Syllabi

MDM

Offered by

Mechanical Department

Course Type	Course Code	Course Name	Credits
MDM	MEMDM301	ELEMENTS OF MECHANICAL ENGINEERING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. BSC101 - Engineering Mathematics I
2. BSC102 - Engineering Physics-I
3. ESC101 - Engineering Mechanics

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis

Course Objectives:

1. To familiarize students with the fundamental disciplines of mechanical engineering, including automotive, thermal, fluid, and manufacturing systems.
2. To impart knowledge on the working principles and classifications of internal combustion engines, and automotive components.
3. To enable students to understand the fundamentals of thermal systems and their applications in various existing systems.
4. To acquaint students with the principles and applications of rotary and reciprocating systems, hydraulic and pneumatic components in industrial automation.
5. To acknowledge the significance of conventional and modern manufacturing processes in industrial applications.

Module	Details	Hrs.
	Course Introduction Concepts in Mechanical Engineering, focusing on automotive systems, thermal systems, rotary and reciprocating systems, fluid systems, and manufacturing processes. The fundamentals and applications of engines, powertrains, heat transfer, hydraulic and pneumatic systems, and modern manufacturing techniques.	**01**
01.	**Introduction to Mechanical Engineering** ***Learning Objective:*** *To understand the fundamental disciplines of mechanical engineering, including automotive, thermal, fluid, and manufacturing systems.*	**6-8**

	Contents: Overview of Mechanical Engineering disciplines: Automotive Systems, Thermal Systems, Rotary and Reciprocating Systems, Fluid Systems, Conventional and Modern Manufacturing processes.	
	Self-Learning Topics: *--*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Classify various mechanical engineering disciplines, including automotive, thermal, fluid, and manufacturing systems. (PI 2.1.2)* *LO 1.2: Illustrate the working principles of rotary and reciprocating systems in mechanical applications. (PI 1.3.1)* *LO 1.3: Compare conventional and modern manufacturing processes based on efficiency, precision, and applicability. (PI 2.2.4)* *LO 1.4: Analyze the role of thermal and fluid systems in mechanical engineering applications. (PI 2.3.1)* *LO 1.5 Evaluate the impact of advancements in automotive and manufacturing systems on engineering design and production. (PI 2.4.4)*	
02.	**Automotive Systems** ***Learning Objective:*** *To learn the principles and functions of internal combustion engines, powertrain systems, braking, steering, and suspension components.*	**6-8**
	Contents: Classification of Internal Combustion Engines, Automotive clutches, Transmission system, Powertrain systems, Brake systems, Steering system, Suspension system, wheels and tyres.	
	Self-Learning Topics: *--*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Classify internal combustion engines based on fuel type, configuration, and applications. (PI 2.1.2)* *LO 2.2: Illustrate the working principles of automotive clutches and transmission systems in power transmission. (PI 1.3.1)* *LO 2.3: Analyze the role of powertrain and brake systems in vehicle performance and safety. (PI 2.3.1)* *LO 2.4: Evaluate the influence of steering and suspension systems on vehicle dynamics and stability. (PI 2.4.4)* *LO 2.5: Apply the principles of wheel and tyre selection based on load, terrain, and performance requirements. (PI 1.2.1)*	
03.	**Thermal Systems** ***Learning Objective:*** *To explore the fundamentals of thermal systems, heat transfer mechanisms, refrigeration cycles, and their applications in buildings and vehicles.*	**6-8**

	Fundamentals of Thermal Systems, Heat Transfer Mechanisms, Refrigeration Cycle, Air Conditioning Systems, Principles of water heaters and geysers, applications in buildings and vehicles. ***Self-Learning Topics:*** *--* ***Learning Outcomes:*** *A learner will be able to* *LO 3.1: Describe the fundamental principles of thermal systems and their role in mechanical engineering. (PI 1.3.1)* *LO 3.2: Illustrate the various heat transfer mechanisms (conduction, convection, and radiation) and their significance in thermal systems. (PI 1.1.1)* *LO 3.3: Analyze the refrigeration cycle and its applications in cooling and refrigeration systems. (PI 2.3.1)* *LO 3.4: Evaluate the principles of air conditioning systems and their use in temperature control in buildings and vehicles. (PI 2.4.4)* *LO 3.5: Apply the principles of water heaters and geysers in designing systems for heating water in residential and commercial buildings. (PI 1.2.1)*	
04.	**Rotary and Reciprocating Systems** ***Learning Objective:*** *To analyze the working principles of rotary and reciprocating systems, including turbines, compressors, pumps, and their industrial applications.* **Contents:** Overview of turbines, compressors, pumps, principles of operation and applications. ***Self-Learning Topics:*** *--* ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: Classify turbines, compressors, and pumps based on their working principles and applications. (PI 2.1.2)* *LO 4.2: Illustrate the fundamental principles governing the operation of turbines, compressors, and pumps. (PI 1.3.1)* *LO 4.3: Analyze the performance characteristics of turbines, compressors, and pumps in various industrial applications. (PI 2.3.1)* *LO 4.4: Evaluate the selection criteria for turbines, compressors, and pumps based on efficiency, power requirements, and application needs. (PI 2.4.4)* *LO 4.5: Apply thermodynamic and fluid mechanics principles to optimize the performance for turbines, compressors, and pumps. (PI 1.2.1)*	**6-8**
05.	**Fluid Systems** ***Learning Objective/s:*** *To understand the fundamental principles and components of hydraulic and pneumatic systems and their applications in automation.* **Contents:** Hydraulic Systems: Basics of hydraulic components, actuators, direction control valves, flow control valves, pressure control valves, filters.	**6-8**

	Pneumatic Systems: Basics of pneumatic components, FRL unit, Muffler, applications in automation.	
	Self-Learning Topics: *--*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: List the basic components of hydraulic and pneumatic systems and their functions. (PI 1.3.1)* *LO 5.2: Illustrate the working principles of hydraulic actuators, valves, and filters in fluid power systems. (PI 2.1.2)* *LO 5.3: Analyze the role of direction, flow, and pressure control valves in hydraulic and pneumatic circuits. (PI 2.3.1)* *LO 5.4: Evaluate the application of pneumatic systems, including FRL units and mufflers, in automation. (PI 2.4.4)* *LO 5.5: Apply hydraulic and pneumatic system concepts to design and optimize industrial automation solutions. (PI 1.2.1)*	
06.	**Manufacturing** ***Learning Objective/s:*** *To apply knowledge of conventional and modern manufacturing processes, including CNC machining, additive manufacturing, and material handling in automation.*	**7-9**
	Contents: Conventional Manufacturing: Casting, forming, machining processes. Modern Manufacturing: Additive manufacturing (3D printing), CNC machining, rapid prototyping. Material Handling: Principles of material handling systems, automation in manufacturing, industrial robotics.	
	Self-Learning Topics: *--*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Classify conventional manufacturing processes such as casting, forming, and machining based on their applications. (PI 2.1.2)* *LO 6.2: Illustrate the principles of modern manufacturing techniques like additive manufacturing, CNC machining, and rapid prototyping. (PI 1.3.1)* *LO 6.3: Analyze the role of material handling systems and automation in improving manufacturing efficiency. (PI 2.3.1)* *LO 6.4: Evaluate the integration of industrial robotics in modern manufacturing for productivity enhancement. (PI 2.4.4)* *LO 6.5: Apply manufacturing process selection criteria to optimize production in industrial settings. (PI 1.2.1)*	
	Course Conclusion Foundational understanding of mechanical systems and their real-world applications in automotive, thermal, fluid systems, and manufacturing, to apply engineering principles in minor courses.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems.
1.2.1	Apply laws of natural science to an engineering problem.
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems.
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s of a system or process that is appropriate in terms of applicability and required accuracy.
2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis.

Course Outcomes: A learner will be able to -

1. Understand the key mechanical engineering disciplines and their applications in real-world engineering systems. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5*)
2. Analyze the components and functioning of automotive systems, including internal combustion engines, transmission, and powertrain. (*LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5*)
3. Apply the principles of thermal systems, including heat transfer, refrigeration, and air conditioning, in practical engineering scenarios. (*LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5*)
4. Explain the operation and applications of rotary and reciprocating systems such as turbines, compressors, and pumps in mechanical engineering. (*LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5*)
5. Design and evaluate hydraulic and pneumatic systems used in automation and industrial processes. (*LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5*)
6. Understand and apply both conventional and modern manufacturing processes, including material handling and automation in manufacturing environments. (*LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEMDM301.1	2	3	--	--	--	--	--	--	--	--	--
MEMDM301.2	3	3	--	--	--	--	--	--	--	--	--
MEMDM301.3	3	3	--	--	--	--	--	--	--	--	--
MEMDM301.4	3	3	--	--	--	--	--	--	--	--	--
MEMDM301.5	3	3	--	--	--	--	--	--	--	--	--
MEMDM301.6	3	3	--	--	--	--	--	--	--	--	--
Average	**3**	**3**	--	--	--	--	--	--	--	--	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Introduction to Mechanical Engineering,R.K. Bansal, Laxmi Publications, 1st Edition.
2. Automobile Engineering, R.B. Gupta, Satya Prakashan, 5th Edition.
3. Thermal Engineering, R.K. Rajput, Laxmi Publications, 11th Edition .
4. Mechanical Engineering: Turbines, Pumps and Compressors, S.K. Som and B.P. Mahajan, Tata McGraw Hill, 3rd Edition .
5. Introduction to Fluid Mechanics, R.W. Fox and A.T. McDonald, Wiley, 8th Edition.
6. Manufacturing Engineering and Technology, S. Kalpakjian and S.R. Schmid, Pearson, 7th Edition.

Reference Books :

1. Engineering Mechanics, S.T. Liu, Pearson Education, 4th Edition .
2. Automobile Engineering, C.P. Kothandaraman, PHI Learning Pvt. Ltd., 1st Edition.
3. Hydraulic and Pneumatic Power Systems, V. R. S. Gupta, S. Chand Publishing, 1st Edition.
4. Manufacturing Engineering and Technology, S.K. Hajra Choudhury, Media Promoters & Publishers Pvt. Ltd., 6th Edition.

Other Resources :

1. NPTEL Course: Oil Hydraulics and Pneumatics, By Prof. S. Chakraborty, IIT Kharagpur, Web link: https://archive.nptel.ac.in/courses/112/106/112106300/
2. NPTEL Course: Thermal Engineering: Basic and Applied, By Prof. S. Chakraborty, IIT Kharagpur, Web link: https://digimat.in/nptel/courses/video/112103316/L19.html
3. NPTEL Course: Principle of Hydraulic Machines and System Design, By Prof. S. Chakraborty, IIT Kharagpur, Web link: https://www.digimat.in/nptel/courses/video/112103249/L01.html

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

One MCQ test as per GATE exam pattern/ level	:	05 Marks
One Class test	:	05 Marks
Flip classroom	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
MDM	MEMDM402	CAD MODELING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ESL204 Engineering Graphics Laboratory

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO5: Engineering tool usage
5. PO8: Individual and Collaborative Team work
6. PO9: Communication

Course Objectives:

1. To familiarize students with basic concepts of CAD modeling.
2. To make students acquaint with feature based CAD modeling.
3. To prepare students to use manipulations and modification tools in CAD modeling.
4. To enable students to build CAD assembly and Design for Assembly.
5. To instruct students to use drafting, rendering and visualization tools to prepare CAD representation and communication purposes.

Module	Details	Hrs.
	Course Introduction CAD Modeling course introduces students to the essential principles and techniques used to create digital models of physical objects and designs. It equips students with essential skills that are vital in modern industries to design product more efficiently, reduce errors, generate and validate innovations at faster rate, and effectively communicate user's ideas. With the increasing reliance on digital design, CAD proficiency is a powerful and highly sought-after skill in today's workforce.	**01**
01.	**Introduction to CAD modeling** ***Learning Objective:***	**5-7**

	To get acquainted with the evolution, role, applications of CAD Modeling, and creating and modifying 2D sketches.	
	Contents: Evolution of CAD modeling, role of CAD tools in product development, Introduction to 2D and 3D modeling, CAD software and hardware requirements, CAD models Creation, Applications of CAD modeling across various disciplines.	
	Self-Learning Topics: *CAD software use interface*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: State benefits of CAD modeling in product design and development. (PI 1.3.1)* *LO 1.2: Summarize hardware and software requirements for running CAD applications effectively. (PI 1.4.1)* *LO 1.3: Assess the evolution of CAD modeling from its early stages to modern-day applications. (PI 2.1.1)* *LO 1.4: Analyze the role of CAD in the entire product development lifecycle, from concept to production, highlighting the key benefits of using CAD in design, prototyping, and manufacturing (PI 2.1.2)* *LO 1.5: Evaluate the advancements in CAD tools that have influenced product development. (PI 2.1.3)* *LO 1.6: Identify applications of CAD modeling across various disciplines. (PI 2.2.2)*	
02.	**Feature Based CAD Modeling**	**6-8**
	Learning Objective: *To get familiarize with feature-based CAD Modeling, its advantages, limitations, and applications.*	
	Contents: Create and modify 2D sketches, Introduction to techniques of CAD modeling, Wire Frame Modeling, Solid Modeling, Surface Modeling, and feature based modeling. Applications of feature based modeling in CAD, various features and their applications in CAD modeling. CAD work flow. Creation of CAD parts using various features like, extrude, revolve, cut, fillet, hole, loft, shell, etc.	
	Self-Learning Topics *Constructive solid geometry*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: State key advantages of feature based CAD modeling. (PI 1.3.1)* *LO 2.2: Compare techniques of CAD modeling. (PI 1.4.1)* *LO 2.3: Identify the significance of solid CAD models, over wireframe and surface CAD models. (PI 2.1.2)* *LO 2.4: Assess characteristics of feature based CAD modeling including their applications in product design. (PI 2.1.3)* *LO 2.5: Group various features of a CAD tool, as per their characteristics. (PI 2.2.2)* *LO 2.6: A task based group activity, before MSE. (Part I) (PI 3.1.3, 3.1.6, 5.1.1, 5.1.2, 8.3.1, 9.1.3, 9.3.1, 9.3.2)*	

	To create CAD models of all components or parts (minimum 6 parts per group, excluding standard parts, max 4 students in one group), in a system or structure fulfilling following aspects, *A. Create sketches during CAD modeling process for each CAD part, by selecting 2D sketching and modifying tools, dimensions and constraints, etc.* *B. Use features in appropriate sequence and use manipulation commands to create and modify each CAD part.* *C. Prepare a document/ report of the activity and present the same for one to one discussion/ communication. (Actual working demonstration, report in soft medium, presentation and group wise discussion of the activity)*	
03.	**Geometric Transformations** ***Learning Objective:*** *To get acquainted with advance CAD modeling features, use of 3D sketches, surface CAD modeling, history based modeling, parametric representation of curves in CAD systems to create and modify complex CAD parts.* **Contents:** Need of modification and manipulations tools in CAD modeling, types of 2D and 3D transformations: - translation, scaling, reflection, rotation, shearing, in 2D and 3D. Homogeneous representation of transformation, Concatenation of transformations ***Self-Learning Topics:*** *Boundary Representations* ***Learning Outcomes:*** *A learner will be able to* *LO 3.1: State importance of homogeneous representations of transformation matrix. (PI 1.3.1)* *LO 3.2: Convert a non-homogeneous transformation matrix to homogeneous transformation matrix. (PI 1.4.1)* *LO 3.3: Apply concatenation rule of transformations, combining multiple transformations to fulfill given modification sequence. (PI 2.1.1)* *LO 3.4: Determine transformation matrix and final coordinates of a geometry bounded by coordinates (2,1), (3,4), (7,7) and (10,3), when rotated about point (8,8) by 30° in cw direction and scaled by 2 units in X direction and 3 units in Y direction w.r.t. point (8,8). (PI 2.1.3)* *LO 3.5: Identify role of transformations in CAD models modifications. (PI 2.2.2)*	**9-11**
04.	**CAD assembly** ***Learning Objectives:*** To understand the role and importance of geometric transformations in CAD modeling and similar modeling tools across various sectors **Contents:** Introduction to CAD assembly, types of assembly in CAD, use of various constrains while creating assembly in CAD modeling tools, creation of parametric assembly of engineering components. resolving interferences and collisions within assemblies. ***Self-Learning Topics: geometric transformations in 3D printing software packages.*** ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: State significance of CAD assemblies. (PI 1.3.1)* *LO 4.2: Assess types of CAD assemblies. (PI 1.4.1)*	**6-7**

	LO 4.3: Identify role of sub-assemblies in CAD assembly. (PI 2.1.2) *LO 4.4: Interpret types of assembly constraints to manage relationships between components. (PI 2.1.3)* *LO 4.5: Analyze methods to resolve interferences and collisions issues within an assembly. (PI 2.2.3)*	
05.	**Drafting and documentation** ***Learning Objective/s:*** *To know various assembly methods, appropriate assembly constraints, design for assembly concepts, for parametric assemblies of engineering components, ensuring flexibility and adaptability in the design.*	**5-7**
	Contents: Importance of 2D drawing representation of 3D CAD parts and assembly, types of drawings - machine drawing, production drawing (working drawing), part drawing, etc., creation of part and assembly drawing from the CAD parts and assembly, use of GD&T, representing GD&T and other annotations on drawing.	
	Self-Learning Topics: *Case study on CAD assembly for discipline specific products.*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: List types of drawings in CAD (PI 1.3.1)* *LO 5.2: State importance of CAD drawing as a way of communicating the product details. (PI 1.4.1)* *LO 5.3: Interpret types of geometrical tolerance required for creating production drawings. (PI 2.1.2)* *LO 5.4: Identify key elements of BOM, justify each one. (PI 2.1.3)* *LO 5.5: Analyze various types of CAD drawings. (PI 2.2.3)* *LO 5.6: A task based group activity, after MSE. (Part II) (PI 3.1.3, 3.1.6, 5.1.1, 5.1.2, 8.3.1, 9.1.3, 9.3.1, 9.3.2)* *To create CAD assembly of all components from work undertaken in Part I and to create detail and assembly drawing for the same. (minimum 6 parts per group, excluding standard parts, max 4 students in one group), fulfilling following aspects,* *A. Identify and apply assembly constraints and geometric transformations to manage relationships between components* *B. Use CAD tools to detect, modify and resolve interferences and collisions between components in an assembly, to ensure functional designs.* *C. Generate part and assembly drawings from a 3D CAD model and assembly respectively, with dimensions, tolerances, and annotations.* *D. Prepare a document/ report of the activity and present the same for one to one discussion/ communication. (Actual working demonstration, report in soft medium, presentation and group wise discussion of the activity)*	
06.	**Advancement in CAD modeling tools** ***Learning Objective/s:*** To get familiarize with significance of converting 3D CAD models into 2D drawings for manufacturing, assembly, and documentation, various types of drawing, part and assembly drawing with GD&T, basics of rendering and visualization.	**6-7**

	Contents: CAD modeling applications in various industrial sectors, recent developments in CAD modeling tools, introduction to discipline specific CAD modeling tools, AI in CAD modeling	
	Self-Learning Topics: *Drawings for patents*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: State recent developments in CAD tools. (PI 1.3.1)* *LO 6.2: Name discipline-specific CAD tools and its application. (PI 1.4.1)* *LO 6.3: Identify different industrial sectors where CAD modeling is used in the process of product development. (PI 2.1.2)* *LO 6.4: Interpret cloud-based CAD modeling tools. (PI 2.1.3)* *LO 6.5: Analyze role of AI in enhancing CAD modeling capabilities. (PI 2.2.3)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
2.2.2	Identify, assemble and evaluate information and resources.
2.2.4	Compare and contrast alternative solution processes to select the best process.
3.1.3	Synthesize engineering requirements from a review of the state-of-the-art
3.1.6	Determine design objectives, functional requirements and arrive at specifications
5.1.1	Identify modern engineering tools such as computer-aided drafting, modeling and analysis; techniques and resources for engineering activities.
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
9.1.1	Read, understand and interpret technical and non-technical information
9.1.3	Create flow in a document or presentation - a logical progression of ideas so that the main point is clear
9.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations.
9.3.2	Use a variety of media effectively to convey a message in a document or a presentation

Course Outcomes: A learner will be able to -

1. Interpret role of CAD modeling in product development including its applications. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5, LO 1.6)*
2. Create CAD parts using feature based modelling technique. (*LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6)*
3. Build parametric assemblies of CAD parts using constrains and geometric transformations. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 5.6)*
4. Generate part and assembly drawings including GD& T and annotations, from 3D CAD data. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6)*
5. Identify recent developments enhancing CAD modeling capabilities. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEMDM402.1	3	3	--	--	--	--	--	--	--	--	--
MEMDM402.2	3	3	3	--	3	--	--	2	3	--	--
MEMDM402.3	3	3	3	--	3	--	--	2	3	--	--
MEMDM402.4	3	3	3	--	3	--	--	2	3	--	--
MEMDM402.5	3	3	--	--	--	--	--	--	--	--	--
Average	**3**	**3**	**3**	**--**	**3**	**--**	**--**	**2**	**3**	**--**	--

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications.
2. CAD / CAM and Automation, Farazdak Haideri , Nirali Prakashan.
3. Machine Drawing by K. L. Narayana, P. Kannaiah and K. Venkata Reddy, New Age International (P) Limited, Publishers

Reference Books :

1. CAD/ CAM, Theory & Practice, Ibrahim Zeid, R. Sivasubramanian, Tata McGraw Hill Publications
2. Machine Drawing, N.D. Bhatt, Charotar Publishing Home Pvt. Ltd.

Other Resources :

1. NPTEL Course: Computer aided Design and Manufacturing I, IIT Guwahati :-Web link https://nptel.ac.in/courses/112102102

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

A task based group activity, before MSE. (Part I)	:	05 Marks
A task based group activity, after MSE. (Part II)	:	05 Marks
Class test	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
MDM	MEMDM503	PRODUCT DESIGN AND DEVELOPMENT	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. HSS301- Product Design

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO6: The Engineer and The World
5. PO7: Ethics
6. PO9: Communication
7. PO11: Life-long Learning

Course Objectives:

1. Acquaint students with product development needs and the role of engineering and industrial design.
2. Familiarize students with design processes and concept evaluation methods.
3. Impart knowledge on customer-driven design using VoC, QFD, and Competitive Benchmarking.
4. Enable students to apply creative problem-solving techniques for innovative product solutions.
5. Acknowledge the importance of industrial design, ergonomics, and DFMA for user-friendly products.
6. Equip students with knowledge of product architecture, serviceability, and sustainable design.

Module	Details	Hrs.
	Course Introduction Overview of product design and development, focusing on the need for innovation, the role of engineering and industrial design, and the design process. Concept generation, evaluation methods, product architecture, and customer-centric design approaches, Quality Function Deployment (QFD). Creativity and systematic problem-solving, advanced design techniques, user-friendly design principles, and Design for X.	**01**
01.	**Engineering Design** ***Learning Objective:***	**7-9**

	To understand the importance of engineering and industrial design in product development.	
	Contents: Need for developing products, The importance of Engineering and Industrial design, The design process(Morris Asimow's), Product lifecycle in product design, Product development process, Various phases of product development, Product planning, Establishing markets - market segmentation - relevance of market research.	
	Self-Learning Topics: *--*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: List the need for developing products and the significance of engineering and industrial design. (PI 1.3.1)* *LO 1.2: Illustrate the product lifecycle and its impact on product design decisions. (PI 1.4.1)* *LO 1.3: List the various phases of the product development process. (PI 2.1.2)* *LO 1.4: Analyze market segmentation and the relevance of market research in product planning. (PI 2.2.2)* *LO 1.5: Apply Morris Asimow's design process to real-world product development scenarios. (PI 2.3.1)*	
02.	**Product Design Process** ***Learning Objective:*** *To learn systematic methods for concept generation, evaluation, and selection.*	**8-10**
	Contents: The design processes, Descriptive and prescriptive design models, Concept development & evaluation, Pugh's matrix, Concept generation and selection method, Embodiment design, Product architecture and Steps in developing product architecture.	
	Self-Learning Topics: *--*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Differentiate between descriptive and prescriptive design models. (PI 2.2.3)* *LO 2.2: Develop and evaluate design concepts using Pugh's matrix. (PI 2.2.4)* *LO 2.3: Demonstrate concept generation and selection methods in product design. (PI 3.3.1)* *LO 2.4: Formulate product architecture and outline steps for developing it. (PI 2.3.1)* *LO 2.5: Develop product architectures by applying structured design methodologies. (PI 3.1.1)*	
03.	**Product Development Process** ***Learning Objective:***	**8-10**

	To apply Quality Function Deployment (QFD) to develop effective product design specifications. **Contents:** Identifying customer needs, Voice of Customer (VoC), Customer populations, Hierarchy of human needs, Need gathering methods, Establishing engineering characteristics, Competitive benchmarking, Quality Function Deployment (QFD), House of Quality (HoQ), Product design specification (PDS), Development of product design with specifications using QFD, Relevant case studies. ***Self-Learning Topics:*** *--* ***Learning Outcomes:*** *A learner will be able to* *LO 3.1: Identify customer needs and interpret the Voice of Customer (VoC) in product design. (PI 2.1.1)* *LO 3.2: Apply competitive benchmarking techniques to establish engineering characteristics. (PI 2.2.2)* *LO 3.3: Develop a House of Quality (HoQ) using Quality Function Deployment (QFD). (PI 2.3.1)* *LO 3.4: Construct a Product Design Specification (PDS) based on customer requirements. (PI 3.1.2)* *LO 3.5: Formulate engineering characteristics from customer requirements to enhance product design. (PI 3.1.2)*	
04.	**Creative Thinking** ***Learning Objectives:*** *To explore creative problem-solving techniques to enhance innovation in design.* **Contents:** Creative thinking methods, Problem-solving methods, brainstorming technique, Gordon technique, Check listing technique, Synectics technique, Morphological analysis and Attribute listing technique. Generating design concepts, Systematic methods of designing. ***Self-Learning Topics:*** *--* ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: Utilize creative thinking techniques like brainstorming, synectics, and morphological analysis. (PI 2.2.4)* *LO 4.2: Apply systematic methods of designing to generate innovative product concepts. (PI 3.2.1)* *LO 4.3: Evaluate problem-solving approaches to improve design efficiency. (PI 2.3.2)* *LO 4.4: Compare different idea generation techniques for effective product design. (PI 3.2.1)* *LO 4.5: Assess the impact of attribute listing in refining product concepts. (PI 2.4.3)*	**7-9**

05.	**Industrial Design** ***Learning Objective/s:*** *To recognize the significance of human factors and ergonomics in user-friendly product design.*	**8-10**
	Contents: Industrial design, Basic forms and elements, Integrating basic forms and elements, The golden rule of proportions, human factors in design (anthropometrics), User-friendly design, DFMA, Design for serviceability, Design for environment.	
	Self-Learning Topics: *--*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Tabulate industrial design elements and their role in product aesthetics and sustainability. (PI 6.4.1)* *LO 5.2: Apply the golden rule of proportions to enhance product ergonomics. (PI 1.4.1)* *LO 5.3: Integrate human factors and anthropometrics into user-friendly designs. (PI 7.2.2)* *LO 5.4: Assess the significance of Design for Manufacturing and Assembly (DFMA). (PI 7.1.1)* *LO 5.5: Evaluate sustainability considerations in Design for Environment (DfE). (PI 6.3.2)* *LO 5.6: Evaluate cost estimation techniques and budgeting strategies for product design and development. (PI 11.1.1)* *LO 5.7: Apply project management principles to optimize design timelines, resources, and financial aspects. (PI 11.2.2)* *LO 5.8: A Task Based Group Activity After MSE (PI 6.1.1, PI 9.1.1, 11.2.1)* *Each group (max 4 students) will conduct a Sustainable & User-Centric Product Redesign Challenge, addressing the following:* *A. Product Selection: Each group selects an everyday product (e.g., a chair, a mobile phone stand, a kitchen appliance).* *B. Analysis Phase: Conduct user analysis using anthropometric data. Identify design flaws and inefficiencies. Evaluate the product's environmental impact.* *C. Redesign Phase: Apply DFMA principles to optimize manufacturing and assembly. Integrate sustainability aspects. Ensure a user-friendly design based on ergonomics and usability.* *D. Presentation & Justification: Prepare a 3-minute pitch showcasing the redesigned product. Use cost analysis and project feasibility to justify design choices. Demonstrate improvements in functionality, aesthetics, and manufacturability.*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No. **P.I. Statement**

1.3.1 Apply fundamental engineering concepts to solve engineering problems

1.4.1 Apply mechanical engineering concepts to solve engineering problems.

2.1.1 Articulate problem statements and identify objectives.

2.1.2 Identify engineering systems, variables, and parameters to solve the problems.

2.2.2 Identify, assemble, and evaluate information and resources.

2.2.3 Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions.

2.2.4 Compare and contrast alternative solution processes to select the best process.

2.3.1 Combine scientific principles and engineering concepts to formulate models (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.

2.3.2 Identify assumptions (mathematical and physical) necessary to allow modeling of a system at the level of accuracy required.

2.4.3 Identify sources of error in the solution process and limitations of the solution.

3.1.1 Recognize that need analysis is key to good problem definition

3.1.2 Elicit and document, engineering requirements from stakeholders

3.2.1 Apply formal idea generation tools to develop multiple engineering design solutions

3.3.1 Apply formal decision-making tools to select optimal engineering design solutions for further development

6.1.1 Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level

6.3.2 Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability

6.4.1 Describe management techniques for sustainable development

7.1.1 Identify situations of unethical professional conduct and propose ethical alternatives

7.2.2 Examine and apply moral & ethical principles to known case studies

9.1.1 Read, understand and interpret technical and non-technical information

11.1.1 Describe the importance of cost estimation and budgeting in engineering projects.

11.1.2 Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap

11.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current

Course Outcomes: A learner will be able to -

1. Apply the understanding of the foundational concepts in product design, development processes.

   (E.g. *LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5*)

2. Apply design models and methods for concept generation, evaluation, and product architecture development. (E.g. *LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5*)
3. Identify customer needs and translate them into engineering characteristics using QFD. (E.g. *LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5*)
4. Apply creative thinking and problem-solving techniques to generate innovative design concepts. (E.g. *LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5*)
5. Use industrial design principles with human factors, sustainability, and user-friendly considerations in product development. (E.g. *LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6, LO 5.7, LO 5.8*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEMDM503.1	3	3	--	--	--	--	--	--	--	--	--
MEMDM503.2	--	3	3	--	--	--	--	--	--	--	--
MEMDM503.3	--	3	3	--	--	--	--	--	--	--	--
MEMDM503.4	--	3	3	--	--	--	--	--	--	--	--
MEMDM503.5	2	--	--	--	--	3	3	--	2	--	3
Average	**3**	**3**	**3**	**--**	**--**	**3**	**3**	**--**	**2**	**--**	**3**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, "Product Design and Development," 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9
2. George E. Dieter, Linda C.Schmidt, "Engineering Design," 4th Edition, McGraw-Hill International Edition, 2009, ISBN 978-007-127189-9

Reference Books :

1. Introduction to Product Design and Development for Engineers, Ali Jamnia, CRC Press Taylor& Francis Group, ISBN 978-1-138-55421-4
2. Integrated Product and Process Design and Development Second Edition The Product Realization Process, Edward B. Magrab, Satyandra K., CRC Press Taylor & Francis Group, ISBN 978-1-4200-7060-6
3. Product Design Paul Rodgers and Alex Milton, Laurence King Publishing, ISBN: 978 1 85669 751 4

Other Resources :

1. NPTEL Course: Product Design and Development
   Web link- https://onlinecourses.nptel.ac.in/noc21_me83/preview
2. NPTEL Course: Product Design and Manufacturing
   Web link- https://onlinecourses.nptel.ac.in/noc21_me66/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

Think-pair-share worksheets	:	05 Marks
One Class test	:	05 Marks
A task based group activity	:	05 Marks
Regularity and attentiveness	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
MDM	MEMDM604	ADDITIVE MANUFACTURING	04

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. HSS301: Product Design
2. MEMDM402: CAD Modelling
3. MEMDM503: Product Design and Development

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO5: Engineering Tool Usage
5. PO6: The Engineer and The World
6. PO9: Communication
7. PO11: Life-Long Learning

Course Objectives:

1. Acquaint students with the fundamentals, evolution, and significance of additive manufacturing.
2. Familiarize students with various technologies, their working principles, and advantages.
3. Impart knowledge of Fused Filament Fabrication (FFF), including materials and mechanisms.
4. Acknowledge the role of AM in sustainability and its impact across industries.
5. Enable proficiency in CAD file preparation, process parameters, and 3D printing workflows.
6. Equip students with hands-on experience in 3D printing and slicing software.

Module	Details	Hrs.
	Course Introduction This course provides an in-depth exploration of Additive Manufacturing (AM), focusing on various AM processes, their working principles, and applications in industries like automotive, medical, aerospace, and more. Students will gain a thorough understanding of technologies such as SLA, FDM, SLS, and EBM, along with specific techniques like Fused Filament Fabrication (FFF). The course will cover material extrusion processes, CAD file preparation, and the full workflow of 3D printing,	**01**

	equipping students with the skills to leverage these technologies in real-world applications.	
01.	**Introduction to Additive Manufacturing** ***Learning Objective:*** *Understand the fundamentals of Additive Manufacturing, its classification, and its real-world applications.*	**7-9**
	Contents: Introduction to Additive Manufacturing, Classification of AM Processes, Advantages & disadvantages, AM Applications in - Design, Concept Models, Form & fit checking, Functional testing, CAD data verification, Rapid Tooling, and Bio fabrication.	
	Self-Learning Topics: *History of AM, Rapid Prototyping vs. Additive Manufacturing, Emerging Trends in AM*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Identify the fundamental concepts and classification of additive manufacturing processes. (PI 1.3.1)* *LO 1.2: Compare the advantages and disadvantages of additive manufacturing with traditional manufacturing methods. (PI 2.2.4)* *LO 1.3: Categorize different AM applications based on their role in design, prototyping, and production. (PI 2.1.2)* *LO 1.4: Analyze the significance of AM in concept modeling, form & fit checking, and functional testing. (PI 1.1.2)* *LO 1.5: Assess the role of AM in CAD data verification, rapid tooling, and bio fabrication. (PI 2.3.1)* *LO 1.6: Evaluate the impact of AM on product development cycles and time-to-market. (PI 1.2.1))*	
02.	**Additive Manufacturing Technologies** ***Learning Objective:*** *Learn the working principles, advantages, and limitations of different AM technologies.*	**9-11**
	Contents: Working principles, Applications, Advantages, and Disadvantages of key additive manufacturing methods: **Liquid Based System** - Stereo lithography apparatus (SLA) & Solid ground curing (SGC), **Solid Based System** - Laminated object manufacturing (LOM) & Fused Deposition Modeling (FDM) and **Powder Based System** - Selective laser sintering (SLS) & Electron Beam Melting (EBM)	
	Self-Learning Topics: *Hybrid AM Processes, Multi-Material AM, Emerging AM Technologies (DLP, MJ, BJ)*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Classify different additive manufacturing technologies based on their material states and process methodology. (PI 1.3.1)*	

	LO 2.2: Identify key process parameters influencing the performance of various AM technologies. (PI 2.1.2) *LO 2.3: Compare the advantages and limitations of different AM technologies (SLA, SGC, LOM, FDM, SLS, and EBM) for various applications. (PI 2.2.4)* *LO 2.4: Analyze the material compatibility and process limitations of AM technologies (SLA, SGC, LOM, and FDM). (PI 1.4.1)* *LO 2.5: Assess the industrial impact of powder-based systems (SLS & EBM) in terms of efficiency and applications. (PI 2.3.1)* *LO 2.6: Evaluate the selection criteria for choosing an appropriate AM technology for specific applications. (PI 1.2.1)*	
03.	**Material Extrusion Process - Fused Filament Fabrication (FFF)** ***Learning Objective:*** *Gain knowledge of the Fused Filament Fabrication (FFF) process and its operational principles.* **Contents:** Introduction to Fused Filament Fabrication, Basic Principles of extrusion-based system - Material Loading, Liquification, Extrusion, Solidification, Positional Control, Bonding and Support Generation, FFF Machine – Technical Specification, Main Parts, Supplies and Accessories of FFF Machine, Features, Functionalities and Requirements of CAD Software, Resin 3D Printing: Process, Applications and Types ***Self-Learning Topics:*** *Filament Manufacturing Techniques, Advanced Support Structures, High-Performance Polymers in FFF* ***Learning Outcomes:*** *A learner will be able to* *LO 3.1: Identify the fundamental principles of the material extrusion process. (PI 1.3.1)* *LO 3.2: Describe the key stages of extrusion-based systems, including material loading, liquefaction and solidification. (PI 2.1.2)* *LO 3.3: Analyze the role of positional control, bonding, and support generation in part formation. (PI 2.3.1)* *LO 3.4: Examine the technical specifications, main parts, and accessories of an extrusion-based 3D printer. (PI 1.4.1)* *LO 3.5: Evaluate the functionalities and requirements of CAD software for 3D printing. (PI 2.2.3)* *LO 3.6: Compare the process, applications, and types of resin 3D printing with material extrusion. (PI 1.2.1)*	**9-11**
04.	**Applications of Fused Filament Fabrication (FFF)** ***Learning Objectives:*** *Explore how FFF technology is applied in industries such as healthcare, automotive, and aerospace.* **Contents:** 3D Printing in the Consumer Goods Industry, Medical Industry, Automotive Industry, Aerospace, Dental Applications, Prosthetics, Architecture, Archeology, Art Restoration, Forensics, Film Industry and Education	**9-11**

	Self-Learning Topics: *Bio printing with FFF, Lightweight Structures in Aerospace, Recycling and Sustainability in FFF*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Identify key applications of FFF in consumer goods, medical, and automotive industries. (PI 1.3.1, PI 3.1.1)* *LO 4.2: Classify the role of FFF in aerospace, dental applications, and prosthetics. (PI 2.1.2, PI 9.1.1)* *LO 4.3: Compare the advantages and limitations of FFF in architecture, archaeology, and art restoration. (PI 2.2.4, PI 11.2.1)* *LO 4.4: Analyze the contributions of FFF in forensics and the film industry. (PI 2.3.1, PI 5.1.1, PI 6.3.2)* *LO 4.5: Categorize the significance of FFF in education and research applications. (PI 1.4.1, PI 11.3.1)* *LO 4.6: A Task-Based Group Activity Before MSE (Part I) (PI 1.3.1, PI 2.1.2, PI 2.2.4, PI 2.3.1, PI 3.2.3, PI 5.2.2, PI 6.3.1, PI 9.1.2, PI 11.3.1)* *Each group (max 4 students) will analyze the applications of Fused Filament Fabrication (FFF) across different industries and propose an innovative use case by addressing the following aspects:* *A. Research & Compare the existing applications of FFF in different industries (e.g., medical, automotive, aerospace, forensics, film, education).* *B. Analyze the advantages and limitations of FFF in a selected industry and justify its suitability.* *C. Propose an innovative use case for FFF in the selected industry and assess its feasibility in terms of design, material selection, and sustainability.* *D. Create a conceptual 3D model (CAD) or a process flow diagram showcasing the proposed application.* *E. Validate the proposed application by evaluating potential challenges, environmental impact, and industry adaptability.* *F. Prepare a technical report summarizing the research, proposed application, and challenges. Present findings in a 5-7-minute group presentation.*	
05.	**CAD File Preparation, Process Parameters and Workflow** ***Learning Objective/s:*** *Develop skills in CAD modeling, slicing, and optimizing process parameters for 3D printing.*	**9-11**
	Contents: **Steps to 3D Print a Model** – Modelling, Slicing, Printing and Post-processing, **Process Parameters influencing the FFF Process** – Machine Parameters and Material Parameters, **FFF 3D Printing Workflow** – Create, Convert, Manipulate, Prepare, Build and Process, Quality Issues in FFF	
	Self-Learning Topics: *Topology Optimization in AM, STL File Repair & Mesh Editing, AI & Machine Learning in AM Workflow*	
	Learning Outcomes :	
	A learner will be able to	

	LO 5.1: Identify the key steps in the 3D printing process, including modeling, slicing, printing, and post-processing. (PI 1.3.1, PI 6.3.1) *LO 5.2: Categorize the machine and material parameters influencing the FFF process. (PI 2.1.2, PI 5.1.1)* *LO 5.3: Analyze the impact of process parameters on print quality and performance. (PI 1.4.1, PI 5.3.2)* *LO 5.4: Evaluate the workflow stages of FFF, including create, convert, manipulate, prepare, build, and process. (PI 2.3.1, PI 11.3.1)* *LO 5.5: Assess common quality issues in FFF and suggest appropriate corrective measures. (PI 2.2.4, PI 6.4.2)*	
06.	**Printing in Fused Filament Fabrication (FFF)** ***Learning Objective/s:*** *Acquire hands-on experience in slicing software and executing a successful 3D print.* **Contents:** Overview and **Interface** of Ideamaker Software, **Printing of 3D model** - Import 3D Models, Slice the model, Estimated Print Result, Save the sliced G-Code files, **Slicing Setting** – Layer, Extruder, Infill, Support, Temperature, Speed, Cooling etc., Filament Setting, Printer Setting ***Self-Learning Topics:*** *Custom G-Code Modifications, Smart Slicing Algorithms, Post-Processing Techniques for FFF* ***Learning Outcomes:*** *A learner will be able to* *LO 6.1: Identify the key features and interface elements of Ideamaker software. (PI 1.3.1, PI 3.1.1)* *LO 6.2: Demonstrate the process of importing, slicing, and estimating print results for a 3D model. (PI 2.2.4, PI 3.2.1)* *LO 6.3: Analyze slicing settings such as layer height, extruder control, infill density, and support structures. (PI 2.3.1, PI 3.3.1, PI 6.2.1)* *LO 6.4: Configure filament and printer settings to optimize the 3D printing process. (PI 2.1.3, PI 5.3.2)* *LO 6.5: Evaluate the impact of slicing parameters on print quality and material efficiency. (PI 1.4.1, PI 2.2.2)* *LO 6.6: A Task-Based Group Activity After MSE (Part II) (PI 1.3.1, 2.1.2, 2.2.4, 2.3.1, 3.2.3, 5.1.1, 5.3.2, 6.3.1, 9.1.2, 9.2.1, 11.3.1)* *Each group (max 4 students) will apply their knowledge of CAD file preparation, process parameters, and 3D printing workflow to design, optimize, and print a functional prototype by addressing the following aspects:* *A. Conceptual Design: Select a real-world problem and conceptualize a functional 3D printed prototype using CAD software.* *B. Process Optimization: Analyze and modify slicing parameters (layer height, infill, support, speed, temperature) for optimal print quality.* *C. 3D Printing Workflow: Convert, slice, and generate G-code for the 3D model, ensuring process compatibility.* *D. Printing & Troubleshooting: Print the prototype using an FFF 3D printer, identify print defects, and suggest corrective actions.* *E. Evaluation & Report: Assess the functionality and quality of the printed model, considering mechanical properties and accuracy. Prepare a technical report and present findings.*	**9-11**

	Course Conclusion Upon completion of this course, students will have acquired comprehensive knowledge and practical skills in Additive Manufacturing technologies. They will be able to select appropriate AM methods for various applications, prepare CAD files, optimize process parameters, and efficiently use FFF technology for 3D printing. Students will also be prepared to apply these concepts in diverse industries, contributing to innovative design and manufacturing solutions.	**01**
	Total	**60**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.2	Apply advanced mathematical techniques to model and solve mechanical engineering problems
1.2.1	Apply laws of natural science to an engineering problem
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve problems.
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2.2	Identify, assemble and evaluate information and resources.
2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions
2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
3.1.1	Recognize that need analysis is key to good problem definition
3.2.1	Apply formal idea generation tools to develop multiple engineering design solutions
3.2.3	Identify suitable criteria for the evaluation of alternate design solutions
3.3.1	Apply formal decision-making tools to select optimal engineering design solutions for further development
5.1.1	Identify modern engineering tools such as computer-aided drafting, modeling and analysis; techniques and resources for engineering activities
5.2.2	Demonstrate proficiency in using discipline-specific tools
5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public
6.3.1	Identify risks/impacts in the life-cycle of an engineering product or activity

6.3.2 Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability

6.4.2 Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline

9.1.1 Read, understand and interpret technical and non-technical information

9.1.2 Produce clear, well-constructed, and well-supported written engineering documents

9.2.1 Listen to and comprehend information, instructions, and viewpoints of others

11.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current

11.3.1 Source and comprehend technical literature and other credible sources of information

Course Outcomes: A learner will be able to -

1. Identify the fundamental concepts, classifications, advantages, and applications of Additive Manufacturing (AM). *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5, LO 1.6)*
2. Analyse different AM technologies based on their working principles, advantages, and limitations. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6)*
3. Demonstrate the basic principles of the FFF process, including material loading, liquefaction, bonding, and the technical specifications of FFF machines. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6)*
4. Integrate diverse FFF applications in various industries such as medical, aerospace, and consumer goods. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 4.6)*
5. Utilize process parameters and workflow optimization techniques to enhance FFF print quality. (*LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5*)
6. Apply slicing software tools and printing settings to successfully perform FFF 3D printing. (*LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO 6.6*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEMDM604.1	3	3	--	--	--	--	--	--	--	--	--
MEMDM604.2	3	3	--	--	--	--	--	--	--	--	--
MEMDM604.3	3	3	--	--	--	--	--	--	--	--	--
MEMDM604.4	3	3	3	--	3	3	--	--	3	--	3
MEMDM604.5	3	3	--	--	3	3	--	--	--	--	2
MEMDM604.6	3	3	3	--	3	3	--	--	3	--	2
Average	**2**	**3**	**2**	**--**	**2.3**	**2.2**	**--**	**--**	**2**	**--**	**2**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. Gibson, I., Rosen, D. W., & Stucker, B. – Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing (Springer, 2015)
2. Chua, C. K., Leong, K. F., & Lim, C. S. – Rapid Prototyping: Principles and Applications (World Scientific, 2010)
3. T. Debroy, H.L. Wei, J.S. Zuback, T. Mukherjee – Additive Manufacturing of Metallic Materials

Reference Books :

1. L. Lu, J. Fuh, Y. Wong – Laser Additive Manufacturing of High-Performance Materials
2. Amit Bandyopadhyay & Susmita Bose – Additive Manufacturing (CRC Press, 2015)

Other Resources:

1. NPTEL Course: Fundamentals of Additive Manufacturing Technologies
   Web link: https://onlinecourses.nptel.ac.in/noc21_me115/preview
2. NPTEL Course: Advances in Additive Manufacturing of Materials: Current Status and Emerging Opportunities
   Web link: https://onlinecourses.nptel.ac.in/noc25_mm02/preview
3. NPTEL Course: Metal Additive Manufacturing
   Web link: https://onlinecourses.nptel.ac.in/noc22_me130/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

One MCQ test as per GATE exam pattern/ level	:	05 Marks
A task based group activity, before MSE. (Part I)	:	05 Marks
A task based group activity, after MSE. (Part II)	:	05 Marks
Regularity and active participation	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
MDL	MEMDL601	CAD MODELING AND 3D PRINTING LABORATORY	01

Examination Scheme		
Continuous Assessment	**Practical /Oral**	**Total**
25	25	50

Pre-requisite:

1. MEMDM402: CAD Modeling

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO5: Engineering tool usage
5. PO9: Communication

Course Objectives:

1. Introduce students to the fundamentals of feature-based modeling in CAD and the use of various CAD tools to create parts.
2. Teach students how to assemble parts into a complete CAD assembly and use constraints to position components.
3. Familiarize students with CAD drafting tools for creating detailed technical drawings from 3D models.
4. Introduce students to different CAD data exchange formats and their applications in design and manufacturing.
5. Teach students the complete process of 3D printing, including slicing settings, machine parameters, and post-processing techniques.

Module	Details	Hrs.
	Course Introduction Hands-on skills in 3D modeling, assembly, drafting, and 3D printing using industry-standard tools. Emphasis on feature-based modeling, parametric design, and data exchange for real-world applications.	**01**
01.	**Creation of CAD parts using feature based modelling Techniques** ***Learning Objective:*** *Understand how to create 3D models using CAD features such as extrude, revolve, loft, and others.*	**05**
	Contents: **Task 1A -**	

	Create a beginner level 3D CAD model of a mechanical part using basic sketches and feature based modelling tools such as extrude, revolve, cut, fillet, hole, etc. Prepare detail drawing for the same. ***(LO 1.1)*** **Task 1B -** Create 3D CAD model using loft, shell, etc. and transformation commands like mirror, pattern, and move. Prepare detail drawing for the same. ***(LO 1.2)***	
	Self-Learning Topics: *Using CAD macros and automation to speed up modeling tasks*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Create 3D CAD models using basic sketches and feature based modelling tools. (PI 1.3.1, 2.1.2, 5.1.1, 5.1.2,9.1.1, 9.1.2)* *LO 1.2: Create 3D CAD models using modification tools and transformation commands. (PI 1.4.1, 2.1.3, 5.1.1, 5.1.2,9.1.1, 9.1.2)*	
02.	**Building CAD assembly** ***Learning Objective:*** *Apply assembly constraints to accurately position and relate parts in a CAD assembly.*	**07**
	Contents: **Task 2A -** Assemble multiple CAD parts using standard assembly constraints such as mate, align, insert, and coincidence in CAD software. Prepare Assembly drawing for the same. ***(LO 2.1)*** **Task 2B -** To develop a parametric assembly of engineering components and perform basic assembly verification such as interference check and degrees of freedom analysis. ***(LO 2.2)***	
	Self-Learning Topics: *Advanced assembly constraint types and best practices*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Build a complete and valid CAD assembly from individual parts using standard assembly constraints. (PI 1.3.1, 2.1.2, 3.1.3 3.1.6, 5.1.1, 5.1.2, 9.1.1, 9.1.2)* *LO 2.2: Develop a parametric assembly of engineering components and apply basic assembly verification techniques. (PI 1.4.1, 2.1.3, 3.1.3 3.1.6, 5.1.1, 5.1.2, 9.1.1, 9.1.2)*	
03.	**Drafting** ***Learning Objective:*** *Understand how to create technical drawings from CAD models, including adding GD&T and annotations.*	**06**
	Contents: **Task 3A -**	

	To generate a fully annotated 2D detailed drawing of a 3D CAD part using standard CAD drafting tools, including Geometric Dimensioning and Tolerance (GD&T). ***(LO 3.1)*** **Task 3B -** To create an assembly drawing from a CAD assembly model including exploded views, bill of materials (BOM), and annotations. ***(LO 3.2)***	
	Self-Learning Topics: *Techniques for creating dynamic exploded views and animations in CAD software*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Generate a fully annotated 2D detailed drawing from a 3D CAD model using standard drafting tools, incorporating appropriate GD&T symbols and conventions. (PI 1.3.1, 1.4.1, 2.1.2, 2.1.3, 5.1.1, 5.1.2, 9.1.1, 9.1.2)* *LO 3.1: Create an assembly drawing from a CAD model by producing exploded views, integrating a bill of materials (BOM), and applying standard annotations. (PI 1.3.1, 1.4.1, 2.1.2, 2.1.3, 5.1.1, 5.1.2, 9.1.1, 9.1.2)*	
04.	**Data Exchange** ***Learning Objectives:*** *Learn about various CAD data exchange formats such as IGES, STL, and DXF, and their use in design processes.*	**05**
	Contents: **Task 4A -** To convert CAD files into various CAD data exchange formats like IGES, PDES, Parasolid, DXF, and STL, and understand their structure, applicability, and interoperability between CAD systems. ***(LO 4.1)*** **Task 4B -** To identify the file formats imported, exported, and supported by IdeaMaker, and evaluate compatibility of 3D models prepared in various CAD formats for slicing and 3D printing. ***(LO 4.2)***	
	Self-Learning Topics: *G-code Customization and Editing Basics*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Compare different CAD file formats (e.g., IGES, STL, DXF) and select the appropriate one for a given application. (PI 1.3.1, 2.1.2, 5.1.1, 5.1.2, 5.3.2, 9.1.1, 9.1.2)* *LO 4.2: Evaluate the compatibility of 3D CAD files with slicing software by analyzing supported formats and import/export options in IdeaMaker. (PI 1.3.1, 1.4.1, 2.1.2, 2.1.3, 5.1.1, 5.1.2, 5.3.2, 9.1.1, 9.1.2)*	
05.	**Printing of 3D model and Post Processing** ***Learning Objective/s:*** *Perform end-to-end slicing and post-processing of 3D models, including slicer settings configuration, G-code generation, and physical model finishing.*	**05**
	Contents:	

	Task 5 - To import a 3D model into slicing software (e.g., IdeaMaker), configure slicing and filament settings, generate G-code, and data transfer to FDM based 3D printer for actual printing, and post processing of printed part.	
	Self-Learning Topics: *Troubleshooting common 3D printing defects and solutions, Advanced post-processing techniques like vapor smoothing and annealing*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Create a 3D model using CAD software and process the same for printing the object. (PI 2.1.2, 2.1.3, 3.1.3, 3.1.6, 5.1.1, 5.1.2, 5.2.2, 9.1.1, 9.1.2, 9.3.1)*	
	Course Conclusion Proficient in creating, assembling, and optimizing CAD models, generating detailed drawings, and preparing designs for manufacturing, enhancing their engineering design capabilities.	**01**
	Total	**30**

P.I. No.	**P.I. Statement**
1.3.1	Apply fundamental engineering concepts to solve engineering problems.
1.4.1	Apply Mechanical engineering concepts to solve engineering problems.
2.1.2	Identify engineering systems, variables, and parameters to solve the problems
2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem.
3.1.3	Synthesize engineering requirements from a review of the state-of-the-art
3.1.6	Determine design objectives, functional requirements and arrive at specifications
5.1.1	Identify modern engineering tools such as computer-aided drafting, modeling and analysis; techniques and resources for engineering activities.
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems
5.2.2	Demonstrate proficiency in using discipline-specific tools.
9.1.1	Read, understand and interpret technical and non-technical information
9.1.2	Produce clear, well-constructed, and well-supported written engineering documents
9.1.3	Create flow in a document or presentation - a logical progression of ideas so that the main point is clear

Course Outcomes: A learner will be able to -

1. Create CAD models using feature-based modeling techniques. *(LO 1.1, LO 1.2)*
2. Build and validate CAD assemblies with parametric constraints. *(LO 2.1, LO 2.2)*
3. Generate detailed and assembly drawings with GD&T and annotations. *(LO 3.1, LO 3.2)*
4. Apply CAD data exchange formats for interoperability. *(LO 4.1, LO 4.2)*
5. Create a 3D model using CAD software and process the same for printing the object. *(LO 5.1)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MEMDL601.1	3	3	--	--	3	--	--	--	3	--	--
MEMDL601.2	3	3	3	--	3	--	--	--	3	--	--
MEMDL601.3	3	3	--	--	3	--	--	--	3	--	--
MEMDL601.4	3	3	--	--	3	--	--	--	3	--	--
MEMDL601.5	--	3	3	--	3	--	--	--	3	--	--
Average	**3**	**3**	**3**	**--**	**3**	**--**	**--**	**--**	**3**	**--**	**--**

NOTE: CO can be mapped to PO at level 3 if at least two PIs are associated with that CO; otherwise, it can be mapped at level 2.

Text Books :

1. CAD/CAM: Principles and Applications, P.N. Rao, McGraw Hill, 4th Edition.
2. Computer-Aided Design and Manufacturing, M.P. Groover & E.W. Zimmers, Pearson, 1st Edition.

Reference Books :

1. Engineering Drawing and Graphics Using AutoCAD, T. Jeyapoovan, Vikas Publishing, 6th Edition.
2. Mastering CAD/CAM, Ibrahim Zeid, McGraw Hill, 1st Edition.

Other Resources :

1. NPTEL Course: Computer Aided Design and Manufacturing, By Prof. S. K. Saha, IIT Delhi.
   Web link: https://archive.nptel.ac.in/courses/112/102/112102304/
2. NPTEL Course: Engineering Drawing and Computer Graphics, By Prof. M. S. Bobji, IISc Bangalore.
   Web link: https://archive.nptel.ac.in/courses/112/108/112108158/

IN-SEMESTER ASSESSMENT (25 MARKS)

Continuous Assessment (25 Marks)

Suggested breakup of distribution

Practical performance based on all the experiments mentioned in the syllabus with proper understanding	: 10 marks
Reverse engineering Group project (maximum 4 students)	: 10 marks
Regularity and active participation	: 05 marks

END SEMESTER EXAMINATION (25 MARKS)

Students will be assessed based on three parameters:

- Machine Drawing Concept/ CAD knowledge
- CAD Skills
- Oral

- Students will be randomly allocated with a detail/assembly drawing of mechanical system/structure having minimum 4 to maximum 7 components (excluding standard components).
- Students will be asked to create CAD models of the parts, build CAD assembly and generate production drawing for the same using CAD tools.

Students will be getting 2 Hours to complete the task including print outs.

Two examiners, one Internal and one External will do the evaluation, based on printout and oral exam.

The evaluation breakup is given below:

- Creation of CAD Models : 05 Marks
- Building CAD Assembly : 05 Marks
- Generation of a Production Drawing : 05 Marks
- Oral Examination : 10 Marks