Trusses & Beams: <ul style="list-style-type: none"> • Finite element formulation for plane trusses. • Finite element formulation for Euler-Bernoulli beams (Governing differential equation, Characteristics of formulation for problems - FEM procedure - Computation of derived quantities like strains and stresses from the nodal values of the field variables, Result post-processing). 	5
4	2-D Problem from structural mechanics:	7

	<ul style="list-style-type: none"> • Introduction to 2-dimensional problem from structural mechanics static analysis, different elements (triangular, rectangular, quadrilateral, axis symmetric, etc.), shape functions. • Basic concepts of Plain stress and Plain strain. Constant strain triangular element Stiffness Matrix and Equation. Finite element Solution of a plane stress Problem. • Higher order elements, isoparametric elements. Need for numerical integration and co-ordinate transformation, Gauss- Legendre integration technique for numerical integration, linear elasticity problems & heat conduction. • Application of FEM to Axisymmetric problems, Axisymmetric solids under rotation. 	
5	Eigen-value problems: Eigen value problems, Mass and stiffness matrices, 2 Dof and 3 Dof spring mass problems. Transverse vibration of beams. Methods to find Eigen values and Eigen vectors.	3
6	Thermal Stresses and Errors in FEM: <ul style="list-style-type: none"> • Thermal Stresses – Formulation – Numericals (1D & 2D). • Sources of errors, error analysis, remedies to minimize the errors. 	3

Suggested learning resources:

Textbooks:

1. Daryl L Logan “A First Course in Finite Element Method” Sixth Edition.
2. Introduction to Finite Element Method By J.N .Reddy.
3. Cook R.D. “Concepts and applications of finite element analysis” Wiley, New York, 1981.
4. Bathe K.J., Cliffs, N.J. “Finite element procedures in Engineering Analysis”, Englewood. Prentice Hall, 1981.

Reference Books:

1. Jacob Fish and Ted Belytschko. 2007. A First Course in Finite Elements. John Wiley & Sons, Inc., Hoboken, NJ, USA.
2. Desai C.S. and J.F. Abel “Introduction to the finite element method.” New York, Van Nostrand Reinhold, 1972.
3. O. P. Gupta, “Finite and boundary element methods in Engineering”, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 2000.
4. Chandrupatla and Belegundu “Introduction to finite elements in Engineering”, Prentice Hall of India Pvt. Ltd. New Delhi, 2001.

CO-PO Mapping Table

Course Outcome (CO)	Mapped POs	Descriptions & Justifications
CO1: Understand the mathematical foundations and formulation techniques of FEM.	PO1, PO2	PO1: Students apply core engineering mathematics to derive FEM equations. PO2: They analyze physical systems and translate them into solvable mathematical models.
CO2: Apply FEM to solve 1D and 2D problems in structural, thermal, and fluid domains.	PO1, PO2, PO5	PO1: Requires strong foundational knowledge of physics and mechanics. PO2: Involves identifying and solving real-world engineering problems. PO5: May involve using simulation tools to solve domain-specific problems.
CO3: Develop and analyze finite element models using shape functions and interpolation.	PO1, PO2	PO1: Students use mathematical tools like interpolation and shape functions. PO2: Critical thinking is needed to assess model accuracy and behavior.

CO4: Implement FEM algorithms using software tools (e.g., ANSYS, MATLAB, Python).	PO5, PO6	PO5: Students gain proficiency in modern engineering tools and coding environments. PO6: Understanding the societal impact of simulation-based design decisions.
CO5: Interpret simulation results to assess physical behavior and validate models.	PO2, PO4	PO2: Students evaluate results to identify errors or inconsistencies. PO4: Involves designing experiments and validating models through simulation.
CO6: Evaluate the limitations and accuracy of FEM solutions through error analysis.	PO2, PO4	PO2: Encourages analytical thinking and understanding of numerical limitations. PO4: Students investigate convergence, stability, and accuracy of FEM solutions.

CO–PO–PSO Mapping Matrix

Mapped Levels:

3: Strong correlation, **2:** Moderate correlation, **1:** Low correlation, **0:** No significant correlation

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	2	2	1
CO2	3	3	2	0	2	0	0	0	0	0	0	1	3	3	2
CO3	3	2	1	0	1	0	0	0	0	0	0	1	3	3	2
CO4	2	1	1	0	3	1	0	1	1	2	1	1	2	3	2
CO5	2	3	2	2	2	0	0	1	1	2	2	2	2	3	2
CO6	2	3	1	3	2	0	0	1	0	1	2	2	2	3	2

PEC-4.2 : Fluid Dynamics

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-xxxx	Fluid Dynamics	3	0	0	1	3	30	20	50	--	

Course outcomes:

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

- CO1:** Explain the fundamental properties of fluids and the governing principles of fluid statics and dynamics.
- CO2:** Analyze fluid flow behavior using continuity, momentum, and energy equations for ideal and real fluids.
- CO3:** Apply dimensional analysis and similarity principles to model and interpret fluid flow systems.
- CO4:** Evaluate internal and external flows in pipes and over surfaces using empirical correlations and theoretical models.
- CO5:** Use computational and experimental tools to simulate, visualize, and validate fluid flow phenomena.
- CO6:** Assess the role of fluid dynamics in engineering applications such as turbomachinery, HVAC, biomedical devices, and environmental systems.

Syllabus:

Unit	Contents	Hrs.
1	Governing equations in Fluid Dynamics: Reynolds Transport Theorem, Derivation of Continuity and Momentum equations using integral and differential approach, dimensionless form of governing equations, special forms of governing equations.	8
2	Exact solutions of Navier-Stokes equations: Fully developed flows, parallel flow in straight channel – Couette flow with and without applied pressure gradients, Fully Developed Flow in a Round Pipe— Poiseuille Flow, unconfined Flow over the horizontal and inclined plate, Creeping flow approximation	7
3	Potential flow: Irrotational flow approximations for continuity and momentum equations, Kelvin's theorem, Bernoulli Equation in Inviscid Regions of Flow, Two-Dimensional Irrotational Regions of Flow, Elementary Planar Irrotational Flows – uniform, source, sink, Irrotational Flows Formed by Superposition – doublet, flow past a half body, a Rankine Oval Body, a circular cylinder, lift and drag Forces on Submerged Bodies – stationary and rotating cylinder. Drag Force acting on a rotating cylinder	6
4	Boundary layer approximation: Boundary layer equations, Laminar flat plate boundary layer exact solution, Turbulent flat plate boundary layer approximate solution, approximate solution methodology for boundary layer equations, Von-Karman integral Momentum equation for boundary layer, Pressure gradients in boundary layer flow, Separation of Boundary Layer, Control of Boundary Layer Separation	7

5	<p>Turbulent flow: Characteristics of turbulent flow, laminar turbulent transition, time mean motion and fluctuations, Reynolds stresses, Prandtl's mixing length theory, derivation of governing equations for turbulent flow- Continuity, Reynolds Navier-Stokes equation, shear stress models, universal velocity distribution law and friction factor in duct flows for very large Reynolds number, Fully developed turbulent flow in a pipe for moderate Reynolds number.</p>	8
6	<p>Experimental techniques: Introduction to measurements related to fluid flow, Analysis of experimental data- types of errors, sources of error, uncertainty analysis, Measurement of temperature- thermoelectric thermometry, resistance thermometry, pyrometry, bimetallic and liquid crystal thermometer, Measurement of pressure-U-tube manometer, pressure transducers, Measurement of volume flow rate- orifice plate meter, flow nozzle, venturi meter, rotameter, velocity measurement based on thermal effect - Hot wire Anemometry, Laser Doppler Velocimetry, Particle Image Velocimetry.</p>	6

Suggested learning resources:

Text Books:

1. Introduction to Fluid Mechanics and Fluid Machines, 3rd Edition, Gautam Biswas (Author), S. Chakraborty, McGraw Hill Education.
0. Muralidhar and Biswas, Advanced Engineering Fluid Mechanics, Alpha Science International, 2005
0. Hydraulics and Fluid Mechanics including Hydraulic Machines, Dr. P. N. 1 and Dr. S. M. Seth, Standard Book House, New Delhi

Reference books:

- 1 Y.A.Cengel, J.M.Cimbala, Fluid Mechanics – Fundamentals and Applications, McGraw Hill, 2004.
- 2 Irwin Shames, Mechanics of Fluids, McGraw Hill, 2003
- 3 Fox R.W., McDonald A.T, Introduction to Fluid Mechanics, John Wiley and S Inc, 1985
- 4 Pijush K. Kundu, Ira M Kohen and David R. Dawaling, Fluid Mechanics, Fifth Edition, 2005.

NPTEL Course:

<https://nptel.ac.in/courses/101103004>

CO-PO Mapping

Course Outcome (CO)	Mapped Program Outcomes (POs)	Description & Justification
CO1: Explain the fundamental properties of fluids and the governing principles of fluid statics and dynamics.	PO1, PO2	This outcome builds foundational engineering knowledge and analytical thinking by introducing students to fluid properties, pressure variation, and basic laws governing fluid motion.
CO2: Analyze fluid flow behavior using continuity, momentum, and energy equations for ideal and real fluids.	PO2, PO4, PO5	Students develop problem-solving and investigative skills by applying governing equations to internal and external flows, supported by both theoretical and empirical approaches.
CO3: Apply dimensional analysis and similarity principles to model and interpret fluid flow systems.	PO2, PO3, PO5	This outcome enhances abstraction and modeling capabilities, enabling students to simplify complex systems and validate results using scale models and non-dimensional parameters.
CO4: Evaluate internal and external flows in pipes and over surfaces using empirical correlations and theoretical models.	PO3, PO4, PO6	Students critically assess flow regimes, friction losses, and boundary layer effects, while considering design constraints, safety, and sustainability in engineering applications.
CO5: Use computational and experimental tools to simulate, visualize, and validate fluid flow phenomena.	PO4, PO5, PO11	This outcome fosters proficiency in modern engineering tools such as CFD software and lab instrumentation, promoting data-driven analysis and technical reporting.
CO6: Assess the role of fluid dynamics in engineering applications such as turbomachinery, HVAC, biomedical devices, and environmental systems.	PO6, PO7, PO12	Students explore interdisciplinary applications of fluid dynamics, encouraging awareness of societal impact, ethical considerations, and lifelong learning in emerging technologies.

CO-PO-PSO Mapping

Scale Used:

3 = Strongly Mapped, 2 = Moderately Mapped, 1 = Weakly Mapped, 0 = Not Mapped

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	1	0	0	0	0	0	0	0	0	3	1	0
CO2	2	3	1	3	2	0	0	0	0	0	0	0	3	2	0
CO3	2	2	2	2	1	0	0	0	0	0	0	0	2	2	0
CO4	1	2	3	2	2	1	1	0	0	0	0	0	3	3	0
CO5	1	1	2	3	3	0	0	0	1	0	2	0	2	3	0
CO6	1	1	0	1	1	3	2	1	0	0	1	3	2	3	0

PEC-4.3 : Advanced Manufacturing Technology

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-xxxx	Advanced Manufacturing Technology	3	0	0	1	3	30	20	50	--	

Course outcomes:

Students who successfully complete this course will have demonstrated an ability to:

- CO1:** Explain the principles, classifications, and applications of advanced manufacturing processes including additive, subtractive, and hybrid techniques.
- CO2:** Analyze the influence of process parameters on product quality, precision, and material behavior in advanced manufacturing systems.
- CO3:** Evaluate and select suitable advanced manufacturing technologies for specific engineering applications based on performance, cost, and sustainability.
- CO4:** Apply digital tools such as CAD/CAM, simulation platforms, and automation systems to model and optimize manufacturing workflows.
- CO5:** Assess the environmental and societal impact of emerging manufacturing technologies and propose sustainable solutions.
- CO6:** Demonstrate ethical responsibility and professional conduct in deploying advanced manufacturing technologies in industrial and research contexts.

Syllabus:

Unit	Contents	Hrs.
1	Surface treatment: Scope, Cleaners, Methods of cleaning, Surface coating types, and ceramic and organic methods of coating, economics of coating. Electro forming, Chemical vapour deposition, thermal spraying, Ion implantation, diffusion coating, Diamond coating and cladding.	6
2	Non-Traditional Machining: Introduction, need, AJM, Parametric Analysis, Process capabilities, USM – Mechanics of cutting, models, Parametric Analysis, WJM –principle, equipment, process characteristics, performance, EDM – principles, equipment, generators, analysis of R-C circuits, MRR, Surface finish, WEDM.	6
3	Laser Beam Machining: Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Plasma Arc Machining – Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Electron Beam Machining - Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Electro Chemical Machining – Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications.	6

4	Processing of ceramics: Applications, characteristics, classification. Processing of particulate ceramics, Powder preparations, consolidation, Drying, sintering, Hot compaction, Area of application, finishing of ceramics. Processing of Composites: Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, MMC, CMC, Polymer matrix composites.	6
5	Fabrication of Microelectronic devices: Crystal growth and wafer preparation, Film Deposition oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, computer aided design in microelectronics, surface mount technology, Integrated circuit economics. E-Manufacturing, nanotechnology, micromachining and High-speed Machining, basic principles, working, applications, advantages.	6

Suggested learning resources:

Textbooks:

1. Manufacturing Engineering and Technology by Kalpakijian, Addison Wesley, 1995.
2. Foundation of MEMS by Chang Liu, Pearson, 2012.
3. Advanced Machining Processes by V. K. Jain, Allied Publications.

NPTEL Course:

https://onlinecourses.nptel.ac.in/noc24_me154/preview

CO-PO mapping table

Course Outcome (CO)	Mapped POs	Description & Justification
CO1: Explain the principles, classifications, and applications of advanced manufacturing processes including additive, subtractive, and hybrid techniques.	PO1, PO2	This outcome builds foundational engineering knowledge (PO1) and enables students to identify and classify complex manufacturing processes (PO2), forming the basis for advanced problem-solving.
CO2: Analyze the influence of process parameters on product quality, precision, and material behavior in advanced manufacturing systems.	PO2, PO3	Students develop analytical skills (PO2) to interpret process–output relationships and apply design thinking (PO3) to optimize manufacturing performance.
CO3: Evaluate and select suitable advanced manufacturing technologies for specific engineering applications based on performance, cost, and sustainability.	PO3, PO7	This outcome promotes informed decision-making in design and development (PO3), while integrating sustainability and societal impact considerations (PO7) into technology selection.
CO4: Apply digital tools such as CAD/CAM, simulation platforms, and automation systems to model and optimize manufacturing workflows.	PO5, PO11	Students gain proficiency in modern engineering tools (PO5) and apply project management principles (PO11) to plan and execute digital manufacturing workflows.
CO5: Assess the environmental and societal impact of emerging manufacturing technologies and propose sustainable solutions.	PO6, PO7	This outcome fosters contextual awareness of societal and environmental implications (PO6) and encourages sustainable engineering practices (PO7) in manufacturing.
CO6: Demonstrate ethical responsibility and professional conduct in deploying advanced	PO8, PO12	Students internalize ethical standards (PO8) and cultivate lifelong learning habits (PO12) to adapt responsibly to evolving

manufacturing technologies in industrial and research contexts.		manufacturing technologies and professional challenges.
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CO–PO–PSO Mapping Matrix

Scale Used:

3 = Strongly Mapped, 2 = Moderately Mapped, 1 = Weakly Mapped, 0 = Not Mapped

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	2	2	1
CO2	0	3	2	0	0	0	0	0	0	0	0	0	2	3	1
CO3	0	0	3	0	0	1	2	0	0	0	0	0	3	2	2
CO4	0	0	0	0	3	0	0	0	0	0	2	0	3	3	1
CO5	0	0	0	0	0	2	3	0	0	0	0	0	1	2	3
CO6	0	0	0	0	0	0	0	3	0	0	0	2	1	1	3

PEC-4.4 : Fundamentals of Green Hydrogen Technology

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-xxxx	Fundamentals of Green Hydrogen Technology	3	0	0	1	3	30	20	50	--	

Course Outcomes:

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

- CO1:** Explain the principles of hydrogen production, storage, and utilization with emphasis on green hydrogen pathways.
- CO2:** Analyze various electrochemical and thermochemical methods for hydrogen generation, including water electrolysis and biomass reforming.
- CO3:** Evaluate the techno-economic feasibility and lifecycle sustainability of green hydrogen technologies for industrial and mobility applications.
- CO4:** Apply system-level modeling tools to design and simulate hydrogen production, storage, and distribution networks.
- CO5:** Assess the environmental, safety, and regulatory aspects of hydrogen infrastructure deployment in societal contexts.
- CO6:** Demonstrate awareness of global hydrogen initiatives and ethical responsibility in promoting clean energy transitions.

Syllabus:

Unit	Contents	Hrs.
1	Introduction to Hydrogen Economy and Green Hydrogen: Overview of hydrogen as an energy carrier, Hydrogen economy: concepts, evolution, and need, Classification of hydrogen: grey, blue, green, turquoise, Role of green hydrogen in decarbonization, Current global and Indian scenario: policies, initiatives, and projects, Challenges and opportunities in green hydrogen deployment.	4
2	Hydrogen Production Technologies: Electrolysis Techniques: Alkaline Electrolyzers, Proton Exchange Membrane (PEM) Electrolyzers, Solid Oxide Electrolyser (SOE), Solar and wind energy integration for green hydrogen, Water purification and resource management for electrolysis, Biomass gasification and thermochemical routes, Techno-economic analysis and efficiency comparisons	6
3	Hydrogen Storage and Transportation: Physical storage: Compressed gas, Liquid hydrogen, Material-based storage: Metal hydrides, Chemical carriers (ammonia, LOHCs), Storage system design considerations, Transportation methods: Pipelines, Cryogenic tankers, Hydrogen blending in NG pipelines, Safety standards, codes, and regulations	5
4	Hydrogen Utilization and Applications:	7

	<p>Fuel cells: PEMFC, SOFC, applications and integration, Hydrogen in internal combustion engines (H₂-ICE), Industrial applications: Steel, Fertilizer, Refineries</p> <p>Mobility and transportation: Fuel cell electric vehicles (FCEVs), hybrid systems,</p> <p>Power-to-X technologies: Synthetic fuels, Ammonia, Methanol</p>	
5	<p>Emerging Trends, Challenges, and Future Prospects: Techno-economic analysis of hydrogen value chain, Hydrogen hubs, microgrids, and sector coupling, Carbon footprint and life-cycle assessment (LCA), Policy framework, incentives, and public-private partnerships, Case studies: National Hydrogen Mission (India), EU Hydrogen Strategy, HyDeploy, etc., Research opportunities and startup ecosystem</p>	6

Textbooks (Recommended for Primary Learning)

1. **"Hydrogen and Fuel Cells: Emerging Technologies and Applications"**
Author: Bent Sørensen
Publisher: Academic Press
Description: Covers hydrogen production, storage, fuel cells, and applications with technical depth. Suitable for engineering students.
2. **"Hydrogen Economy: Supply Chain, Life Cycle Analysis and Energy Transition for Sustainability"**
Authors: Antonio Scipioni, Alessandra Manzardo, Javier G. Pérez
Publisher: Academic Press
Description: Excellent introduction to hydrogen's role in the energy transition, with chapters on production, storage, LCA, and policy.

Reference Books (For Deeper Understanding & Advanced Study)

1. **"Fuel Cell Fundamentals"**
Authors: Ryan O'Hayre, Suk-Won Cha, Whitney Colella, Fritz B. Prinz
Publisher: Wiley
Description: Comprehensive reference for understanding fuel cell technologies, design, and applications.
2. **"Hydrogen Energy and Vehicle Systems"**
Author: Scott E. Grasman
Publisher: CRC Press
Description: Focuses on hydrogen applications in transportation, vehicle design, and energy systems integration.
3. **"Green Hydrogen: Renewable Energy for a Low Carbon Future"**
Editors: V. Subramanian et al.
Publisher: CRC Press (Recent publication)
Description: Covers green hydrogen production, storage, utilization, and policy frameworks—updated with current trends and global case studies.

Supplementary Reading (Reports, White Papers & Journals)

- **IEA Global Hydrogen Review** (International Energy Agency)
- **IRENA Report on Green Hydrogen: A Guide to Policy Making**
- **NITI Aayog – India's Green Hydrogen Policy and Roadmap**
- **Journal:** International Journal of Hydrogen Energy (Elsevier)
- **Journal:** Renewable and Sustainable Energy Reviews (Elsevier)

CO-PO Mapping Table

Course Outcome (CO)	Mapped POs	Description & Justification
CO1: Explain the principles of hydrogen production, storage, and utilization with emphasis on green hydrogen pathways.	PO1, PO2	Builds foundational engineering knowledge (PO1) and enables students to identify and classify hydrogen technologies and their applications (PO2), forming the basis for sustainable energy solutions.
CO2: Analyze various electrochemical and thermochemical methods for hydrogen generation, including water electrolysis and biomass reforming.	PO2, PO3	Develops analytical skills (PO2) to compare hydrogen production methods and apply design thinking (PO3) to optimize process efficiency and scalability.
CO3: Evaluate the techno-economic feasibility and lifecycle sustainability of green hydrogen technologies for industrial and mobility applications.	PO3, PO7	Promotes informed decision-making in technology selection (PO3), while integrating sustainability and environmental impact assessments (PO7).
CO4: Apply system-level modeling tools to design and simulate hydrogen production, storage, and distribution networks.	PO5, PO11	Builds proficiency in modern engineering tools (PO5) and applies project planning and resource management principles (PO11) to simulate hydrogen infrastructure.
CO5: Assess the environmental, safety, and regulatory aspects of hydrogen infrastructure deployment in societal contexts.	PO6, PO7	Fosters contextual awareness of societal, legal, and environmental implications (PO6) and encourages responsible engineering practices for sustainable development (PO7).
CO6: Demonstrate awareness of global hydrogen initiatives and ethical responsibility in promoting clean energy transitions.	PO8, PO12	Reinforces ethical standards (PO8) and cultivates lifelong learning habits (PO12) to adapt responsibly to evolving energy technologies and global sustainability goals.

CO–PO–PSO Mapping Matrix

Mapped Levels:

3: Strong correlation, 2: Moderate correlation, 1: Low correlation, 0: No significant correlation

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	2	2	1
CO2	0	3	2	0	0	0	0	0	0	0	0	0	2	3	1
CO3	0	0	3	0	0	1	3	0	0	0	0	0	3	2	2
CO4	0	0	0	0	3	0	0	0	0	0	2	0	3	3	1
CO5	0	0	0	0	0	2	3	0	0	0	0	0	1	2	3
CO6	0	0	0	0	0	0	0	3	0	0	0	3	1	1	3

PEC-4.5 : Experimental Stress Analysis

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-xxxx	Experimental Stress Analysis	3	0	0	1	3	30	20	50	--	

Course outcomes:

Students who successfully complete this course will have demonstrated an ability to:

- CO1:** Explain the fundamental concepts of stress, strain, and material behavior under various loading conditions using experimental approaches.
- CO2:** Apply principles of strain measurement techniques such as strain gauges, photoelasticity, and digital image correlation to analyze stress fields.
- CO3:** Analyze experimental data to determine stress concentration, residual stresses, and validate theoretical models.
- CO4:** Use modern instrumentation and data acquisition systems to conduct stress analysis experiments and interpret results.
- CO5:** Evaluate the limitations, accuracy, and applicability of different experimental methods in real-world engineering scenarios.
- CO6:** Demonstrate professional ethics, safety awareness, and teamwork while conducting laboratory-based stress analysis investigations.

Syllabus:

Unit	Contents	Hrs.
1	Introduction to Experimental Stress Analysis: Importance and Scope of Experimental Stress Analysis, Equilibrium equations in 3D, Shear force and bending moment diagrams, Concepts of Stress and Strain tensors. Mohr circle, transformation of stress and strain components in 3D, Principal Stresses and Strains.	6
2	Constitutive relations, theories of yielding and composite materials: Constitutive equations in 3D, isotropic materials, anisotropic material, fibre composite materials, theories of yielding, piezo-electric sensors. Overview of Experimental Methods.	4
3	Measurement of strain through strain gages: Electrical Resistance Strain Gauges: Working Principles, Types, and Applications. Wheatstone Bridge Circuits and Gauge Factor. Rosette strain gages: Measurement of strain in a thin elastic beam, compare it with theoretical prediction, and study geometrical nonlinearity; measure strain in a circular tube loaded with a torsional member using full bridge.	8

4	Photoelasticity: Principles of Photoelasticity: Stress-Optic Law, Plane and Circular Polariscopes Techniques, Fringe Patterns: Isoclinics and Isochromatics, Determination of material fringe value, Pure bending moment through four-points bend specimen, study of Saint Venant's principle through photoelasticity	8
5	Advanced Techniques in Stress Analysis: Moire' interferometry, Principle, Types, and Applications; Digital Image Correlation (DIC): Principles, Equipment, and Applications; Thermoelastic Stress Analysis Using Infrared Thermography, Ultrasonic Stress Analysis Methods, Fiber Optic Strain Sensors.	6
6	Applications and Case Studies: Fiber Optic Strain Sensors, its principle, applications, and its strength and limitations; case studies of applications of various measuring techniques in actual cases in industrial applications.	6

Suggested learning resources:

Textbooks:

- Dally, J. W., and Riley, W. F., Experimental Stress Analysis
- Sadhu Singh, Experimental Stress Analysis
- Srinath, L. S., Experimental Stress Analysis

Reference Books:

- Hetenyi, M., Handbook of Experimental Stress Analysis
- Ramesh, K., Digital Photoelasticity: Advanced Techniques and Applications

Useful Links:

- https://onlinecourses.nptel.ac.in/noc21_me02/preview

CO-PO Mapping

Course Outcome (CO)	Mapped POs	Description & Justification
CO1: Explain the fundamental concepts of stress, strain, and material behavior under various loading conditions using experimental approaches.	PO1, PO2	Builds foundational engineering knowledge (PO1) and enables students to identify and interpret mechanical behavior using experimental techniques (PO2), forming the basis for real-world stress analysis.
CO2: Apply principles of strain measurement techniques such as strain gauges, photoelasticity, and digital image correlation to analyze stress fields.	PO2, PO3	Develops analytical skills (PO2) and applies design thinking (PO3) to select and implement appropriate experimental methods for stress evaluation.
CO3: Analyze experimental data to determine stress concentration, residual stresses, and validate theoretical models.	PO2, PO4	Encourages critical analysis (PO2) and investigation of complex problems (PO4) by comparing experimental results with theoretical predictions.
CO4: Use modern instrumentation and data acquisition systems to conduct stress analysis experiments and interpret results.	PO5, PO11	Promotes proficiency in modern tools (PO5) and integrates project planning and execution (PO11) in laboratory-based investigations.
CO5: Evaluate the limitations, accuracy, and applicability of	PO3, PO7	Supports design evaluation (PO3) and sustainability awareness (PO7) by assessing

different experimental methods in real-world engineering scenarios.		the practicality and environmental impact of experimental techniques.
CO6: Demonstrate professional ethics, safety awareness, and teamwork while conducting laboratory-based stress analysis investigations.	PO8, PO9, PO12	Reinforces ethical conduct (PO8), collaborative skills (PO9), and lifelong learning (PO12) in the context of experimental engineering practice.

CO-PO-PSO Mapping

Mapped Levels:

3: Strong correlation, 2: Moderate correlation, 1: Low correlation, 0: No significant correlation

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	2	2	1
CO2	0	3	2	0	0	0	0	0	0	0	0	0	3	3	1
CO3	0	3	2	2	0	0	0	0	0	0	0	0	3	3	2
CO4	0	0	0	0	3	0	0	0	0	0	2	0	3	3	1
CO5	0	0	3	0	2	1	2	0	0	0	0	0	2	2	2
CO6	0	0	0	0	0	0	0	3	3	2	0	3	1	1	3

PEC-4.5 : Modern IC Engine

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Modern IC Engine	3	0	0	1	3	30	20	50	--	

Course outcomes:

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

- CO1:** Explain the working principles, thermodynamic cycles, and classifications of modern internal combustion engines.
- CO2:** Analyze the influence of fuel types, injection systems, and combustion chamber design on engine performance and emissions.
- CO3:** Evaluate advanced technologies such as turbocharging, variable valve timing, and hybrid integration in enhancing IC engine efficiency.
- CO4:** Apply diagnostic tools and simulation software to model engine behavior and assess performance parameters.
- CO5:** Assess the environmental impact, regulatory standards, and sustainability challenges associated with modern IC engines.
- CO6:** Demonstrate awareness of ethical practices, safety norms, and emerging trends in engine design and mobility solutions.

Syllabus:

Unit	Contents	Hrs
1	<p>Overview of thermodynamics of fuel-air cycles and real cycles Otto cycle, Diesel cycle, Atkinson cycle, Stirling cycle, Brayton cycle. Assumptions in fuel air cycle and its analysis, Composition of cylinder gases</p> <p>Engine construction and operation Construction and working principle of SI, CI engines and gas turbines, Major engine components, Four stroke and two stroke engines</p>	6
2	<p>Engine fuels Basic requirements of engine fuels: Chemical structure of petroleum, Heat value of fuels, Rating of SI Engine fuels, Rating of CI engine fuels, Combustion equation for hydrocarbon fuels, Properties and ratings of petrol and diesel fuels, Fuel supply systems of SI and CI engines, non-conventional fuels for IC engines; LPG, CNG, Methanol, Ethanol, Non-edible vegetable oils, Hydrogen.</p>	5
3	<p>Carburettor & Fuel Injection systems Construction and working of carburettor, Inlet and exhaust valve timings, Fuel feed and fuel injection pumps, Petrol injection, Electronic Fuel Injection systems (EFI), Multi-point fuel injection system (MPFI)</p>	5

4	Combustion in SI and CI Engines: Ignition systems, Stages of combustion in engines, Flame propagation and factors affecting it, Knocking and pre-ignition, Factors affecting knocking and Control of knocking, Combustion chamber requirements, Turbo charging and super charging, Engine emissions, Engine emissions and emission standards	5
5	Engine lubrication systems Engine lubrication systems, Hydrodynamic theory of lubrication, Properties of lubricants, Types of lubricants and additives Grading of lubricating oils, Engine cooling Air and water cooling systems, Working principles of air and water cooling systems, Variation of gas temperatures, Components of water cooling system	6
6	Engine performance and testing of engines Performance parameters, Engine power, BHP, Fuel consumption, Air consumption, Engine heat balance sheet, Mechanical efficiency, Engine efficiencies, Testing of engines and related numerical problems	6

Suggested learning resources:

Practicals:

1. Engine dismantling and engine assembly: SI and CI engines.
2. Identification of engine components and checking them for defects.
3. Performance testing of SI/CI engine
4. Tailpipe emission testing of given engine

References:

1. Heywood, J. B. , *Internal Combustion Engine Fundamentals*, McGraw Hill Publishing Co., New York, 1990.
2. Sharma, S. P, Chandramohan, *Fuels and Combustion*, Tata McGraw Hill Publishing Co, 1987.
3. Mathur and Sharma, *A course on Internal combustion Engines*, Dhanpat Rai & Sons, 1998.
4. Pulkrabek, W. W., *Engineering Fundamentals of the Internal Combustion Engine*, Prentice-Hall of India Private Limited, 2002.
5. Prof. P.L. Ballaney, *Internal Combustion Engines*, Khanna Publications, Delhi, India
6. R.K. Mohanty, *A Text Book of Internal Combustion Engines*, Standard Book House, Delhi, India

CO-PO Mapping

Course Outcome (CO)	Mapped POs	Description & Justification
CO1: Explain the working principles, thermodynamic cycles, and classifications of modern internal combustion engines.	PO1, PO2	Builds foundational engineering knowledge (PO1) and enables students to identify and classify engine types and operating cycles (PO2), forming the basis for advanced mobility systems.
CO2: Analyze the influence of fuel types, injection systems, and combustion chamber design on engine performance and emissions.	PO2, PO3	Develops analytical skills (PO2) to interpret combustion behavior and applies design thinking (PO3) to optimize engine efficiency and emission control.

CO3: Evaluate advanced technologies such as turbocharging, variable valve timing, and hybrid integration in enhancing IC engine efficiency.	PO3, PO7	Promotes informed decision-making in engine design (PO3) and integrates sustainability considerations (PO7) by assessing energy efficiency and environmental impact.
CO4: Apply diagnostic tools and simulation software to model engine behavior and assess performance parameters.	PO5, PO11	Enhances proficiency in modern engineering tools (PO5) and applies project planning and execution principles (PO11) in virtual testing and diagnostics.
CO5: Assess the environmental impact, regulatory standards, and sustainability challenges associated with modern IC engines.	PO6, PO7	Fosters contextual awareness of societal, legal, and environmental implications (PO6) and encourages responsible engineering practices for sustainable transportation (PO7).
CO6: Demonstrate awareness of ethical practices, safety norms, and emerging trends in engine design and mobility solutions.	PO8, PO12	Reinforces ethical conduct and safety awareness (PO8) and cultivates lifelong learning (PO12) to adapt responsibly to evolving automotive technologies and global energy transitions.

CO–PO–PSO Mapping Matrix

Mapped Levels:

3: Strong correlation, 2: Moderate correlation, 1: Low correlation, 0: No significant correlation

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	2	2	1
CO2	0	3	2	0	0	0	1	0	0	0	0	0	3	3	2
CO3	0	0	3	0	0	1	3	0	0	0	0	0	3	2	2
CO4	0	0	0	0	3	0	0	0	0	0	2	0	3	3	1
CO5	0	0	0	0	0	2	3	0	0	0	0	0	2	2	3
CO6	0	0	0	0	0	0	0	3	2	2	0	3	1	1	3

PEC-4.7 : Operations Research

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-xxxx	Operations Research	3	0	0	1	3	30	20	50	--	

Course outcomes:

At the end of the course student will able to:

- CO1:** Explain the fundamental concepts, models, and scope of operations research in engineering and management decision-making.
- CO2:** Formulate linear programming problems and solve them using graphical and simplex methods.
- CO3:** Apply optimization techniques such as transportation, assignment, and network models to real-world engineering scenarios.
- CO4:** Analyze decision-making problems under uncertainty using game theory, decision trees, and queuing models.
- CO5:** Use software tools and computational methods to simulate and solve complex operations research problems.
- CO6:** Evaluate the ethical, economic, and societal implications of operations research models in industrial and public systems.

Syllabus:

Unit	Content	Hrs.
1	Introduction to operations research and linear programming problem: Scope, phases, and applications of operations research, advantages and limitations of operations research. Linear Programming Problem (LPP)- formulation and graphical solution to LPP, simplex method, artificial variable technique- Big M method and two-phase method, duality and sensitivity analysis.	8
2	Transportation, assignment and sequencing problem: Mathematical formulation of transportation problem (TP), methods to obtain initial basic feasible solution, TP with and without degeneracy. Assignment problem (AP)- Mathematical formulation, variations of AP, Travelling Salesman Problem. Sequencing Problem-Assumptions in sequencing problem, processing of n jobs through two machines, processing of n jobs through three machines.	8
3	Replacement model and waiting line theory: Replacement of items whose maintenance and repair cost increases with time ignoring money value and considering money value, replacement of items that fails suddenly- group replacement. Waiting line theory- Kendall's notation, waiting line with single channel Poisson arrivals with exponential service times, infinite population.	8
4	Games theory and simulation:	8

	Minimax criteria for optimality, characteristics of game, dominance principles, 2X2 game- arithmetic and algebraic method, 2Xn and mX2 game- graphical and method of subgames, 3X3 game- method of matrices Simulation- Monte Carlo simulation, advantages and limitations of simulation, applications of simulation	
5	Network analysis: Network construction, identification of critical path, float calculations, Programme Evaluation and Review Technique (PERT) time calculations, crashing of network, resource scheduling, network updating	8

Suggested learning resources:

Text Books:

- Operations Research- theory, methods & applications, Eighteenth revised edition 2017, S. D. Sharma, Kedar Nath Ram Nath
- Operations Research, Revised and enlarged edition 2012 Prem Kumar Gupta and D S Hira, S Chand & Company Ltd.

Reference Books:

- Operations Research-An Introduction, Ninth edition 2014, Hamdy A Taha, Pearson Education India
- Operations Research: Methods and Problems, Maurice Saseini, Arhur Yaspan and Lawrence Friedman, John Wiley and Sons., New York

CO-PO Mapping Table

CO Code	Mapped POs	Description and Justification
CO1	PO1, PO2	Students apply mathematical and engineering fundamentals to understand operations research models. They analyze decision variables and system constraints, developing analytical thinking for complex problems.
CO2	PO2, PO4	Learners formulate and analyze linear programming problems. They apply research-based mathematical methods like graphical and simplex techniques to solve structured optimization problems.
CO3	PO2, PO3, PO4	Students analyze real-world systems using optimization models. They design efficient solutions using transportation, assignment, and network techniques, and interpret results using modeling tools.
CO4	PO2, PO5	Learners evaluate decision-making under uncertainty. They use modern tools such as game theory and queuing models to simulate and solve complex scenarios.
CO5	PO5, PO6	Students apply computational tools and simulation software to solve operations research problems. They assess the societal and ethical implications of optimization decisions in engineering and public systems.
CO6	PO6, PO8, PO12	Learners evaluate the broader impact of operations research models on society. They reflect on ethical considerations in decision-making and engage in lifelong learning through evolving methodologies and tools.

CO-PO-PSO Mapping

Mapped Levels:

3 – High Contribution, 2 – Moderate Contribution, 1 – Low Contribution, 0– No Significant Contribution

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	0	0	0	0	0	0	0	0	0	0	2	0
CO2	0	3	0	2	0	0	0	0	0	0	0	0	2	0
CO3	0	3	2	2	0	0	0	0	0	0	0	0	3	2
CO4	0	2	0	0	3	0	0	0	0	0	0	0	2	2
CO5	0	0	0	0	3	2	0	0	0	0	0	0	2	3
CO6	0	0	0	0	0	3	0	2	0	0	0	2	0	3

PEC-4-8 : Machine Learning

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-xxxx	Machine Learning	3	0	0	1	3	30	20	50	--	

Course Outcomes:

Students who successfully complete this course will have demonstrated an ability to:

- CO1:** Explain the fundamental concepts, types, and applications of machine learning in engineering and interdisciplinary contexts.
- CO2:** Formulate supervised and unsupervised learning problems and apply appropriate algorithms for classification, regression, and clustering.
- CO3:** Analyze model performance using metrics such as accuracy, precision, recall, F1-score, and confusion matrices.
- CO4:** Implement machine learning algorithms using programming tools and libraries such as Python, scikit-learn, and TensorFlow.
- CO5:** Evaluate the ethical, societal, and security implications of machine learning systems in real-world applications.
- CO6:** Design and optimize machine learning workflows for engineering problems involving data preprocessing, feature selection, and model tuning.

Syllabus:

Units	Contents	Hrs.
1	Introduction to AI & Machine Learning in Mechanical Engineering: History and evolution of AI and ML, Differences between AI, ML, and Data Science. Importance of ML in engineering, Overview of ML approaches: Supervised, Unsupervised, Reinforcement Learning Basic concepts: Reasoning, problem-solving, knowledge representation, planning, perception	6
2	Feature Engineering and Data Preprocessing: Importance of data quality and preprocessing, Techniques for feature extraction: Statistical features, Principal Component Analysis (PCA), Feature selection methods, Dimensionality reduction techniques	7
3	Supervised Learning Algorithms: Linear and logistic regression, Decision trees and random forests, Support Vector Machines (SVM), K-Nearest Neighbors (KNN), Model evaluation metrics: Accuracy, precision, recall, F1-score	6
4	Unsupervised Learning and Clustering: Clustering algorithms: K-Means, Hierarchical clustering, Dimensionality reduction: PCA, t-SNE, Anomaly detection techniques, Applications in mechanical systems: Fault detection, pattern recognition	7

5	Deep Learning and Neural Networks: Introduction to neural networks and deep learning, Convolutional Neural Networks (CNNs) for image data, Recurrent Neural Networks (RNNs) for time-series data, Applications in mechanical engineering: Predictive maintenance, image-based inspections	8
6	Advanced Topics and Applications in Mechanical Engineering: Reinforcement learning and its applications, Physics-informed machine learning models, Integration of ML with Computer-Aided Engineering (CAE) tools, Case studies: Digital twins, smart manufacturing, structural health monitoring	7

Suggested learning resources:

Textbooks:

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow Concepts, Tools, and Techniques to Build Intelligent Systems, O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.
2. Introduction to Machine Learning with Python by Andreas C. Müller & Sarah Guido
3. Machine Learning For Dummies by John Paul Mueller & Luca Massaron

Reference Books:

1. Tom Mitchell “Machine Learning” McGraw Hill Publication, ISBN :0070428077 9780070428072
2. Marc Peter Deisenroth (Author), A. Aldo Faisal (Author), Cheng Soon Ong (Author), MATHEMATICS FOR MACHINE LEARNING, Cambridge University Press (23 April 2020); Cambridge University Press.

CO-PO Mapping

CO Code	Mapped POs	Description and Justification
CO1	PO1, PO2	Students apply mathematical and engineering fundamentals to understand machine learning principles and algorithms. They analyze problem domains and identify suitable learning paradigms, supporting foundational and analytical competencies.
CO2	PO2, PO3, PO4	Learners formulate supervised and unsupervised learning problems and select appropriate algorithms. They design and implement models for classification, regression, and clustering, integrating problem analysis, solution design, and research-based methods.
CO3	PO2, PO4	Students evaluate model performance using statistical metrics and validation techniques. This involves analytical thinking and interpretation of experimental results, reinforcing problem analysis and research-based evaluation.
CO4	PO5, PO12	Learners implement machine learning algorithms using modern programming tools and libraries. This fosters proficiency in contemporary technologies and promotes lifelong learning through hands-on experimentation and tool adaptation.
CO5	PO6, PO8	Students assess the ethical, societal, and security implications of machine learning systems. They reflect on responsible AI practices, data privacy, and fairness, supporting societal awareness and professional ethics.
CO6	PO3, PO5, PO12	Learners design and optimize machine learning workflows, including data preprocessing and model tuning. This outcome strengthens solution design, tool usage, and continuous learning in evolving data-driven environments.

CO-PO-PSO Mapping

Mapped Levels:

3 – High Contribution, 2 – Moderate Contribution, 1 – Low Contribution, 0– No Significant Contribution

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	0	0	0	0	0	0	0	0	0	0	2	0	0
CO2	0	3	3	2	0	0	0	0	0	0	0	0	3	2	0
CO3	0	3	0	3	0	0	0	0	0	0	0	0	2	0	0
CO4	0	0	0	0	3	0	0	0	0	0	0	2	3	2	0
CO5	0	0	0	0	0	3	0	3	0	0	0	0	0	3	0
CO6	0	0	3	0	2	0	0	0	0	0	0	3	3	3	0

PEC-4.9 : Renewable Energy Resources

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-xxxx	Renewable Energy Resources	3	0	0	1	3	30	20	50	--	

Course Outcomes (COs):

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

- CO1:** Explain the principles, classifications, and global significance of renewable energy sources.
- CO2:** Analyze the working and performance characteristics of solar, wind, biomass, hydro, and geothermal energy systems.
- CO3:** Evaluate the technical, economic, and environmental feasibility of renewable energy projects.
- CO4:** Apply mathematical and simulation tools to model and optimize renewable energy systems.
- CO5:** Assess the impact of renewable energy technologies on society, environment, and policy frameworks.
- CO6:** Design integrated renewable energy solutions for engineering applications, considering sustainability and energy efficiency.

Syllabus:

Units	Contents	Hrs
1	Introduction to energy: Energy demand growth and supply, Historical perspectives, Fossil fuels: Consumption and Reserves, Environmental impacts of burning fossil fuels, Sustainable development and the role of renewable energy.	6
2	Wind and Hydro power systems : Atmospheric circulations, factors influencing the winds, wind turbines and types, coefficient of power, torque, Betz limit, Aerodynamic design principle for blades, Introduction to hydro power plant and types, overview of micro, mini and small hydropower plant, types and operational characteristics of hydro turbine	6
3	Bio energy and bio-fuels: Biomass source and characterization, direct combustion, pyrolysis, mechanism of bio-renewable energy, Gasifiers, updraft gasifier, downdraft gasifier, gasifier-based electricity-generating systems, application of biogas slurry in agriculture, bio ethanol for energy generation	6
4	Fuel cells: Working principle of fuel cells, fuel cell electrochemistry, types of fuel cells: Alkaline fuel, Fuel Cells, Phosphoric acid fuel cell, Solid oxide fuel cell,	6

	Molten carbonate fuel cell, Direct methanol Fuel Cell, their applications, relative merits and demerits. Introduction to thermal heat storage.	
5	<p>Tidal energy: Tidal power plants: single basin & two basin plants, variation in generation level, Ocean thermal electricity conversion, electricity generation from waves, shortline and floating wave systems.</p> <p>Geothermal energy: Introduction, Geothermal sites in India, high temperature and low temperature sites in India, Conversion technologies, Steam and binary systems, geothermal power plant, open loop and closed loop system</p>	6
6	<p>Solar energy: Principles of solar energy conversion: Photovoltaic (PV) cells and solar thermal systems, Efficiency of solar cells and factors affecting performance, Solar power plants: Concentrated solar power (CSP) vs. photovoltaic systems, Solar thermal collectors and applications, Energy storage for solar power systems,</p>	6

Suggested learning resources:

Text Books :

- Godfrey Boyle, Renewable energy, Oxford press, 2012
- Twidell J and Weir T., Renewable energy resources, Taylor and Francis, 2006
- Rai G.D., Non-conventional energy sources, Khanna Publication, 2009
- B.H. Khan, Non-conventional energy sources, Mcgrawhill education, 2006.
- "Solar energy" by S. P. Sukhatme, Fourth edition, McGraw Hill Education.

Reference Books:

- Wind Energy Systems by Johnson G. L., Prentice Hall,1985
- Introduction to Hydro Energy Systems: Basics, Technology and Operation by Wagner H. and Mathur J, Springer, 2009.
- Bio-fuels: biotechnology, chemistry, and sustainable development by DM Mousdale, CRC Press, 2008.
- Fuel Cells: From Fundamentals to Applications by S Srinivasan, Springer, 2006

NPTEL Course:

<https://nptel.ac.in/courses/103103206>

CO-PO Mapping

CO Code	Mapped POs	Description and Justification
CO1	PO1, PO2	Students apply fundamental concepts of physics and engineering to understand renewable energy sources. They analyze global energy challenges and classify technologies based on scientific principles and sustainability goals.
CO2	PO2, PO3, PO4	Learners analyze the performance of solar, wind, biomass, hydro, and geothermal systems. They design and evaluate energy conversion setups using research-based methods, integrating problem analysis, solution design, and experimentation.

CO3	PO2, PO6	Students assess the feasibility of renewable energy projects by analyzing technical parameters, cost-effectiveness, and environmental impact. This promotes analytical thinking and societal awareness in energy planning.
CO4	PO4, PO5	Learners apply mathematical models and simulation tools to optimize renewable energy systems. This fosters research-based problem solving and modern tool usage in energy engineering.
CO5	PO6, PO8	Students evaluate the societal, environmental, and policy implications of renewable technologies. They reflect on ethical responsibilities and sustainability in energy deployment, supporting professional ethics and public welfare.
CO6	PO3, PO5, PO12	Learners design integrated renewable energy solutions for engineering applications. They use modern tools and engage in continuous learning to improve energy efficiency and system performance in evolving technological contexts.

CO-PO-PSO Mapping

Mapped Levels:

3 – High Contribution, 2 – Moderate Contribution, 1 – Low Contribution, 0 – No Significant Contribution

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	0	0	0	0	0	0	0	0	0	0	2	0	0
CO2	0	3	3	2	0	0	0	0	0	0	0	0	3	2	0
CO3	0	3	0	0	0	3	0	0	0	0	0	0	2	3	0
CO4	0	0	0	3	3	0	0	0	0	0	0	0	3	2	0
CO5	0	0	0	0	0	3	0	3	0	0	0	0		3	0
CO6	0	0	3	0	2	0	0	0	0	0	0	3	3	3	0

PEC-4.10 : Steam and Gas Turbines

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Steam and Gas Turbines	3	0	0	1	3	30	20	50	-----	

Prerequisites: Engineering Thermodynamics, Fluid Mechanics, Heat Transfer

Course Outcomes (COs):

After learning the course the students should be able to:

- CO1:** Explain the thermodynamic principles and working cycles of steam and gas turbines.
- CO2:** Analyze the performance parameters of steam and gas turbines using energy balance and efficiency calculations.
- CO3:** Evaluate the design and operational characteristics of turbine components such as nozzles, blades, and combustion chambers.
- CO4:** Apply governing equations and flow analysis to solve problems related to impulse and reaction turbines.
- CO5:** Assess the environmental impact, fuel usage, and emission characteristics of turbine systems.
- CO6:** Design and optimize turbine systems for engineering applications considering thermal efficiency, material constraints, and sustainability.

Syllabus:

Unit	Contents	Hrs.
1	Steam Nozzles: Types of nozzles, velocity of steam, discharge through nozzle, critical pressure ratio and condition for maximum discharge, physical significance of critical pressure ratio, nozzle efficiency	6
2	Steam Turbine: Principle of operation, types of steam turbines, compounding of steam turbines, impulse turbine - velocity diagram, calculation of work, power and efficiency, condition for maximum efficiency, Reaction turbines - velocity diagram, degree of reaction, reheat factor, governing of steam turbine - throttle, nozzle and bypass governing, Methods of attachment of blades to turbine rotor, Labyrinth packing, Losses in steam turbine, Special types of steam turbine- back pressure, pass out and mixed pressure turbine.	10
3	Gas Turbine: Classification, open and closed cycle, gas turbine, fuels, the actual Brayton cycle, optimum pressure ratio for maximum thermal efficiency, work ratio, air rate,	10

	effect of operating variables on the thermal efficiency and work ratio, and air rate, simple open cycle turbine with regeneration, reheating and Intercooling, Combined steam and gas turbine plant, requirements of combustion chamber, types of combustion chambers.	
4	Jet Propulsion: Fundamentals of propulsion technology, Turbojet Engine, thrust, thrust power, propulsive efficiency, thermal efficiency, Turboprop, Ramjet and Pulsejet engines	8

Suggested learning resources:

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year): -

1. Groover, M. P. - Automation, Production Systems, and Computer-Integrated Manufacturing (Pearson)
2. Tönshoff, H.K., & Denkena, B. - Digital Manufacturing (Springer)
3. Tao, F., Cheng, Y., & Zhang, M. - Digital Twin Driven Smart Manufacturing (Elsevier)
4. Alasdair Gilchrist - Industry 4.0: The Industrial Internet of Things

Reference Books:

1. Power Plant Engineering, P.K. Nag, McGraw-Hill Education
2. Power Plant Engineering, R. K. Hegde, Pearson India Education
3. Gas Turbines, V. Ganeshan, McGraw Hill Education
4. Thermal Engineering, R.K.Rajput, Laxmi Publication
5. Steam Turbine Theory and Practice, William J. Kearton, CBS Publication

List of Open-Source Software/learning websites:

<http://nptel.ac.in/courses/112104117/18>

<http://nptel.ac.in/courses/112104117/4>

<http://nptel.ac.in/courses/112104117/17>

CO-PO Mapping

CO Code	Mapped POs	Description and Justification
CO1	PO1, PO2	Students apply thermodynamic principles and engineering fundamentals to understand the working cycles of steam and gas turbines. They analyze energy conversion processes and system behavior, reinforcing foundational and analytical skills.
CO2	PO2, PO4	Learners calculate performance parameters such as efficiency, work output, and heat balance. They interpret experimental and theoretical data, integrating problem analysis and research-based evaluation.
CO3	PO3, PO4	Students evaluate turbine components including nozzles, blades, and combustion chambers. They design and assess mechanical configurations using engineering principles and experimental insights.
CO4	PO2, PO5	Learners apply governing equations and flow analysis to impulse and reaction turbines. They use modern tools and simulation techniques to solve fluid flow and thermodynamic problems.
CO5	PO6, PO8	Students assess the environmental impact and emissions of turbine systems. They reflect on sustainability, fuel usage, and ethical considerations in energy conversion technologies.
CO6	PO3, PO5, PO12	Learners design and optimize turbine systems for engineering applications. They use modern tools and engage in lifelong learning to improve thermal efficiency and adapt to evolving energy technologies.

CO-PO-PSO Mapping

Mapped Levels:

3 – High Contribution, **2** – Moderate Contribution, **1** – Low Contribution, **0** – No Significant Contribution

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	0	0	0	0	0	0	0	0	0	0	2	0	0
CO2	0	3	0	3	0	0	0	0	0	0	0	0	2	0	0
CO3	0	0	3	2	0	0	0	0	0	0	0	0	3	2	0
CO4	0	3	0	0	3	0	0	0	0	0	0	0	2	2	0
CO5	0	0	0	0	0	3	0	3	0	0	0	0	0	3	0
CO6	0	0	3	0	2	0	0	0	0	0	0	3	3	3	0

V-5 : MDM II Biomass Processing Technologies

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
MDM II	Biomass Processing Technologies	3	1	0	0	4	30	20	50	-	-

Course Outcomes:

Students who successfully complete this course will have demonstrated an ability to:

- CO 1:** Classify different types of biomass, including lignocellulosic materials and bio-based wastes, and their roles in producing energy and chemicals.
- CO 2:** Describe the principles of biorefineries and the economic aspects of process integration and product options.
- CO 3:** Understand the processes for producing bioethanol and apply Monod kinetics to optimize fermentation.
- CO 4:** Assess technologies like gasification and pyrolysis for energy production and resource recovery.

Syllabus:

Unit	Contents	Hrs.
1	Introduction to Biomass Energy : Global energy scenario and fossil fuel depletion. Biomass as a renewable energy source. Availability, abundance, and energy potential of biomass. Photosynthesis and energy production. Types of biomass: virgin, waste (municipal, industrial, agricultural, forestry). Energy crops: maize, sorghum, sugarcane, perennial herbaceous crops, woody crops. Microalgae as biofuel feedstock. Challenges in improving biomass for biofuel conversion.	6
2	Biorefinery Concepts and Feedstocks : Introduction to biorefineries. Types of biorefineries and their feedstocks. Feedstock properties and selection. Economic aspects of biorefineries. Market demand, production costs, scalability. Case studies on successful biorefineries.	6
3	Biomass Pretreatment and Conversion Processes : Challenges in lignocellulosic biomass conversion. Pretreatment methods: acid, alkali, autohydrolysis, hybrid methods. Role of pretreatment in biomass processing. Physical and thermal conversion processes. Equipment, applications, and products. Thermal conversion products: syngas, biooil, biochar. Case studies on successful thermal conversion.	6
4	Microbial Conversion and Biofuels: Microbial conversion processes. Biodiesel production from vegetable oils, microalgae, and syngas. Transesterification and biodiesel purification. Bioethanol and biobutanol production. Fermentation technologies and	6

	microorganisms. Biohydrogen and biogas production. Fuel cell integration. Biooil and biochar production and upgradation.	
5	Organic Commodity Chemicals and Integrated Biorefineries : Biomass as feedstock for organic chemicals. Production of lactic acid, succinic acid, acetic acid, PHA. Integrated biorefineries: corn, soybean, sugarcane, lignocellulosic, algal. Hybrid chemical and biological conversion processes. Techno-economic evaluation and life-cycle assessment of biorefineries.	8

Useful Learning Resources

Tutorials

1. Overview of biomass energy, including global energy scenarios, biomass types, and their potential as a renewable resource.
2. Introduction to biorefinery concepts, types of feedstocks, economic aspects, and case studies of successful biorefineries.
3. Examination of biomass pretreatment methods, including acid and alkali processes, and their role in improving conversion efficiency.
4. Study of microbial conversion processes for biodiesel, bioethanol, biobutanol, and biohydrogen production, along with fermentation technologies.
5. Exploration of biomass as a feedstock for organic chemicals, including the production of lactic acid, succinic acid, and integrated bio refineries.

Reference Books:

1. "Biomass to Renewable Energy Processes" by Jay Cheng
2. "Biomass Processing Technologies" by Rajesh Kumar Sharma and Sandeep Kumar
3. "The Biorefinery: A Sustainable Approach to the Production of Fuels and Chemicals" by David S. Armenta
4. "Biofuels: Production and Utilization" by S. K. Singh and M. S. Ranjan
5. "Lignocellulosic Biomass for Bioenergy" by R. A. B. D. Bevan

T. Y. B. Tech : Mechanical Engineering

[Level 5.5, UG] Semester -VI

Sr No	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	PCC		Mechanical System Design	3	0	2	1	4	30	20	50	50	50
2	PCC		Computer Aided Design and Manufacturing	3	0	2	1	4	30	20	50	50	50
3	PCC		Fluid Machinery	3	0	2	0	4	30	20	50	50	50
4	PEC		Program Elective Course - II (Specify List) *	3	1	0	0	4	30	20	50	--	--
5	MDM		Multidisciplinary Minor III	3	1	0	1	4	30	20	50	--	--
6	ELC		Project-II	0	0	4	2	2				CIE-100	
Total Credit								22					

Exit Option to B VOC:

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC		Finite Element Analysis	3	1	0	1	4	30	20	50		
02	PCC		Generative design	3	1	0	1	4	30	20	50		

*Program Elective Course II – Discipline-wise List

Design Engineering	Thermal Engineering/Fluid Science	Manufacturing Science and Engineering	Other Disciplines
Advanced Finite Element Method (FEM)	Industrial Hydraulics and Pneumatics	Micro & Nano Machining	Biomass Energy Conversion
Design for Fatigue and Fracture	Computational Fluid Dynamics	Digital Manufacturing	Automotive Energy Conversion
Piping Design	Heat Exchangers: Fundamentals and Design Analysis	Micro Fluidics	Deep Learning

VI-1: Mechanical System Design

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Mechanical System Design	3	0	2	1	4	30	20	50	50	50

Course Outcomes (COs):

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

- CO1:** Explain the principles, methodologies, and constraints involved in mechanical system design.
- CO2:** Analyze mechanical components and assemblies using strength, stiffness, and reliability criteria.
- CO3:** Apply design standards, codes, and safety considerations in the selection and integration of machine elements.
- CO4:** Use analytical and computational tools to model, simulate, and validate mechanical systems.
- CO5:** Evaluate design alternatives based on performance, manufacturability, cost, and sustainability.
- CO6:** Develop complete mechanical system designs through iterative processes, documentation, and interdisciplinary collaboration.

Syllabus:

Unit	Contents	Hrs.
1	Design against fluctuating load: Stress concentration, fatigue failure, endurance limit, notch sensitivity, Goodman and Soderberg diagrams, and modified Goodman diagram.	6
2	Bearings: Working principle of hydrodynamic, hydrostatic bearing and rolling contact bearing. Classification of bearings. Selection of bearings from manufacturer's catalogue. Comparison of sliding contact and rolling contact bearings.	4
3	Design of gears: Terminology, force analysis, gear tooth failures of spur gear, helical gear, bevel gear and worm gear. Design of all above-mentioned types of gears. Methods of lubrication.	10
4	Friction drives: Belts, Clutches and Brakes: types, power and torque transmission, and absorption derivations.	6
5	Balancing: Static and dynamic balance, balancing of revolving masses on several planes, balancing of reciprocating masses in single and multi cylinder engines, balancing machines.	6
6	Mechanical vibrations: Fundamentals, undamped and damped free vibrations of single degree freedom system, forced vibration of single degree of freedom system, critical speed of shafts.	8

Suggested learning resources:

Text Books

1. Bhandari V.B. - "Design of Machine Elements", McGraw Hill Education (India) Ltd.

2. Shigley J.E. and Mischke C.R. "Mechanical Engineering Design" McGraw Hill Publ. Co.Ltd.
3. Ballaney, P.L., "Theory of Machines and Mechanisms", 2005, ISBN 9788174091222
4. Hannah and Stephens, "Mechanics of Machines: Advanced Theory and Examples", 1970, ISBN 0713132329 Edward Arnold London

Reference Books

1. Spotts M.F. -"Design of Machine Elements", Prentice HallInternational.
2. Black P.H. and O. Eugene Adams - "Machine Design" - McGraw Hill BookCo.Ltd.
3. "Design Data" - P.S.G. College of Technology,Coimbatore.
4. Hall A.S .; Holowenko A.R. and Laughlin H.G. - "Theory and Problems of Machine Design" - Schaum"s outlineseries.
5. Ulicker Jr. J.J., Penock G.R. & Shigley J.E. "Theory of Machines and Mechanisms" Tata McGraw Hills.
6. Ghosh Amitabha & Mallik Asok Kumar, "Theory of Mechanisms and Machines" east-West Press Pvt. Ltd. New Delhi

Weblinks:

<https://archive.nptel.ac.in/courses/112/105/112105125/>

<https://archive.nptel.ac.in/courses/112/106/112106137/>

CO-PO Mapping

CO Code	Mapped POs	Description and Justification
CO1	PO1, PO2	Students apply engineering fundamentals and design principles to understand the constraints, methodologies, and lifecycle considerations in mechanical system design. They analyze design requirements and system behavior.
CO2	PO2, PO4	Learners analyze mechanical components and assemblies using strength, stiffness, and reliability criteria. They interpret data and apply research-based methods to evaluate system performance and safety.
CO3	PO3, PO6	Students apply design codes, standards, and safety norms in selecting and integrating machine elements. They consider societal and environmental implications, promoting responsible engineering practice.
CO4	PO4, PO5	Learners use analytical and computational tools (e.g., CAD, FEA) to model and validate mechanical systems. This fosters research-based problem solving and proficiency in modern engineering tools.
CO5	PO3, PO6, PO8	Students evaluate design alternatives based on performance, cost, manufacturability, and sustainability. They reflect on ethical and societal impacts of design decisions, supporting professional responsibility.
CO6	PO3, PO5, PO12	Learners develop complete mechanical system designs through iterative processes and documentation. They collaborate across disciplines and engage in lifelong learning to adapt to evolving design technologies and practices.

CO-PO-PSO Mapping

Mapped Levels:

3 – High Contribution, 2 – Moderate Contribution, 1 – Low Contribution, 0– No Significant Contribution

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	0	0	0	0	0	0	0	0	0	0	2	0	0
CO2	0	3	0	3	0	0	0	0	0	0	0	0	2	0	0
CO3	0	0	3	0	0	2	0	0	0	0	0	0	3	2	0
CO4	0	0	0	3	3	0	0	0	0	0	0	0	3	2	0
CO5	0	0	2	0	0	3	0	3	0	0	0	0	2	3	0
CO6	0	0	3	0	2	0	0	0	0	0	0	3	3	3	0

VI-2 : Computer Aided Design & Manufacturing

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<i><td></i>	Computer Aided Design & Manufacturing	3	0	2	1	4	30	20	50	50	50

Course outcomes:

Students who successfully complete this course will have demonstrated an ability to:

- CO1:** Explain the principles, scope, and evolution of computer-aided design and manufacturing systems.
- CO2:** Apply geometric modeling techniques and CAD tools to create and analyze engineering components.
- CO3:** Demonstrate the use of CNC programming and automation strategies in manufacturing processes.
- CO4:** Analyze the integration of CAD, CAM, and CAE systems in product lifecycle management and digital manufacturing.
- CO5:** Evaluate the impact of CAD/CAM technologies on productivity, quality, and sustainability in engineering industries.
- CO6:** Design and simulate complete CAD/CAM workflows using software tools, considering manufacturability, cost-effectiveness, and process optimization.

Syllabus:

Unit	Contents	Hrs.
1	Introduction: Definitions, Historical developments. Geometric Modelling, Nameable Un-nameable shapes, Affine and convex combination. Introduction to Equations - Implicit, explicit, parametric. Coordinate systems, Concepts of Torsion and Curvature, Osculating Plane, Binormal Vector. Concepts of Continuity.	4
2	Design of Curves: Cubic Hermite curves - Algebraic and geometric forms, Blending functions, Subdivision, Reparameterization, Truncating, Space curve, four-point form, straight line and Composite Hermite curves (C^n & G^n continuity). Spline curve, Bezier curves - Control polygons and Bernstein basis, De Casteljau algorithm, First and second derivatives at the ends, Continuity aspects. B-Spline Curves - periodic, open and non-uniform knot vectors and corresponding curves, Rational B-Splines, NURBS.	8
3	InDesign of surfaces: Hermite Surface - Algebraic and geometric form, tangent and twist vectors, blending functions, plane surface, cylindrical surface, ruled surface, surface of revolution. Bezier surface - Control net representation, Continuity aspects.	6
4	Introduction to Solid Modelling - Topology, Generalized concept of boundary, set theory, Boolean operators (Union, Difference and Intersection). Set memberships classification, Euler and modified form of equations. Solid model construction: Boolean models, Instances and parameterised shapes, sweep, Boundary Representation (B-Rep), Constructive Solid Geometry (CSG), Generative design	8

5	Geometric versus coordinate transformations, 2D geometric transformations, Homogeneous coordinate Composite transformations, 3D transformations, Inverse transformations, geometric mapping, Examples of transformation applications in mechanical engineering	5
6	Introduction to NC/CNC/DNC machines, Classification of NC systems, Axis nomenclature, Interpolation, features of CNC controllers, Types of CNC machines, Construction features of CNC machines, Manual Part Programming, NC word format, Details of G and M codes, Canned cycles, subroutines and Do loops, Tool radius and length compensations. Exercises on CNC turning center and machining center programming	6

Suggested learning resources:

Textbooks:

1. Michael E. Mortenson, Geometric Modeling, John Wiley & Sons; 2nd edition
2. David Rogers, J. Alan Adams, Mathematical Elements for Computer Graphics (GENERAL ENGINEERING), McGraw Hill; 2nd edition.
3. Ibrahim Zeid, R Sivasubramanian, CAD CAM Theory And Practice, Ibrahim Zeid, McGraw Hill Education; 2nd edition
4. Martti Mantyla, Introduction to Solid Modelling, Computer Science Press.

Reference Books:

1. Gerald Farin, Curves and Surfaces for CAGD, Morgan Kaufmann Publishers In; 5th edition
2. Les Piegl (Author), Wayne Tiller, The NURBS Book, Springer-Verlag.

Practical Course Strategy

- Students will be expected to work in teams of two or three.
- Lab-work will be assigned each week. The lab-work will consist of study as well as designing curves & surfaces. Students are expected to complete the homework in teams. However, each student is required to submit his/her homework individually.
- The team will be required to simulate their work on MATLAB or any other coding based platforms. A report showing the detailed calculations and results of representations must be performed for each assigned team.
- Students will be expected to write simple codes (in MATLAB, JULIA, PYTHON, etc.) for specific problem in order to get a better grasp of the material covered in the course.
- Students are expected to participate actively in the course. 5% of the final grade will be based on class participation.
- Some typical design based assignments are provided for students can familiarize themselves with coding environment. The course instructor has the freedom to add on more design and CAM based lab-work as and when required**.

Sr. No.	Practical Lab Work List	COs Mapped
1.	Formation of varying degree curves and studying their nature.	CO1, CO2
2.	Study of Known shapes of curves and modelling them by Algebraic Forms	CO1, CO2

3.	Study of Known shapes of curves and modelling them by Parametric Forms	CO1
4.	Time Study of various parametric forms and algebraic of circle	CO2
5.	Formation of Hermite curves by – <ul style="list-style-type: none"> . Varying Magnitude of a single tangent vector in a specified range. a. Varying Magnitude of a both tangent vectors in a specified range. b. Varying Direction Cosines which impact direction of tangent vectors. 	CO2
6.	Study of Bezier Curve by – <ul style="list-style-type: none"> . Reversal of control points defined a. Formation of close Bezier Curve with desired continuity C_0, C_1 b. Repeating Certain control points – Multiplicity study 	CO1, CO2
7.	Coding of B-Spline Curves <ul style="list-style-type: none"> . Studying impact by Varying the control points a. Studying impact by Varying Degree of Curve 	CO2
8.	Coding for formation of Surfaces <ul style="list-style-type: none"> . Ruled Surfaces / Tabulated Surface a. Surface of Revolution (Sphere, Cylindrical, Arbitrary Curve rotated about and axis) b. Bezier Surface 	CO3
9.	Construct a Boolean Tree Structure for a given 3d object with all the instances, scaling, rotation performed on the primitives utilized for the formation of object.	CO4
10.	Assignment to check for Affine transformation properties of curves. <ul style="list-style-type: none"> . Translation of curves / Known Figure a. Rotation of curves / Known Figure b. Scaling of Curves / Known Figure 	CO2, CO5
11.	Generative Design of Knuckle Joint, Bracket or any other component Under Realistic Load Conditions (Fusion 360 or other licensed software oncampus)	CO4
12.	Assignment on CNC Coding for few specific workpieces.	CO6

Weblinks:

<https://archive.nptel.ac.in/courses/112/102/112102101/>

CO-PO Mapping

CO Code	Mapped POs	Description and Justification
CO1	PO1, PO2	Students apply engineering fundamentals and analytical reasoning to understand the principles, evolution, and scope of CAD/CAM systems. They identify key challenges in digital design and manufacturing environments.
CO2	PO2, PO4	Learners use geometric modeling techniques and CAD tools to create and analyze engineering components. They apply problem analysis and research-based methods to evaluate design accuracy and performance.
CO3	PO3, PO5	Students demonstrate CNC programming and automation strategies, integrating design with manufacturing. They use modern tools and apply solution design principles to real-world production systems.
CO4	PO2, PO4, PO5	Learners analyze the integration of CAD, CAM, and CAE systems in product lifecycle management. They interpret data, simulate workflows, and use digital tools to optimize engineering processes.

CO5	PO6, PO8	Students evaluate the impact of CAD/CAM technologies on productivity, quality, and sustainability. They reflect on ethical and societal implications of automation and digital manufacturing.
CO6	PO3, PO5, PO12	Learners design and simulate complete CAD/CAM workflows using software tools. They optimize for manufacturability and cost, while engaging in lifelong learning to adapt to evolving technologies and industry practices.

CO-PO-PSO Mapping

Mapped Levels:

3 – High Contribution, **2** – Moderate Contribution, **1** – Low Contribution, **0** – No Significant Contribution

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	0	0	0	0	0	0	0	0	0	0	2	0	0
CO2	0	3	0	3	0	0	0	0	0	0	0	0	3	2	0
CO3	0	0	3	0	3	0	0	0	0	0	0	0	3	2	0
CO4	0	2	0	3	3	0	0	0	0	0	0	0	3	3	0
CO5	0	0	0	0	0	3	0	3	0	0	0	0	0	3	0
CO6	0	0	3	0	3	0	0	0	0	0	0	3	3	3	0

VI-3 : Fluid Machinery

Course Code	Course Type	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
			L	T	P	S	Cr	Theory			Laboratory	
								MSE	TA	ESE	ISE	CIE
<td>	PCC	Fluid Machinery	3	0	2	0	4	30	20	50	50	50

Course Outcomes (COs):

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

- CO1:** Explain the operating principles, classifications, and energy conversion mechanisms of fluid machines.
- CO2:** Analyze the performance characteristics of hydraulic turbines, pumps, and compressors using fluid dynamics and thermodynamic principles.
- CO3:** Apply governing equations and velocity diagrams to evaluate work transfer and efficiency in fluid machines.
- CO4:** Use experimental data and performance curves to assess the behavior of fluid machinery under varying operating conditions.
- CO5:** Evaluate the selection and application of fluid machines in engineering systems based on technical, economic, and environmental criteria.
- CO6:** Design and optimize fluid machinery components and systems considering flow conditions, material constraints, and sustainability.

Syllabus

Unit	Contents	Hrs
1	Impact of Jet: Force of fluid flow in nozzles, inclined plate, fixed and moving vanes, work done, efficiency. Calculation force exerted on series of moving vanes, velocity diagrams & their analysis.	05
2	Introduction and classification of hydrodynamic machines. Impulse Turbine: Principle and Construction, Working, velocity triangles, Power, efficiencies, Number of buckets & jets, Non-dimension parameters. Performance characteristics.	06
3	Reaction Turbine: Francis & Kaplan Turbines-construction and Working, draft tubes and its efficiency, Velocity diameter & analysis requirement of head & flow. cavitations . concept of unit speed, unit head , specific speed Governing, Performance & Selection . Governing of turbines	08
4	Centrifugal pumps: Working principles, Construction, Types, Various heads, multistage pumps, Velocity triangles, Minimum starting speed, cavitation, Maximum permissible suction head (MPSH) and Net positive suction head (NPSH). Methods of priming, calculations of efficiencies, Discharge, Blade angles, Head, Power required Impeller dimensions etc. Specific speed and performance characteristics of pumps.	08
5	Reciprocating pumps: Working principle, types, Indicator diagram, effect of air vessel, multiple cylinder pumps. Introduction to Air lift pump, hydraulic ram,	07

	deep bore well pump, propeller pump submersible pump, Gear pump (restricted to working principle and construction)	
6	Introduction to Fluid power : constructional and working principle of hydraulic and pneumatic circuits. Basic nomenclature, function and symbols of various components used in hydraulic and pneumatic circuits.	06

Text Books

1. Modi & Seth, Fluid Mechanics & Fluid Machinery, Standard Book House 2002.
2. R.K.Rajput, A Text book of Fluid Mechanics and Hydraulic Machines, S.Chand Co.Ltd.,2002
3. Jagdish Lal , Hydraulic Machines Including Fluidics, Metropolitan book.
4. Espisito, Fluid Power with Application, Prentice Hall International,1998
5. J.J.Pipenger ,Industrial Hydraulics, McGraw Hill, N.York, 1981.

Reference Books

1. S.R. Majumdar, Pneumatic Systems Principles and Maintenance, Tata McGraw-Hill, N.Delhi, 2000.
2. S.R. Majumdar, Oil Hydraulic Systems and Maintenance, Tata McGraw-Hill, N.Delhi, 2001.
3. ISO-1219:1988 Fluid Systems and Components.
4. Yeaple Franklin, Hydraulics and Pneumatics Power and Control, McGraw Hill Book. Co. N.York, 1966.

Fluid Machinery Laboratory Teaching Scheme Practical: 2 hrs / week	Examination Scheme CIE 100 marks
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Course outcome :

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

- Evaluate performance of hydraulic turbines.
- Evaluate performance of centrifugal pump.
- Describe the construction, working and application of components used in hydraulic and pneumatic circuits.
- Design of various hydraulic and pneumatic circuits.

List of experiments:

The journal consisting of at least seven experiments among the following should be submitted. Two experiments out of first three and the sixth experiment is compulsory.

1. Study and trial on Pelton Turbine for performance testing.
2. Study and trial on Francis Turbine for performance testing.
3. Study and trial on Kaplan Turbine for performance testing.
4. Study & trial on centrifugal pump for performance testing.
5. Study & trial on gear pump for performance testing.
6. Hydraulic and pneumatic circuits for some application

8. Demonstration of working of Hydraulic Press
9. Demonstration of cut sections of various Hydraulic Components.

Weblinks:

<https://archive.nptel.ac.in/courses/112/104/112104117/>

CO-PO Mapping

CO Code	Mapped POs	Description & Justification
CO1	PO1, PO2	Students gain foundational knowledge of fluid machinery types and operating principles, enabling them to apply core engineering concepts (PO1) and analyze basic energy conversion mechanisms (PO2).
CO2	PO1, PO2, PO4	By analyzing performance characteristics of turbines and pumps, students apply theoretical knowledge (PO1), solve fluid-related problems (PO2), and interpret performance data through investigative approaches (PO4).
CO3	PO1, PO2, PO3	Applying velocity diagrams and governing equations helps students solve design-related problems (PO3), while reinforcing analytical thinking (PO2) and engineering fundamentals (PO1).
CO4	PO4, PO5	Students use experimental data and performance curves to investigate machine behavior (PO4) and apply modern tools such as CFD software or lab instrumentation for analysis and validation (PO5).
CO5	PO6, PO7, PO12	Evaluating fluid machinery selection based on technical, economic, and environmental factors fosters societal awareness (PO6), sustainability thinking (PO7), and encourages continuous learning in evolving technologies (PO12).
CO6	PO3, PO5, PO7	Designing and optimizing fluid machinery components cultivates solution development skills (PO3), promotes use of modern engineering tools (PO5), and integrates environmental considerations for sustainable design (PO7).

CO-PO-PSO Mapping

Mapped Levels:

3: Strong correlation, **2:** Moderate correlation, **1:** Low correlation, **0:** No significant correlation

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	3	0	0
CO2	3	3	0	2	0	0	0	0	0	0	0	0	3	2	0
CO3	3	2	3	0	0	0	0	0	0	0	0	0	3	2	0
CO4	0	0	0	3	3	0	0	0	0	0	0	0	2	3	0
CO5	0	0	0	0	0	2	2	0	0	0	0	2	2	3	0
CO6	0	0	3	0	3	0	2	0	0	0	0	0	3	3	0

VI-4-1: Advanced Finite Element Method

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MS E	TA	ESE	ISE	ESE
<td>	Advanced Finite Element Method	3	1	0	0	4	30	20	50	--	

Course outcomes:

Students who successfully complete this course will have demonstrated an ability to:

- CO1:** Understand the mathematical foundations and variational principles that govern advanced FEM formulations.
- CO2:** Apply FEM techniques to solve complex problems in structural, thermal, and fluid domains using appropriate element types and boundary conditions.
- CO3:** Analyze the accuracy, convergence, and stability of FEM solutions for nonlinear and dynamic systems.
- CO4:** Develop and implement FEM algorithms using commercial or open-source software for engineering applications.
- CO5:** Evaluate FEM results critically in the context of real-world constraints such as material behavior, loading conditions, and design requirements.
- CO6:** Integrate FEM with optimization and multi-physics approaches for advanced engineering problem-solving.

Syllabus:

Unit	Contents	Hrs
1	3D Finite Element Analysis Solid elements (tetrahedral, hexahedral), shape functions, numerical integration FEM formulations for physics of 3D heat conduction, elasticity, incompressible materials and viscous flow. Babuska- Brezzi Condition	6
2	Transient and Coupled Field Problems Time-dependent FEM (structural dynamics, conduction, convection, diffusion) Coupled thermo-mechanical and multi-physics problems	6
3	Plate and Shell Bending Need for a higher order theory, Kirchhoff and Mindlin plate theories, shell element modeling. Applications to aerospace, automotive, and civil systems	8
4	Introduction to Non-Linear FEA Geometric, material, and contact non-linearity, Various strain and stress measures for non-linearity analysis. Conversion of engineering stress -strain	6

	curve to True stress strain curve , Johnson-Cook plasticity model, Total and Updated Lagrangian formulations	
5	Solving Non-Linear Problems Non-Linear Bending of Beams, Large deformation, plasticity, hyperelasticity, viscoelasticity, Frictional/contact problems and nonlinear solution algorithms	8
6	Applications and Case Studies Simulations in Solvers (ANSYS, Abaqus, etc.): metal forming, crash, biomedical, NVH, Fatigue and Crash Solver settings, mesh convergence, interpretation	8

Suggested learning resources:

Textbooks:

- Introduction to Finite Element Method By J.N .Reddy.
- Cook R.D. “Concepts and applications of finite element analysis” Wiley, New York, 1981.
- Bathe K.J., Cliffs, N.J. “Finite element procedures in Engineering Analysis”, Englewood. Prentice Hall, 1981.
- “Practical Finite Element Analysis”, First Ed., N. Gokhale, S. S. Deshpande, S. V. Bedekar, A. N. Thite, Published By - Finite to Infinite, Pune, India.

Reference Books:

- An Introduction to Nonlinear Finite Element Analysis by J. N. Reddy, Oxford University Press, 2004, ISBN 0198525
- The Finite Element Method: Linear Static and Dynamic Finite Element Analysis by T. J. R. Hughes, Dover Publications, 2000.29X.
- Desai C.S. and J.F. Abel “Introduction to the finite element method.” New York, Van Nostrand Reinhold, 1972.

Practical Course Strategy

- Students will be expected to work in teams of two or three.
- Lab-work will be assigned each week. The Lab-work will consist of mathematical derivations and numerical simulations. Students are expected to complete the homework in teams. However, each student is required to submit his/her homework individually.
- The team will be required to simulate their work on ANSYS or similar licensed solvers. A report showing the detailed calculations and results of simulations performed will be required for each assigned team.
- Students are expected to participate actively in the course. 5% of the final grade will be based on class participation.
- Some typical simulation based assignments are provided for students to get hold of licensed FE solvers. The course instructor has the freedom to add or change lab-work as and when required**.

Suggestive List of Practical / Lab Work**

Practical No.	Title	Linked CO	Objective
1	3D Heat Conduction Analysis in a Cubic Block	CO1	Apply 3D FEM to solve a steady-state thermal conduction problem using brick elements.
2	Structural Analysis of a 3D Bracket under Load	CO1	Analyze 3D elasticity problem with stress-strain evaluation using isoparametric elements.

Practical No.	Title	Linked CO	Objective
3	Transient Thermal Response of a Heat Sink	CO2	Model and analyze transient heat conduction in a fin using time-stepping algorithms.
4	Coupled Thermo-Mechanical Analysis of a Bimetallic Strip	CO2	Simulate thermal expansion and stress in a bimetallic structure due to heating.
5	Bending of a Simply Supported Plate	CO3	Use Mindlin plate theory to analyze deflection and bending stresses in a square plate.
6	Bending of a cantilver beam into a circle	CO4	Understand small and large deformations and associated large rotations .
6	Large Deformation Analysis of a Rubber Seal	CO4	Demonstrate geometric and material non-linearity through hyperelastic modeling.
7	Elasto-Plastic Analysis of a Notched Specimen under Tension	CO5	Analyze non-linear stress-strain behavior and plastic deformation using iterative solvers.
8	Modal and Crash Simulation of a Car FUPD,RUPD System (FUPD : Front Under-run Protection Device and Rear Under run Protection Device)	CO6	Perform NVH modal analysis and crash simulation for energy absorption and failure study.
9	Weld Joint Simulation under Static Loading	CO4, CO5	Model weld geometry, simulate stress concentration and plasticity at the weld zone.
10	Pre-Tensioned Bolt Assembly Analysis	CO4, CO5	Simulate bolt preload using contact and pretension elements, study clamping effects.
11	Rolling Element Bearing Load Distribution	CO1, CO5	Analyze contact forces and deformation in a ball or roller bearing under radial load.
12	Shrink Fit Simulation between Shaft and Hub	CO2, CO5	Model thermal expansion to simulate interference fit; evaluate stress distribution.
13	Low-Cycle Fatigue Analysis Using Strain-Life (ϵ -N) Approach	CO6	Simulate cyclic loading on a notched component using the strain-life method; account for plastic strain.
14	High-Cycle Fatigue Using Non-Linear Stress-Life (S-N) Curves	CO6	Use non-linear S-N data to predict fatigue life in elastic regime under varying amplitude loading.
15	Weld Fatigue Analysis with Structural Hot Spot Method	CO4, CO6	Evaluate fatigue at weld toe/root using hot spot stress method; ideal for welded beam structures.
16	Multi-Axial Fatigue of a Shaft Under Combined Bending and Torsion	CO6	Apply critical plane-based multi-axial fatigue models to evaluate life under complex stress state.

Weblinks:

<https://nptel.ac.in/courses/112106130>

CO-PO Mapping

CO Statement (with CO No.)	Mapped POs	Description & Justification
CO1: Understand the mathematical foundations and variational principles that govern advanced FEM formulations.	PO1, PO2	Builds foundational engineering knowledge (PO1) and analytical ability (PO2) by introducing students to the mathematical rigor behind FEM, essential for modeling complex systems.
CO2: Apply FEM techniques to solve complex problems in structural, thermal, and fluid domains using appropriate element types and boundary conditions.	PO1, PO3, PO5	Enables students to design and solve engineering problems (PO3) using FEM tools (PO5), applying core engineering principles (PO1) to real-world mechanical systems.
CO3: Analyze the accuracy, convergence, and stability of FEM solutions for nonlinear and dynamic systems.	PO2, PO4	Enhances problem-solving depth (PO2) and investigative skills (PO4) by encouraging critical evaluation of numerical results and solution behavior under complex conditions.
CO4: Develop and implement FEM algorithms using commercial or open-source software for engineering applications.	PO5, PO12	Promotes proficiency in modern tools (PO5) and fosters independent learning (PO12) through hands-on development and customization of FEM software solutions.
CO5: Evaluate FEM results critically in the context of real-world constraints such as material behavior, loading conditions, and design requirements.	PO3, PO6, PO7	Encourages contextual design thinking (PO3), societal awareness (PO6), and sustainability considerations (PO7) by integrating engineering analysis with practical constraints.
CO6: Integrate FEM with optimization and multi-physics approaches for advanced engineering problem-solving.	PO1, PO5, PO12	Strengthens interdisciplinary application of engineering knowledge (PO1), tool-based innovation (PO5), and continuous learning (PO12) for solving emerging and complex challenges.

CO-PO-PSO Mapping

Mapped levels

3 – High Contribution , 2 – Moderate Contribution , 1 – Low Contribution , 0– No direct contribution

CO No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	0	3	0
CO2	3	0	3	0	2	0	0	0	0	0	0	0	3	2	0
CO3	2	3	0	3	2	0	0	0	0	0	0	0	0	3	0
CO4	0	0	0	0	3	0	0	0	0	0	0	2	0	3	0
CO5	0	2	3	0	2	2	1	0	0	0	0	0	2	0	2
CO6	2	0	2	0	3	0	0	0	0	0	0	3	2	3	0

VI-4.2 : Industrial Hydraulics and Pneumatics

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Industrial Hydraulics and Pneumatics	3	1	0	0	4	30	20	50	--	--

Course Outcomes (COs):

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

- CO1** Explain the fundamental principles of fluid power systems, including hydraulic and pneumatic components and circuits.
- CO2** Analyze the behavior and performance of hydraulic and pneumatic systems under various operating conditions.
- CO3** Design basic fluid power circuits for industrial applications, considering system requirements and constraints.
- CO4** Select appropriate components and control strategies for hydraulic and pneumatic systems based on functional needs.
- CO5** Evaluate system efficiency, safety, and reliability using analytical and simulation tools.
- CO6** Demonstrate the integration of fluid power systems with automation and control technologies in industrial settings.

Syllabus:

Unit	Contents	Hrs.
1	Introduction to Hydraulics and Pneumatics: Introduction to oil hydraulics and pneumatics, their structure, advantages and limitations. Properties of fluids, Fluids for hydraulic systems, governing laws. Distribution of fluid power, ISO symbols, and energy losses in hydraulic systems.	8
2	Pumps & Power Units: Types, classification, principle of working and constructional details of vane pumps, gear pumps, radial and axial plunger pumps, screw pumps, power and efficiency calculations, characteristics curves, selection of pumps for hydraulic Power transmission. Power units and accessories: Types of power units, reservoir assembly, constructional details, pressure switches, temperature switches. Accumulators: Types, selection/ design procedure, applications of accumulators. Types of Intensifiers, Pressure switches /sensors, Temperature switches/sensors, Level sensors.	8
3	Hydraulic Actuators: (i) Linear and Rotary. (ii) Hydraulic motors - Types- Vane, Gear, Piston types, radial piston. (iii) Methods of control of acceleration, deceleration. (iv) Types of cylinders and mountings. (v) Calculation of piston velocity, thrust under static and dynamic applications, considering friction, inertia loads. (vi) Design considerations for cylinders. Cushioning of cylinder. (Numerical treatment).	8

4	<p>Industrial Circuits: Simple reciprocating, Regenerative, Speed control (Meter in, Meter out and bleed off), Sequencing, Synchronization, transverse and feed, circuit for riveting machine, automatic reciprocating, fail safe circuit, counter balance circuit, actuator locking, circuit for hydraulic press, unloading circuit (Numerical treatment), motor breaking circuit.</p>	8
5	<p>Pneumatics: Principle of Pneumatics: (i) Laws of compression, types of compressors, selection of compressors. (ii) Comparison of Pneumatic with Hydraulic power transmissions. (iii) Types of filters, regulators, lubricators, mufflers, and dryers. (iv) Pressure regulating valves, (v) Direction control valves, two-way, three way, four-way valves. Solenoid operated valves, push button, lever control valves. (vi) Speed regulating Methods used in Pneumatics. (vii) Pneumatic actuators-rotary, reciprocating. (viii) Air motors- radial piston, vane, axial piston (ix) Basic pneumatic circuit, selection of components, (x) Application of pneumatics in low cost automation and in industrial automation. Introduction to vacuum and vacuum measurement, Vacuum pumps, types, introduction to vacuum sensors and valves. Industrial application of vacuum.</p>	6
6	<p>System Design: Design of hydraulic/pneumatic circuit for practical application, Selection of different components such as reservoir, various valves, actuators, filters, pumps based on design.</p>	5

Suggested learning resources:

Textbooks:

1. Esposito, Fluid Power with application, Prentice Hall
2. Majumdar S.R, Oil Hydraulic system- Principle and maintenance , Tata McGraw Hill
3. Majumdar S.R, Pneumatics Systems Principles and Maintenance , Tata McGraw Hill
4. H.L. Stewart, Hydraulics and Pneumatics , Taraporewala Publication GMH1'

Reference Books:

1. J. J. Pipenger, Industrial Hydraulics, McGraw Hill
2. Pinches, Industrial Fluid Power, Prentice Hall
3. D. A. Pease, Basic Fluid Power, Prentice Hall
4. B. Lall, Oil Hydraulics, International Literature Association
5. Yeaple, Fluid Power Design Handbook
6. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books.
7. ISO - 1219, Fluid Systems and components, Graphic Symbols
8. Michael J, Pinches and Ashby J. G, "Power Hydraulics", Prentice Hall.
9. Dr. R.K. Bansal, Fluid Mechanics, Laxmi Publication (P) Ltd.
10. Product Manuals and books from Vickers/ Eaton, FESTO, SMC pneumatics

Weblinks:

<https://archive.nptel.ac.in/courses/112/105/112105047/>

CO-PO Mapping

CO No.	Mapped POs	Description & Justification
CO1: Explain the fundamental principles of fluid power systems, including hydraulic and pneumatic components and circuits.	PO1, PO2	Builds foundational engineering knowledge (PO1) and analytical ability (PO2) by introducing students to core fluid mechanics and control principles essential for system understanding.
CO2: Analyze the behavior and performance of hydraulic and pneumatic systems under various operating conditions.	PO2, PO4	Enhances problem analysis (PO2) and investigative skills (PO4) by requiring students to interpret system responses and troubleshoot performance issues using data and simulations.
CO3: Design basic fluid power circuits for industrial applications, considering system requirements and constraints.	PO3, PO5	Develops design skills (PO3) and tool usage (PO5) through hands-on circuit creation and simulation using software and hardware platforms.
CO4: Select appropriate components and control strategies for hydraulic and pneumatic systems based on functional needs.	PO1, PO6	Reinforces engineering knowledge (PO1) and societal awareness (PO6) by guiding students to make informed, context-sensitive decisions in component selection and control logic.
CO5: Evaluate system efficiency, safety, and reliability using analytical and simulation tools.	PO4, PO7, PO8	Promotes investigative rigor (PO4), sustainability awareness (PO7), and ethical responsibility (PO8) by assessing system performance and safety in industrial contexts.
CO6: Demonstrate the integration of fluid power systems with automation and control technologies in industrial settings.	PO5, PO9, PO12	Encourages tool proficiency (PO5), teamwork and interdisciplinary collaboration (PO9), and lifelong learning (PO12) through exposure to real-world automation and mechatronic systems.

CO-PO-PSO Mapping

Mapping levels:

3 – High Contribution, 2 – Moderate Contribution ,1 – Low Contribution

0 – No direct contribution

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	0	2	0
CO2	2	3	0	3	2	0	0	0	0	0	0	0	0	3	0
CO3	0	0	3	0	3	0	0	0	0	0	0	0	3	2	0
CO4	2	0	0	0	2	2	0	0	0	0	0	0	2	2	0
CO5	0	2	0	3	2	0	2	2	0	0	0	0	0	3	2
CO6	0	0	0	0	3	0	0	0	2	0	0	3	2	3	0

VI-4.3 : Micro and Nano Machining

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Micro and Nano Machining	3	1	0	0	4	30	20	50	---	

Course outcomes:

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

- CO1:** Explain the principles, mechanisms, and classifications of micro and nano machining processes.
- CO2:** Analyze the influence of process parameters on material removal, accuracy, and surface integrity in micro/nano machining.
- CO3:** Select appropriate micro/nano machining techniques for different materials and applications.
- CO4:** Design basic process flows and setups for micro/nano fabrication considering dimensional and functional constraints.
- CO5:** Evaluate the role of advanced instrumentation and control in precision machining at micro/nano scales.
- CO6:** Demonstrate awareness of industrial applications, sustainability, and ethical considerations in micro/nano manufacturing.

Syllabus:

Unit	Contents	Hrs.
1	<p>Introduction to micro machining</p> <p>Miniaturization, Trend of miniaturization, basic concepts in machining, applications- Bio medical and BioMEMS, watchmaker and jewelry, automotive, aerospace, telecommunication and information technology, Classification of micromachining-Subtractive, additive, mass containing, Joining, MEMS Vs mechanical micromachining, mechanical micromachining Vs ultra precision machining, Operator's skill and sensing in micro machining, things to remember in micro machining</p> <p>Scaling laws-Different types of scale reduction of a system, scaling laws, Types of scaling laws, scaling factor</p>	8
2	<p>Difference between macro and micro machining</p> <p>Size effect in micro cutting- grain size to chip thickness, uncut chip thickness to cutting edge radius, material flow angle of four distinct mechanisms, metal behavior at micro scale machining, failure of ductile, brittle , alloys, anisotropic materials, burr formation-material properties, burr reduction strategies, burr reduction by supporting materials, deburring, Surface roughness- effect of material properties, tool wear, key aspects in micro machining, advantages micro mechanical machining</p> <p>Importance of non-traditional machining in micro machining domain, Classification of Non-traditional Micromachining, Thermal Micromachining, Chemical and Electrochemical Micromachining, Hybrid Micromachining</p>	8

3	<p>Introduction to Different Non-traditional Micromachining Processes- Micro Ultrasonic Machining (USM), Micro Electro-Discharge Machining (EDM), Micro Laser Beam Machining (LBM), Micro Ion Beam Machining (IBM), Micro Electron Beam Machining (EBM), Micro Chemical Machining (CM), Micro Electrochemical Machining (ECM), Introduction to Various Hybrid Micromachining- Electrochemical Grinding (ECG), Electrochemical Discharge Micromachining, Abrasive Assisted Micromachining, Ultrasonic Assisted Micromachining, Laser Assisted Micromachining</p> <p>Mechanical micromachining- Micro tools fabrication and Micro machines</p> <p>Micro cutting tools, required properties of tool, micro tool fabrication processes</p> <p>Diamond turning</p> <p>Need of diamond turning, applications of diamond turning process, classification of diamond turning process, difference with conventional machines, features of Diamond turning machines</p>	8
4	<p>Nanotechnology</p> <p>Fundamentals behind nanotechnology, tools of nanotechnology- tools for measuring nanostructures-scanning probe instruments, spectroscopy, electrochemistry, electron microscopy and tools to make nanostructures-nanoscale lithography, , dip pen lithography, E-beam lithography, molecular synthesis, nanoscale crystal growth, polymerization, nano bricks and building blocks</p>	6
5	<p>Applications for nanotechnology</p> <p>Smart materials-self healing structures, recognition, separation, catalysts, heterogeneous nanostructures and composites</p> <p>Sensors- natural nano scale sensors, electromagnetic sensors, biosensors</p> <p>Biomedical applications- drugs delivery, photodynamic therapy, molecular motors</p>	6

Textbooks:

1. V K Jain, "Introduction to micromachining", Narosa Publication
2. Balasubramaniam et al, "Diamond turn machining: theory and practice (2017)", CRC Press USA
3. Charles P. Poole Jr and Frank J. Owens, "Introduction to Nanotechnology", Wiley-India

Reference Books:

1. Cheng & Huo, "Micro-cutting: Fundamentals and applications", Wiley
2. Dornfeld and Lee, "Precision Manufacturing", Springer
3. Mark Ratner and Daniel Ratner, "Nanotechnology", Pearson Education
4. Lynn E. Foster, "Nanotechnology-Science, Innovation and Opportunity", Pearson Education

Weblinks:

<https://archive.nptel.ac.in/courses/117/108/102108078/>

CO-PO Mapping

CO No.	Mapped POs	Description & Justification
CO1	PO1, PO2	Builds foundational engineering knowledge and analytical ability by introducing students to the physics and classification of micro/nano machining processes.
CO2	PO2, PO4	Enhances problem analysis and investigative skills by examining how process variables affect machining outcomes at micro/nano scales.
CO3	PO1, PO3	Reinforces engineering fundamentals and design skills through selection of suitable machining techniques for specific materials and tolerances.
CO4	PO3, PO5	Develops design and tool usage capabilities by guiding students to create process flows and setups using CAD/CAM and simulation tools.
CO5	PO4, PO5, PO12	Promotes investigative rigor, modern tool proficiency, and lifelong learning through exposure to instrumentation, sensors, and control systems used in precision machining.
CO6	PO6, PO7, PO8	Encourages societal awareness, sustainability, and ethical responsibility by discussing real-world applications and implications of micro/nano manufacturing technologies.

CO-PO-PSO Mapping

Mapping levels:

3 – High Contribution, 2 – Moderate Contribution, 1 – Low Contribution, 0 – No direct contribution

CO No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	0	2	0
CO2	0	3	0	3	0	0	0	0	0	0	0	0	0	3	0
CO3	2	0	3	0	0	0	0	0	0	0	0	0	3	2	0
CO4	0	0	3	0	3	0	0	0	0	0	0	0	3	3	0
CO5	0	0	0	2	3	0	0	0	0	0	0	3	2	3	0
CO6	0	0	0	0	0	2	2	2	0	0	0	0	0	0	3

VI-4.4: Biomass Energy Conversion

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Biomass Energy Conversion	3	1	0	0	4	30	20	50	--	--

Course Outcomes:

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

- CO1:** Describe the types, sources, and characteristics of biomass and their relevance in energy conversion.
- CO2:** Explain the thermochemical, biochemical, and physicochemical pathways for biomass conversion into energy.
- CO3:** Analyze the performance and efficiency of biomass-based energy systems under varying operating conditions.
- CO4:** Design basic biomass conversion systems considering feedstock properties, process parameters, and energy output.
- CO5:** Evaluate the environmental, economic, and sustainability aspects of biomass energy technologies.
- CO6:** Demonstrate awareness of current trends, policies, and ethical considerations in biomass utilization for energy generation.

Syllabus:

Unit	Contents	Hrs.
1	Biomass Resources and Classification: Overview of biomass: Agricultural residues, forestry waste, energy crops, Properties: Calorific value, moisture content, ash composition, Biomass collection, transportation, preprocessing, densification (briquettes, pellets)	8
2	Thermochemical Conversion Technologies: Combustion systems and designs, Pyrolysis: Mechanisms, types (slow, fast, flash), Gasification: Fixed bed, fluidized bed, entrained flow Biochar, syngas and bio-oil analysis, Reactor design and efficiency calculations	7
3	Biochemical Conversion Technologies: Biomass cookstoves, boilers, and dryers, Combined Heat and Power (CHP) from biomass, Co-firing with coal in thermal power plants, Distributed power generation for rural areas	7
4	Biomass Energy Systems and Applications: Biomass cookstoves, boilers, and dryers, Combined Heat and Power (CHP) from biomass, Co-firing with coal in thermal power plants, Distributed power generation for rural areas	6

5	Environmental and Policy Aspects: Emissions and pollution control, Carbon neutrality and LCA of biomass systems, Government policies (MNRE schemes, renewable obligations) , Case studies: Bagasse-based plants, rice husk gasifiers, biogas grids	6
6	Integration and Deployment of Deep Learning Models: Model Deployment Strategies: Edge Computing, Cloud Services, Tools: TensorFlow Lite, ONNX, Docker, Case Studies: Real-world Applications in Mechanical Engineering Ethical Considerations and Model Interpretability	8

Reference Books:

1. Thomas B. Reed, Agua Das, "Handbook of Biomass Downdraft Gasifier Engine Systems", NREL
2. Anju Dahiya, "Bioenergy: Biomass to Biofuels", Academic Press.
3. John Twidell, Tony Weir, "Renewable Energy Resources", Taylor & Francis

Weblinks:

https://onlinecourses.nptel.ac.in/noc22_ch28/preview

CO-PO Mapping

CO No.	Mapped POs	Description & Justification
CO1	PO1, PO2	Strengthens engineering fundamentals and analytical skills by introducing students to biomass sources, classifications, and their energy potential.
CO2	PO1, PO3	Reinforces core knowledge and design thinking by exploring thermochemical, biochemical, and physicochemical conversion pathways relevant to engineering applications.
CO3	PO2, PO4	Enhances problem analysis and investigative ability through performance evaluation of biomass systems under varying operating conditions using experimental and simulation data.
CO4	PO3, PO5	Develops design and tool usage capabilities by guiding students to create biomass conversion system layouts using modeling tools and process optimization techniques.
CO5	PO6, PO7	Promotes societal and environmental awareness by evaluating sustainability, emissions, and life-cycle impacts of biomass energy technologies.
CO6	PO8, PO12	Encourages ethical reasoning and lifelong learning by exposing students to current policies, global trends, and responsible innovation in biomass utilization.

CO-PO-PSO Mapping

Mapping Levels

3 – Strongly related, **2** – Moderately related, **1** – Slightly related, **0** – Not related

CO \ PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	3	0	0
CO2	3	0	2	0	0	0	0	0	0	0	0	0	2	2	0
CO3	0	3	0	2	0	0	0	0	0	0	0	0	0	3	0
CO4	0	0	3	0	2	0	0	0	0	0	0	0	0	3	0
CO5	0	0	0	0	0	2	3	0	0	0	0	0	0	0	3
CO6	0	0	0	0	0	0	0	2	0	0	0	3	0	0	3

VI-4.5 : Design for Fatigue and Fracture

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<tbd>	Design for Fatigue and Fracture	3	1	0	0	4	30	20	50	--	--

Course Outcomes:

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

- CO1:** Explain the fundamental mechanisms of fatigue and fracture in engineering materials, including crack initiation, propagation, and failure modes.
- CO2:** Analyze stress-life, strain-life, and fracture mechanics approaches to predict fatigue life and crack growth under cyclic loading conditions.
- CO3:** Apply design principles to mitigate fatigue and fracture in mechanical components, considering material selection, geometry, and loading conditions.
- CO4:** Use analytical and numerical tools (e.g., S-N curves, Paris law, FEA) to evaluate fatigue performance and fracture toughness in real-world engineering applications.
- CO5:** Assess the impact of fatigue and fracture failures on safety, reliability, and ethics in engineering design, referencing case studies and industry standards.
- CO6:** Demonstrate lifelong learning by exploring emerging materials, surface treatments, and design innovations that enhance fatigue resistance and fracture control.

Syllabus:

Unit	Contents	Hrs
1	Fundamentals of Fatigue Stress-life (S-N) approach, High-cycle vs Low-cycle fatigue, Fatigue loading types: fully reversed, fluctuating, random, Stress concentration and notch sensitivity, Material fatigue behavior in AM (additive manufacturing) components.	5
2	Design for Fatigue Strength Mean stress correction theories: Goodman, Soderberg, Gerber Design of components under fluctuating loads, Cumulative damage and Miner's Rule, Influence of surface finish, size, and reliability, AI-based fatigue life prediction, load spectrum analysis	5
3	Fracture Mechanics – Fundamentals: Modes of fracture: brittle, ductile, Griffith theory of brittle fracture, Fracture toughness, KIC and critical crack length, Introduction to Linear Elastic Fracture Mechanics (LEFM), Fracture in composites and biomaterials	5

4	Crack Propagation and Fatigue Crack Growth Fatigue crack initiation and growth stages, Paris' law and crack growth rate Threshold stress intensity factor, Life estimation from crack growth data Fracture analysis in layered materials and thin films	5
5	Experimental Techniques and Digital Tools Fatigue testing machines and methods (rotating beam, axial loading), Fractography (SEM analysis), Digital Image Correlation (DIC), Finite Element Analysis for fatigue and fracture simulation, Machine learning for failure prediction, digital twins in testing	5
6	Case Studies and Modern Applications Fatigue in gears, shafts, pressure vessels, aircraft structures, Fracture in welded joints and composite structures, Fatigue failure analysis (field failure case studies), Industry standards: ASTM, ISO, ASME, Design-for-durability in EVs, wind turbine blades, biomedical implants	5

Reference Books:

1. Suresh, S., Fatigue of Materials, Cambridge University Press
2. Anderson, T.L., Fracture Mechanics: Fundamentals and Applications, CRC Press
3. Juvinall & Marshek, Fundamentals of Machine Component Design, Wiley
4. Dieter, G.E., Mechanical Metallurgy, McGraw-Hill
5. Bannantine, Comer & Handrock, Fundamentals of Metal Fatigue Analysis, Prentice Hall
6. Research papers on fatigue in AM materials, fracture in composites, AI in durability – IEEE, Elsevier

Weblinks:

https://onlinecourses.nptel.ac.in/noc22_mm42/preview

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CO PO Mapping

CO No.	Mapped POs	Description & Justification
CO1	PO1, PO2	Builds foundational understanding of fatigue and fracture mechanisms, supporting core engineering knowledge and analytical reasoning.
CO2	PO2, PO4	Enhances problem analysis and investigation skills through fatigue life prediction and crack growth modeling using analytical and numerical methods.
CO3	PO3, PO5	Applies design principles to mitigate fatigue and fracture, integrating material selection, geometry optimization, and engineering tools.
CO4	PO4, PO5	Strengthens investigative and tool usage skills by evaluating fatigue performance and fracture toughness using S-N curves, Paris law, and FEA.

CO5	PO6, PO7	Promotes ethical and societal awareness by analyzing real-world failure cases and emphasizing safety, reliability, and professional responsibility.
CO6	PO8, PO12	Encourages lifelong learning and ethical reasoning by exploring emerging materials, surface treatments, and global standards for fatigue and fracture control.

CO-PO-PSO Mapping

Mapping levels

3 – Strongly related, **2** – Moderately related, **1** – Slightly related, **0** – Not related

CO \ PO/PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	3	0	0
CO2	0	3	0	2	0	0	0	0	0	0	0	0	2	3	0
CO3	0	0	3	0	2	0	0	0	0	0	0	0	2	3	0
CO4	0	0	2	3	2	0	0	0	0	0	0	0	2	3	0
CO5	0	0	0	0	0	2	3	0	0	0	0	0	0	0	3
CO6	0	0	0	0	0	0	0	2	0	0	0	3	0	0	3

VI-4.6 : Computational Fluid Dynamics

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Computational Fluid Dynamics	3	1	0	0	4	30	20	50	--	--

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- CO1:** Explain the fundamental governing equations of fluid flow and heat transfer.
- CO2** Apply discretization techniques to convert partial differential equations into algebraic form.
- CO3** Develop CFD models using appropriate numerical methods and simulation tools.
- CO4** Analyze flow and thermal characteristics through simulation results and post-processing.
- CO5** Evaluate the accuracy, stability, and limitations of various numerical schemes.
- CO6** Demonstrate ethical and professional responsibility in CFD-based engineering decisions.

Syllabus:

Unit	Contents	Hrs
1	Introduction to CFD: Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Basics of PDE: Elliptic, Parabolic and Hyperbolic Equations.	6
2	Governing Equations: Review of Navier-Stokes Equation and simplified forms, Solution Methodology: FDM and FVM with special emphasis on FVM, Stability, Convergence and Accuracy.	7
3	Finite Volume Method: Domain discretizations, types of mesh and quality of mesh, SIMPLE, pressure velocity coupling, Checkerboard pressure field and staggered grid approach	6
4	Geometry Modelling and Grid Generation: Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance	7
5	Methodology of CFDHT: Objectives and importance of CFDHT, CFDHT for Diffusion Equation, Convection Equation and Convection-Diffusion Equation	8
6	Solution of N-S Equations for Incompressible Flows: Semi-Explicit and Semi-Implicit Algorithms for Staggered Grid System and Non Staggered Grid System of N-S Equations for Incompressible Flows	

Suggested learning resources:

References:

1. John A. Anderson, Jr., Computational Fluid Dynamics, The Basic with applications by John A. Anderson, Jr., McGraw Hill International editions, Mechanical Engineering series.
2. Dr. Suhas Patankar, Numerical Heat Transfer and Fluid Flow, Crc Press.
3. H.K. Versteeg, W.Malalasekera, Introduction to Computational Fluid Dynamics, An: The Finite Volume Method, PHI; 2nd edition.
4. Ferziger and Peric, Computational Methods for Fluid Dynamics, Springer Publication.
5. Chuen-Yen Chow, An Introduction to Computational Fluid Mechanics, Seminole Pub Co.
6. Muralidhar K (Author), Sundararajan, Computational Fluid Flow & Heat Transfer, Narosa Publishing House.

Weblinks:

<https://nptel.ac.in/courses/112105045>

CO PO Mapping

CO No.	Mapped POs	Description & Justification
CO1	PO1, PO2	Builds foundational understanding of fluid flow and heat transfer equations using first principles of mathematics and engineering science. Essential for modeling and analyzing complex thermal-fluid systems.
CO2	PO2, PO3	Enables students to apply discretization techniques to transform PDEs into solvable algebraic forms, bridging theoretical knowledge with practical design and solution development.
CO3	PO5, PO12	Promotes proficiency in modern CFD tools and simulation platforms, fostering independent learning and adaptability to evolving computational technologies.
CO4	PO4, PO10	Strengthens analytical skills through interpretation of simulation results and enhances communication by presenting technical findings effectively.
CO5	PO4, PO11	Cultivates engineering judgment by evaluating numerical scheme performance, stability, and limitations—critical for reliable and efficient CFD modeling in project environments.
CO6	PO6, PO8	Encourages ethical awareness and societal responsibility in applying CFD to safety-critical and environmentally sensitive engineering decisions.

CO-PO-PSO Mapping

Mapping levels

3 – Strongly related, 2 – Moderately related, 1 – Slightly related, 0 – Not related

CO\PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	0	0	0	0	0	0	1	2	2	0
CO2	2	3	2	2	2	0	0	0	0	0	1	1	2	3	0
CO3	1	2	2	2	3	0	0	0	0	1	1	2	3	3	1
CO4	1	2	2	3	2	0	0	0	0	3	1	1	2	3	1
CO5	1	2	2	3	2	0	0	0	0	2	3	1	2	3	1
CO6	0	1	1	1	1	2	0	3	0	1	1	1	1	1	3

VI- 4.7 : Digital Manufacturing

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<i><td></i>	Digital Manufacturing	3	1	0	0	4	30	20	50	--	--

Course Outcomes (COs):

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

- CO1:** Explain the principles, scope, and evolution of digital manufacturing in the context of Industry 4.0.
- CO2:** Apply CAD/CAM, simulation, and digital twin technologies to model and optimize manufacturing processes.
- CO3:** Analyze the role of automation, robotics, and IoT in enhancing productivity and flexibility in smart factories.
- CO4:** Evaluate data-driven decision-making approaches using manufacturing analytics and cyber-physical systems.
- CO5:** Demonstrate proficiency in digital manufacturing tools for process planning, monitoring, and control.
- CO6:** Assess the ethical, environmental, and societal implications of digital transformation in manufacturing.

Syllabus:

Unit	Contents	Hrs.
1	Introduction to Digital Manufacturing: Definition and evolution of digital manufacturing, Key concepts and terminology, Differences between traditional and digital manufacturing, Overview of Industry 4.0	6
2	Digital Manufacturing Technologies: Additive Manufacturing (3D Printing), Computer Numerical Control (CNC) Machines, Robotics and Automation, Internet of Things (IoT) in Manufacturing, Cyber-Physical Systems	6
3	Data Analytics in Manufacturing: Importance of data in manufacturing, Data collection and management, Big Data Analytics, Predictive Maintenance, Case studies on data-driven manufacturing.	6
4	Digital Twins and Simulation: Concept of Digital Twins, Applications of Digital Twins in manufacturing, Simulation techniques and tools, Virtual commissioning of manufacturing systems	6
5	Smart Manufacturing Systems:	6

	Characteristics of smart manufacturing, Smart factories and their components, Real-time monitoring and control, Role of AI and Machine Learning in Smart Manufacturing	
6	Integration and Implementation: Integration of digital technologies in existing systems, Challenges and solutions in digital manufacturing implementation, Case studies of successful digital manufacturing projects, Future trends and developments.	6

Suggested learning resources:

Text Books

1. Groover, M. P. - Automation, Production Systems, and Computer-Integrated Manufacturing (Pearson)
2. Tönshoff, H.K., & Denkena, B. - Digital Manufacturing (Springer)
3. Tao, F., Cheng, Y., & Zhang, M. - Digital Twin Driven Smart Manufacturing (Elsevier)
4. Alasdair Gilchrist - Industry 4.0: The Industrial Internet of Things

Reference Books:

1. Tien-Chien Chang - Digital Manufacturing: In Design and Production
2. Michael Grieves - Digital Twin: Manufacturing Excellence through Virtual Factory Replication
3. Jay Lee, Behrad Bagheri, & Hung-An Kao - A Cyber-Physical Systems Approach to Smart Manufacturing
4. Sharma, R. & Kundra, T. K. - Introduction to Digital Manufacturing (McGraw-Hill)
5. Kuehn, W. - Digital Factory: Integration of Simulation & Virtual Reality (Springer)
6. Zhang, X. & Tao, F. - Smart Manufacturing: Concepts and Methods (Elsevier)

ONLINE/E RESOURCES:

Related NPTEL/Swayam Courses:

1. Automation in Manufacturing (IIT Kanpur)
2. Computer Integrated Manufacturing (IIT Roorkee)

List of Practicals:

ANY EIGHT experiments to be conducted during the course.

1. 3D Printing Basics: Print simple geometric shapes to understand machine setup, material loading, and basic operation.
2. CNC Machining Introduction: Create a basic part using CNC milling or turning with simple tool paths.
3. Laser Cutting and Engraving: Design and cut/engrave basic shapes or patterns on various materials like wood or acrylic.
4. Basic Robotics Programming: Program a robotic arm to perform simple pick-and-place operations.
5. Simulation of Manufacturing Processes: Use simulation software (e.g., Arena or Simul8) to model a basic production line.
6. IoT in Manufacturing: Set up a simple IoT device to monitor environmental conditions (temperature, humidity) in a manufacturing setup.

7. Digital Twin Creation: Create a digital model of a simple physical object using CAD software and link it to real-time data.
8. Predictive Maintenance: Analyze sensor data to predict and schedule maintenance for a piece of equipment.
9. Virtual Reality (VR) in Manufacturing: Explore a virtual factory setup using basic VR tools and software.
10. Data Analytics for Manufacturing: Use basic statistical tools to analyze production data and identify trends or anomalies.

Weblinks: https://onlinecourses.nptel.ac.in/noc21_mg83/preview

CO-PO Mapping

CO No.	Mapped POs	Description & Justification
CO1	PO1, PO6	Builds foundational understanding of digital manufacturing principles and their societal relevance. Helps students contextualize technological evolution within ethical and industrial frameworks.
CO2	PO2, PO3	Enables students to apply digital tools like CAD/CAM and digital twins for process modeling and optimization, fostering analytical and design capabilities.
CO3	PO5, PO11	Promotes the use of automation, robotics, and IoT in smart manufacturing environments, while reinforcing project planning and resource management skills.
CO4	PO4, PO10	Strengthens data analysis and interpretation skills through manufacturing analytics, and enhances communication of technical insights using digital platforms.
CO5	PO5, PO12	Encourages hands-on proficiency with digital manufacturing tools and supports lifelong learning through exposure to evolving technologies.
CO6	PO6, PO8	Instills ethical awareness and responsibility in deploying digital manufacturing solutions, especially in contexts involving sustainability and workforce impact.

CO-PO-PSO Mapping

Mapping levels

3 – Strongly related, **2** – Moderately related, **1** – Slightly related, **0** – Not related

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2	0	2	0	1	1	1	2	2	2
CO2	2	3	3	2	3	1	0	1	0	2	2	2	3	3	1
CO3	2	2	2	2	3	1	0	1	0	2	3	2	3	3	2
CO4	1	2	2	3	2	1	0	1	0	3	2	2	2	3	2
CO5	1	2	2	2	3	1	0	1	0	2	2	3	3	3	2
CO6	1	1	1	1	1	3	0	3	0	1	1	2	1	2	3

VI- 04.08 : Automotive energy conversion

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Automotive energy conversion	3	1	0	0	4	30	20	50	--	--

Course Outcomes:

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

- CO1:** Explain the principles of energy conversion in internal combustion engines and alternative powertrains.
- CO2:** Analyze thermodynamic cycles and energy flow in conventional and hybrid automotive systems.
- CO3:** Evaluate the performance, efficiency, and emissions of various automotive energy systems.
- CO4:** Apply simulation tools and experimental methods to study energy conversion processes in vehicles.
- CO5:** Assess the impact of automotive energy technologies on environmental sustainability and regulatory compliance.
- CO6:** Demonstrate awareness of emerging energy conversion technologies such as fuel cells, electric drives, and hydrogen systems.

Syllabus:

Unit	Contents	Hrs
1	Internal Combustion Engines and Alternative Fuels: Thermodynamics and Heat Engines: Principles of thermodynamic cycles, heat engine efficiency, and the conversion of heat into mechanical energy. Spark Ignition (SI) and Compression Ignition (CI) Engines: Comparison of combustion processes, fuel injection systems, and factors affecting efficiency.	6
2	Hybrid and Electric Vehicle Technologies: Principles of hybrid systems, electric motors, battery technology, and charging systems. Renewable Energy Sources: Exploring the potential of solar and other renewable energy sources for vehicle propulsion.	7
3	Advanced Engine Technologies: Exploring emerging engine technologies like direct injection, variable valve timing, and advanced combustion strategies. Fuel Cell Vehicles (FCEVs): Fuel cell technology, hydrogen storage, and the conversion of chemical energy into electrical energy.	6

4	Fuel Cells and Advanced Energy Storage: Principles of fuel cell operation and types used in vehicles, Integration of fuel cells into automotive powertrains, Advanced energy storage systems: supercapacitors and flywheels.	7
5	Energy Recovery and Waste Heat Utilization: Regenerative braking systems: mechanisms and benefits, Waste heat recovery techniques: thermoelectric generators and Rankine cycles, Impact of energy recovery on overall vehicle efficiency.	8

Suggested learning resources:

Reference Book:

1. "Fundamentals of Advanced Energy Conversion" by MIT open Course Ware.
2. Jack Erjavec and Rob Thompson, "Automotive Technology: A Systems Approach", Delmar Pub; 7th edition.
3. Mark Warner, The Electric Vehicle Conversion Handbook, HP Books.
4. D. Yogi Goswami, ENERGY CONVERSION 2ED, CRC Press; 2nd edition; TAYLOR & FRANCIS

Weblinks:

<https://archive.nptel.ac.in/courses/108/103/108103009/>

CO -PO Mapping

CO No.	Mapped POs	Description & Justification
CO1	PO1, PO2	Builds foundational understanding of energy conversion principles in automotive systems using thermodynamics and engineering science. Enables students to analyze energy flow and combustion processes using first principles.
CO2	PO2, PO3	Enhances analytical and design skills by evaluating thermodynamic cycles in conventional and hybrid vehicles. Supports development of efficient and sustainable automotive systems.
CO3	PO4, PO11	Strengthens investigative abilities and engineering judgment by assessing performance, efficiency, and emissions. Encourages consideration of constraints like fuel economy, cost, and regulatory standards.
CO4	PO5, PO12	Promotes hands-on proficiency with simulation and experimental tools, while fostering lifelong learning through exposure to evolving energy technologies.
CO5	PO6, PO7	Encourages awareness of environmental and societal impacts of automotive energy systems. Supports sustainable engineering practices and compliance with global standards.
CO6	PO1, PO8	Introduces emerging technologies such as fuel cells and hydrogen systems, while reinforcing ethical responsibility in adopting clean and transformative energy solutions.

CO-PO-PSO Mapping

Mapping levels

3 – Strongly related, **2** – Moderately related. **1** – Slightly related, **0** – Not related

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	0	1	1	1	3	2	1
CO2	2	3	2	2	2	1	1	1	0	2	2	2	3	3	1
CO3	1	2	2	3	2	2	3	2	0	2	3	2	3	3	3
CO4	1	2	2	3	3	1	1	1	0	2	2	3	3	3	2
CO5	1	1	1	2	2	3	3	2	0	1	2	2	2	2	3
CO6	2	1	1	1	2	2	2	3	0	1	1	2	2	2	3

VI- 4.9 : Course: Piping Design

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Piping Design	3	1	0	0	4	30	20	50	--	--

Course Outcomes:

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

CO1: Explain the fundamentals of piping systems, components, and layout principles used in industrial applications.

CO2: Apply relevant codes and standards (e.g., ASME, ANSI) in the design and analysis of piping systems.

CO3: Design piping layouts considering stress analysis, material selection, and fluid flow requirements.

CO4: Use CAD tools and software to model and simulate piping networks for various engineering applications.

CO5: Evaluate piping systems for safety, reliability, and compliance with environmental and operational constraints.

CO6: Demonstrate awareness of ethical, economic, and sustainability considerations in piping design for process industries.

Syllabus:

Unit	Contents	Hrs.
1	Fundamentals of piping: Classification of pipe, Codes and standards, Pipe Fabrication, vibration, its prevention and control in piping systems, Mechanical Properties of material, schedule number, Piping materials and selection	6
2	Design calculations for piping Determination of pipe size, Calculation of pressure drop in pipe, Equivalent length of pipe line for fittings and valves, Energy losses in pipe line, Different types of pumps and their selection criteria, NPSHA & NPSHR, Power required by pump, Calculation of flow measurement in pipe line.	7
3	Piping component and Flow through pipe line Types of Fitting, Different types of flange and gasket, their selection criteria and applications, Different types of valves, their selection criteria and applications, Determination of valve size, Steam separators and steam traps, Calculation of pressure drop for two phase flow through pipe line by using Lockhart and Martinelli correlations, Piping drainage and water hammer in process plant, Calculations for water hammer in pipeline.	6

4	Mechanical design of piping: Operating pressure and temperature, Design Pressure & Design Temperature for Piping Systems, Design equation for longitudinal, hoop and allowable stresses, Determinations of thickness required by steel pipe for withstanding internal and external pressure, Determinations of thickness required by jacketed steel pipe for withstanding external pressure.	7
5	Pipe supports and P & I diagram: Functions of Supports and selection, Types of loads, Different types of piping support, Determination of support location, Maximum span between the supports suggested by ASME B 31.1, Thermal expansion in pipe line, Different types of expansion joints and their applications, Difference between a PFD and P&ID, Typical P&I diagrams for pumps, distillation column, Reactors and Shell and tube heat exchanger.	8

Suggested learning resources:

Reference Book:

- 1 Perry R.H., “Chemical Engineers’ Handbook”, McGraw-Hill, 2009.
- 2 Coulson J.M, Richardson J.F and Sinnott, R.K., “Coulson and Richardson’s Chemical Engineering”, Vol. 6, 4th Edition, Elsevier, Newelhi, 2006.
- 3 McCabe W.L, Smith J.C, Harriott P., “Unit Operations of Chemical Engineering”, Mc Graw Hill Publication.

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CO-PO Mapping

No.	Mapped POs	Description & Justification
CO1	PO1, PO2	Builds foundational understanding of piping systems, components, and layout principles using engineering science and analytical reasoning. Enables students to interpret industrial piping requirements based on first principles.
CO2	PO3, PO6	Develops design capabilities by applying national and international codes (ASME, ANSI) while reinforcing awareness of legal, safety, and societal responsibilities in engineering practice.
CO3	PO2, PO4	Enhances problem analysis and investigative skills by integrating stress analysis, material selection, and fluid dynamics into piping design decisions.
CO4	PO5, PO12	Promotes proficiency in CAD and simulation tools for modeling piping networks, while encouraging lifelong learning through evolving digital technologies.
CO5	PO4, PO11	Strengthens engineering judgment and project management by evaluating piping systems for reliability, safety, and operational constraints.
CO6	PO7, PO8	Instills ethical and environmental awareness in the context of piping design, especially for process industries where sustainability and professional responsibility are critical.

CO-PO-PSO Mapping

Mapping levels

3 – Strongly related, **2** – Moderately related, **1** – Slightly related, **0** – Not related

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	0	1	1	1	3	2	1
CO2	2	2	3	2	2	3	2	2	0	2	2	2	3	2	2
CO3	2	3	2	3	2	2	1	1	0	2	3	2	3	3	2
CO4	1	2	2	2	3	1	1	1	0	2	2	3	3	3	2
CO5	1	2	2	3	2	3	2	2	0	2	3	2	3	3	3
CO6	1	1	1	1	1	3	3	3	0	1	2	2	2	2	3

VI- 4.10 : Heat Exchangers: Fundamentals and Design Analysis

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Heat Exchangers: Fundamentals and Design Analysis	3	1	0	0	4	30	20	50	--	--

Course Outcomes (Cos):

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

- CO1:** Explain the fundamental modes of heat transfer and their relevance to heat exchanger operation.
- CO2:** Analyze the thermal and hydraulic performance of various types of heat exchangers using analytical and empirical methods.
- CO3:** Apply design methodologies to size and select appropriate heat exchangers for specified industrial applications.
- CO4:** Evaluate the impact of flow arrangement, material selection, and operating conditions on heat exchanger efficiency and reliability.
- CO5:** Use computational tools and software to simulate heat exchanger performance and optimize design parameters.
- CO6:** Assess the role of heat exchangers in energy conservation, sustainability, and emerging technologies across interdisciplinary domains.

Syllabus:

Unit	Contents	Hrs.
1	BASIC DESIGN METHODOLOGIES Classification of heat exchanger, selection of heat exchanger, Thermal-Hydraulic fundamentals, Overall heat transfer coefficient, LMTD method for heat exchanger analysis for parallel, counter, multipass and cross flow heat exchanger, e-NTU method for heat exchanger analysis, Fouling, Rating and sizing problems, heat exchanger design methodology.	8
2	FOULING OF HEAT EXCHANGERS Basic consideration, effect of fouling on heat transfer and pressure drop, cost of fouling, design of heat exchangers subject to fouling, fouling resistance, cleanliness factor, techniques to control fouling.	8
3	Piping Design Documentation Process Flow Diagrams (PFDs): Representation of process systems, symbols, and conventions, Piping and Instrumentation Diagrams (P&IDs): Detailed schematics showing piping, equipment, and instrumentation, Piping Isometrics: 3D representation of piping systems, dimensioning, and annotations, General Arrangement (GA) Drawings: Layout of equipment and piping in a plant, Line Lists and Material Take-Off (MTO): Compilation of piping components and materials required.	8

4	DESIGN OF DOUBLE PIPE HEAT EXCHANGERS Thermal and Hydraulic design of inner tube and annulus, hairpin heat exchanger with bare and finned inner tube, total pressure drop.	8
5	DESIGN OF SHELL & TUBE HEAT EXCHANGERS Basic components, basic design procedure of heat exchanger, TEMA code, J-factors, conventional design methods, Bell-Delaware method.	8

Reference Books:

- 1 Heat Exchanger Selection, Rating and Thermal Design by Sadik, Kakac, CRC Press
- 2 Fundamentals of Heat Exchanger Design by Ramesh K Shah, Wiley Publication
- 3 Compact Heat Exchangers by Kays, V.A. and London, A.L., McGraw Hill
- 4 Heat Exchanger Design Handbook by Kuppan, T, Macel Dekker, CRC Press
- 5 Heat Exchanger Design Handbook by Schunder E.U., Hemisphere Pub.
- 6 Process Heat transfer by Donald Q Kern, McGraw Hill

Weblinks: <https://archive.nptel.ac.in/courses/112/105/112105248/>

CO-PO Mapping

Course Outcome (CO)	Mapped Program Outcomes (POs)	Description & Justification
CO1: Explain the fundamental modes of heat transfer and their relevance to heat exchanger operation.	PO1, PO2	This outcome develops foundational understanding of conduction, convection, and radiation, enabling students to apply core engineering principles and analyze thermal behavior in heat exchangers.
CO2: Analyze the thermal and hydraulic performance of various types of heat exchangers using analytical and empirical methods.	PO2, PO4, PO5	Students enhance their problem-solving and investigative skills by evaluating performance metrics such as effectiveness, pressure drop, and NTU, using both theoretical and experimental approaches.
CO3: Apply design methodologies to size and select appropriate heat exchangers for specified industrial applications.	PO3, PO5, PO6	This outcome supports design thinking and tool proficiency, while encouraging consideration of safety, sustainability, and operational constraints in selecting suitable heat exchanger configurations.
CO4: Evaluate the impact of flow arrangement, material selection, and operating	PO3, PO6, PO7	Students critically assess design parameters and operating conditions, promoting awareness of ethical,

conditions on heat exchanger efficiency and reliability.		environmental, and societal implications in thermal system design.
CO5: Use computational tools and software to simulate heat exchanger performance and optimize design parameters.	PO5, PO4, PO11	This outcome fosters proficiency in modern engineering tools and simulation platforms, while encouraging data-driven decision-making and technical documentation.
CO6: Assess the role of heat exchangers in energy conservation, sustainability, and emerging technologies across interdisciplinary domains.	PO6, PO7, PO12	Students explore the broader impact of thermal systems in energy efficiency and sustainable development, cultivating interdisciplinary awareness and lifelong learning.

CO-PO-PSO Mapping

Mapping levels

3 – Strongly related, **2** – Moderately related, **1** – Slightly related, **0** – Not related

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1	3	2	0	0	0	0	0	0	0	0	0	0	3	1	0
CO 2	2	3	0	3	2	0	0	0	0	0	0	0	3	2	0
CO 3	1	2	3	2	3	1	0	0	0	0	0	0	3	3	0
CO 4	1	1	3	1	2	2	2	0	0	0	0	0	2	3	0
CO 5	1	1	2	3	3	0	0	0	1	0	2	0	2	3	0
CO 6	1	1	0	1	1	3	2	1	0	0	1	3	2	3	0

VI- 4.11 : Micro Fluidics

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	MSE	TA	ESE	ISE	CIE
		<i><tbd></i>	Micro Fluidics	3	1	0	0	4	30	20	50

Course Outcomes (COs):

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

- CO1:** Explain the fundamental principles governing fluid behaviour at microscale
- CO2:** Analyze microchannel flow characteristics using theoretical and computational methods.
- CO3:** Apply scaling laws and dimensionless parameters to evaluate microfluidic systems
- CO4:** Design basic microfluidic devices for targeted engineering and biomedical applications
- CO5:** Evaluate fabrication techniques for microfluidic components and devices
- CO6:** Assess the role of microfluidics in lab-on-chip technologies and interdisciplinary innovations.

Syllabus:

Unit	Contents	Hrs
1	Introduction: Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.	6
2	Microscale fluid mechanics: Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects. Exact solutions, Couette flow, Poiseuille flow, Stokes drag on a sphere, Time-dependent flows, Two-phase flows, Thermal transfer in microchannels.	8
3	Capillary flows: Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Lucas-Washburn equation, Interfacial boundary conditions, Marangoni effect	6
4	Electrokinetics: Electrohydrodynamics fundamentals, Electro-osmosis, Debye layer, Thin EDL limit, Boltzman ionic distribution, Stokes Einstein equation, Ideal electroosmotic flow, Ideal EOF with back pressure, Osmotic pressure, velocity scale in electroosmosis, Helmholtz-Smoluchowski velocity, Streaming potential, Lenz's Law, Ionic advection, and conduction current, Electroosmotic velocity profile, Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size, Huckel equation	8

5	Microfabrication techniques: Materials, Clean room, Silicon crystallography, Miller indices, Oxidation, photolithography- mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding, Polymer micro fabrication, PMMA/COC/PDMS substrates, micromolding, hot embossing, fluidic interconnections.	6
6	Microfluidics components: Micropumps, Check-valve pumps, Valve-less pumps, Peristaltic pumps, Rotary pumps, Centrifugal pumps, Ultrasonic pump, EHD pump, MHD pumps, Microvalves, Pneumatic valves, Thermopneumatic valves, Thermomechanical valves, Piezoelectric valves, Microflow sensors, Differential pressure flow sensors, Drag force flow sensors, Lift force flow sensors, Thermal flow sensors, Droplet generators, Kinetics of a droplet, Dynamics of a droplet, In-channel dispensers, T-junction and Cross-junction, Droplet formation, breakup and transport.	6

Suggested learning resources:

Text Books

1. Nguyen, N. T., Werely, S. T., Fundamentals and applications of Microfluidics, Artech House Inc., 2002.
2. Madou, M. J., Fundamentals of Microfabrication, CRC press, 2002.

Reference Books

1. Bruus, H., Theoretical Microfluidics, Oxford University Press Inc., 2008.
2. Tabeling, P., Introduction to microfluidics, Oxford University Press Inc., 2005.
3. Kirby, B.J., Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge University Press, 2010.
4. Colin, S., Microfluidics, John Wiley & Sons, 2009.

Weblinks:

<https://nptel.ac.in/courses/112105187>

CO-PO Mapping

Course Outcome (CO)	Mapped Program Outcomes (POs)	Description & Justification
CO1: Explain microscale fluid behavior and governing principles.	PO1, PO2, PO4	This outcome builds foundational knowledge in fluid dynamics at the microscale, enhancing students' ability to apply core engineering concepts and analyze physical phenomena relevant to microfluidic systems. It also introduces investigative thinking through conceptual interpretation.

CO2: Analyze microchannel flow using theoretical and computational tools.	PO1, PO2, PO3, PO4, PO5	Students develop analytical and modeling skills using simulation tools and theoretical frameworks. This supports design thinking, problem-solving, and proficiency in modern engineering software relevant to microfluidic analysis.
CO3: Apply scaling laws and dimensionless parameters to evaluate system performance.	PO1, PO2, PO3, PO4, PO5	This outcome strengthens students' ability to abstract and generalize fluid behavior across scales, supporting analytical reasoning, design evaluation, and tool-based validation in microfluidic contexts.
CO4: Design microfluidic devices for biomedical and environmental applications.	PO3, PO5, PO6	Students engage in design of functional microfluidic systems, integrating technical constraints, societal needs, and sustainability considerations. This fosters creativity, tool usage, and ethical awareness in engineering design.
CO5: Evaluate fabrication techniques such as soft lithography and 3D printing.	PO1, PO2, PO3, PO4, PO5	This outcome promotes understanding of manufacturing processes and constraints, encouraging students to apply theoretical knowledge to practical fabrication and assess the suitability of different techniques.
CO6: Assess the role of microfluidics in lab-on-chip technologies and interdisciplinary innovations.	PO5, PO6, PO7, PO12	Students explore emerging applications of microfluidics, fostering awareness of societal impact, sustainability, and the need for lifelong learning. This outcome supports interdisciplinary thinking and responsible innovation.

CO-PO-PSO Mapping

Mapping levels

3 – Strongly related, **2** – Moderately related, **1** – Slightly related, **0** – Not related

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	1	0	0	0	0	0	0	0	0	3	1	0
CO2	2	3	1	3	2	0	0	0	0	0	0	0	3	2	0
CO3	2	2	2	1	1	0	0	0	0	0	0	0	2	2	0
CO4	1	2	3	1	2	1	1	0	0	0	0	0	3	3	0
CO5	2	1	1	2	3	0	0	0	1	0	0	0	2	3	0
CO6	1	1	0	1	1	2	2	1	0	0	1	2	2	3	0

VI- 4.12 : Course: Deep Learning

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Deep Learning	3	1	0	0	4	30	20	50	--	--

Course Outcomes:

Students who successfully complete this course will have demonstrated an ability to:

- CO1:** Explain the foundational concepts of neural networks, activation functions, and learning algorithms used in deep learning.
- CO2:** Analyze the architecture and training dynamics of deep neural networks, including convolutional and recurrent models.
- CO3:** Apply optimization techniques and regularization strategies to improve model performance and generalization.
- CO4:** Design and implement deep learning models for classification, regression, and sequence modeling tasks using appropriate frameworks.
- CO5:** Evaluate model performance using metrics, validation techniques, and interpretability tools to ensure robustness and fairness.
- CO6:** Explore the role of deep learning in interdisciplinary applications such as computer vision, natural language processing, and healthcare analytics.

Syllabus:

Unit	Contents	Hrs.
1	Introduction to Deep Learning and Neural Networks: Overview of Machine Learning and Deep Learning, Biological vs. Artificial Neural Networks, Activation Functions and Loss Functions, Optimization Techniques: Gradient Descent, Backpropagation, Overfitting, Underfitting, and Regularization Methods	8
2	Convolutional Neural Networks (CNNs) for Mechanical Applications: Convolution Operations and Pooling Layers, Architectures: LeNet, AlexNet, VGG, ResNet Transfer Learning and Fine-Tuning, Applications: Defect Detection, Thermal Imaging Analysis	7
3	Recurrent Neural Networks (RNNs) and Time-Series Analysis: RNN Architectures: Vanilla RNNs, LSTM, GRU, Sequence Modeling and Prediction, Applications: Vibration Analysis, Predictive Maintenance, Challenges: Vanishing/Exploding Gradients, Sequence Length Handling	7
4	Autoencoders and Generative Models: Autoencoders: Structure and Training, Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), Applications: Design Optimization, Anomaly Detection	6

5	Reinforcement Learning in Mechanical Systems: Fundamentals of Reinforcement Learning (RL), Deep Q-Networks (DQN) and Policy Gradient Methods, Applications: Robotics Control, Adaptive Systems, Simulation Environments: OpenAI Gym, Custom Simulators	6
6	Integration and Deployment of Deep Learning Models: Model Deployment Strategies: Edge Computing, Cloud Services, Tools: TensorFlow Lite, ONNX, Docker, Case Studies: Real-world Applications in Mechanical Engineering Ethical Considerations and Model Interpretability	8

Suggested learning resources:

Textbooks:

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow Concepts, Tools, and Techniques to Build Intelligent Systems, O’Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press
3. Charu C. Aggarwal , Neural Networks and Deep Learning, Springer Nature.
4. François Chollet , Deep Learning with Python, Manning; First Edition

Weblinks:

https://onlinecourses.nptel.ac.in/noc20_cs62/preview

CO-PO Mapping

Course Outcome (CO)	Mapped Program Outcomes (POs)	Description & Justification
CO1: Explain the foundational concepts of neural networks, activation functions, and learning algorithms used in deep learning.	PO1, PO2	This outcome builds theoretical understanding of deep learning principles, enabling students to apply mathematical and algorithmic reasoning to neural network behavior. It supports analytical thinking and foundational engineering knowledge.
CO2: Analyze the architecture and training dynamics of deep neural networks, including convolutional and recurrent models.	PO2, PO4, PO5	Students develop the ability to investigate and interpret the behavior of complex models, enhancing their skills in experimentation, performance evaluation, and use of modern tools.
CO3: Apply optimization techniques and regularization strategies to improve model performance and generalization.	PO2, PO3, PO5	This outcome strengthens students’ problem-solving and design capabilities by integrating techniques that enhance model robustness and reduce overfitting, using both theoretical and practical approaches.

CO4: Design and implement deep learning models for classification, regression, and sequence modeling tasks using appropriate frameworks.	PO3, PO5, PO6	Students engage in end-to-end model development using industry-standard platforms, while considering ethical, safety, and sustainability aspects in deployment.
CO5: Evaluate model performance using metrics, validation techniques, and interpretability tools to ensure robustness and fairness.	PO4, PO5, PO11	This outcome promotes investigative rigor, tool proficiency, and responsible engineering practice by encouraging students to assess fairness, transparency, and reliability in model evaluation.
CO6: Explore the role of deep learning in interdisciplinary applications such as computer vision, natural language processing, and healthcare analytics.	PO6, PO7, PO12	Students examine the societal impact and interdisciplinary relevance of deep learning, fostering awareness of emerging technologies, ethical considerations, and lifelong learning.

CO-PO-PSO Mapping

Mapping levels

3 – Strongly related, **2** – Moderately related, **1** – Slightly related, **0** – Not related

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	3	1	0
CO2	2	3	1	3	2	0	0	0	0	0	0	0	3	2	0
CO3	2	2	2	2	3	0	0	0	0	0	0	0	3	3	0
CO4	1	2	3	2	3	1	1	0	0	0	0	0	3	3	0
CO5	1	1	2	3	3	0	0	0	1	0	2	0	2	3	0
CO6	1	1	0	1	1	3	2	1	0	0	1	3	2	3	0

VI-05- Advances in Farm Equipment and Food Technology

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
MDM III	Advances in Farm Equipment and Food Technology	3	1	0	1	4	30	20	50	–	

Course Outcomes:

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

- CO1:** Explain the principles and operational features of advanced farm machinery used in modern agricultural practices.
- CO2:** Analyze the performance, efficiency, and suitability of mechanized equipment for various soil, crop, and climatic conditions.
- CO3:** Apply design and selection criteria to recommend appropriate farm equipment for specific agricultural operations.
- CO4:** Evaluate post-harvest technologies and food processing systems for quality enhancement, safety, and sustainability.
- CO5:** Use computational tools and automation technologies to model, simulate, and optimize farm and food processing systems.
- CO6:** Assess the role of advanced equipment and food technologies in improving productivity, reducing environmental impact, and supporting rural development.

Syllabus:

Unit	Contents	Hrs.
1	Introduction to farm machinery: Modern trends, principles, procedures, fundamentals and economic considerations of Farm machinery, Importance of farm machinery in the contest of enhanced production, multiple cropping, labour scarcity	6
2	Primary and Secondary Tillage implements: Definition and Objectives of Tillage, Primary and Secondary Tillage, Physical, Chemical and Biological Influences of Tillage, Concept of ploughing, Tools used for ploughing, Disc Ploughs, Harrows, Seedbed preparation and irrigation	8
3	Seeding and Planting Machines: Methods of Seeding and Planting and their Mechanization, Tools and Implements for Intercultural Operations, Drills, Planters, Seed and Fertilizer Metering Devices	7
4	Crop Protection and Harvesting: Objectives and Types of Spraying and Dusting, Working Principle and Components of Sprayers and Dusters, Safety in Handling Plant Protection Machines, Machinery for transport and material handling, Crop Harvesting Methods and their Mechanization,	8

	Mowers, Reapers and Windrowers, Pickers and Stripers, Root crop harvesting machinery	
5	Food processing technology: General aspects of food industry, world food demand and Indian scenario, quality and nutritive aspects, Food additives, Food additives, Preliminary food processing methods, thermal processing of foods, Steam generation, Fuel utilization, Electric Power Utilization, Process Controls in Food Processing	7
6	Introduction to food preservation: Objectives and techniques of food preservation, Canning, Preservation principle of canning of food items, Drying techniques, Low temperature food preservation, cold storage, freezing of food products, cryogenic freezing, Preservation by fermentation, Non-thermal and minimal processing technologies, Use of preservatives in foods, packaging of food.	6

Useful Learning Resources

Tutorials

1. Study of Different Farm Operations and Familiarization with Farm Machines and Equipment.
2. Study of Power Requirement of Farm Machines and Equipments.
3. Visit to Agriculture farm site to explore various types of Farm machinery.
4. Case study to understand food preservation in case of milk products/beverages/poultry farm products/meat

Text Books:

1. Bernacki C, Haman J & Kanafajski CZ. 1972. Agricultural Machines, Oxford & IBH
2. Arthur W Judge 1967. High Speed Diesel Engines, Chapman & Hall
3. Boson ES, Verniaev OV & Sultan-Shakh EG. 1990. Theory, Construction and Calculations of Agricultural Machinery Vol. I. Scientific publishers (India).
4. Food Processing Technology: Principles and Practice (Woodhead Publishing Series in Food Science, Technology and Nutrition), Third addition, June 2009 by P.J. Fellows

Weblinks:

<http://www.digimat.in/nptel/courses/video/126105009/L01.html>

CO-PO Mapping

Course Outcome (CO)	Mapped Program Outcomes (POs)	Description & Justification
CO1: Explain the principles and operational features of advanced farm machinery used in modern agricultural practices.	PO1, PO2	This outcome builds foundational engineering knowledge and analytical thinking by introducing students to the mechanics, design, and functionality of advanced agricultural equipment.
CO2: Analyze the performance, efficiency, and suitability of mechanized equipment for various soil, crop, and climatic conditions.	PO2, PO4, PO5	Students develop problem-solving and investigative skills by evaluating equipment performance under diverse field conditions, using both

		theoretical and empirical approaches.
CO3: Apply design and selection criteria to recommend appropriate farm equipment for specific agricultural operations.	PO3, PO5, PO6	This outcome supports design thinking and tool proficiency, while encouraging consideration of safety, sustainability, and operational constraints in equipment selection.
CO4: Evaluate post-harvest technologies and food processing systems for quality enhancement, safety, and sustainability.	PO3, PO6, PO7	Students critically assess food processing systems and post-harvest technologies, promoting awareness of ethical, environmental, and societal implications in agri-food engineering.
CO5: Use computational tools and automation technologies to model, simulate, and optimize farm and food processing systems.	PO5, PO4, PO11	This outcome fosters proficiency in modern engineering tools and simulation platforms, while encouraging data-driven decision-making and technical documentation.
CO6: Assess the role of advanced equipment and food technologies in improving productivity, reducing environmental impact, and supporting rural development.	PO6, PO7, PO12	Students explore the broader impact of agricultural technologies on sustainability and rural empowerment, cultivating interdisciplinary awareness and lifelong learning.

CO-PO-PSO Mapping

Mapping levels

3 – Strongly related, **2** – Moderately related, **1** – Slightly related, **0** – Not related

CO \ PO / PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	0	0	0	0	0	0	3	1	0
CO2	2	3	1	3	2	0	0	0	0	0	0	0	3	2	0
CO3	1	2	3	2	3	1	0	0	0	0	0	0	3	3	0
CO4	1	1	3	1	2	2	2	0	0	0	0	0	2	3	0
CO5	1	1	2	3	3	0	0	0	1	0	2	0	2	3	0
CO6	1	1	0	1	1	3	2	1	0	0	1	3	2	3	0

Proposed I

Integrated Project-Based Learning and Evaluation Framework (5th, 6th, and 7th Semester)

Summary:

The Progressive Integrated Project Work Articulation and Evaluation Framework at COEP Technological University provides undergraduate engineering students a structured, continuous, and immersive project-based learning experience across the 5th, 6th, and 7th semesters. This framework focuses on long-term engagement with a single engineering problem, enhancing technical expertise, problem-solving, and project management skills. The three-phase approach covers Problem Definition & Feasibility (5th semester), Design & Implementation (6th semester), and Final Implementation & Evaluation (7th semester). The framework aligns with outcome-based education (OBE) best practices and fosters innovation, research, and entrepreneurship.

Introduction

The Proposed Progressive integrated Project Work Articulation and Evaluation Framework at COEP Technological University is designed to provide undergraduate engineering students with a structured, continuous, and immersive project-based learning experience across the 5th, 6th, and 7th semesters of their academic program. This progressive project model emphasizes long-term engagement on a single, meaningful engineering problem, allowing students to evolve their technical expertise, problem-solving capabilities, and project management skills in a systematic manner.

The framework introduces a three-phased approach — starting from Problem Definition & Feasibility (5th semester), progressing to Design & Implementation (6th semester), and culminating in Final Implementation & Evaluation (7th semester). Through this progression, student teams remain consistent, enabling deep collaboration and sustained focus on their project objectives over multiple semesters.

The model is aligned with national and international best practices in outcome-based education (OBE) and is intended to mirror the iterative, long-duration nature of real-world engineering projects encountered in industry and research. This articulation encourages innovation, research output (including paper publications and patent filings), and entrepreneurial thinking.

A robust evaluation mechanism is embedded within each semester, involving multiple review stages, comprehensive rubrics, and clear deliverables — ensuring continuous assessment of both technical competencies and soft skills like teamwork, communication, and project management. The cumulative project work carries a total of 9 credits, distributed across the three semesters, reflecting its academic rigor and importance.

This document details the semester-wise course outcomes, deliverables, evaluation rubrics, and guidelines to ensure smooth implementation and fair assessment, thereby fostering a rich, application-oriented learning environment at COEP Technological University.

Key Features of the Progressive Project Work

- Continuous project across 5th to 7th semesters with the same student group
- Project topic finalized in the 5th semester
- Progressive development: Micro (5th Sem) → Mini (6th Sem) → Capstone (7th Sem) with total 9 credits (2 + 2 + 5) distribution.

Semester-wise Project Deliverables and Credits

Semester	Course Name	Focus	Deliverables	Credits
5th	Project Phase I	Problem Definition & Feasibility	Project Proposal, Literature Review Report, Feasibility Report, Initial Demo	2
6th	Project Phase II	Design & Implementation	System Design Document, Intermediate Implementation, Progress Report, Demo	2
7th	Project Phase III	Final Implementation & Evaluation	Final Report, Working Project Demo, Viva, Optional: Research Paper/Patent	5

Total project credits = 9 credits (2 + 2 + 5)

- Project Evaluation guidelines: Two evaluations per semester (Progress Mid Sem Review and End Sem Final Review). Marks can be averaged or weighted as per your department's scheme. Mid-Semester will focus on progress, functionality, design, and teamwork. And End-Semester will deep dive into system implementation, testing, documentation, and final presentation quality. Also Comprehensive understanding, clear communication, technical knowledge, and ability to defend the project.
- Final Evaluation Calculation for the Semester: Individual Student-Teacher Assessment Marks (20%), Mid-Semester Marks (30%) and End-of-Semester Marks (50%)

Advantages of This Model

1. Continuity → Deeper understanding of the problem and solution evolution
2. Industry Relevance → Mimics real-world long-term projects
3. Research / Innovation Focus → Encourages paper publication, patents, entrepreneurship
4. Efficient Teaming → No reshuffling; stable collaboration dynamics

First, just to be clear, the NBA **12 Program Outcomes** (POs) are generally:

PO#	Program Outcome
PO1	Engineering knowledge
PO2	Problem analysis
PO3	Design/development of solutions
PO4	Conduct investigations of complex problems
PO5	Modern tool usage
PO6	The engineer and society
PO7	Environment and sustainability
PO8	Ethics
PO9	Individual and team work
PO10	Communication
PO11	Project management and finance
PO12	Life-long learning

PSO#	Program Specific Outcome
PSO1	Apply domain knowledge to solve complex engineering problems.
PSO2	Design and develop efficient solutions using modern tools and techniques.
PSO3	Demonstrate communication, teamwork, and project management skills in professional practice.

5th Semester — Project Phase I (Problem Definition & Feasibility)

1. Course Outcomes (COs)

CO1: Identify and define a relevant engineering problem

CO2: Conduct literature review and feasibility analysis

CO3: Develop an initial proof-of-concept/prototype

CO4: Prepare and present project proposal and literature report

Rationale (in brief)

- **PO1–PO4 (Technical Core)** → Strong across all COs because it's a project phase with problem-solving and prototyping.
- **PO5 (Tool usage)** → Moderate to strong for CO2 & CO3 (feasibility + prototype).
- **PO6–PO7 (Society & Sustainability)** → Minimal but considered (ethics/societal relevance of project definition).
- **PO8 (Ethics)** → Light link when defining problem & literature review (plagiarism, citation, responsible innovation).
- **PO9–PO11 (Soft skills, Communication, Management)** → Especially strong in CO4 (proposal writing + teamwork).
- **PO12 (Lifelong learning)** → Moderate in all — students learn how to independently research and adapt.

2. Articulation Matrix (CO–PO)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	
CO1: Identify and define a relevant engineering problem		3	3	2	2	1	1	1	1	2	2	1	2
CO2: Conduct literature review and feasibility analysis		3	3	2	3	2	1	1	1	2	2	1	2
CO3: Develop an initial proof-of-concept/prototype		3	3	3	3	3	1	1	1	2	2	2	2
CO4: Prepare and present project proposal and literature report		2	2	2	2	2	1	1	2	3	3	2	2

(Scale: 3 – Strong; 2 – Moderate; 1 – Low contribution; blank – No contribution)

Now, based on your COs, here's the CO–PSO Mapping Table:

COs / PSOs	PSO1	PSO2	PSO3
CO1: Identify and define a relevant engineering problem	3	2	2
CO2: Conduct literature review and feasibility analysis	3	2	2
CO3: Develop an initial proof-of-concept/prototype	2	3	2
CO4: Prepare and present project proposal and literature report	2	2	3

(Scale: 3 – Strong; 2 – Moderate; 1 – Low contribution; blank – No contribution)

Justification Table for CO–PO–PSO Mapping (for NBA SAR Annexure)

CO	Justification of PO and PSO Mappings
CO1	Strongly aligned with PO1 & PO2 (problem identification & analysis). PO3 & PO4 moderately linked (preliminary solution framework). PSO1 strongly relevant (domain knowledge application). Communication and teamwork moderately engaged (PO9, PO10, PSO3).
CO2	Strongly supports PO1, PO2, PO4 (literature review, feasibility). PO5 moderately linked (tools usage for analysis). PSO1 strong (domain knowledge), PSO2 moderate (tool knowledge). Collaboration (PO9), ethics (PO8) lightly considered.
CO3	Strongest contribution to PO3, PO4, PO5 (prototype development, modern tools). PSO2 strongest here. PO1, PO2 remain high (design based on knowledge/analysis). Moderate teamwork and project management relevance (PO9, PO11).
CO4	Strongly maps to PO9, PO10 (teamwork, communication), PO11 (project management). PSO3 strongest (professional practice). PO5 moderate (tools for documentation/presentation). PO1-PO4 moderate for synthesizing final reports.

3. Evaluation

[Team Details]

- **Project Title:** _____
- **Team Members:** _____
- **Guide Name:** _____

Individual Student-Teacher Assessment (20% Weightage)

Component	Marks Range	Marks Awarded	Remark
Individual Contribution: Effort, initiative, and leadership in the project	0–10		
Team Collaboration: Effective teamwork, contribution to group tasks	0–5		
Communication Skills: Individual's communication, presentation, and technical understanding	0–5		
Total Marks (Individual Assessment)	20 Marks		
Weighted Marks (20%)			20 × 0.20 4 Marks

Signature of Guide: _____

Signature of Evaluator: _____

Date of Evaluation: _____

Mid-Semester Evaluation Sheet (30% Weightage)

Component	Marks Range	Marks Awarded	Remark
Problem Definition: Clarity of problem statement, alignment with real-world needs	0–5		
Literature Survey: Depth, relevance, and thoroughness of literature reviewed, practicality of proposed solution	0–5		
Feasibility Study: Quality of feasibility analysis	0–5		
Prototype/PoC: Basic working model demonstrating the approach, technical demonstration	0–5		

Component	Marks Range	Marks Awarded	Remark
Progress in Teamwork: Collaboration, task division, adherence to timelines	0–5		
Communication & Presentation: Clear explanation, structured presentation, Q&A handling	0–5		
Project Review Focus: Progress, functionality, design, teamwork	0–5		
Total Marks (Mid-Semester)	30		
	Marks		
Weighted Marks (30%)			30 × 0.30 = 9 Marks

Signature of Guide: _____

Signature of Evaluator: _____

Date of Evaluation: _____

End-of-Semester Evaluation Sheet (50% Weightage)

Component	Marks Range	Marks Awarded	Remark
Problem Definition & Objectives: Clarity of problem statement and objectives, well-defined goals	0–10		
Literature Survey & Feasibility: Depth and quality of literature search and feasibility analysis	0–10		
Initial Prototype (PoC): Technical accuracy, functionality of prototype or demonstration	0–15		
Documentation (Proposal): Structure, completeness, quality of the proposal	0–10		
Presentation & Viva: Presentation clarity, responsiveness to questions, demonstration of knowledge	0–15		
Internal Assessment Focus: System implementation, testing, documentation, and final presentation quality	0–10		
Total Marks (End-Semester)	60		
	Marks		
Weighted Marks (50%)			60 × 0.50 = 30 Marks

Signature of Guide: _____

Signature of Evaluator: _____

Date of Evaluation: _____

6th Semester — Project Phase II (Design & Implementation)

1. Course Outcomes (COs)

CO1-6: Design detailed system architecture and specifications

CO2-6: Implement and test core modules

CO3-6: Integrate components into a working system

CO4-6: Document design and development progress

2. Articulation Matrix (CO–PO)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1: (Design	3	3	2	2	1	1	1	1	2	2	1	2
CO2: Implement & Test)	3	3	2	3	2	1	1	1	2	2	1	2
CO3: (Integrate System)	3	3	3	3	3	1	1	1	2	2	2	2
CO4: Documentation)	2	2	2	2	2	1	1	2	3	3	2	2

Explanation Highlights:

- **CO1-6** aligns best with **PO1, PO2, PO3, and PSO1**, as it involves high-level design and application of domain knowledge.
- **CO2-6** and **CO3-6** are strong on **technical execution, tool use (PO5), and system integration**, which ties into **PSO2**.
- **CO4-6** is strongly aligned with **PO9, PO10, PO11, and PSO3**, reflecting the importance of **communication, documentation, and teamwork**.
- **Ethics (PO8)** and **Sustainability (PO7)** are only slightly addressed unless the specific project focuses on these aspects.

CO–PSO Mapping Table

Course Outcomes (COs)	PSO1 (Apply domain knowledge)	PSO2 (Design & tools)	PSO3 (Teamwork & communication)
CO1-6: Design detailed system architecture and specifications	3	2	2
CO2-6: Implement and test core modules	3	3	2

Course Outcomes (COs)	PSO1 (Apply domain knowledge)	PSO2 (Design & tools)	PSO3 (Teamwork & communication)
CO3-6: Integrate components into a working system	3	3	3
CO4-6: Document design and development progress	2	2	3

 **Legend:**

- 3 = Strong correlation
- 2 = Moderate correlation
- 1 = Slight correlation
- Blank = No significant correlation

Summary:

- **PSO1 (Domain Knowledge):** Strongly reflected in CO1–CO3, as students apply core mechanical engineering principles.
- **PSO2 (Design & Tools):** Key in CO2 and CO3, where implementation and integration require modern engineering tools.
- **PSO3 (Communication & Teamwork):** Most relevant to CO3 and especially CO4, where collaboration and documentation are emphasized.

3. Evaluation

[Team Details]

- **Project Title:** _____
- **Team Members:** _____
- **Guide Name:** _____

Individual Student-Teacher Assessment (20% Weightage)

Component	Marks Range	Marks Awarded	Remark
Individual Contribution: Effort, initiative, and leadership in the project	0–10		
Team Collaboration: Effective teamwork, contribution to group tasks	0–5		
Communication Skills: Individual's communication, presentation, and technical understanding	0–5		

Component	Marks Range	Marks Awarded	Remark
Total Marks (Individual Assessment)	20		
	Marks		
Weighted Marks (20%)			20 × 0.20 = 4 Marks

Signature of Guide: _____

Signature of Evaluator: _____

Date of Evaluation: _____

Mid-Semester Evaluation Sheet (30% Weightage)

Component	Marks Range	Marks Awarded	Remark
System Design: Architecture, UML, Specifications	0–5		
Module Implementation & Testing: Functional modules, efficiency, test cases developed	0–5		
Intermediate Prototype Integration: Quality of intermediate prototype integration, functionality check	0–5		
Team Progress & Collaboration: Task division, timeline adherence, collaborative approach	0–5		
Communication & Presentation: Clarity of explanation, structured demo, handling of questions	0–5		
Project Review Focus: Progress, functionality, design, teamwork	0–5		
Total Marks (Mid-Semester)	30		
	Marks		
Weighted Marks (30%)			30 × 0.30 = 9 Marks

Signature of Guide: _____

Signature of Evaluator: _____

Date of Evaluation: _____

End-of-Semester Evaluation Sheet (50% Weightage)

Component	Marks Range	Marks Awarded	Remark
System Design (Architecture): Clear, robust system design; architecture diagrams; component-level breakdown	0–10		
Module Implementation: Accuracy, functionality, testing of individual modules	0–15		
Integration & Intermediate Prototype: Integration of subsystems, working prototype	0–10		
Documentation (Design, Progress Report): Comprehensive, structured, and clear documentation	0–10		
Presentation & Viva: Quality of demo, technical explanation, Q&A responses	0–15		
Internal Assessment Focus: System implementation, testing, documentation, and final presentation quality	0–10		
Total Marks (End-Semester)	60		
	Marks		
Weighted Marks (50%)			60 × 0.50 = 30 Marks

Signature of Guide: _____

Signature of Evaluator: _____

Date of Evaluation: _____

7th Semester — Project Phase III (Final Implementation & Evaluation)

1. Course Outcomes (COs)

CO1-7: Complete full implementation, integration, validation

CO2-7: Apply project management, ethics, teamwork

CO3-7: Prepare and defend comprehensive project report

CO4-7: Communicate project outcomes effectively (presentation, demo)

2. Articulation Matrix (CO–PO)

Final CO–PO–PSO Mapping Table

COs / Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
implementation, integration, validation	3	3	3	3	2	2	1	1	2	2	2	2	3	3	2
CO2-7Project management, ethics, teamwork	2	2	2	2	3	3	1	3	3	3	3	2	2	2	3
CO3-7Report preparation and defense	2	2	2	2	2	3	1	2	3	3	2	2	2	2	3
CO4-7Effective communication and demo	2	2	2	2	2	3	1	2	3	3	2	2	2	2	3

- **CO1-7:** Strong focus on **technical competence**, aligning with **PO1–PO4** and **PSO1/PSO2**.
- **CO2-7:** Emphasizes **ethics, team dynamics, and management**, linking it closely with **PO6, PO8, PO9, PO11**, and **PSO3**.
- **CO3-7** and **CO4-7:** Deal with **documentation, presentation, and communication**, hence strongly mapped to **PO10, PO9**, and **PSO3**.

3. Evaluation

[Team Details]

- **Project Title:** _____
- **Team Members:** _____
- **Guide Name:** _____

Individual Student-Teacher Assessment (20% Weightage)

Component	Marks Range	Marks Awarded	Remark
Individual Contribution: Effort, initiative, and leadership in the project	0–10		
Team Collaboration: Effective teamwork, contribution to group tasks	0–5		
Communication Skills: Individual's communication, presentation, and technical understanding	0–5		
Total Marks (Individual Assessment)	20 Marks		
Weighted Marks (20%)			20 × 0.20 = 4 Marks

Signature of Guide: _____

Signature of Evaluator: _____

Date of Evaluation: _____

Mid-Semester Evaluation Sheet (30% Weightage)

Component	Marks Range	Marks Awarded	Remark
Final Implementation: Full functionality, completeness, integration of components	0–10		
Testing, Validation, & Performance: Test results, validation against problem statement, performance metrics	0–10		
Team Collaboration & Task Completion: Adherence to timelines, task division, collaboration quality	0–5		
Progress in Documentation: Quality of the final report, documentation of milestones	0–5		
Communication & Presentation: Demo quality, clarity in technical explanation	0–5		
Project Review Focus: Final implementation, testing, validation, teamwork	0–5		
Total Marks (Mid-Semester)	30		
	Marks		
Weighted Marks (30%)			30 × 0.30 = 9 Marks

Signature of Guide: _____

Signature of Evaluator: _____

Date of Evaluation: _____

End-of-Semester Evaluation Sheet (50% Weightage)

Component	Marks Range	Marks Awarded	Remark
Final Implementation & Integration: Complete and integrated system, adherence to problem objectives	0–20		
Testing & Validation: Thorough testing, validation results, performance analysis	0–15		

Component	Marks Range	Marks Awarded	Remark
Project Management & Teamwork: Planning, resource management, teamwork throughout the semester	0–10		
Documentation (Final Report, User Manual): Final report quality, clarity, technical depth, user manual quality	0–10		
Final Presentation & Viva: Presentation clarity, demo quality, technical and non-technical explanations	0–15		
Internal Assessment Focus: Final implementation, testing, documentation, final presentation quality	0–10		
Total Marks (End-Semester)	70		
	Marks		
Weighted Marks (50%)			70 × 0.50 = 35 Marks

Signature of Guide: _____

Signature of Evaluator: _____

Date of Evaluation: _____

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VI-Exit Option-01- Finite Element Analysis

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	T A	ESE	ISE	ESE
tbd	Finite Element Analysis	3	1	0	1	4	30	20	50		

Course Outcomes:

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

1. Understand the different techniques used to solve mechanical engineering problems.
2. Derive and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.
3. Apply mechanics of materials and machine design topics to provide preliminary results used for testing the reasonableness of finite element results.
4. Solve complex problems in solid mechanics, vibrations and heat transfer.

Syllabus:

Unit	Contents	Hrs.
1	<p>Fundamental Concepts of FEA Introduction: Solution methodologies to solve engineering problems, governing equations, mathematical modelling of field problems in engineering, discrete and continuous models. Brief history of FEM, Finite Element terminology (nodes, elements, domain, continuum, degrees of freedom, loads & constraints), general steps involved in FEM, applications of FEM in various fields, advantages and disadvantages of FEM, consistent units system, essential and natural boundary conditions, symmetric boundary conditions. Introduction to different approaches used in FEA : Direct approach, Variational formulation- Principal of Minimum Potential Energy (PMPE), Galerkin weighted residual method, Principle of Virtual Work, Rayleigh-Ritz method, relation between FEM and Rayleigh-Ritz method Types of Analysis (Introduction) : Linear static analysis, Non-linear analysis, Dynamic analysis, Linear buckling analysis, Thermal analysis, Fatigue analysis, Crash analysis.</p>	6
2	<p>1D Elements Types of 1D elements, displacement function, global and local coordinate systems, polynomial form of interpolation functions- linear, quadratic and cubic, properties of shape function, primary and secondary variables. Formulation of elemental stiffness matrix and load vector for bar, truss and beam using any approach, Formulation of load vector due to uniform temperature change (only for bar).</p>	6

	Assembly of global stiffness matrix and load vector, properties of stiffness matrix, half bandwidth, treatment of boundary conditions- elimination approach, stress and reaction forces calculations.	
3	<p>2D Elements Two-Dimensional Stress Analysis: Plane Stress/Strain problems in 2D elasticity, constitutive relations Constant Strain Triangle (CST), Linear Strain Rectangle (LSR), displacement function, Pascal's triangle, compatibility and completeness requirement, geometric isotropy, convergence requirements, strain field, stress field, Formulation of element stiffness matrix and load vector for Plane Stress/Strain problems Assembly of global stiffness matrix and load vector, Boundary conditions, solving for primary variables (displacement), stress calculations</p>	6
4	<p>Isoparametric Elements and Numerical Integration Concept of isoparametric elements, Terms isoparametric, super parametric and subparametric. <u>Coordinate mapping</u>: Natural coordinates, Area coordinates (for triangular elements), higher order triangular and quadrilateral elements (Lagrangean and serendipity elements), geometry associative mesh, quality checks, mesh refinement- p vs h refinements, Uniqueness of mapping - Jacobian matrix. <u>Numerical integration</u>: Gauss Quadrature in one and two dimensions, Order of Gauss integration, full and reduced integration, sub-modeling, substructuring.</p>	6
5	<p>1D Steady State Heat Transfer Problems Introduction, One dimensional steady-state heat transfer problem- Governing differential equation, Finite Element formulation using Galerkin's approach for composite wall and thin Fin , essential and natural boundary conditions and solving for temperature distribution</p>	6
6	<p>Dynamic Analysis Types of dynamic analysis, general dynamic equation of motion, lumped and consistent mass, Mass matrices formulation of bar, truss and beam element. Undamped-free vibration: Eigenvalue problem, evaluation of eigenvalues and eigenvectors (characteristic polynomial technique).</p>	6

Useful Learning Resources

Textbooks

1. Daryl L, A First Course in the Finite Element Method. Logan, 2007.
2. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002.
3. Y.M.Desai, T.I.Eldho and A.H.Shah, Finite Element Method with Applications in Engineering, Pearson Education, 2011
4. P., Seshu, Text book of Finite Element Analysis, PHI Learning Private Ltd. , New Delhi, 2010.

Reference Books:

1. Bathe K. J., Finite Element Procedures Prentice, Hall of India (P) Ltd., New Delhi.
2. R. D. Cook, et al., Concepts and Applications of Finite Element Analysis. Wiley, India

3. David V. Hutton, Fundamental of Finite Element Analysis, Tata McGraw-Hill
4. Gokhale N. S., et al., Practical Finite Element Analysis, Finite to Infinite, Pune, 2008.

Weblinks:

https://onlinecourses.nptel.ac.in/noc22_me43/preview

https://onlinecourses.nptel.ac.in/noc20_me91/preview

VI- Exit Option- 02-Generative Design

Course Code	Course Name	Teaching Scheme					Evaluation Scheme				
		Weightage in Hr.					Weightage in %				
		L	T	P	S	Cr	Theory			Laboratory	
						MSE	TA	ESE	ISE	ESE	
tbd	Generative Design	3	1	0	1	4	30	20	50		

Course outcomes:

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

1. **Apply Generative Design Principles:** Understand and implement the fundamentals of generative design, including design space definition, objectives, and constraints, using both traditional and AI-driven methods.
2. **Develop Parametric and Algorithmic Models:** Create and manipulate parameter-driven and algorithmic models to enable automated design exploration and optimization workflows.
3. **Utilize Optimization and AI Tools:** Employ optimization techniques (topology, shape, evolutionary algorithms) and integrate AI/ML tools to guide and enhance mechanical design decisions.
4. **Solve Real-World Design Challenges:** Apply generative design tools and workflows to real-world engineering problems, incorporating data analysis, sustainability considerations, and advanced manufacturing technologies.

Syllabus:

Unit No.	Contents	Lecture
01	<p>Introduction to Generative Design</p> <p>Contrast between traditional CAD/hand-design methods with AI-driven design exploration, design objectives vs. constraints, design space definition, overview of role of algorithms in autonomous generation of many feasible designs, real-world examples.</p> <p>Self study: Study and discuss real-world examples (e.g. a generatively designed chair or bracket) to illustrate faster, lighter, cost-effective solutions. Study interdisciplinary links, e.g. how data on loads/materials feed into design goals.</p>	6

02	<p>Parametric & Algorithmic Modelling</p> <p>Parametric design and its role in generative workflows, parameter-driven models - the basis of automated design exploration, constraint-based modelling in Fusion 360 (or similar), introduction to algorithmic (programmatic) design concepts, and parameters/data used to generate geometry.</p> <p>Self Study: Parametric variables in CAD, design tables. Basics of algorithmic design (e.g. using parameter lists or pseudocode to vary shapes). Comparison: parametric design vs. generative design. Setting up a CAD model for optimisation.</p>	6L
03	<p>Optimisation Techniques in Mechanical Design Content:</p> <p>Introduces optimisation fundamentals, objective functions, types of constraints, and the difference between shape/topology optimisation and generative design, classic optimisation algorithms (gradient-based vs. evolutionary) and multi-objective trade-offs, Topology optimisation (material distribution) - a precursor to generative design, evolutionary algorithms (genetic algorithms, particle swarm) and machine learning to guide design choices. Compared to shape optimisation (one solution), generative design produces many iterative models optimised for varied criteria.</p> <p>Self Study: Optimisation basics (objective, constraints), local vs. global optima. Topology optimisation (concept of removing material to achieve a light-weight design).</p>	6
04	<p>Unit 4: Generative Design Workflow and Tools</p> <p>Creating or importing a preliminary CAD model (the “design space”), applying loads and fixtures, setting up manufacturing constraints (like allowable manufacturing methods, symmetry), and specifying objectives (e.g. minimise weight), Use of cloud computing and AI simulation.</p> <p>Self Study: Study the process which explores all possible permutations of a solution in a software, quickly generating design alternatives. Learn Key skills include filtering and comparing outcomes (e.g. by stiffness vs. mass) and selecting feasible designs.</p>	6
05	<p>Data Science and AI Integration in Design</p> <p>Basic data analysis skills relevant to design: collecting performance data (from simulations or tests), plotting trends, and using simple statistics, machine learning models to predict design performance or assist optimization (e.g. regression to predict stress from geometry), the role of AI.</p> <p>Self-Study: Learn how machine learning allows the system to learn from each design iteration and continuously improves the design outcomes. Conceptual overview of ML in design (prediction vs. optimisation). Interdisciplinary ties: how manufacturing data or material databases feed generative processes.</p>	6
06	<p>Applications, Projects, and Future Trends</p> <p>Real-world applications of generative design in mechanical engineering (automotive parts, aerospace components, biomedical implants, consumer products), additive manufacturing (3D printing) and the concept of sustainable design (multi-materials, eco-criteria). Current trends (e.g. AI-driven digital twins, integration with IoT sensor data) and outlook.</p> <p>Self study: Additive manufacturing considerations (how design freedom allows complex shapes). Multi-objective optimisation (balancing</p>	6

	weight, cost, aesthetics). Emerging trends: generative design in industry and research.	
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Note: Content mentioned for self-study is integral part of the syllabus and it will be considered for evaluation of the course.

Suggested Learning Resources

1. Autodesk: Generative Design in Manufacturing

<https://www.autodesk.com/learn/ondemand/course/generative-design-in-manufacturing>

2. Autodesk: Fusion 360 Generative Design Overview

<https://help.autodesk.com/view/fusion360/ENU/?guid=GD-OVERVIEW>

3. Formlabs: Generative Design 101

<https://formlabs.com/global/blog/generative-design>

4. GUVI: Generative Design in Mechanical Engineering

<https://www.guvi.in/blog/generative-design-in-mechanical-engineering/>

5. Autodesk University: Fusion 360 Introduction to Generative Design

<https://www.autodesk.com/autodesk-university/article/Fusion-360-Introduction-Generative-Design>

6. All3DP Pro: Fusion 360 Generative Design – Hands-On Tutorial

<https://all3dp.com/2/fusion-360-generative-design-tutorial/>

7. ASME Digital Collection: Generative Design – Reframing the Role of the Designer

<https://asmedigitalcollection.asme.org/mechanicaldesign/article/145/4/041411/1156493/Generative-Design-Reframing-the-Role-of-the>

8. University of California, Santa Cruz: CMPM147 – Generative Design Course

<https://courses.engineering.ucsc.edu/courses/cmpm147>

9. Introduction to Generative Design for Manufacturing

<https://www.autodesk.com/learn/ondemand/course/fusion360-generative-design-intro-expert>

10. Generative Design Course

<https://www.youtube.com/watch?v=PSSt8wswNJQ>

<https://www.youtube.com/watch?v=bDJQF0BbBBs>

<https://www.youtube.com/watch?v=oROzWsvK19o>