25MMET401	MATERIALS AND DESIGN FOR 3D PRINTING	Category	L	T	P	R	Credit	Year of Introduction
		VAC	4	0	0	0	4	2025

Preamble: This course introduces the fundamentals of materials and design considerations used in 3D printing and additive manufacturing. It covers various printing technologies, materials used for additive manufacturing, and design principles for optimizing printed components. The course also highlights process parameters, post-processing techniques, and industrial applications of 3D printing in modern engineering.

Pre-requisite: 25MMET401 Introduction to Smart Manufacturing

Course Outcomes: After the completion of the course, the student will be able to:

CO	Course Outcomes	Knowledge Level
CO1	Explain the fundamentals of additive manufacturing and 3D printing technologies.	K2 Understand
CO2	Explain the materials used in 3D printing and their properties.	K2 Understand
CO3	Apply additive manufacturing design guidelines to optimize material usage, build orientation and assembly for 3D printing applications.	K3 Apply
CO4	Apply design principles for developing components using additive manufacturing.	K3 Apply

Mapping of course outcomes with program outcomes and program specific outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1		-	-	-	-	-	-	-	-	2	-
CO2	2	2		-	-	-	-	-	-	-	-	2	-
CO3	2	2	1	-	1	-	-	-	-	-	-	2	-
CO4	2	2	3	-	1	-	-	-	-	-	-	3	2
Avg	2.25	1.75	2	-	1	-	-	-	-	-	-	2.25	2

Mapping of course outcomes with Knowledge and Attitude Profile (WK)

	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CO1	*	*		*					
CO2	*			*	*		*		
CO3	*				*	*		*	
CO4	*			*		*		*	*

WKs Mapped with the course

WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
*	*		*	*	*	*	*	*

Mark Distribution:

Total Marks	CIE Marks	ESE Marks	ESE Duration
100	**40**	**60**	**2.5 hrs**

Continuous Internal Evaluation Pattern:

Attendance : 5 marks
Continuous Assessment Test : 20 marks
Continuous Assessment Assignment : 15 marks

SYLLABUS

Module 1 (14 hrs)

Introduction to additive manufacturing – Evolution of manufacturing technologies – Comparison between conventional manufacturing and additive manufacturing – Basic principles of 3D printing – Process chain in additive manufacturing – CAD modelling and file preparation (STL format) – Slicing and tool path generation – Overview of major 3D printing technologies: FDM, SLA, SLS, Binder Jetting, Material Jetting and DED – Advantages, limitations and industrial applications of 3D printing.

Module 2 (14 hrs)

Material requirements for additive manufacturing – Polymers used in 3D printing (PLA, ABS, PETG, Nylon, TPU) – Metal powders for additive manufacturing – Ceramic and composite materials – Powder characteristics and material properties – Material behaviour during printing – Material selection for additive manufacturing – Mechanical and thermal properties of printed parts – Recycling and sustainability aspects of 3D printing materials.

Module 3 (14 hrs)

Design principles for additive manufacturing – Design guidelines for 3D printing – Topology optimization – Lattice structures and lightweight design – Design for support structures – Design for

minimum material usage – Part orientation and build strategy – Design for assembly and part consolidation – Case studies in design optimization for additive manufacturing.

Module 4 (14 hrs)

Process parameters affecting 3D printing – Layer thickness, printing speed, temperature, infill density and orientation – Dimensional accuracy and surface finish – Defects in printed parts – Post-processing techniques (heat treatment, machining, polishing, surface coating) – Testing and quality control of printed parts – Industrial applications in aerospace, automotive, biomedical and consumer products – Emerging trends in additive manufacturing and hybrid manufacturing.

Text Books:

1. Gibson, I., Rosen, D., Stucker, B., & Khorasani, M., Additive Manufacturing Technologies: *3D Printing, Rapid Prototyping and Direct Digital Manufacturing*, 3rd Edition, Springer, 2021.
2. Gebhardt, A., *3D Printing: Understanding Additive Manufacturing*, 2nd Edition, Hanser Publishers, 2012.
3. Awari, G.K., Thorat, V.S., Ambade, S.B., & Kothari, A., *Additive Manufacturing and 3D Printing Technology: Principles and Applications*, CRC Press / Routledge, 2021.

Reference Books:

1. Leary, M., *Design for Additive Manufacturing*, 2nd Edition, Elsevier, 2025.
2. Chua, C.K., Leong, K.F., & Lim, C.S., *3D Printing and Additive Manufacturing: Principles and Applications*, 4th Edition, World Scientific, 2017.
3. Bandyopadhyay, A., & Bose, S., *Additive Manufacturing*, 2nd Edition, CRC Press, 2019.
4. Redwood, B., Schöffer, F., & Garret, B., *The 3D Printing Handbook: Technologies, Design and Applications*, 1st Edition, 3D Hubs / Wiley, 2017.

END SEMESTER EXAMINATION - MODEL QUESTION PAPER

Course Code	**25MMET401**
Course Name	**Materials and Design for 3D Printing**
Max. Marks: 60	**Duration: 2.5 Hours**

Part A
(Answer all questions. Each question carries 3 marks)

Qn No.	Question	Marks	CO	BL
1	Compare conventional manufacturing and additive manufacturing with suitable examples.	3	1	L2
2	Explain the process chain involved in additive manufacturing from CAD modelling to finished part.	3	1	L2
3	Discuss the properties and applications of PLA and ABS materials used in 3D printing.	3	2	L2

4	Explain the importance of powder characteristics in metal additive manufacturing.	3	2	L2
5	Describe the concept of topology optimization and its significance in additive manufacturing.	3	3	L2
6	Explain the role of part orientation in influencing print quality and build performance.	3	3	L2
7	Discuss the effect of layer thickness and infill density on the quality of 3D printed components.	3	4	L2
8	Explain any three post-processing techniques used to improve the performance of 3D printed parts.	3	4	L2
Part B (Answer any one full question from each Module. Each carry 9 marks)				
Module I				
Qn No.	**Question**	**Marks**	**CO**	**BL**
9	Explain the working principles, advantages, limitations and industrial applications of FDM, SLA and SLS technologies with suitable illustrations.	9	1	L2
OR				
10	Describe the complete workflow of additive manufacturing, including CAD modelling, STL file generation, slicing, tool path generation and final printing. Explain the importance of each stage.	9	1	L2
Module II				
Qn No.	**Question**	**Marks**	**CO**	**BL**
11	Explain the selection criteria for materials used in additive manufacturing. Discuss the mechanical, thermal and sustainability aspects of polymers, metals and composites used in 3D printing.	9	2	L2
OR				
12	Compare PLA, ABS, PETG, Nylon and TPU with respect to material properties, printability, applications and performance in additive manufacturing.	9	2	L2
Module III				
Qn No.	**Question**	**Marks**	**CO**	**BL**

13	Redesign a conventional assembly for additive manufacturing by applying lattice structures, support structure considerations, and part consolidation strategies.	9	3	L3
OR				
14	Apply topology optimization and build orientation principles to optimize a 3D printed component for improved performance, weight reduction, and manufacturability, and justify the selected design strategy using suitable case studies.	9	3	L3
Module IV				
Qn No.	**Question**	**Marks**	**CO**	**BL**
15	Apply suitable additive manufacturing process parameters to minimize dimensional errors and enhance the surface finish and strength of a printed part.	9	4	L3
OR				
16	Apply appropriate defect identification, quality control, and post-processing techniques to improve the quality and performance of 3D printed components for aerospace, automotive, and biomedical applications.	9	4	L3