Naan Mudhalvan – Polytechnic – Even Semester 2024-25
4th Semester – Course Curriculum

ABOUT THE COURSE

COURSE NAME:	Additive Manufacturing
TOTAL DURATION:	60 HRS
MODE OF DELIVERY	PHYSICAL CLASSROOM TRAINING AT RESPECTIVE COLLEGES
TRAINER TO STUDENT RATIO:	1:60
TOTAL MARKS:	70 (External) + 30 (Internal) **(Final Assessment shall be done by TNSDC)**

TABLE 1	
OVERALL COURSE OBJECTIVE:	• Analyse the fundamental principles of additive manufacturing, including how 3D printing creates objects layer by layer. • Apply various additive manufacturing technologies such as Fused Deposition Modeling (FDM), Selective Laser Sintering (SLS), Stereolithography (SLA), and Selective Laser Melting (SLM). • Evaluate the differences, advantages, and limitations of each technology and how to select the appropriate one for different applications. • Analyse the wide range of materials used in AM, including plastics, metals, ceramics, and composite.
LEARNING OUTCOME:	• Application of various types of additive manufacturing technologies and select the right process for a given application based on material, geometry, and other factors. • Design and prepare 3D models for additive manufacturing, ensuring they are optimized for printing, minimizing errors and material waste. • Analyse the properties and applications of different AM materials, and the ability to choose the right material for specific use cases, balancing performance and cost. • Develop skills in various post-processing methods, allowing students to finish printed parts to meet required tolerances and surface finishes • Analyse real-world applications of additive manufacturing across different industries

	and assess its potential for solving complex manufacturing challenges.

TABLE 2: MODULE-WISE COURSE CONTENT AND OUTCOME				
SL. NO	**MODULE NAME**	**MODULE CONTENT**	**MODULE LEARNING OUTCOME**	**DURATIO N (HRS)**
1	Introduction to Additive Manufacturi ng	Overview of Additive Manufacturing (AM); History, Types of AM, Applications in various industries (Aerospace, Automotive, Medical, etc.).	Analyse the concept of Additive Manufacturing and its historical evolution. Identify various types of 3D printing technologies and their industrial applications.	3
2	AM Technologies and Processes	Detailed study of AM technologies: FDM (Fused Deposition Modeling), SLA (Stereolithograph y), SLS (Selective Laser Sintering), and others.	Apply the working principles of various 3D printing processes. Identify suitable applications for each AM technology.	6
3	Materials for Additive Manufacturi ng	Materials used in AM: Polymers, Metals, Ceramics, and Composite materials. Material properties, selection criteria, and challenges.	Evaluate different materials used in AM and their specific properties. Learn how to select materials based on process and application	5
4	CAD Modeling for Additive Manufacturi ng	Introduction to Computer-Aided Design (CAD); Designing for Additive Manufacturing (DFAM). Software tools used for 3D modeling (AutoCAD, SolidWorks, etc.).	Application of the principles of CAD and how to design parts for 3D printing. Apply the techniques to optimize designs for AM processes (e.g., minimizing material use, ensuring printability).	6
5	Slicing Software and 3D Printing Setup	Introduction to slicing software; Process of converting CAD files into STL format; Setting	Use slicing software to convert 3D models for AM. Understand the importance of correct setup for 3D printers to	5

		up 3D printers; Layer-based printing.	ensure high-quality prints.	
6	Post-Processing Techniques	Techniques after printing: Support removal, polishing, curing, surface finishing, and quality checks.	Implement post-processing steps in AM, and learn how to achieve the desired finish and mechanical properties of 3D printed parts	4
7	Design for Additive Manufacturing (DFAM)	In-depth study of design considerations for AM: Geometry, support structures, orientation, overhangs, and infill patterns.	Design components effectively for AM processes by considering factors like part orientation, support structures, and geometry for minimizing waste and improving strength.	6
8	Applications of Additive Manufacturing	Real-world applications of AM in industries such as automotive, aerospace, medical devices, consumer goods, and architecture. Case studies of successful applications	Evaluate various industrial applications of AM, learn through case studies, and identify new opportunities for innovation using 3D printing.	4
9	Challenges and Future Trends	Challenges in AM: Speed, cost, material limitations, quality control, and scalability. Future trends in AM including multi-material printing, AI integration, and sustainable AM.	Identify the challenges currently faced by the AM industry. Apply the emerging trends and future directions for AM technologies.	3
10	Practical Demonstration and Hands-on Project	Hands-on training: Setting up a 3D printer, printing a simple object, post-processing techniques. Practical project development.	Apply knowledge of 3D printing technologies and processes to complete a hands-on project, from design to printing and post-processing.	5

TABLE 3: OVERALL COURSE LEARNING OUTCOME ASSESSMENT CRITERIA AND USECASES			
LEARNING OUTCOME	**ASSESSMENT CRITERIA**	**PERFORMANCE CRITERIA**	**USECASES**
Understanding Additive Manufacturing Concepts	Knowledge of AM technologies and processes.	Correctly identify and explain different 3D printing processes (FDM, SLA, SLS, etc.) and their applications	Automotive part prototyping, Aerospace lightweight structures.
Mastery of AM Technologies	Ability to select appropriate AM technology based on material and design requirements.	Demonstrate the ability to choose the correct AM process (e.g., FDM for prototypes, SLS for durable parts).	Creating custom prosthetics, Manufacturing of tooling and molds.
Material Selection for AM	Understanding material properties and selection.	Show proficiency in selecting materials based on strength, flexibility, thermal resistance, and cost.	Medical implants, Aerospace components, Functional prototypes.
Design for Additive Manufacturing (DFAM)	Application of DFAM principles in CAD modeling.	Design parts that are optimized for 3D printing (e.g., minimizing material usage, reducing the need for support).	Creating intricate geometries for customized products, Designing lightweight structures for drones.
Slicing and 3D Printing Setup	Ability to use slicing software and	Successfully slice a 3D model and	3D printing a mechanical part,

	configure 3D printers.	configure the 3D printer for efficient printing.	Printing of architectural models.

TABLE 4: LIST OF FINAL PROJECTS (20 PROJECTS THAT COMPREHENSIVELY COVER ALL THE LEARNING OUTCOME)	
SL.NO	**FINAL PROJECT**
1	**Rapid Prototyping** • Task 1: Design a digital model of the product or component. • Task 2: Slice the model into layers using slicing software. • Task 3: Print the prototype using a 3D printer. • Task 4: Perform a functional test on the prototype to check its design. • Task 5: Refine the design based on feedback and print the revised prototype
2	**Custom Medical Implants** • Task 1: Obtain a 3D scan of the patient's anatomy (e.g., CT or MRI). • Task 2: Design a custom implant based on the scan data. • Task 3: Export the design as an STL file for printing. • Task 4: Print the implant using biocompatible materials. • Task 5: Conduct post-print quality control tests and prepare the implant for surgery.
3	**Aerospace Components** • Task 1: Design complex, lightweight parts for aerospace applications. • Task 2 : Optimize the part for strength and material usage using software. • Task 3: Slice the design for 3D printing and choose the appropriate material. • Task 4 : Print the part using metal 3D printing or another suitable method. • Task 5: Conduct performance testing, including stress and thermal tests.
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5	Customized Footwear • Task 1: Scan the customer's feet to capture shape and size. • Task 2: Design a custom shoe or sole using CAD software. • Task 3: Choose materials suitable for footwear (e.g., TPU for flexibility). • Task 4: Print the customized footwear. • Task 5: Perform a wear test to ensure comfort and performance.
6	**Jewellery Design** • Task 1: Design intricate jewellery pieces using CAD tools. • Task 2: Create a 3D model of the piece, incorporating design features like texture. • Task 3: Convert the model into an STL file for 3D printing. • Task 4: Print the jewellery using a resin printer or metal printer (for casting). • Task 5: Post-process the printed jewellery, including polishing and finishing.
7	**Spare Parts on Demand** Task 1: Identify the broken or obsolete part needed. Task 2: Design a digital model of the replacement part. Task 3: Choose the correct material for the part (e.g., metal, plastic). Task 4: Print the part to specifications. Task 5: Install the part in the machinery or equipment.
8	**Tooling and Jigs** • Task 1: Design custom tooling, jigs, or fixtures based on production requirements. • Task 2: Create 3D models of the parts using CAD software. • Task 3: Print the tools using durable materials such as nylon or carbon fiber. • Task 4: Test the functionality and accuracy of the tools. • Task 5: Adjust the design if necessary and reprint for further testing.
9	**Construction and Architecture** • Task 1: Design building models or architectural elements using CAD tools. • Task 2: Use 3D printing to produce scaled models for presentations. • Task 3: Optimize design structures for material efficiency and strength. • Task 4: Print detailed architectural models with concrete or composite materials. • Task 5: Assemble the printed components in a construction setting for full-scale implementation.
10	**Aerospace Heat Exchangers** Task 1: Design complex heat exchanger components with optimized airflow. • Task 2: Use software to simulate thermal performance. • Task 3: Choose the material (e.g., titanium or aluminium) for heat resistance.

	• Task 4: Print the heat exchanger with intricate lattice structures. • Task 5: Test the heat exchanger’s performance under operating conditions.
11	**Educational Models** Task 1: Identify the educational need for a specific 3D model (e.g., anatomy, molecular structure). • Task 2: Design or source educational 3D models. • Task 3: Print the models using educational-grade materials. • Task 4: Conduct classroom demonstrations with printed models. • Task 5: Update or iterate on designs based on feedback and new learning objectives.
12	**Customized Eyewear** Task 1: Take precise measurements of the customer's face and eyes. • Task 2: Design a custom eyewear frame using CAD software. • Task 3: Choose suitable materials (e.g., flexible polymers or lightweight metals). • Task 4: Print the eyewear frame using 3D printing technology. • Task 5: Fit the lenses into the frame and test for comfort and functionality
13	**Art and Sculpture** • Task 1: Design the artwork or sculpture using 3D modeling software. • Task 2: Choose the appropriate material for the sculpture (e.g., resin, PLA). • Task 3: Slice the design for 3D printing. • Task 4: Print the artwork layer by layer. • Task 5: Post-process the printed sculpture, including sanding, painting, and finishing.
14	**Consumer Electronics Enclosures** • Task 1: Design protective enclosures for electronics. • Task 2: Optimize the design for airflow, heat dissipation, and accessibility. • Task 3: Choose materials that are durable and heat-resistant (e.g., ABS, polycarbonate). • Task 4: Print the enclosure and assemble it with the internal electronic components. • Task 5: Test the enclosure’s performance, including temperature regulation and durability.
15	**Low-Volume Manufacturing** • Tasks: 1. Design a product for low-volume production. 2. Create a digital model and select the best material for the product. 3. Use slicing software to prepare the model for printing. 4. Print multiple units of the product in one print session. 5. Inspect the parts for quality and prepare them for shipping.
16	**Automotive Tooling & Prototyping** • Task 1: Design automotive components or tools using CAD. • Task 2: Choose materials that match the functional needs of the part (e.g., strong composites).

	• Task 3: Print prototypes or low-volume parts for testing. • Task 4: Assemble the parts into an automotive prototype or production model. • Task 5: Test the prototypes for fit, function, and performance in Real world automotive conditions.
17	**Food Production** • Task 1: Design 3D printable food items using CAD software. • Task 2: Select appropriate edible materials (e.g., chocolate, dough, or sugar). • Task 3: Print the food products layer by layer using food-safe 3D printers. • Task 4: Ensure food safety and hygiene during the production process. • Task 5: Package and present the food products for consumption or sale.
18	**Metal 3D Printing for Tooling** • Task 1: Design specialized metal tools for specific manufacturing needs. • Task 2: Choose the appropriate metal for the tool (e.g., steel, titanium). • Task 3: Slice the design to optimize it for metal 3D printing. • Task 4: Print the metal tools using a laser or electron beam melting process. • Task 5: Post-process the printed metal tools with heat treatment or finishing.
19	**Spare Parts for Obsolete Machinery** • Task 1: Identify obsolete or damaged machinery parts that need replacement. • Task 2: Reverse engineer the part by scanning or measuring it. • Task 3: Create a 3D model of the part using CAD software. • Task 4: Print the replacement part using the same material or a suitable alternative. • Task 5: Install and test the replacement part in the machinery for proper functionality.
20	**Development of Custom Prosthetics Using 3D Printing** Task 1: Understand the functional and aesthetic needs of prosthetic users. Task 2: Create a 3D design of a custom prosthetic limb based on user-specific data. Task 3: Print and assemble the prosthetic limb based on the CAD design. Task 4: Test the prosthetic limb’s performance and gather feedback from the user. Task 5: Choose suitable materials for 3D printing that balance strength, flexibility, and cost.

TABLE 5: COURSE ASSESSMENT RUBRICS (TOTAL MARKS: 70)				
ASSESSMENT CRITERIA	**DESCRIBE THE CRITERIA OF THE BELOW CATEGORY PERFORMANCE**			**TOTAL MARKS**
	FAIR	**GOOD**	**EXCELLENT**	
1.Understanding of Additive Manufacturing Principles	Basic understanding of key AM technologies, but lacks depth.	Solid understanding of AM principles with some application examples.	Deep understanding of AM technologies, clear articulation of process, and real-world examples.	10
2. Design for Additive Manufacturing (DFAM)	Able to design simple parts but struggles with optimization for AM.	Designs functional parts considering some DFAM principles.	Demonstrates advanced design skills, optimizing parts for 3D printing.	10
3. Material Selection and Application	Limited knowledge of material properties and selection for AM.	Correct material selection based on properties and application needs.	Expert material selection, considers performance, cost, and application suitability.	10
4. 3D Printing and Slicing Software Usage	Basic operation of slicing software and printer setup.	Able to slice models and set up printers with few errors.	Expert use of slicing software and printer configuration with minimal issues.	10
5.Post-Processing Techniques	Limited understanding of post-processing methods.	Knowledge of basic post-processing techniques.	Comprehensive understanding and application of advanced post-processing methods	5
6. Practical Application and Prototyping	Completed the project with minimal application of learned skills.	Prototyped a functional part, demonstrating reasonable design choices.	Successfully developed and tested a high-quality functional prototype.	10
7. Problem-Solving and Troubleshooting	Struggles with identifying and solving issues during printing.	Can troubleshoot common issues and find reasonable solutions.	Demonstrates critical thinking and advanced problem-solving techniques in real-world scenarios.	5

8.Industry Applications and Use Cases	Shows limited understanding of AM applications in industry.	Adequately explains common industrial applications of AM.	Demonstrates a comprehensive understanding of innovative and emerging AM applications.	5
9.Communication of Results and Reporting	Basic report with minimal analysis and explanation.	Clear and coherent report with thorough analysis of the results.	Detailed, clear, and professional report with insightful analysis and recommendations.	5

Category	Assessment Criteria	Performance Levels	Weightage (Marks)
Practical Skills Proficiency	Demonstrates the ability to perform job-specific tasks effectively, using relevant tools, techniques, or methodologies (e.g., operating 3D printers, using slicing software, post-processing techniques).	Fair, Good, Excellent	20
Technical Knowledge Application	Applies theoretical concepts to practical scenarios with accuracy and relevance (e.g., designing for 3D printing, material selection, AM processes, and design optimization).	Fair, Good, Excellent	15
Project Execution	Completes assigned projects or use cases demonstrating innovation, thoroughness, and skill application relevant to industry standards (e.g., creating functional prototypes, customizing designs).	Fair, Good, Excellent	25
Communication and Reporting	Clearly presents findings, solutions, or project outcomes using professional communication and documentation standards (e.g., technical reports, presentations, design documentation).	Fair, Good, Excellent	10