Savitribai Phule Pune University, Pune

Maharashtra, India

Faculty of Science and Technology

National Education Policy (NEP)-2020 Compliant Curriculum TE - Third Year

Engineering (Sandwich) (2024 Pattern)

in

Mechanical Engineering

(With effect from Academic Year 2026-27)

Contents

Nomenclature

AEC	Ability Enhancement Courses
AICTE	All India Council for Technical Education
CO	Course Outcome
CEP	Community Engagement Project
CCE	Comprehensive Continuous Evaluation
HSSM	Humanities, Social Science, and Management
MDM	Multidisciplinary Minor
MEC	Mechanical Engineering
MOOC	Massive Open Online Course
NPTEL	National Programme on Technology Enhanced Learning
NEP	National Education Policy
OEL	Open Elective
PCC	Program Core Course
PEO	Program Educational Objectives
PSO	Program Specific Objectives
SWAYAM	Study Webs of Active-learning for Young Aspiring Minds
UGC	University Grants Commission
VEC	Value Education Course
VSE	Vocational and Skill Enhancement Course
WK	Knowledge and Attitude Profile

Preface by Board of Studies

Dear Students and Teachers,

We, the members of the Board of Studies – Mechanical Engineering, are very happy to present the Third Year Mechanical Engineering syllabus, effective from the Academic Year 2025–26 (2024 Pattern). We are confident that you will find this syllabus both interesting and challenging. The present curriculum will be implemented for Third Year Engineering from the academic year 2026–27, and it will be subsequently extended to the Third and Final Years in the academic years 2026–27 and 2027–28, respectively.

Mechanical Engineering is one of the most sought-after branches among engineering students, which necessitates continuous revision and up gradation of the syllabus. Mechanical Engineering is a dynamic discipline that integrates principles from core engineering fields and supports innovation across manufacturing, design, energy, materials, and automation. This curriculum is designed to provide students with a comprehensive understanding of the fundamentals, emerging technologies, and practical applications in Mechanical Engineering, while also equipping them to meet the demands of a rapidly evolving industry.

The revised syllabus aligns with the vision of NEP-2020, and conforms to the frameworks set by Savitribai Phule Pune University, AICTE New Delhi, UGC, and various accreditation agencies. It takes into account recent technological developments, innovations, and industry needs to ensure students are well-prepared for professional challenges.

Wherever applicable, additional learning resources such as NPTEL and SWAYAM links are provided at the end of each course. Students are encouraged to utilize these platforms for self-learning, engage in online courses, and undertake additional projects to enhance their knowledge and skill set. On successful completion, they are advised to submit their course certifications, which will further support and enrich their academic growth.

This curriculum is the result of collaborative efforts involving academic experts, industry professionals, and alumni to ensure relevance and excellence. It is designed not only to meet current industry expectations but also to prepare students for higher studies, research, and entrepreneurial ventures in the field of Mechanical Engineering.

We hope this curriculum inspires students to become technically competent professionals, responsible citizens, and contributors to the technological and sustainable advancement of society.

Dr. Pradeep A. Patil
Chairman
Board of Studies - Mechanical Engineering

Program Specific Outcomes

PSO1: SPECIFY, DESIGN and **EVALUATE** mechanical components and systems using modelling and analysis software.

PSO2: APPLY knowledge of machines, tools, automation, properties of advanced materials and modern management methods for manufacturing of mechanical components and systems.

PSO3: **APPLY** core aspects of thermal and fluid engineering to determine the performance of mechanical systems including power absorbing and power generating systems.

Program Educational Objectives

Program Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments that the program is preparing a graduate to achieve.

PEO1: The graduate will have a successful career in mechanical engineering with strong technical, research & professional skills.

PEO2: The graduate will possess an ability to work in diversified fields along with team work and leadership qualities.

PEO3: The graduate will continue to learn and to adapt in a society of constantly evolving technological environment

Program Outcomes

Program Outcomes (POs) are statements that articulate what students are expected to know, understand, and be able to do by the time they graduate from the program. These outcomes are aligned with the overall educational objectives of the program and reflect the skills, knowledge, attitudes, and behaviors acquired by students throughout their academic journey. On successful completion of B.E. in Mechanical Engineering, graduating students/graduates will be able to:

PO No.	Title	Program Outcome Description
PO1	Engineering Knowledge	Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop the solution of complex engineering problems.
PO2	Problem Analysis	Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
PO3	Design / Development of Solutions	Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for public health and safety, whole-life cost, net zero carbon, culture, society and environment. (WK5)
PO4	Conduct Investigations of Complex Problems	Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8)
PO5	Engineering Tool Usage	Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling, recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
PO6	The Engineer and The World	Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7)
PO7	Ethics	Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	Individual and Collaborative Team Work	Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	Communication	Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
PO10	Project Management and Finance	Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects in multidisciplinary environments.
PO11	Life-Long Learning	Recognize the need for, and have the preparation and ability for: (i) independent and life-long learning, (ii) adaptability to new and emerging technologies, and (iii) critical thinking in the broadest context of technological change. (WK8)

Knowledge and Attitude Profile (WK)

WK No.	Focus Area	Description
WK1	Natural Sciences and Social Sciences	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
WK2	Mathematics and Data Analysis	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
WK3	Engineering Fundamentals	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering Specialist Knowledge	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Engineering Design and Environmental Considerations	Knowledge, including efficient resource use, environmental impacts, whole- life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
WK6	Engineering Practice (Technology)	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7	Role of Engineering in Society	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Research and Critical Thinking	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
WK9	Ethics and Inclusive Behavior	Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability, etc., with mutual respect.

Reference: Self-Assessment Report (SAR) Format Undergraduate Engineering Programs Graduate Attributes and Professional Competencies Version 4.0 (GAPC V4.0) - (August 2024) Page 55-56

General Rules and Guidelines

Term	Definition
Course Outcomes (COs)	Course Outcomes are narrower statements that describe what students are expected to know and be able to do at the end of each course. These relate to the skills, knowledge, and behavior that students acquire throughout the course.
Assessment	Assessment is one or more processes, carried out by the institution, that identify, collect, and prepare data to evaluate the achievement of **Program Educational Objectives (PEOs)** and **Program Outcomes (POs)**.
Evaluation	Evaluation is one or more processes, performed by the **Evaluation Team**, to interpret the data and evidence gathered through assessment practices. It determines how well PEOs or POs are being achieved, and informs decisions for improvement.

Assessment and Evaluation:

Assessment and Evaluation shall be conducted in two parts:
1. Comprehensive Continuous Evaluation (CCE)
2. End-Semester Examination (ESE)

Component	Description	Marks
Comprehensive Continuous Evaluation (CCE)	Conducted at institute level, covering all Units of the syllabus. The design and mark allocation follow the Continuous Assessment Sheet structure.	30
End-Semester Examination (ESE)	Conducted at university level, typically covering the entire syllabus through summative examination.	70
	Total Marks per Subject	**100**

A) <u>Comprehensive Continuous Evaluation (CCE) : It can be conducted via Mode 1 or Mode 2</u>

<u>Mode 1:</u>

To design a Comprehensive Continuous Evaluation (CCE) scheme for a theory subject of 30 marks with the specified parameters, the allocation of marks and the structure can be as per continuous assessment sheet;

Savitribai Phule Pune University

Board of Studies (Mechanical and Automobile Engineering)

Comprehensive Continous Evaluation (CCE)

Class: TE A — **Subject: Heat & Mass Transfer**

Exam Seat No.	Roll No.	Name of Student	Unit 1		Unit 2		Unit 3		Unit 4		Unit 5		Cumulative Sum				30 Marks Distribution				Marks obtained out
			Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Field Activity	Quiz	Internal Test	Attendance	Field Activity	Quiz	Internal Test	Attendance	
			A	B	C	D	E	F	G	H	I	J	SUM(A+C+E+G+I)	SUM(B+D+F+H+J)							
			10	10	10	10	10	10	10	10	10	10	50	50	100	100	15	5	5	5	30
T242520252	2026	R A PANCAL	9	8	9	8	9	8	9	9	9	8	45	41	60	75	14	4.1	3	3.8	24.35
T242520253	2027																				
T242520254	2028																				
T242520255	2029																				

Figure 1 Template Comprehensive Continuous Evaluation (CCE)

Field Activities / Home Assignments

Field activities and home assignments are essential components of experiential learning. Under this head, course projects, industrial visits, and guest lectures are to be incorporated. For each unit, one such activity should be designed and executed to reinforce theoretical learning through practical exposure.

1. **Course Projects**

   Course Projects should be framed based on real-world problems relevant to the subject. Each course project must be communicated through one of the following modes. It is recommended to complete all the communication modes across different course projects:

- **Poster Presentation**
- **PowerPoint Presentation**
- **Model Making**
- **Field or Survey Report with Oral Presentation** (e.g., case study)
- **Submission of Digital Content (e.g. Video Summary)**

To evaluate these field activities, **assessment rubrics** should be designed. The rubrics should include criteria such as clarity, innovation, subject relevance, presentation skills, and technical content.

Note: Part of work of any co-curricular activities (relevant to subject contents) like national level project competitions, club activities, paper presentations, startup activities can be accepted as a course projects.

2. **Industrial Visit**

An industrial visit should be planned in alignment with the subject's scope and should particularly address advancements in the respective field. The purpose is to provide students exposure to actual engineering practices and systems.

Assessment of industrial visits should be carried out using any of the following tools:

- Quiz (based on the visit)
- Interactive video or oral discussion
- Submission of a detailed visit report

3. **Guest Lectures**

Guest lectures should be relevant to the course and highlight advanced topics or recent trends in the field. Subject experts from academia or industry may be invited.

Assessment methods for guest lectures may include:

- Quiz conducted post-lecture
- Attendance monitoring
- Evaluation of attentiveness and participation

Rubrics can be developed, if possible, to objectively assess student involvement in guest lectures.

4. **Quiz**

Unit-wise quizzes should be planned and can be conducted either **online** (via LMS, Google Forms) or **offline**. Each quiz should include a **pool of 20 questions**, from which **students are required to attempt any 10**. The quizzes should be diversified across the following question types:

- Simple Multiple Choice Questions (MCQs)

- Numerical MCQs
- Image-based Questions
- Match the Following
- Fill in the Blanks
- Drag and Drop (using images or words)

This variety ensures the assessment caters to different cognitive skills and learning styles.

5. Internal Tests

Two major internal tests should be conducted as follows:

1. **Midterm Examination**: This should cover **Unit I and Unit II**, and should include questions targeting **Bloom's Taxonomy Levels 2, 3, and 4** (UNDERSTAND, APPLY, and ANALYZE).
2. **End term Examination**: This should cover the **remaining units** and should also include questions mapped to **BL Levels 2, 3, and 4**.

Mode 2:

Theory Examination: The theory examination shall be conducted in two different parts Comprehensive Continuous Evaluation (CCE) and End-Semester Examination (ESE). Comprehensive Continuous Evaluation (CCE) :

1. CCE of 30 marks based on all the Units of course syllabus to be scheduled and conducted at institute level.
2. Case studies included under each unit are intended to support applied learning and are part of Comprehensive Continuous Evaluation
3. These case studies will be assessed through internal assessment components such as presentations, assignments, or group discussions. They shall not be included in the End-Semester Theory Examination.
4. To design a Comprehensive Continuous Evaluation scheme for a theory subject of 30 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Sr. No.	Parameters	Marks	Coverage of Units
1	Unit Test	12 Marks	Unit 1 & Unit 2 (6 Marks/Unit)
2	Assignments/Case Study	12 Marks	Unit 3 & Unit 4 (6 Marks/Unit)
3	Seminar Presentation/ Open Book Test/ Quiz	06 Marks	Unit 5

6. CCE of 15 marks based on all the Units of course syllabus to be scheduled and conducted at institute level. To design a CCE scheme for a theory subject of 15 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Sr. No.	Parameters	Marks	Coverage of Units
1	Unit Test	10 Marks	Unit 1 & Unit 2 (5 Marks/Unit)

2	Seminar Presentation/ Open Book Test/ Assignments/ Case Studies	05 Marks	Unit 3 & Unit 4

- **Unit Test–**

Format: Questions designed as per Bloom's Taxonomy guidelines to assess various cognitive levels (Remember, Understand, Apply, Analyze, Evaluate, and Create).

Implementation: Schedule the test after completing Units 1 and 2. Ensure the question paper is balanced and covers key concepts and applications.

- **Sample Question Distribution**–

1. Remembering (2 Marks): Define key terms related to [Topic from Units 1 and 2].
2. Understanding (2 Marks): Explain the principle of [Concept] in [Context].
3. Applying (2 Marks): Demonstrate how [Concept] can be used in [Scenario]
4. Analyzing (3 Marks): Compare & contrast [Two related concepts] from Units 1 and 2
5. Evaluating (3 Marks): Evaluate the effectiveness of [Theory/Model] in [Situation].

- **Assignments / Case Study :** Students should submit one assignment or one Case Study Report based on Unit 3 and one assignment or one Case Study Report based on Unit 4.

– ***Format*:** Problem-solving tasks, theoretical questions, practical exercises, or case studies that require in-depth analysis and application of concepts.

– ***Implementation:*** Distribute the assignments or case study after covering Units 3 and 4. Provide clear guidelines and a rubric for evaluation.

- **Seminar Presentation:–**

Format: Oral presentation on a topic from Unit 5, followed by a Q&A session.–

Deliverables: Presentation slides, a summary report in 2 to 3 pages, and performance during the presentation

Implementation: Schedule the seminar presentations towards the end of the course. Provide students with ample time to prepare and offer guidance on presentation skills.

- **Open Book Test:–**

Format: Analytical and application-based questions to assess depth of understanding.–**Implementation**: Schedule the open book test towards the end of the course, ensuring it covers critical aspects of Unit 5

- **Quiz :**–

Format: Quizzes can help your students practice existing knowledge while stimulating in terest in learning about new topic in that course. You can set your quizzes to be completed individually or in small groups.

Implementation: Online tools and software can be used create quiz. Each quiz is made up of a variety of question types including multiple choice, missing words, true or false etc

- **Example Timeline for conducting CCE:–**

1. Weeks 1-4 : Cover Units 1 and 2

2. Week 5 : Conduct Unit Test (12 marks)
3. Weeks 6-8 : Cover Units 3 and 4
4. Week 9 : Distribute and collect Assignments / Case Study (12 marks)
5. Weeks 10-12 : Cover Unit 5
6. Week 13 : Conduct Seminar Presentations or Open Book Test or Quiz (6 marks)

- **Evaluation and Feedback:–**

1. Unit Test: Evaluate promptly and provide constructive feedback on strengths and areas for improvement.
2. Assignments / Case Study: Assess the quality of submissions based on the provided rubric. Offer feedback to help students understand their performance.
3. Seminar Presentation: Evaluate based on content, delivery, and engagement during the Q&A session. Provide feedback on presentation skills and comprehension of the topic.
4. Open Book Test: Evaluate based on the depth of analysis and application of concepts. Provide feedback on critical thinking and problem-solving skills.

B) <u>End-Semester Examination (ESE)</u>

Detailed Scheme for 70 Marks: Unit-Wise Allocation (14 Marks per Unit): Each unit will have a combination of questions designed to assess different cognitive levels. By following this scheme, you can ensure a comprehensive and fair assessment of students' understanding and application of the course material, adhering to Bloom's Taxonomy guidelines for cognitive skills evaluation.

Detailed Scheme for 35 Marks: Unit-Wise Allocation (08 Marks for Unit 1 , 09 Marks for Unit 2, Unit 3 and Unit 4) : Each unit will have a combination of questions designed to assess different cognitive levels. By following this scheme, you can ensure a comprehensive and fair assessment of students' understanding and application of the course material, adhering to Bloom's Taxonomy guidelines for cognitive skills evaluation

Question Paper Design

The following structure is to be followed for designing an ESE for a **theory subject of 70 marks** covering **all 5 units** of the syllabus, with **questions set as per Bloom's Taxonomy** guidelines and **14 marks allocated per unit**.

2. Balanced Coverage

Ensure balanced coverage of all units with questions that assess different **cognitive levels of Bloom's Taxonomy**:

a) **Remembering**: Basic recall of facts and concepts.
b) **Understanding**: Explanation of ideas or concepts.
c) **Applying**: Use of information in new situations.
d) **Analyzing**: Drawing connections among ideas.

e) **Evaluating**: Justifying a decision or course of action.

f) **Creating**: Producing new or original work (if applicable).

3. Detailed Scheme

- **Unit-Wise Allocation**: **14 Marks per Unit**

  Each unit will have a combination of questions designed to assess different cognitive levels. By following this scheme, you can ensure a comprehensive and fair assessment of students' understanding and application of the course material, adhering to **Bloom's Taxonomy guidelines** for cognitive skills evaluation.

Curriculum Structure - Semester V

NEP 2020 Compliant Curriculum Structure

Third Year Engineering (2024 Pattern)

Mechanical Engineering -(Sandwich)

Level 5.0															
Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credits			
			L	T	P	CCE*	ESE	TW	OR	PR	Total	L	T	P	Total
Semester V															
PCC301MSW	Major Course-7	Heat & Mass Transfer	3			30	70	-	-	-	100	3			3
PCC302MSW	Major Course-8	Kinematics of Machinery	3			30	70	-	-	-	100	3			3
PCC303MSW	Major Course-9	Machine Design	3			30	70	-	-	-	100	3			3
PCC304MSW	Major Course-10	Manufacturing Engineering - II	3			30	70	-	-	-	100	3			3
PCC305MSW	Major Course-9A	Machine Design Lab			2					50	50			1	1
PCC306MSW	Major Course-10A	Digital Manufacturing & MQC Lab			2				50		50			1	1
MDM331MSW	Multidisciplinary Course-3	Smart Mechatronics System			2				50		50			2	2
MDM332MSW	Multidisciplinary Course-4	Engineering Simulation & Analysis Lab			2					50	50			2	2
MDM333MSW	Multidisciplinary Course-5	Heat & Mass Transfer Lab			2					50	50			2	2
OLE341	Open Elective -	OE is to be chosen compulsory from faculty other than of the major discipline	2				50				50	2			2
		Total	**14**	**0**	**10**	**120**	**330**	**0**	**100**	**150**	**700**	**14**	**0**		**22**

***CCE: Comprehensive Continuous Evaluation**

Sem V : Open Elective (OEC) Baskets		
25OEC203A	Digital Marketing	Management Studies
25OEC203B	Lifestyle Management and Preventive Healthcare	Health Sciences / Public Health
25OEC203C	Food Quality Control and Standards	Food l Science and Technology
25OEC203D	Supply chain Management	Management Studies

Level 5.0															
Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credits			
			L	T	P	CCE*	ESE	TW	OR	PR	Total	L	T	P	Total
Semester VI															
PCC307MSW	Major Course-7	Industrial In-plant Training-I	-	-	14			150	100	-	250	-	-	8	8
PCC308MSW	Major Course-8	Industrial Mini-Project	-	-	12			100	50	-	150	-	-	6	6
PCC309MSW	Major Course-9	Seminar	-	-	2			25	25	-	50	-	-	2	2
PCC310MSW	Major Course-10	Process Planning & Tool Selection (Self-Study-I)	-	-	-	30	70	-	-	-	100	3	-	-	3
PCC311MSW	Major Course-11	Advanced Materials & Manufacturing (Self-Study-II)	-	-	-	30	70			-	100	3	-	-	3
		Total	-	-	**28**	**60**	**140**	**275**	**175**	-	**650**	**6**	-	16	**22**

***CCE: Comprehensive Continuous Evaluation**

Note: Students can opt for Open Electives offered by different faculties such as Arts, Science, Commerce, Management, Humanities, or Inter-Disciplinary Studies.

- Elective I & II: Courses like *Project Management*, *Business Analytics*, or *Financial Management* can be opted from Inter-Disciplinary Studies, Commerce, and Management faculties, respectively.

Savitribai Phule Pune University, Pune

Maharashtra, India

TE - Mechanical Engineering (Sandwich) (2024 Pattern)

Semester-V Courses

Savitribai Phule Pune University Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)				
PCC301-MSW: Heat & Mass Transfer				
Teaching Scheme		**Credit**	**Examination Scheme**	
Theory	**3 Hours/Week**	**3**	**CCE**	**30 Marks**
Practical	**NA**		**End-Semester**	**70 Marks**

Prerequisite Courses, if any:

- Fluid Mechanics, Engineering Thermodynamics, Engineering Mathematics

Course Objectives:

1. To introduce the fundamental mechanisms of heat transfer: conduction, convection, and radiation.
2. To study heat conduction with heat generation, fins, thermal insulation, and transient heat transfer.
3. To apply heat transfer principles in real engineering applications including energy systems, manufacturing, and process industries.
4. To provide knowledge to analyze radiation heat transfer with and without radiation shields.
5. To evaluate heat transfer equipment such as heat exchangers used in thermal systems.

Course Outcomes:

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

CO1: Explain fundamental heat transfer mechanisms and analyze heat conduction in engineering systems.

CO2: Analyze fins, insulation systems, and transient heat conduction problems.

CO3: Apply convection heat transfer principles and empirical correlations to determine heat transfer rates.

CO4: Analyze radiation heat exchange between surfaces and thermal systems.

CO5: Evaluate the performance of heat exchangers using LMTD and NTU methods.CO5.

Course Contents

Unit I	**Introduction and Conduction (Steady State)**	**(08 Hours)**

Introduction and basic concepts: Introduction, Application areas of heat transfer. Basic modes of Heat Transfer, mechanisms and governing laws for these modes. Concept of 1D, 2D and 3D heat transfer. General three dimensional heat conduction equation in Cartesian coordinates (with derivation), cylindrical and spherical coordinates (no derivation). Thermal Conductivity, variable thermal conductivity, thermal diffusivity. (Simple numerical on modes and laws of transfer of heat transfer)

One dimensional steady state heat conduction: One dimensional steady state heat conduction equation for the plane wall, cylinder and sphere, Overall heat transfer coefficient. Electrical Analogy - thermal resistance of composite structures and thermal contact resistance. Conduction with internal heat generation for plane wall, solid cylinder and solid sphere (Numerical on electrical analogy.)

Real World Assignment

1. Identify the applications of modes of heat transfer and draw the schematics of the same.
2. Draw the thermal resistance circuit of any thermal system or heat transfer equipment and analyze the heat transfer mechanism.

3. Analyze heat transfer through a real composite wall and apply thermal resistance concept.
4. Identify and analyze 1D, 2D, and 3D heat flow in a practical system.

Exemplar / Practical Applications

Industrial case , Copper, aluminum, steel, and insulation materials , Thermal Contact Resistance in Mechanical Assemblies, Industrial system diagrams (furnace wall, pipe insulation, electronic cooling), Simple electrical circuit (resistors, power supply), Machine learning/Numerical Analysis to predict Heat Flow/heat flux

Unit II	Finned Surfaces, Thermal Insulation and Transient Heat Conduction.	(08 Hours)

Finned surfaces: Extended surface, types of fins, analysis of fins of uniform cross section area for temperature distribution and heat transfer rate for infinitely long & adequately long (with insulated end) fins. Fin efficiency & effectiveness. (Numerical on extended surfaces.)

Thermal insulation and transient heat conduction: Thermal Insulation-types and selection, Critical radius of Insulation for cylinder and sphere, Unsteady state heat transfer, lumped heat capacity analysis, Heisler's charts. Biot's Number, Fourier's Number & their significance. (Numerical on critical radius and lumped heat capacity.)

Real World Assignments

1. Analysis of heat transfer enhancement through fin for any motor/engine/compressor etc.
2. Identify and analyze the thermal insulation systems.
3. Analyse the transient cooling or heating practically using lumped method
4. Analyse the transient cooling or heating practically using Heisler's charts
5. Optimization of Pipe Insulation Using Critical Radius in Steam Power Plants/Electrical Wires.

Exemplar / Practical Applications

Boiler walls, steam pipes, heat exchangers, car radiators, CPU heat sinks, Nuclear fuel rods, engine components, Metal quenching, food cooling, annealing processes, Quenching of metal rods, food freezing, Steam pipes, Electrical wires, Industrial piping systems.

Unit III	Convective Heat Transfer, Mass Transfer	(08 Hours)

Basic concept of convection and forced convection: Concept of hydrodynamics & thermal boundary layer thickness, local and average heat transfer coefficient. Reynolds number, Prandtl number, Nusselt number. Empirical co-relations for external, internal flows, laminar & turbulent flow through conduits. (Numerical on forced convection with given empirical co-relations).

Free or natural convection, **boiling and condensation:** Grashof's number, Rayleigh number, flow over horizontal and vertical plate, Empirical co-relations for cylinders and sphere. **Introduction to mass transfer:** Introduction to mass transfer, diffusion using Fick's Law of Diffusion, and basic applications. (Numerical on natural convection with given empirical co-relations).

Real World Assignment

1. Determine forced convective HTC in pipe flow
2. Determine natural convection HTC on flat plate.
3. Identify and analyze practical applications of free convection
4. Identify and analyze practical applications of force convection

Exemplar / Practical Applications

Steam pipes, electrical wires, industrial piping systems

Unit IV	Radiation Heat Transfer	(06 Hours)

Basic Concepts of Radiation: Radiation, spectrum of radiation, black body radiation, radiation intensity, Laws of radiation-Kirchhoff, Planck's, Wien's displacement law, Stefan Boltzmann & Lamberts Co-sine law. Emissivity, absorptivity, transmissivity, reflectivity, radiosity, emissive power, irradiation. (Simple

numerical on basic radiation).

Radiation heat exchange: Radiation heat exchange between surfaces, shape factor & its laws, radiation between parallel plates, cylinder & spheres. Radiation shields. (Numerical on Radiation shields).

Real World Assignment

1. Study of Radiation & Spectrum (Basic Observation)
2. Determine emissivity of black and grey surface
3. Identify and analyze practical radiation heat transfer systems
4. Analyze radiation shield concept practically

Exemplar / Practical Applications

1. Sun, Rainbow, Furnace, Sunlight, Thermal equilibrium, Spectroscopy, Stars, Solar energy, Illumination, Surface, Coating, Glass, Mirror, Surface radiation, Heater, Solar flux, Buildings, Geometry, Furnace walls, Pipes, Satellites, Thermos flask. element beneath a ceramic glass surface.

Unit V	Heat Exchangers, Boiling and Condensation	(07 Hours)

Introduction & LMTD Method: Introduction and detailed classification of heat exchangers. Overall heat transfer coefficient, fouling factor and its effect on heat exchanger performance. Log Mean Temperature Difference (LMTD) method for heat exchanger analysis. (Numerical on LMTD Method). Effectiveness–**NTU method:** Effectiveness–NTU method for heat exchanger performance evaluation. Boiling and Condensation heat transfer: Pool boiling curve and regimes of pool boiling, Critical heat flux, film and drop wise condensation. (Numerical on Effectiveness-NTU Method).

Real World Assignment

1. Identify and classify heat exchangers used in real systems.
2. Evaluate performance of any heat exchanger using LMTD or NTU approach
3. Study and analyze the effect of deposits on performance of heat exchanger.
4. Identify and photograph dropwise and filmwise condensation process.

Exemplar / Practical Applications

Sun, Rainbow, Furnace, Sunlight, Thermal equilibrium, Spectroscopy, Stars, Solar energy, Illumination, Surface, Coating, Glass, Mirror, Surface radiation, Heater, Solar flux, Buildings, Geometry, Furnace walls, Pipes, Satellites, Thermos flask. element beneath a ceramic glass surface.

Learning Resources

Text Books:

1. P.K. Nag, Heat & Mass Transfer, McGraw Hill Education Private Limited.
2. M.M. Rathod, Engineering Heat and Mass Transfer, Third Edition, Laxmi Publications, New Delhi
3. V. M. Domkundwar, Heat Transfer, Dhanpat Rai & Co Ltd.
4. S.P. Sukhatme, A Textbook on Heat Transfer, Universities Press.
5. R.C. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New Age Science.
6. Joshi's Process Equipment Design, by V.V. Mahajani , S.B. Umarji ,Trinity Press
7. S. P. Venkatesan, Heat Transfer, Ane Books Pvt. Ltd.

Reference Books:

1. Franck P. Incropera, David P. DeWitt – Fundamentals of Heat and Mass Transfer,
2. Y. A. Cengel and A.J. Ghajar, Heat and Mass Transfer – Fundamentals and Applications, Tata McGraw Hill Education Private Limited.
3. A.F. Mills, Basic Heat and Mass Transfer, Pearson.
4. Holman, Fundamentals of Heat and Mass Transfer, McGraw – Hill publication.
5. M. Thirumaleshwar, Fundamentals of Heat and Mass Transfer, Pearson Education India.
6. B.K. Dutta, Heat Transfer-Principles and Applications, PHI.
7. C.P. Kothandaraman, S. V. Subramanyam, Heat and Mass Transfer Data Book, New Academic Science.
8. Process heat Transfer, D. Q. Kern, Wiley Publication

MOOC / NPTEL/ YouTube Links: -

https://nptel.ac.in/courses/112101097

https://nptel.ac.in/courses/112106315

Savitribai Phule Pune University
Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)

PCC302-MSW: Kinematics of Machinery

Teaching Scheme		Credit	Examination Scheme	
Theory	**3 Hours/Week**	**3**	**CCE**	**30 Marks**
Practical	**NA**		**End-Semester**	**70 Marks**

Prerequisite Courses, if any:

- Engineering Mathematics - I and II, Engineering Physics, Engineering Mechanics, Geometric Modelling & Drafting

Course Objectives:

1. To develop an understanding of kinematic principles of mechanisms and their application in real-life engineering systems.
2. To analyze displacement, velocity, and acceleration of mechanisms using analytical and graphical methods.
3. To synthesize mechanisms for desired motion, path, and function generation using appropriate techniques.
4. To apply principles of gear kinematics for the analysis of power transmission systems.
5. To design cam profiles for specified follower motions in industrial applications.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1. APPLY kinematic concepts to analyze mechanisms used in engineering applications
CO2. ANALYZE displacement, velocity, and acceleration of mechanisms using analytical and graphical methods.
CO3. DESIGN and SYNTHESIZE mechanisms for specified motion and path generation problems.
CO4. ANALYZE gear systems and APPLY kinematic principles in power transmission applications.
CO5. DESIGN cam profiles for required follower motion considering practical constraints

Course Contents

Unit I	Fundamentals of Mechanism	(07 Hours)

Introduction: kinematic link, kinematic pair, kinematic chain, types of constrained motions, types of joints, mechanism, machine, Degree of freedom and Mobility.

Inversions of Mechanisms: Four-Bar Chain, Slider crank Chain, Double slider crank Chain.

Mechanisms with Higher pairs: Equivalent Linkages and their Cases (Sliding Pairs in Place of Turning Pairs, Spring in Place of Turning Pairs, Cam Pair in Place of Turning Pairs)

Real World Assignment

1. Identify and classify kinematic pairs and determine DOF of mechanisms used in a bicycle or IC engine.
2. Analyze different inversions of slider-crank mechanism in real machines like pumps and shapers.
3. Replace higher pairs in cam or gear systems with equivalent lower pair mechanisms and compare motion.

Exemplars / Practical Applications

Mechanisms used in IC engines, pumps, and quick return mechanisms demonstrate real-life kinematic chains and inversions.

Unit II	Kinematic Analysis of Mechanisms: Analytical Method & Graphical Method	(07 Hours)

Analytical methods: Displacement, velocity and acceleration analysis of slider crank Mechanism. Vector and Complex Algebra Methods (Theoretical Treatment only).

Graphical methods: Displacement, velocity and acceleration analysis of mechanisms by Relative Velocity Method (Mechanisms up to 6 Links), Coriolis component of Acceleration (Theoretical treatment only)

Instantaneous Centre of Velocity, Kennedy's Theorem, Angular Velocity ratio Theorem, Analysis of mechanism by ICR method (Mechanisms up to 6 Links)

Real World Assignment

1. Determine velocity and acceleration of piston in an IC engine using graphical or analytical methods.
2. Perform motion analysis of a crank-rocker mechanism used in conveyor or machinery systems.
3. Locate instantaneous centers in mechanisms like excavator arm and analyze motion transmission.

Exemplar / Practical Applications

Motion analysis of IC engines, robotic arms, and industrial machinery helps in predicting velocity and acceleration of links.

Unit III	Synthesis of Mechanisms	(07 Hours)

Steps in Synthesis: Type synthesis, Number Synthesis, Dimensional synthesis, Tasks of Kinematic synthesis - Path, function and motion generation (Body guidance), Precision Positions, Chebychev spacing, Mechanical and structural errors

Graphical Synthesis: Inversion and relative pole method for three-position synthesis of Four-Bar and Single Slider Crank Mechanisms

Analytical Synthesis: Three-position synthesis of the Four-Bar mechanism using Freudenstein's equation

Real World Assignment

1. Design a four-bar mechanism for the windshield wiper to achieve the required angular motion.
2. Synthesize a mechanism for path generation in applications like welding or cutting.
3. Develop a linkage mechanism for pick-and-place automation using precision positions.

Exemplars / Practical Applications

Mechanism synthesis is applied in windshield wipers, folding systems, and industrial automation linkages.

Unit IV	Kinematics of Gears	(08 Hours)

Introduction: Classification, terminology, law of gearing, involute and cycloidal tooth profile,

Spur Gear: path of contact, arc of contact sliding velocity, Interference and undercutting, Minimum number of teeth to avoid interference, Force Analysis (theoretical treatment only)

Helical and Spiral Gears: Terminology, Geometrical Relationships, virtual number of teeth for helical gears

Bevel Gear & Worm and Worm Wheel: Terminology, Geometrical Relationships

Gear Train: Types, Analysis of Epicyclic gear Trains, Holding torque - simple, compound and Epicyclic gear Trains, compound Epicyclic gear Train

Real World Assignment

1. Analyse gear ratios and torque transmission in an automobile gearbox or industrial gear trains.
2. Study interference in gears and suggest design modifications to avoid undercutting.
3. Evaluate the working of the epicyclic gear train used in differential or automatic transmission systems.

Exemplars / Practical Applications

Gear systems in automobiles, industrial gearboxes, and differential mechanisms illustrate power transmission applications.

Unit V	Cams & Followers	(08 Hours)

Introduction: Types of cams and followers, and their classification, analysis of standard motions to the follower,

Cam Profile: Determination of cam profiles for different follower motions

Methods of control: pressure angle, radius of curvature and undercutting. Jump phenomenon of Eccentric cam,

Real World Assignment

1. Design a cam profile for IC engine valve timing based on the given motion requirements.
2. Develop a cam mechanism for automated machines like packaging or printing systems.
3. Analyze pressure angle and follower motion to avoid undercutting and jumping in cam systems.

Exemplars / Practical Applications

Cam mechanisms are widely used in IC engines, textile machines, and automated production equipment.

Learning Resources

Text Books:

1. S. S. Rattan, “Theory of Machines”, Third Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi.
2. Bevan T, “Theory of Machines”, Third Edition, Longman Publication
3. G. Ambekar, “Mechanism and Machine Theory”, PHI
4. J. J. Uicker, G. R. Pennock, J. E. Shigley, “Theory of Machines and Mechanisms”, Fifth Edition, International Student Edition, Oxford

Reference Books:

1. Ghosh Malik, “Theory of Mechanism and Machines”, East-West Pvt. Ltd.
2. Hannah and Stephans, “Mechanics of Machines”, Edward Arnolde Publication
3. R. L. Norton, “Kinematics and Dynamics of Machinery”, First Edition, McGraw Hill Education (India) P Ltd. New Delhi
4. Sadhu Singh, “Theory of Machines”, Pearson
5. Dr. V. P. Singh, “Theory of Machine”, Dhanpatrai and Sons
6. C. S. Sharma & Kamlesh Purohit, “Theory of Machine and Mechanism”, PHI.

MOOC / NPTEL/ YouTube Links: -

1. Kinematics of Machines – IIT Kanpur (NPTEL): https://nptel.ac.in/courses/112104121
2. Kinematics of Mechanisms and Machines – IIT Kharagpur (NPTEL): https://onlinecourses.nptel.ac.in/noc25_me46/preview
3. Theory of Mechanisms – IIT Madras (NPTEL): https://nptel.ac.in/courses/112106270
4. Mechanism and Robot Kinematics – NPTEL: https://onlinecourses.nptel.ac.in/noc22_me108/preview

Savitribai Phule Pune University
Third Year of Mechanical Engineering
(Sandwich) (2024 Pattern)

PCC303-MSW : Machine Design

Teaching Scheme	Credit	Examination Scheme
Theory :03Hours/Week Tutorial :-	03	CCE : 30 Marks End-Semester :70 Marks

Prerequisite Courses, if any:

The basics of material elastic behavior, stress, strain, its relationship, failure modes, different theories of failure and its applications. The design cycle, basis of design considerations like strength, rigidity, manufacture, assembly and cost, standards and codes. The preferred sizes and series, tolerances and types of fits. Construction of SMD and BMD. Roots of equations, Interpolation rule.

Course Objectives:

1. **UNDERSTAND** various design considerations, design procedure.
2. **SELECT** materials for a specific application.
3. **EVALUATE** the stresses in machine components due to various types of loads and failure.
4. **DESIGN** various machine components such as shafts, couplings, keys, screws, joints, springs.
5. **ANALYZE** machine components subjected to variable loading for finite and infinite life.

Course Outcomes:

After successful completion of the course, learner will be able to:
On completion of the course, learner will be able to
CO. 1 **DESIGN** levers and components subjected to eccentric loading by selecting appropriate material.
CO. 2 **DESIGN** shafts, keys and couplings under different loading conditions.
CO. 3 **EVALUATE** the stresses developed in the different type of welded and threaded joints.
CO.4 **APPLY** the design procedure for different types of springs and **EVALUATE** dimensions of machine components under fluctuating loads.
CO. 5 **ANALYZE** different stresses developed in power screws and **APPLY** those in the procedure to design screw jack.

Course Contents

Unit I	Fundamentals of Machine Design and Material Selection	(07 Hours)

Selection of materials and factor of safety, Service factor, Design of hand / foot lever, lever for safety valve, bell crank lever, Design of components subjected to eccentric loading., Design process , Design considerations, Engineering materials and their properties, Stress concentration, Static and fluctuating loads.

Real World Assignment

1 Ergonomic Lever Design for Hand Lever or Foot Lever for bore-well pump
2 The Material selection and analysis of failed mechanical component such as snapped bolt, fan blade etc.
3 Stress Concentration for plate with a central hole

Exemplar / Practical Applications

Bicycle Braking Systems, Lever Safety Valve, C-Clamps, Leaf Springs.

Unit II	Design of Shafts, Keys and Couplings	(07 Hours)

Shaft design on the Strength basis, torsional rigidity basis and lateral rigidity basis, Design of shaft as per A.S.M.E. code. Design of square and rectangular keys, Kennedy key and splines. Design of Flange Coupling and Bushed-Pin Flexible Coupling.

Real World Assignment

1 Design of shafts for real world applications like lathe, pump, automobile etc.
2 Design, and analyze keys used in real mechanical systems for torque transmission.
3 Identify different types of couplings used in transmission system and justify their use.

Exemplar / Practical Applications

Automotive transmissions**,** Industrial machinery, Conveyor, pumps**,** Agricultural equipment.

Unit III	**Design of Mechanical Joints**	**(08 Hours)**

Introduction to threaded joints, Bolts of uniform strength, locking devices, eccentrically loaded bolted joint in shear, Eccentric load perpendicular and parallel to axis of bolt, Eccentric load on circular base. Applications of joints in mechanical systems

Introduction to welded joints, Strength of butt, parallel and transverse fillet welds, Axially loaded unsymmetrical welded joints, Eccentric load in plane of welds, Welded joints subjected to bending and torsional moments. Design of cotter and knuckle joints

Real World Assignment

1. Design a cotter joint for bicycle so as to transmit power from pedal to axle of bicycle.
2. Design a knuckle joint for tractor and trailer so that tractor can pull the trailer.

Exemplar / Practical Applications

Steam Engine, Hand Pump, automotive steering mechanism, train coupling, tractor -trolley linkage, Pressure Vessels, pipe lines, automotive frames.

Unit IV	**Design of Springs and Mechanical Components under Variable Loads**	**(08 Hours)**

Springs: Types and applications of springs, Stress and deflection equations for helical compression Springs, Springs in series and parallel, Design of helical springs, concentric helical springs, surge in spring, Design of Multi-leaf springs, Nipping of Leaf springs, Shot Peening.

Analysis of machine elements under variable loads: Fatigue Failure, Stress-Life (S–N) Curve and Endurance Limit, Factors Affecting Endurance Strength (Modifying Factors and Notch Sensitivity), Reversed Stress Concept, Fatigue Failure Theories: Soderberg, Goodman, and Gerber Criteria, Modified Goodman Diagram for Design Applications, Design for Finite and Infinite Life, Cumulative Damage in Fatigue, Fatigue Design Under Combined Stresses (Theoretical Approach)

Real World Assignment

1 Survey on suspension system in automobile
2 Design a helical compression spring for a suspension system.
3 Fatigue Design of an Automotive Drive Shaft
4 Fatigue Analysis of a Connecting Rod

Exemplar / Practical Applications

Automotive Suspension, Connecting rod, Crank Shaft, Transmission shaft.

Unit V	**Design of Power Screw**	**(08 Hours)**

Content

Terminology of Power Screw, Torque analysis and Design of power screws with square and trapezoidal threads, Collar friction torque, Self-locking screw, Efficiency of square threaded screw, Efficiency of self-locking screw, Design of screw, nuts and C-Clamp. Design of screw jack, Differential and Compound Screw and Re-circulating Ball Screw (Theoretical treatment only).

Real World Assignment

1 Design a Power screw for a Hydraulic Press

2 Design of Automotive steering gear (Recirculating Ball Type)

3 Design of Mobile Scissor Lift Power Screw

Exemplar / Practical Applications

Screw Jack, machine vice, Mechanical Press.

Learning Resources

Text Books:

1 Bhandari V.B., Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd.

2 Shigley J.E. and Mischke C.R., Mechanical Engineering Design, McGraw Hill Publication Co. Ltd.

Reference Books:

1 Spotts M.F. and Shoup T.E., Design of Machine Elements, Prentice Hall International.

2. Juvinal R.C., Fundamentals of Machine Components Design, John Wiley and Sons.

3. Black P.H. and O. Eugene Adams, Machine Design, McGraw Hill Book Co. Inc.

4. Willium C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House.

5. Hall A.S., Holowenko A.R. and Laughlin H.G, Theory and Problems of Machine Design, Schaum's Outline Series.

6. C. S. Sharma and Kamlesh Purohit, Design of Machine Elements, PHI Learing Pvt. Ltd.

7. D. K. Aggarwal & P. C. Sharma, Machine Design, S.K Kataria and Sons.

8. P. C. Gope, Machine Design: Fundamentals and Applications, PHI Learing Pvt. Ltd.

9. Design Data - P.S.G. College of Technology, Coimbatore.

10. K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers.

MOOC / NPTEL/YouTube Links: -

Savitribai Phule Pune University
Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)

PCC304-MSW: Manufacturing Engineering -II

Teaching Scheme		Credit	Examination Scheme	
Theory	**3 Hours/Week**	**3**	**CCE**	**30 Marks**
Practical	**NA**		**End-Semester**	**70 Marks**

Prerequisite Courses, if any:

- Workshop Practices, Manufacturing Processes-I

Course Objectives:

To understand the use of multi point cutters in gear manufacturing.

1. **KNOW** about fundamentals of metal cutting process, tool wear and tool life.
2. **IMPART** the knowledge of machining phenomenon like milling, gear and thread manufacturing.
3. **IMPART** the knowledge of grinding, super finishing processes.
4. **GENERATE** CNC program for appropriate machining processes like turning and milling.
5. **UNDERSTAND** the basic concepts, importance and functions of Jigs, Fixtures.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1**. DEFINE** metal cutting principles and mechanics of metal cutting and tool life.
CO2**. DESCRIBE** features of gear and thread manufacturing processes.
CO3**. SELECT** appropriate grinding wheel and demonstrate the various surface finishing processes.
CO4. **GENERATE** CNC program for Turning / Milling processes and generate tool path using CAM software.
CO5. **SELECT** appropriate jigs/fixtures and to draw the process plan for a given component.

Course Contents		
Unit I	**Mechanics of Metal Cutting**	**(08 Hours)**

Introduction to metal cutting, Elements of machining process, Geometry of single-point cutting tool, Orthogonal and Oblique cutting processes, Chip formation, Types of chips, Chip thickness ratio, Process parameters and their effect on machining, chip breakers,
Merchant's Circle of forces analysis – forces and energy calculations, power consumed – MRR- Effect of Cutting variables on forces,
Concepts of Machinability- Factors affecting machinability, Machinability Index, Tool Life, Tool life equation of Taylor, Tool wear and its types, Factors affecting on tool life.

Real World Assignment
CCE Activities

1. Prepare a detailed Excel sheet for cutting force calculations using Merchant's Circle for different tool geometries and workpiece materials (mild steel, aluminum, brass). Plot force vs. cutting speed and depth of cut.
2. Visit a CNC turning center or workshop and measure chip thickness ratio for different cutting conditions. Compare theoretical and experimental values and submit a tabulated report.

Exemplars / Practical Applications
• Automobile Industry: Turning of crankshaft journals on CNC lathes — demonstrates multi-variable cutting parameter optimization for high MRR and surface finish.
• Aerospace Manufacturing: Machining of titanium alloy turbine blades — illustrates low machinability challenges and role of cutting fluid, tool geometry, and chip control.

Unit II	**Gear and Thread Manufacturing**	**(07 Hours)**

Gear Manufacturing: Introduction, Materials of gears, Methods of gear manufacturing-casting, forging, forming etc, milling of gears (indexing methods and numerical), Helical gear cutting, Gear Shaping and Gear hobbling,

Thread Manufacturing: Various methods of thread manufacturing, thread rolling, die threading & tapping, Thread milling, Thread grinding etc.

Real World Assignment
CCE Activities: Prepare a detailed Excel-based indexing calculator: input module, number of teeth, and pressure angle; auto-calculate indexing method (simple/compound/differential), index crank movement, and gear blank dimensions.

Exemplars / Practical Applications
• Automobile Gearbox Manufacturing: Gear hobbing of helical gears for passenger vehicle transmissions — illustrates high-volume, precise gear production with CNC gear hobbers.

Unit III	**Grinding & Surface finishing**	**(07 Hours)**

Grinding processes: Types and Operations of grinding machines, Grinding wheel– Shapes, Designation and selection, Abrasives & classification, Bond & bonding, Grit, Grade & Structure of wheels, Types of grinding wheels, mounting of grinding wheels, Glazing and loading of wheels, Dressing and truing of wheels, Balancing of wheels, Diamond wheels.

Super-finishing processes: Introduction to Honing, Lapping, Buffing and Burnishing. Construction, working and controlling parameters)

Real World Assignment
CCE Activities: Conduct an industrial visit to a precision grinding unit (surface grinder, cylindrical grinder, or centerless grinder). Observe the wheel designation, dressing procedure, and workpiece setup. Submit a structured visit report with photographs, process parameters, and observations.

Exemplars / Practical Applications

• Automotive Engine Manufacturing: Honing of engine cylinder bores after boring to produce the precise crosshatch surface pattern that aids oil retention and piston ring seating.

• Crankshaft Grinding: CNC cylindrical grinding of crankshaft main and pin journals — demonstrates in-process gauging and automatic compensation to achieve tight tolerances.

Unit IV	CNC Programming	(07 Hours)

CNC Programming- CNC part programming adaptable to suitable controller. Steps in developing CNC part program.

CNC part programming for Lathe Machine – Threading & Grooving cycle (Canned cycle).

CNC part programming for Milling Machine - Linear & circular interpolation, milling cutter, tool length compensation & cutter radius compensation. Pocketing, contouring & drilling, subroutine and Do loop using canned cycle.

Real World Assignment

CCE Activities: Write a complete CNC part program (G-code) for turning a stepped shaft (3 different diameters, one groove, one chamfer) on a CNC lathe using FANUC-compatible controller. Include tool change, feedrate, spindle speed, and use of canned cycles (G71, G70) and grooving cycle (G75).

Exemplars / Practical Applications

• Automotive Industry: CNC turning of wheel hub blanks on multi-turret CNC lathes — demonstrates use of grooving and threading canned cycles for high-volume production.

Unit V	Jig and Fixture	(07 Hours)

Significance and purpose of jigs and fixtures and their functions in the manufacturing processes, Concept of degree of freedom, 3-2-1 principle of location. General guidelines to design jigs and fixtures, advantages of jigs and fixtures.

Jigs: Definition, Elements of jig with the types, Location guidelines, Principles of clamping, Principles of guiding, Channel jig, Template jig, Plate jig, Angle plate jig, Turn over jig, Box jig, Latch type jig.

Fixtures: Definition. Elements of fixtures, Location guidelines, Principles of clamping, Principles of setting element, turning fixture, welding fixture, Milling fixture, Assembly and Inspection fixtures.

Real World Assignment

CCE Activities: Student should able to design a jig or fixture for simple products.

Exemplars / Practical Applications

• Automobile Industry: Welding fixture for car body panels — ensures precise geometric alignment of door frame, roof, and chassis parts for consistent weld quality across thousands of units.

• Engine Manufacturing: Drill jig for connecting rod bolt holes — drill bushes guide drills with micron-level positional accuracy to ensure correct bolt circle diameter.

Learning Resources

Text Books:

1. P. N. Rao, “Manufacturing Technology Vol. I & II” , Tata McGraw Hill Publishers
2. P. C. Sharma, “Production Engineering”, S.Chand Publications
3. A Text Book of Manufacturing Technology, R. K. Rajput, Laxmi Publications (p) LTD
4. Elanchezhian, C., T. Sunder Selwyn, and B. Vijaya Ramnath. Design of Jigs, Fixtures and Press Tools. Eswar press, 2004.

Reference Books:

1. . Jigs & Fixtures, P.H. Joshi, Third edition, McGraw Hill, 2017
2. Production Technology Manufacturing Systems VOL-I & II, R. K. Jain, Khanna Publishers
3. Materials and Processes in Manufacturing" (8th Edition),E.P. DeGarmo, J. T Black, R.A. Kohser, Prentice Hall of India, New Delhi (ISBN 0-02-978760).
4. CNC Machines, B. S. Pabla, M. Adithan, New Age International, 2018
5. Manufacturing Science, Amitabh Ghosh and AshokKumar Mallik, Affiliated East-West Press, 2010

MOOC / NPTEL/ YouTube Links: -

1. https://nptel.ac.in/content/storage2/courses/108105063/pdf/L-
2. https://nptel.ac.in/content/storage2/courses/112105127/pdf/LM-32.pdf
3. https://nptel.ac.in/content/storage2/courses/112105127/pdf/LM-34.pdf
4. https://nptel.ac.in/courses/112/107/112107143/

Savitribai Phule Pune University Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)				
PCC305-MSW: Machine Design Lab				
Teaching Scheme		**Credit**	**Examination Scheme**	
Theory	**NA**	**1**	**PR**	**50 Marks**
Practical	**2 Hours/Week**		**CCE**	**-**

Prerequisite Courses, if any:

- Engineering Mathematics - I and II, Engineering Physics, Engineering Mechanics, Geometric Modelling & Drafting

Course Objectives:

1. To APPLY kinematic principles for analysis of mechanisms in engineering systems.
2. To DESIGN machine elements such as shafts, joints, springs, and screws using standard procedures.
3. To INTEGRATE mechanism analysis with machine design for practical applications.
4. To DEVELOP graphical and CAD-based solutions for mechanical systems.
5. To IMPLEMENT real-world engineering solutions through mini-projects

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: ANALYZE mechanisms using graphical methods.
CO2: APPLY kinematic principles for motion analysis and synthesis.
CO3: DESIGN machine elements based on strength and functional requirements.
CO4: INTEGRATE analysis and design concepts for real-world applications.
CO5: DEMONSTRATE working models or simulations of mechanical systems.

Course Contents

Experiment-1	**Study of Kinematic Pairs, Chains and Degree of Freedom of Mechanisms**	**(08 Hours)**

Objective:

To understand the concept of kinematic pairs, kinematic chains, and mechanisms, and to determine the degree of freedom of planar mechanisms using Gruebler's criterion through analysis of real mechanical systems.

Task:

1. Identify links and joints in mechanisms such as bicycle or IC engines.
2. Classify kinematic pairs and chains.
3. Calculate degree of freedom of given mechanisms.

Exemplars / Practical Applications

1. IC Engine Mechanism – Conversion of reciprocating and rotary motion.
2. Quick Return Mechanism – Used in shaping machines

Experiment-2	**Graphical Velocity and Acceleration Analysis of Planar Mechanisms**	**(02 Hours)**

Objective:

To determine velocity and acceleration of links in planar mechanisms using graphical methods and to analyze complete kinematic behavior.

Task:

1. Draw velocity diagram for slider-crank or four-bar mechanism.
2. Determine velocity of key points.
3. Construct acceleration diagram.
4. Identify radial, tangential components.
5. Interpret motion characteristics.

Exemplars / Practical Applications:

1. IC Engine Mechanism – Piston motion analysis.
2. Robotic/Industrial Mechanisms – Dynamic behavior evaluation.

Experiment-2	**Synthesis of Four-Bar Mechanism for Desired Motion**	**(02 Hours)**

Objective:

To design and synthesize a four-bar mechanism for specified motion or path generation using graphical techniques**.**

Task:

1. Define required motion (e.g., wiper mechanism).
2. Perform graphical synthesis.
3. Verify mechanism functionality**.**

Exemplars / Practical Applications:

1. Windshield Wiper Mechanism.
2. Pick-and-Place Automation Systems.

Experiment-4	**Analysis of Gear Trains (Simple and Epicyclic)**	**(02 Hours)**

Objective:

To analyze different gear trains and determine velocity ratios and torque transmission characteristics.

Task:

1. Study simple, compound, and epicyclic gear trains.
2. Calculate velocity ratios.
3. Interpret power transmission behavior.

Exemplars / Practical Applications:

1. Automobile Gearbox.
2. Differential Mechanism.

Experiment-5	**Design and Construction of Cam Profile for Various Follower Motions**	**(02 Hours)**

Objective:

To design and construct cam profiles for different follower motions such as uniform velocity, SHM, and uniform acceleration considering pressure angle and curvature.

Task:

1. Select follower motion type and draw displacement diagram.
2. Construct cam profile using graphical method.
3. Analyze pressure angle and check for undercutting.

Exemplars / Practical Applications:

1. IC Engine Valve Timing Mechanism.
2. Automated Packaging and Textile Machines.

Experiment-6	**Design of Lever or Component under Eccentric Loading**	**(02 Hours)**

Objective:

To design mechanical components such as levers subjected to eccentric loading by selecting suitable material and evaluating induced stresses.

Task:

1. Select application (hand/foot lever).
2. Calculate forces and stresses.
3. Determine dimensions based on design criteria

Exemplars / Practical Applications:

1. Borewell Pump Lever.
2. Safety Valve Mechanism.

Experiment-7	**Design of Shaft, Key and Coupling**	**(02 Hours)**

Objective:

To design shaft, key, and coupling considering strength and rigidity using standard design procedures.

Task:

1. Calculate torque and bending moment.
2. Design shaft dimensions.
3. Design key and coupling.

Exemplars / Practical Applications:

1. Automotive Transmission Shaft.
2. Industrial Power Transmission Systems.

Experiment-8	**Design and Analysis of Mechanical Joints (Cotter and Knuckle Joint)**	**(02 Hours)**

Objective:

To design cotter and knuckle joints and evaluate stresses for safe power transmission.

Task:

1. Select appropriate joint type.
2. Perform design calculations.
3. Verify safety against failure.

Exemplars / Practical Applications:

1. Tractor-Trailer Linkage.
2. Bicycle Power Transmission Joint

Experiment-9	**Design of Helical Compression Spring**	**(02 Hours)**

Objective:

To design a helical compression spring considering stress, deflection, and fatigue criteria.

Task:

1. Calculate spring dimensions.
2. Select suitable material.
3. Evaluate performance under load.

Exemplars / Practical Applications:

1. Automobile Suspension System.
2. Engine Valve Springs.

Experiment-10	**Design and Analysis of Power Screw Mechanism**	**(02 Hours)**

Objective:

To design a power screw considering torque, efficiency, and self-locking conditions.

Task:

1. Calculate torque and efficiency.
2. Design screw and nut.
3. Analyze performance.

Exemplars / Practical Applications:

1. Screw Jack.
2. Mechanical Press.

Experiment-11	**Mini Project**	**(02 Hours)**

Objective:

To integrate mechanism analysis and machine design into a real-world application.

Task:

1. Select a real-world problem.
2. Perform analysis and design.
3. Develop CAD model or working prototype.
4. Demonstrate and document results.

Exemplars:

1. Automated Pick-and-Place Mechanism
2. Cam-Based Packaging System
3. Gear-Based Lifting Mechanism
4. Mechanical Press using Power Screw

(*Example provided above for understanding; you may choose any real-life application other than this)

Learning Resources

Text Books:

1. S. S. Rattan, *Theory of Machines*, Third Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi.
2. J. J. Uicker, G. R. Pennock, J. E. Shigley, *Theory of Machines and Mechanisms*, Fifth Edition, Oxford.
3. V. B. Bhandari, *Design of Machine Elements*, Tata McGraw Hill Publication Co. Ltd.
4. J. E. Shigley and C. R. Mischke, *Mechanical Engineering Design*, McGraw Hill Publication Co. Ltd.
4. G. Ambekar, *Mechanism and Machine Theory*, PHI.

Reference Books:

1. R. L. Norton, *Kinematics and Dynamics of Machinery*, McGraw Hill Education (India).
2. Ghosh & Malik, *Theory of Mechanism and Machines*, East-West Press.
3. Spotts M. F. and Shoup T. E., *Design of Machine Elements*, Prentice Hall International.
4. Juvinal R. C., *Fundamentals of Machine Component Design*, John Wiley and Sons.
5. *Design Data Handbook*, PSG College of Technology, Coimbatore.
   K. Mahadevan and K. Balveera Reddy, *Design Data Handbook for Mechanical Engineers*, CBS Publishers.

MOOC / NPTEL/ YouTube Links: -

1. Kinematics of Machines – IIT Kanpur (NPTEL): https://nptel.ac.in/courses/112104121
2. Kinematics of Mechanisms and Machines – IIT Kharagpur (NPTEL): https://onlinecourses.nptel.ac.in/noc25_me46/preview
3. Theory of Mechanisms – IIT Madras (NPTEL): https://nptel.ac.in/courses/112106270
4. Mechanism and Robot Kinematics – NPTEL: https://onlinecourses.nptel.ac.in/noc22_me108/preview

Dynamics of Machines – IIT Kanpur (YouTube Series):

Savitribai Phule Pune University Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)				
PCC306-MSW: Digital Manufacturing & MQC Lab				
Teaching Scheme		**Credit**	**Examination Scheme**	
Theory	**NA**	**1**	**OR**	**50 Marks**
Practical	**2 Hours/Week**		**CCE**	**-**

Prerequisite Courses, if any:

Fundamentals of measurement, Construction and operating of conventional machine tools, principles of machining and forming processes, cutting tool and machining parameters

Course Objectives:

1.Understand the principles of engineering metrology and apply modern measuring instruments for dimensional and geometrical inspection.

2.Develop skills in advanced measurement systems such as optical instruments and Coordinate Measuring Machines (CMM).

3.Gain proficiency in CNC programming and machining, including process planning and tolerance specification.

4.APPLY knowledge of Designing limiting gauges

5.APPLY knowledge of Electronic/Electrical measuring instruments

6.DEVELOP necessary skills for measurement, calibration and testing of instruments

Course Outcomes:

After successful completion of the course, Student will be able to

CO1: DEMONSTRATE the use of conventional and digital measuring instruments for linear and angular measurements and evaluate component dimensions.

CO2: ANALYZE and DETERMINE the geometry and dimensions of components using advanced measurement systems such as optical projectors and Coordinate Measuring Machine

CO3: APPLY statistical process control techniques by constructing and interpreting control charts using suitable software tools

CO4: DEVELOP and VALIDATE CNC part programs using G and M codes and APPLY CNC simulation tools for machining operations.

CO5: IDENTIFY surface patterns/ flatness of given specimens by using optical flat.

CO6. COMPILE the information of opportunities of entrepreneurships/business in various sectors of metrology like calibrations, testing, coordinate and laser metrology etc in an industry visit report.

Course Contents

Term Work

The student shall complete the following activity as Term Work;

1. Study and measurement of linear and angular dimensions using conventional and digital measuring instruments such as Vernier calliper, micrometer, height gauge, dial gauge, and bevel protractor.
2. Determination of geometry and dimensions of a given composite object using an optical projector or toolmaker's microscope.
3. Surface roughness measurement of a given sample using surface tester. Students should also plot of flow chart of its usage.
4. Limit Gauges: Concepts, uses and applications of Go –No Go Gauges, Taylor's principle and Design of gauges (Numerical and student activity)
5. Determination of geometry and dimensions of a given sample by using Coordinate Measuring Machine.
6. Preparation and analysis of control charts ($\bar{X}$ and R Charts) using suitable statistical software.

7. Preparation of manual CNC part programs using G-codes and M-codes as per ISO (DIN 66025) and RS274 standards for CNC lathe/milling machines, and execution on a CNC simulator.
8. Machining of a mechanical component using CNC machines (Lathe/Mill/HMC/VMC), including preparation of manufacturing drawings with appropriate geometrical and dimensional tolerances and detailed process planning.
9. Determination of geometry and dimensions of given composite object / single point tool, by using Optical Projector / Tool makers' Microscope and differentiate between its usefulness in real life.
10. Applications of Open Education Resources like Scilab in measurement / Students should develop any online calculator/app for calculations/numerical analysis relevant to metrology.
11. Industry Visit to provide exposure to students (Anyone to be covered to fulfil CO6 essentially)

- Demonstration of CMM with the help of software and its futuristic improvements as per Industry 4.0 requirements.
- Design of Go –No Go gauges and Sensor applications with modernization as per IOT and Industry 4.0
- Calibration Process as per NABL accreditation norms
- Laser Metrology and its relevant setup functions to be carried out by engineers along with safety precautions to reduce measurement lead time and uncertainty.

(*Note: Any eight practical shall be performed from the given list)

Learning Resources

Text Books:

1. Jain R.K., Engineering Metrology, Khanna Publication.
2. D.S.Kumar, Mechanical Measurements and Control Metropolitan Book Co.Pvt.Ltd.
3. I.C.Gupta, Engineering Metrology, Dhanpath Rai.
4. Bewoor A. K. and Kulkarni V. A., Metrology and Measurements, McGraw hill Publication

Reference Books:

1. Narayana K.L., Engineering Metrology.
2. Galyer J.F & Shotbolt C.R., Metrology for engineers
3. Judge A.W., Engineering Precision Measurements, Chapman and Hall
4. Francis T. Farago, Mark A. Curtis, Handbook of dimensional measurement

MOOC / NPTEL/ YouTube Links: -

1. nptel.ac.in/courses/112106179
2. www.nptelvideos.in/2012/12/mechanical-measurements-and-metrology.html
3. https://nptel.ac.in/courses/112/107/112107242/
4. freevideolectures.com › Mechanical › IIT Madras
5. https://nptel.ac.in/courses/112/106/112106139

Savitribai Phule Pune University
Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)

MDM 331-MSW: Smart Mechatronics System

Teaching Scheme		Credit	Examination Scheme	
Theory	**NA**	**2**	**0R**	**50 Marks**
Practical	**2 Hours/Week**		**CCE**	**-**

Prerequisite Courses, if any:

Basics of Electrical components, Binary to Decimal Conversion, Data communication Module, Op amp Circuits, Linear Algebra, Laplace Transformation method, Logic gates.

Course Objectives:

1. UNDERSTAND the key elements of mechatronics, principle of sensor and its characteristics.
2. UNDERSTAND the concept of signal processing and use of interfacing systems such as ADC, DAC, Digital I/O.
3. UNDERSTAND the block diagram representation and concept of transfer function.
4. UNDERSTAND the system modeling and analysis in time domain, controller modes and its industrial applications.
5. UTILIZE the concepts of PLC system and its ladder programming and significance of PLC system in industrial application.

Course Outcomes:

On completion of the course, learner will be able to

CO1. DEFINE key elements of mechatronics, principle of sensor and its characteristics.

CO2. UTILIZE concept of signal processing and MAKE use of interfacing systems such as ADC, DAC, Digital I/O.

CO3. DETERMINE the transfer function by using block diagram reduction technique.

CO4. APPLY the concept of different controller modes to an industrial application.

CO5. DEVELOP the ladder programming for industrial application.

Course Contents

Term Work

The Term work shall consist of completion of Practical, Self-learning Study Assignments and Presentations. Oral examination shall be based on the Term work undertaken during the semester.

Practical (**Any one** experiments out of experiment no **1 to 3** from the following list whereas experiment no. **4 to 10** are mandatory).

1. Experiment on measurement of temperature using suitable sensor.
2. Experiment on measurement of load using suitable sensor.
3. Experiment on measurement of displacement using suitable sensor.
4. Development of a data acquisition / mechatronics system using low cost open source hardware and software.
5. Experiment on interfacing of suitable sensor and actuator with DAQ.
6. Modeling and analysis of mechanical system and its verification using suitable simulation software.
7. PID control of Mechanical System using suitable simulation software and experimental verification (verification only if experimental setup is available).

8. Ladder Logic Simulation of suitable application.

9. Demonstration of PLC controlled electro hydraulic / elector pneumatic circuit.

10. Industrial visit to understand integration and application of Mechatronics.

Assignments:

1. Application of Sensors and Actuators in Health Science and Selection of Suitable Sensor and Actuator.

2. Block Diagram Representation of Feedback Control System and determination of Closed Loop Transfer Function.

Learning Resources

Text Books:

1. William Bolton, Mechatronics: Electronics Control Systems in Mechanical and Electrical Engineering, 6th Ed, 2019

2. K.P. Ramchandran, G.K. Vijyaraghavan, M.S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Willey Publication, 2008

Reference Books:

1. Alciatore and Histand, Introduction to Mechatronics and Measurement Systems, 5th Ed, 2019
2. Bishop (Editor), Mechatronics – An Introduction CRC 2006
3. Mahalik, Mechatronics – Principles, concepts and applications, Tata Mc-Graw Hill publication, New Delhi
4. C.D.Johnson, Process Control Instrumentation Technology, Prentice Hall,New Delhi
5. Bolton, Programmable Logic Controller, 4th Ed, Newnes, 2006

MOOC / NPTEL/ YouTube Links: -

1. https://www.elprocus.com/what-is-a-biosensor-types-of-biosensors-and-applications/
2. https://www.elprocus.com/color-sensor-working-and-applications/
3. https://www.youtube.com/watch?v=kbjCGGTXqUo&ab_channel=Controlengineering
4. https://youtu.be/clTA0pONnMs?list=PLHMDN3JFtE5wEz95H2XuzRaafK3fUsaki
5. https://nptel.ac.in/content/storage2/courses/108105063/pdf/L 12(SS)%20(IA&C)%20((EE)NPTEL).pdf
6. https://nptel.ac.in/content/storage2/courses/112104158/lecture5.pdf

Savitribai Phule Pune University Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)				
MDM 332-MSW: Engineering Simulation and Analysis				
Teaching Scheme		**Credit**	**Examination Scheme**	
Theory	**NA**	**2**	**PR**	**50 Marks**
Practical	**2 Hours/Week**		**CCE**	**NA**

Prerequisite Courses, if any:

- Engineering Mechanics, Solid Mechanics, Mechanical Vibration and Heat Transfer

Course Objectives:

1. To develop foundational understanding of Finite Element Analysis methodology by formulating and solving 1D bar, truss element and thermal problems computationally.
2. To up skill students in applying FEA software tools for stress, deflection, and concentration analysis of structural components under various loading conditions.
3. To equip students with the ability to perform dynamic analysis including modal analysis to determine natural frequencies and mode shapes of mechanical components.
4. To provide exposure to advanced FEA techniques such as sub modeling and coupled analysis.
5. To enhance practical skills in interpreting simulation results and validating them with theoretical concepts.

Course Outcomes:

After successful completion of the course, learner will be able to:

CO1: Analyze stress analysis problems of 1D bar and truss elements using FEA software.

CO2: Evaluate stress concentration factors, stresses, and deflections in machine components with geometric discontinuities and complex 3D geometries using FEA software.

CO3: Interpret results from modal analysis—understanding natural frequencies, mode shapes, and their physical significance—to make informed vibration-related design decisions.

CO4: Implement submodeling techniques to perform refined localized analysis of critical regions within a mechanical system and justify the choice of boundary conditions.

CO5: Analyze steady-state heat transfer analysis through composite structures and coupled thermal structural Analysis to assess thermomechanical behavior of engineering components.

Course Contents

Experiment-1	**Stress analysis of 1D bar element**	**(02 Hours)**

Description: Performe stress analysis on a one-dimensional bar element to determine axial stress, strain, and displacement under applied loads using FEA software. Students will interpret the results to understand material behavior. Students will interpret the results to understand stress distribution and validate structural response calculations

Exemplars / Practical Applications

Analysis of axial stress and deformation in tie rods, Structural assessment of elevator cables and suspension components, Design verification of connecting rods etc.

Experiment-2	**Structural analysis of a 1D truss element**	**(02 Hours)**

Description: Analyzing a 1D truss element using FEA software to determine nodaand force reaction under given loading conditions. The results are used to understaverify the structural response of the truss member.

Exemplars / Practical Applications:

Analysis of bridge truss members, Design verification of roof trusses used in industutrial assessment of transmission tower members subjected to wind and cable loads etc.

Exemplars / Practical Applications

Experiment-3	**Determination of static stress concentration factor calculation for a plate with center hole subjected to axial loading in tension using FEA software**	**(02 Hours)**

Description: Analyze flat plate with a central hole under axial tensile loading and examine how stresses are distributed around the hole. The static stress concentration factor is determined by comparing the peak stress at the hole edge with the average applied stress in the plate.

Exemplars / Practical Applications:

Perforated structural plates and panels used in aerospace and automotive components, stress concentration effects in machine parts such as brackets, gusset plates, and mounting plates with holes etc**.**

Experiment-4	**Stress and deflection analysis of any machine component consisting of 3-D elements using FEA software.**	**(02 Hours)**

Description:

Analyzing a three-dimensional machine component using FEA software to determine stress distribution and deflection under applied loads. The results are used to evaluate structural performance and identify critical regions of stress and deformation.

Exemplars / Practical Applications:

Gear tooth to assess contact stresses, Structural analysis of a bracket or mounting frame used in machinery,

Analysis of a crankshaft to determine stress concentration and deflection under engine loading conditions. Etc

Experiment-5	**Modal analysis of any machine component using FEA software.**	**(02 Hours)**

Description:

Perform modal analysis of a machine component using FEA software to determine its natural frequencies and corresponding mode shapes. The results are used to understand the dynamic behavior of the component and identify conditions that may lead to resonance.

Exemplars / Practical Applications

Study of a turbine blade to determine mode shapes and prevent failure due to vibrational stresses, Modal Analysis of an Aero plane wing, Analysis of a bracket or support frame to ensure it does not resonate under operational vibrations etc.

Experiment-6	**Analysis of mechanical system using submodeling approach**	**(02 Hours)**

Description: Analyzing a mechanical system using the submodeling approach in FEA, where a global model is first solved to obtain overall response and boundary conditions. A detailed local model is then created for a critical region to evaluate stresses and deformations with higher accuracy

Exemplars / Practical Applications

Bicycle frame analysis, gear tooth contact region, bracket connected to a large machine assembly,local deflection and stress evaluation in a turbine blade root region etc.

Experiment-7	**Steady state heat transfer through composite wall using FEA software**	**(02 Hours)**

Description: Using FEA software to analyze steady-state heat transfer through a composite wall made of different materials with varying thermal properties. The temperature distribution and heat flow are determined to understand thermal performance under constant boundary conditions.

Exemplars / Practical Applications

Thermal behavior in furnace or boiler walls with refractory and metal layers, Analysis of heat transfer through building walls made of brick, insulation, and concrete layers etc

Experiment-8	**Coupled Thermal-Structural Analysis using FEA software**	**(02 Hours)**

Description:

Performing coupled thermal-structural analysis using FEA software to study the interaction between temperature distribution and resulting mechanical stresses in a component. The results help evaluate how thermal loads influence deformation and structural integrity under operating conditions etc

Exemplars / Practical Applications

Engine components like cylinder heads under combined heat and mechanical loading, Turbine blades to study thermal stresses and deformation due to high-temperature gas flow and brake discs to assess thermal expansion and stress during repeated braking cycles etc

Learning Resources

Text Books:

1. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis,
Finite to Infinite, Pune, 1st Edition, 2008.
2. S. S. Bhavikatti, Finite Element Analysis, New Age International Publishers, Third Edition, 2015.
3. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall
India, 2002.
4. G Lakshmi Narasaiah, Finite Element Analysis, BS Publications / BSP Books, 2nd edition, 2020.
5. J. N. Reddy, An Introduction to the Finite Element Method, Mcgraw Hill Series in Mechanical, 2005.
6. P. Seshu, Text book of Finite Element Analysis, PHI Learning Private Limited, New Delhi, 10th Printing, 2012.

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. S. Moaveni, Finite element analysis, theory and application with Ansys, Prentice Hall
5. O.C. Zienkiewicz, The Finite Element Method: Its Basis and Fundamentals, Sixth Edition, Elsevier
Butterworth-Heinemann, 2005.

MOOC / NPTEL/ YouTube Links: -

1. NPTEL – FEM Course by Prof. C.S. Upadhyay, IIT Kanpur
2. ANSYS Learning Hub — ansys.com/training (free student access)
3. SimScale Community — cloud-based FEA practice (free tier available)

Savitribai Phule Pune University
Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)

MDM 333-MSW: Heat and Mass Transfer Lab

Teaching Scheme		Credit	Examination Scheme	
Theory	**NA**	**2**	**PR**	**50 Marks**
Practical	**2 Hours/Week**		**CCE**	**NA**

Prerequisite Courses, if any:

- Fluid Mechanics, Engineering Thermodynamics, Engineering Mathematics

Course Objectives:

1. To introduce the fundamental mechanisms of heat transfer: conduction, convection, and radiation.
2. To study heat conduction with heat generation, fins, thermal insulation, and transient heat transfer.
3. To apply heat transfer principles in real engineering applications including energy systems, manufacturing, and process industries.
4. To provide knowledge to analyze radiation heat transfer with and without radiation shields.
5. To evaluate heat transfer equipment such as heat exchangers used in thermal systems.

Course Outcomes:

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

CO1: Explain fundamental heat transfer mechanisms and analyze heat conduction in engineering systems.

CO2: Analyze fins, insulation systems, and transient heat conduction problems.

CO3: Apply convection heat transfer principles and empirical correlations to determine heat transfer rates.

CO4: Analyze radiation heat exchange between surfaces and thermal systems.

CO5: Evaluate the performance of heat exchangers using LMTD and NTU methods.CO5.

Course Contents

Term Work

Complete eight experiments and two assignments (Sr. no.10 to 13).

1. Determination of Thermal Conductivity of insulating powder.
2. Determination of Thermal Conductivity of metal rod.
3. Determination of local and average heat transfer coefficient in Natural Convection.
4. Determination of local and average heat transfer coefficient in Forced Convection.
5. Determination of temperature distribution, fin efficiency in Natural / Forced Convection.
6. Determination of Emissivity of a Test surface.
7. Determination of Stefan Boltzmann Constant.
8. Determination of heat transfer, overall heat transfer coefficient and effectiveness of Plate Heat Exchanger.
9. Study of Pool boiling phenomenon and determination of Critical Heat Flux (CHF).
10. Assignment to solve transient heat transfer problem using Heisler and Grober Charts.
11. Design of heat exchanger for any simple application.
12. Industrial visit to heat treatment industry/ heat exchanger manufacturing industry.
13. Demonstration of dropwise and filmwise condensation.
14. Virtual laboratory: study of the performance of heat exchanger /study of variation of Thermal Conductivity.

Link for Virtual Lab: - https://www.vlab.co.in/

Learning Resources
Text Books: 1.Franck P. Incropera, David P. DeWitt – Fundamentals of Heat and Mass Transfer, 2.Y. A. Cengel and A.J. Ghajar, Heat and Mass Transfer – Fundamentals and Applications, 3.Tata McGraw Hill Education Private Limited. 4.S.P. Sukhatme, A Textbook on Heat Transfer, Universities Press. 5.R.C. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New Age Science. 6.Joshi's Process Equipment Design, by V.V. Mahajani , S.B. Umarji ,Trinity Press
Reference Books: 1. P.K. Nag, Heat & Mass Transfer, McGraw Hill Education Private Limited. 2. M.M. Rathod, Engineering Heat and Mass Transfer, Third Edition, Laxmi Publications, New Delhi 3. V. M. Domkundwar, Heat Transfer, Dhanpat Rai & Co Ltd. 4. A.F. Mills, Basic Heat and Mass Transfer, Pearson. 5. S. P. Venkatesan, Heat Transfer, Ane Books Pvt. Ltd. 6. Holman, Fundamentals of Heat and Mass Transfer, McGraw – Hill publication. 7. M. Thirumaleshwar, Fundamentals of Heat and Mass Transfer, Pearson Education India. 8. B.K. Dutta, Heat Transfer-Principles and Applications, PHI. 9. C.P. Kothandaraman, S. V. Subramanyam, Heat and Mass Transfer Data Book, New Academic Science. 10. Process heat Transfer, D. Q. Kern, Wiley Publication
MOOC / NPTEL/ YouTube Links: - 1. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785 2. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785 3. https://www.youtube.com/watch?v=J_zqQcncAu4&index=3&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3 4. https://www.youtube.com/watch?v=SNnd0f3xXlg&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3&index=11 5. https://www.youtube.com/watch?v=SNnd0f3xXlg&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3&index=11 6. https://www.youtube.com/watch?v=lnFjt30goiY&index=18&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3

Savitribai Phule Pune University, Pune

Maharashtra, India

TE - Mechanical Engineering (2024 Pattern)

Semester VI Courses

Savitribai Phule Pune University Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)				
PCC307MSW: Industrial In-plant Training-I				
Teaching Scheme		**Credits**	**Examination Scheme**	
Practical	**14 Hrs./Week**	**8**	**TW**	**150 Marks**
			Oral	**100 Marks**

Prerequisites: Eagerness to have exposure to real life industrial environment and positive attitude to acquire professional skills through participation in different activities in industry during training.

Course Objectives:

1. To expose students to the industrial environment to learn the real time technical / managerial skills required for professional development.
2. To familiarize students with types of industry, various departments, processes, materials, machines, products with different industry attributes.
3. To understand the working of industrial environment with reference to professional ethics, attitude and approach to problem solving and different administrative considerations.
4. To promote academic and personal development of students imbibing individual confidence to handle various engineering assignments.
5. To provide experience in writing technical reports and technical presentations with effective communication skills.

Course Outcomes:

On completion of the course, learner will be able to

CO1. To **UNDERSTAND** industrial practices and technical details followed in industry.

CO2. To **ANALYZE** and **SOLVE** engineering problems by applying engineering knowledge with teamwork and multidisciplinary approach.

Course Contents

Students are expected to get exposure and learn the different industrial aspects during their Industrial In-Plant Training - I. Student shall undergo industrial training in Large or Medium size Core mechanical industry in various departments. During training, students are expected to focus on different aspects of industry such as type of industry, profile of industry, product and processes, machines, equipment, instrumentation, automation, energy consumption and any other relevant aspects depending on type of industry. Following are the few guidelines for the for better understanding and outcome of Industrial training.

1. **Orientation:** Types of Industry, Industrial Environment, Industrial Psychology, Industrial Management, Industrial Relations, Government Policies, Associated organizations and their role. Company profile, Organizational structure of the company, Organizational behavior, Scale and type of production, Types of products, Safety and Quality Policies of Company, Statutory Approvals, Permissions and Approvals of Products.

2. **Departments in Manufacturing Industries:** R & D (research and development), quality control, shipping, distribution, production, purchasing, recruiting or human resources, operations, finance, accounting, accounts payable, accounts receivable, billing, sales, marketing, advertising, maintenance, Engineering, Technology, Projects, etc., There could be additional departments within other departments depending on the size and type of business.

3. **Industrial Design and Drawing Practice:** Design and Drawing Standards, Study of mechanical components and component design such as gears, gear boxes, chain and belt drives, couplings, shaft, keys, bearings, brackets, bolted and welded connections. Sub-assembly and assembly drawings. Simple assignments based on the above items.

4. **Manufacturing processes**: To understand manufacturing concepts applied in industry. Study of material requirements, material standards. Heat treatments applied to products.

5. **Machine Tools**: Machine tool classifications, types of machines tool, special machine tools, machine tool design, CNC controls, Programming languages and codes, Machine tool maintenance.

6. **Manufacturing Automation**: Automation level, types of automation, application of hydraulics and pneumatics, mechatronics control, use of sensors and feedback in control, robotic control over the process.

7. **Material Handling**: Unit load concept, types of material handling equipment, selection of Material handling equipment, design requirement of material handling system.

8. **Measurement and Quality Control**: Precision measurement, Control chart, Statistical process control, Process capability, TQM, Work time measurement, software used in industry.

9. **Processes and Operation Planning**: Production planning and control, Order preparation, Material planning, Process planning, tool selection, Route sheets, documents in process planning, production control- dispatching, follow-up.

10. **Machines, Personal and Plant safety:** Safety rules in organization, posters exhibits and publicity, fire prevention and protection, Health and sanitation, Protective wearing apparel, Safety signs, Industrial safety standards.

Operational Guidelines
1. Duration of training will be full sixth semester (second semester of Third Year) 2. It is expected that students get exposure to all departments in industry. 3. The student shall be asked to complete two assignments / case studies in various departments or any Specific Industry Project. 4. Institute will assign a supervisor faculty to each student for Mentoring and Guidance. 5. Supervisor will guide and monitor student's training by visiting the industry on regular basis with specified Schedule. 6. Student shall maintain logbook (Diary Notes) during the training. 7. During training student is expected to complete two assignments / case studies with identification of industry problem.
Term Work Guidelines
Term Work shall consist of a 1. Comprehensive report based on observations, learning and contributions during training and minimum two case studies / assignments. 2. Logbook / diary maintained by student during training Industrial In-plant Training – I report shall include points mentioned below: 1. Industry profile, Product/Service and process details, list of customers, Organizational Structure, Plant layout for small enterprise, detailed layout of shop floor, Safe working practices followed in the industry. 2. The department details where the student has undergone training. Training details (Classroom training) if given shall be included. 3. Understandings, observations and technical details of machines, equipment, instrumentation, automation and different processes available and followed in the department / industry. 3. The activities done during the training with technical details should be included in the report. Technical details in the form of drawings, figures, process sheets, machine specifications etc. 4. Two assignments / case studies other than Mini Project completed during the training should

be included in the report. Mini project work should not be included in in-plant training report to avoid duplication.

5. Assignment / case study report should contain subtopics like Introduction, problem/ task identification, Objectives, Methodology, process to be followed/action plan, Observation and solution, Comparison with the earlier status, include graphs wherever necessary, Quantification (the results should be represented in terms of %), Conclusions highlighting major outcome of assignment.

Instructions for In-Plant Training Report

Black hardbound copies of the report of Industrial In-plant Training – I to be submitted to the department. (03 Copies)

Report should be preferably of 70 - 90 pages.

Report text should be Times New Roman 12 pt. and both side justified, 1.15-line spacing, double spacing for paragraph,

Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.

Header for e.g. Institute Name, Mechanical Engineering Times New Roman 10 pt. and left aligned.

Footer for e.g. Mechanical Engineering (Sandwich Pattern) Times New Roman 10 pt. and left aligned and page number at center.

Entire report shall be one chapter. No chapters for In-Plant Training - I report.

Use the paper size 8.5'' × 11'' or A4 (210 × 197 mm). Please follow the margins given below.
Top 1", Left 1.5", Bottom 1.25", Right 1".

Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, black and white. Illustrations downloaded from internet are not acceptable.

Examination

Oral will be based on Term Work completed during training. Oral Examination shall be conducted by appointing one Internal Examiner and one External Examiner from industry.

Savitribai Phule Pune University Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)				
PCC308MSW: Industrial Mini-Project				
Teaching Scheme		**Credits**	**Examination Scheme**	
Practical	**12 Hrs./Week**	**6**	**TW**	**100 Marks**
			Oral	**50 Marks**

Prerequisites: Better understanding of industry during training for identifying a problem statement based on need of the industry, systematic approach to provide solution to industrial problem, Readiness to participate in hands on activity.

Course Objectives:

1. To make students able to define industry problem based on theory knowledge and industry exposure received during training.
2. To understand methodological approach to provide solution to problem identified.
3. To understand professional ethics, team work and multidisciplinary approach in industrial assignments.
4. To familiarize with activities like need analysis, detailing of component specifications, critical issues involved in implementation of project, etc.
5. To promote individual level confidence for handling engineering assignments.
6. To provide experience in writing technical reports and technical presentations with effective communication skills.

Course Outcomes:
On completion of the course, learner will be able to

CO1. To **IDENTIFY** specific areas for improvement in industry with better understanding.

CO2. To **DEVELOP** and **IMPLEMENT** systematic approach to solve specific industrial problem.

CO3. To **DEVELOP** methodology for providing solution to industrial problems with teamwork and multidisciplinary approach

CO4. To **UNDERSTAND** and **IMPLEMENT** basic principles of project management.

CO5. To **SOLVE** and **ANALYZE** industrial problems.

CO6. To **PRESENT** outcome and details of project work with effective presentation skills.

Course Contents

Mini project is to be completed during the training. It could be a requirement/need based task given to the student by the industry/industry guide. It may be based on literature survey or need based analysis carried out by student. Mini project should be different than the two assignments completed under Industrial In-Plant Training – I.

Task carried out for mini project should be put in the following format.

1. Introduction, problem/ task identification
2. Objectives
3. Methodology, process to be followed/action plan
4. Observation and solution
5. Comparison with the earlier status, include graphs wherever necessary
6. Quantification (the results should be represented in terms of %)
7. Conclusion.

In depth analysis, quantification of results with detailed analysis with very well defined problem definition, objectives, methodology, actual work carried out, results and discussion and outcomes are expected in the report of mini project. Black hard bound report of Mini project should comprise of 50 – 70 pages.

Mini Project may be

1. Task given by the industry for achieving particular objectives.

2. A physical model may be of a die, Jig or fixture, dashboards, etc. can be considered as Mini Project

3. Kaizen implementation and results (quantification of results)

4. Industrial data based task, may be including, process improvement, work study, work measurement etc.

5. Any idea implementation in order to save time, efforts, money and waste etc. to improve productivity. It must be in quantified form. (% saving compared to earlier)

6. Plant layout improvement projects (quantification of results)

7. Material handling/Material Flow projects. (quantification of results)

8. Energy audits and suggestions for improvement, results of implementation

9. Inventory management system analysis projects.

10. Any safe working idea, 3 D (danger, difficult, dirt/dust) implementation project.

11. Application of any technique under LEAN manufacturing or any other technique implementation project.

12. Any other similar task as which can be put as a mini project.

Operational Guidelines

1. Duration of training will be full sixth semester (second semester of Third Year)
2. During training period, mini project is to be completed at individual level.

Term Work Guidelines

Term Work of Mini Project shall consist of a

1. Comprehensive report based on all the steps carried out during completion of Mini project.
2. Details of mini project also should be mentioned in the Logbook / diary.

Instructions for Mini Project Report

Black hardbound copies of the report of **Mini Project** to be submitted to the department. (03 Copies)

Report should be preferably of 70 - 90 pages.

Report text should be Times New Roman 12 pt. and both side justified, 1.5-line spacing, double spacing for paragraph,

Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.

Header for e.g. Institute Name, Mechanical Engineering Times New Roman 10 pt. and left aligned.

Footer for e.g. Mechanical Engineering (Sandwich Pattern) Times New Roman 10 pt. and left aligned and page number at center

Use the paper size 8.5'' × 11'' or A4 (210 × 197 mm). Please follow the margins given below.

Top 1", Left 1.5", Bottom 1.25", Right 1",

Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, black and white. Illustrations downloaded from internet are not acceptable. Illustrations should not be more than two per page, one per page is enough. Figure No. and Title at bottom of figure and table with 12 pt
Examination
Oral will be based on Mini Project in front of external and internal guide at the end of the semester training term.

Savitribai Phule Pune University Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)				
PCC309MSW: Seminar				
Teaching Scheme		**Credits**	**Examination Scheme**	
Practical	**2 Hrs./Week**	**2**	**OR**	**50 Marks**

Prerequisites: Technologies, Products, Patents, Writing and Presenting skill, Drafting tools, Communication skills.

Course Objectives:

1. Prepare a well-organized report employing elements of technical writing and critical thinking.
2. Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

Course Outcomes:

On completion of the course, learner will be able to

CO1. Read and **UNDERSTAND** recent trends and technologies in the area of mechanical engineering.

CO2. **RECOGNIZE** problems after doing research literature survey using various resources.

CO3. **PREPARE** concise, **COMPREHEND** and conclude selective topic in area of mechanical engineering

CO4. **MAKE** use of new and recent technology (e.g. Latex) for creating technical reports

Course Contents

The Seminar topic must be related to one of the following

1. Mechanical Engineering, 2. Interdisciplinary subjects, 3. Recent trends in Engineering

INSTRUCTIONS FOR SEMINAR REPORT WRITING

It is important that the procedures listed below be carefully followed by all the students.

Prepare 3 COPIES of your Seminar report.

1. Limit your seminar report to preferably 20 – 25 pages
2. Header For e.g. ***Savtribai Phule Pune University***
3. The footer For e.g. **Mechanical Engineering**

Institute Name, Mechanical Engineering Times New Roman 10 pt. and centrally aligned.

4. Page number as second line of footer, Times New Roman 10 Pt, centrally aligned
5. Print the report using

a) Letter quality computer printing.

b) The main part of the report should be Times New Roman 12 pt. and justified.

c) Use 1.15 line spacing.

d) Entire report shall be one chapter. No chapters for Seminar report.

6. Use the paper size 8.5'' × 11'' or A4 (210 × 197 mm).

Please follow the margins given below.

Top 1" 25.4 mm

Left 1.5" 37 mm

Bottom 1.25" 32 mm

Right 1" 25.4 mm

7. All paragraphs will be 1.15 line spaced with a one blank line between each paragraph. Each paragraph will begin with without any indentation.
8. Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.
9. Sub-Section headings should be aligning at the left with 12 pt, bold and Title Case (the first letter of each word is to be capitalized).
10. Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, black and white. Illustrations
11. Photographs if any should of glossy prints
12. Equations if any, should be typed in text (it should not be copied as image)
13. Please use the SI system of units. If students would like to add the equivalent in inch-pound (British) units, they must be stated in parenthesis after the SI units. In case the final result comes out in any other units (say due to empirical formula etc.) convert the unit to SI unit.
14. Please number the pages on the front side, centrally below the footer
15. References should be either in order as they appear in the report or in alphabetical order by last name of first author
16. Symbols and notations if any should be included in nomenclature section only
17. Following will be the order of report

i) Cover page and Front page as per specimen on separate sheet
ii) Certificate from Institute as per specimen on separate sheet
iii) Acknowledgement
iv) List of Figures
v) List of Tables
vi) Nomenclature
vii) Contents

18. All section headings and subheadings should be numbered. For sections use numbers 1, 2, 3, … and for subheadings 1.1, 1.2, … etc and section subheadings 2.1.1, 2.1.2, ... etc.
19. References should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If figures and tables are taken from any reference then indicate the source of it.

Savitribai Phule Pune University Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)			
PCC310MSW: Process Planning & Tool Selection			
Teaching Scheme	**Credits**	**Examination Scheme**	
(Self-Study-I)	**3**	**In-Semester**	**30 Marks**
		End-Semester	**70 Marks**

Prerequisites: Basic knowledge of Engineering graphics, Machine Drawing, Manufacturing Processes, Cutting Tools, Production Practices.

Course Objectives:

1. To understand the role of Product and Process Engineering and to perform part print analysis.
2. To demonstrate application of geometric dimensioning and tolerance analysis.
3. To perform Work-piece control and selection of operation.
4. To analyze factors affecting Selection of Equipment & Tooling.
5. To Estimate the total unit time for a component.
6. To demonstrate process Selection, process planning and understand the benefits of CAPP.

Course Outcomes:
On completion of the course, learner will be able to

CO1. **INTERPRET** and **ANALYSE** Part print of an industrial component.

CO2. **ILLUSTRATE** the meaning of geometric dimensions and understand the tolerance chart.

CO3. **UNDERSTAND** Principles of location and clamping and **ESTABLISH** suitable manufacture sequence.

CO4. **SELECT** appropriate equipment and tooling requirements.

CO5. **ESTIMATE** the total unit time per piece for a component in mass production.

CO6. **DESIGN** of Process picture sheet and operation route sheet on GPM for batch production or a special purpose machine for mass production.

Course Contents

Unit 1	**Process Engineering and Part Print Analysis**

Product and Process Engineering: Product design and role of product designer, Process engineering and its functions, Co-ordination of process Engineering with other departments., Organization chart, general classification of manufacturing processes, concept of design for manufacturing, communication in engineering Industry, glossary of terms used in process planning.

Analysis of Part Print: Preliminary analysis, Its general characteristics, Principal processes, alternate processes, functional surfaces of the work piece processing areas, nature of work to be performed, finishing and identifying operations.

Unit 2	**Geometric dimensioning and tolerance analysis**

Dimensional Analysis: Types of dimensions, concept of baseline dimensions, GDT terminology

Tolerance Analysis: Tolerance stack-up analysis, tolerance chart, and tolerance grades and its calculations

Unit 3	**Work-piece control and selection of operations**

Work piece control: Causes of work-piece variations, influencing work-piece control variables, techniques of work piece control – Equilibrium theories, concept of location, geometric, dimensional and mechanical control.

Classification of operations: Basic Process Operations, Principal and Auxiliary Processes, identification of major, critical, qualifying, re-qualifying and supporting operations, product and process critical area.

Unit 4	**Equipment & Tooling Selection**

Types of tooling: Cutting tools, forming tools, Assembly tools, Factors affecting selection of tooling, Cutting tool materials, Desirable properties of tool material,

Jigs and Fixtures: Design principles of jigs and fixtures, Types of locators, various of clamping devices , Types of bushes, Economics of Jigs and fixtures, Indexing devices

Unit 5	**Economics of Process Planning**

Definition, Cost accounting, Elements of cost, Estimation of cost elements, Methods of cost estimation, Data requirement for cost estimation, Steps in making cost estimation, Factors in cost estimation, Selection of process parameters, Machining time calculations, Estimation of total unit time.

Unit 6	**Process Sheet Design**

Steps in process planning, Process symbols, routing description, operation number and description, Preparation of process picture sheet, Operation route sheet for complete manufacturing part, Calculation of cycle time.

Computer aided process planning: Advantages over manual process planning, approaches for CAPP: Generative Process Planning, Knowledge-based Process Planning, Feature Recognition in Computer Aided Process Planning, recent trends.

Books and other resources

Text Books:

1. Eary D. F., Johnson G. E., —Process Engineering for manufacture, Prentice Hall of India.
2. P. C. Sharma, Production Engineering, S. Chand, ISBN 81 219 0421 8.
3. Narayana K. L., Kannaiah P., Vankata Reddy K., —Production Drawing, New age.
4. Groover Mikell P., Automation, Production Systems.

References Books:

1. Scallan P., —Process Planning-Design/Manufacture Interface‖, John Wiley & Sons, 1995.

Savitribai Phule Pune University Third Year of Mechanical Engineering (Sandwich) (2024 Pattern)			
PCC311MSW: Advanced Materials & Manufacturing			
Teaching Scheme	**Credits**	**Examination Scheme**	
(Self-Study-II)	**3**	**In-Semester**	**30 Marks**
		End-Semester	**70 Marks**

Prerequisite Courses: Engineering Materials & Metallurgy, Manufacturing Process, Digital Manufacturing

Course Objectives:

1. **DESCRIBE** what are composite materials and their differences with respect to conventional materials.
2. **COMPREHEND** the challenges associated with Polymer Matrix composites.
3. **UNDERSTAND** the requirement of Metal Matrix Composites
4. **COMPREHEND** the advanced special metal forming processes.
5. **CLASSIFY AND DESCRIBE** various advanced welding processes.
6. **UNDERSTAND** need of Non- conventional Machining Process.

Course Outcomes:

On completion of the course, learner will be able to

CO1. **DEFINE & COMPARE** composites with traditional materials.
CO2. **IDENTIFY & ESTIMATE** different parameters of the Polymer Matrix Composite
CO3. **CATEGORISE** and **APPLY** Metal Matrix Process from possessions landscape.
CO4. **ASSESS** the parameters for special forming operation and SELECT appropriate special forming operation for particular applications.
CO5. **CLASSIFY** various advanced welding processes and **SELECT** suitable welding processes for particular applications.
CO6. **COMPREHEND** various non-conventional machining processes and **SELECT** suitable processes for particular applications.

Course Contents

Unit 1	**Introduction to Composites**	**07 Hrs.**

Definitions, Need of Composites, Classification of Composites, Reinforcements and matrices, Types of reinforcements, Types of matrices, Types of composites, Natural Composites, Carbon Fiber composites, Properties of composites in comparison with standard materials. Advantages and Disadvantages. Natural Composites, Hybrid materials and their difference with Composite materials, Applications.		
Unit 2	**Polymer Matrix Composite**	**08 Hrs.**
Polymer resins – thermosetting resins, thermoplastic resins – reinforcement fibers – roving's – woven fabrics – non woven random mats – various types of fibers. PMC processes – hand layup processes – spray up processes – compression moulding – reinforced reaction injection moulding – resin transfer moulding – Pultrusion – Filament winding – Injection moulding. Fiber reinforced plastics (FRP), Glass Fiber Reinforced Plastics (GFRP). Laminated Composites.		
Unit 3	**Metal Matrix Composite**	**07 Hrs.**
Characteristics and types of MMC, advantages and limitations of MMC, Reinforcements – particles – fibers. Effect of reinforcement – volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process – diffusion bonding – stir casting – squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface-measurement of interface properties.		
Unit 4	**Special Forming Processes**	**07 Hrs.**
Special Forming Processes: HVF, HERF (Explosive Forming) techniques- super plastic forming techniques-Hydro Forming-Stretch forming, Laser beam forming-principles and process parameters-Advantages, limitations and applications of different forming processes. Orbital forging-Isothermal-Hot and cold isostatic pressing-High speed extrusion, Water hammer forming, Incremental Sheet forming, Magnetic Pulse forming, Metal Spinning, Electro Hydraulic Forming, Micro forming.		
Unit 5	**Advanced Welding Techniques**	**08 Hrs.**
Advanced Welding Processes: Atomic hydrogen welding, Electron beam welding, Laser Beam welding - principle, working and applications, Cold Metal Transfer - concepts, processes and applications, Friction stir welding, Underwater welding, Welding automation in aerospace, nuclear and surface transport vehicles, Robotic Welding, Plasma Arc Welding, Plasma Transferred Arc Welding.		
Unit 6	**Non-Conventional Machining Process**	**08 Hrs.**

Need of Non-Conventional Machining Process, (Principle, MRR, Process Parameters) Abrasive Jet Machining, Water Jet Machining, Ultrasonic Machining, EDM, WEDM, ECM, ECG, EBM, LBM Influence of tool material, geometry, di-electric fluid and process parameters on machining characteristics, Micro machining.

Compiled By

Books and other resources
Text Books: 1. Chawla K.K., Composite materials Science and Engineering, Springer New York- 2016 2. Daniel Gay- Composite Materials- Design and Applications, CRC Press, 2014 3. Autar Kaw- Mechanics of Composite Materials, Taylor and Francis, Second Edition- 2006 4. Dr. R. S. Parmar,"Welding Processes and Technology", Khanna Publications Edition 2017 5. Dr. V. D. Kodgire and S. V. Kodgire, “Material Science & Metallurgy For Engineers”, Everest Publication 6. P K Mishra, Non-Conventional Machining Narora Publication.
References Books: 1. A Bent Strong- Fundamentals of Composites Manufacturing-Materials, Methods and Applications, Society of Manufacturing Engineers, 2008 2. M. W. Hyer, Scott R. White- Stress Analysis of Fiber-reinforced Composite Materials, DEStech Publications, Inc., 2009 3. Clyne T.W. and Withers P.J-Introduction to Metal Matrix Composites, Cambridge University Press, 1995 4. Dr. Sadhu Singh, "Theory of Plasticity and Metal Forming Processes", Khanna Publishers Edition 2008 5. Ali Hasan - Islam Nawaz, "Advanced Welding Technology", SCITECH Publications India Pvt. Ltd. Edition 2018 6. Hassan EI-HOLY, Advanced Machining Process, 2nd edition (2005) McGraw Hil Mechanical Engineering Series, 2010
Web References: 1-Introduction of Composite - https://nptel.ac.in/courses/112/104/112104229/ 2-Composite Materials and Structure - https://nptel.ac.in/courses/101/104/101104010/ 3-Manufacturing of composite - https://nptel.ac.in/courses/112/104/112104221/ 4-Polymer Process - https://nptel.ac.in/courses/113/105/113105077/ 5-NPTEL Course on “Advances in welding and joining technologies” by Prof. Swarup Bag IIT Guwahati. 6-NPTEL Course on Advanced Machining Processes-https://nptel.ac.in/courses/112/103/112103202/

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