ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY

(AUTONOMOUS)

(Anjugramam-Kanyakumari Main Road, Palkulam,Variyoor P.O.-629 401, K.K.Dist.)

Approved by AICTE, New Delhi and Affiliated to Anna University, Chennai

Accredited with A+ Grade by NAAC

Minor Degree Course

3D PRINTING

Curriculum & Syllabus

(*2024-2025 Admitted Students Onwards*)

Proceedings of the 3rd Academic Council [28.11.2025]

CREDIT INFO		
Sl.No	**Category**	**Credits**
1	**Minor Courses**	**18**

CREDIT DISTRIBUTION

Course Category	**Credit/Semester**								**No. of Credits**
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	
Minor Courses					**6**	**6**	**6**	**-**	**18**

Minor in 3D Printing							
Sl.no	Course Code	Course Title	Course Type	L	T	P	Credit
1.	24 3D 501	Fundamentals of 3D Printing and Digital Manufacturing	PEC	3	0	0	3
2.	24 3D 502	3D Modelling, CAD and Additive Manufacturing Design	PEC	3	0	0	3
3.	24 3D 601	Materials, Processes and Quality Control In 3D Printing	PEC	2	0	2	3
4.	24 3D 602	Smart Additive Manufacturing, AI and Digital Twin	PEC	3	0	0	3
5.	24 3D 701	Biomedical, Electronics and Industrial Applications of 3D Printing	PEC	3	0	0	3
6.	24 3D 702	3D Printing Applications In Smart Engineering Systems	PEC	1	0	4	3

Course Code:	24 3D 501	Course Title:	FUNDAMENTALS OF 3D PRINTING AND DIGITAL MANUFACTURING
Credits:	3	L – T – P	3 – 0 – 0

Course objectives:

The course enables the students to:

- Understand the fundamentals of 3D printing, additive manufacturing, and digital manufacturing technologies used in modern industries.
- Explain the workflow of additive manufacturing, including digital design, slicing, printing, and post-processing techniques.
- Apply different 3D printing technologies, materials, and process parameters for rapid prototyping and customized product development.
- Analyze the role of Industry 4.0, Industry 5.0, smart manufacturing, and sustainability in digital production systems.
- Design simple engineering prototypes using CAD models and 3D printing software for multidisciplinary engineering applications.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Interactive Lectures with Industrial Case Studies
2. Demonstration of 3D Printing Technologies
3. Hands-on CAD and Slicing Software Sessions
4. Project-Based Learning
5. Problem-Based Learning
6. Flipped Classroom
7. Laboratory-Based Prototype Development
8. Industry Expert Talks
9. Collaborative Design Activities
10. Mini Projects and Technical Presentations

UNIT I – INTRODUCTION TO 3D PRINTING AND DIGITAL MANUFACTURING	[9 hours]

Evolution of Manufacturing – Conventional Manufacturing versus Additive Manufacturing – Fundamentals of 3D Printing – Digital Manufacturing Concepts – Product Development Lifecycle – Rapid Prototyping – Rapid Tooling – Rapid Manufacturing – Industry 4.0 and Industry 5.0 – Mass Customization – Applications of 3D Printing in Healthcare, Electronics, Aerospace, Robotics, Agriculture, Consumer Products, and Smart Manufacturing.

UNIT II – ADDITIVE MANUFACTURING TECHNOLOGIES AND WORKFLOW	[9 hours]
Additive Manufacturing Workflow – CAD Model Preparation – STL and 3MF File Formats – Slicing Concepts – Tool Path Generation – Layer-by-Layer Fabrication – Fused Deposition Modeling (FDM) – Stereolithography (SLA) – Selective Laser Sintering (SLS) – Material Jetting – Binder Jetting – Direct Metal Printing (Concepts) – Process Selection Criteria – Printer Calibration – Build Orientation and Support Structures.	

UNIT III – MATERIALS FOR 3D PRINTING AND PROCESS PARAMETERS	[9 hours]
Materials for Additive Manufacturing – Thermoplastics (PLA, ABS, PETG, TPU) – Photopolymer Resins – Metal Powders – Ceramic Materials – Composite Materials – Biomaterials – Filament Properties – Material Selection – Printing Parameters – Layer Height – Infill Density – Print Speed – Nozzle Temperature – Bed Temperature – Surface Finish – Print Defects – Quality Control and Testing.	

UNIT IV- DIGITAL DESIGN, SLICING AND POST-PROCESSING	[9 hours]
Introduction to CAD for 3D Printing – Design for Additive Manufacturing (DfAM) – Parametric Modeling Concepts – Reverse Engineering – 3D Scanning (Overview) – Mesh Repair – Slicing Software – Print Preview – Build Optimization – Post-Processing Techniques – Surface Finishing – Assembly – Inspection and Dimensional Verification – Cost Estimation – Sustainable Manufacturing Practices.	

UNIT V- APPLICATIONS OF 3D PRINTING IN SMART ENGINEERING SYSTEMS	[9 hours]
3D Printing in Smart Manufacturing – Biomedical Implants and Prosthetics – Electronics Enclosures and IoT Devices – Robotics Components – Drone Parts – Automotive and Aerospace Components – Precision Agriculture Tools – Customized Consumer Products – Educational Prototypes – Digital Twin Integration – AI-Assisted Additive Manufacturing – Sustainable Product Design – Entrepreneurship Opportunities – Engineering Case Studies.	

Course outcomes:
On completion of the course, the student will have the ability to:

CO1	Explain the principles, workflow, and applications of additive manufacturing and digital manufacturing in modern engineering.	K2
CO2	Select suitable 3D printing technologies, materials, and process parameters for engineering product development.	K3
CO3	Develop digital models and prepare printable files using slicing software for additive manufacturing.	K3
CO4	Analyze the quality, sustainability, and economic aspects of 3D printing in industrial and engineering applications.	K4
CO5	Design and fabricate simple prototypes using digital manufacturing tools to solve real-world engineering problems.	K5

COs and POs Mapping:

CO NO	Course Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	2	-	1	-	-	-	-	1
CO2	3	3	2	-	3	-	1	-	-	-	-	1
CO3	2	2	3	2	3	-	1	-	-	-	-	2
CO4	2	3	1	2	2	1	3	-	-	-	1	2
CO5	2	3	3	2	3	1	2	-	2	2	1	3

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

Component	**Type of assessment**	**Max Marks**	**Reduced Marks**	**Total**	**Final marks**
Continuous Internal Examination (CIE)	CIE – I	100	60	100	40
	CIE – II	100			
	Skill Assessment – I	40	40		
	Skill Assessment - II	40			
End Semester Examination (ESE)	Theory Exam	100	60	60	60
				Total	100

End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

Text Books:

1. Ian Gibson, David Rosen and Brent Stucker, Additive Manufacturing Technologies, 3rd Edition, Springer, 2021.
2. Andreas Gebhardt and Jan-Steffen Hötter, Additive Manufacturing: 3D Printing for Prototyping and Manufacturing, Hanser Publications, 2016.
3. Chee Kai Chua and Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications, 5th Edition, World Scientific, 2023.

Reference Books:

1. Neil Hopkinson, Richard Hague and Philip Dickens, Rapid Manufacturing: An Industrial Revolution for the Digital Age, Wiley.
2. John M. Jordan, 3D Printing, MIT Press Essential Knowledge Series.
3. Lihui Wang and Kai Ding, Cloud-Based Cyber-Physical Systems in Manufacturing, Springer.
4. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson.
5. Milan Brandt (Ed.), Laser Additive Manufacturing: Materials, Design, Technologies and Applications, Woodhead Publishing.

Suggested Skill Activities:

Students shall complete the following laboratory and skill-oriented activities.

1. Create simple 3D CAD models using Fusion 360 or FreeCAD.
2. Convert CAD models into STL/3MF formats for additive manufacturing.
3. Prepare print files using slicing software such as Cura or PrusaSlicer.
4. Optimize print orientation, support structures, and process parameters.
5. Fabricate prototypes using FDM or SLA 3D printers.
6. Measure and evaluate dimensional accuracy of printed components.
7. Analyze the effects of layer height, infill, and print speed on product quality.
8. Perform basic post-processing and surface finishing of printed parts.
9. Develop a customized engineering prototype for a multidisciplinary application.
10. Complete a mini project on product development using digital manufacturing.

Course Code:	24 3D 502	Course Title:	3D MODELLING, CAD AND ADDITIVE MANUFACTURING DESIGN
Credits:	**3**	**L – T – P**	**3 – 0 – 0**

Course objectives:

The course enables the students to:

- Understand the principles of Computer-Aided Design (CAD), 3D modelling, and Design for Additive Manufacturing (DfAM) for product development.
- Develop parametric 3D models, assemblies, and engineering components using modern CAD software.
- Apply Design for Additive Manufacturing (DfAM), topology optimization, lattice structures, and lightweight design techniques for additive manufacturing.
- Prepare digital models for additive manufacturing using slicing software, print optimization, and build preparation techniques.
- Design innovative engineering products suitable for 3D printing in healthcare, electronics, robotics, agriculture, and smart manufacturing applications.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Interactive Lectures with Industrial Product Design Case Studies
2. Hands-on CAD Modelling Sessions
3. Laboratory-Based Product Design Exercises
4. Demonstration of Slicing and Build Preparation Software
5. Project-Based Learning
6. Problem-Based Learning
7. Flipped Classroom
8. Collaborative Design Workshops
9. Industry Expert Lectures
10. Mini Projects and Technical Presentations

UNIT I – FUNDAMENTALS OF CAD AND 3D MODELLING	[9 hours]
Introduction to Computer-Aided Design (CAD) – Product Design Process – Parametric Modelling Concepts – Coordinate Systems – Sketching Techniques – Geometric Constraints – Dimensions – Feature-Based Modelling – Extrude – Revolve – Sweep – Loft – Fillets – Chamfers – Pattern Features – Editing and Modification of 3D Models – Applications in Product Design and Digital Manufacturing.	

UNIT II – ASSEMBLY MODELLING AND DESIGN FOR ADDITIVE MANUFACTURING (DfAM)	[9 hours]
Assembly Modelling – Mating and Constraints – Assembly Analysis – Design Intent – Design for Additive Manufacturing (DfAM) Principles – Part Consolidation – Lightweight Design – Internal Channels – Lattice	

Structures – Support Structure Design – Overhang Considerations – Self-Supporting Geometry – Print Orientation – Functional Product Design – Design Validation.

UNIT III – TOPOLOGY OPTIMIZATION, REVERSE ENGINEERING AND 3D SCANNING	[9 hours]
Topology Optimization Concepts – Generative Design Fundamentals – Weight Reduction Techniques – Structural Optimization – Reverse Engineering Workflow – 3D Scanning Technologies – Point Cloud Processing – Mesh Generation – Mesh Editing – STL Repair – Surface Reconstruction – Model Validation – Product Redesign – Applications in Biomedical, Aerospace, Robotics, and Consumer Products.	

UNIT IV- SLICING, BUILD PREPARATION AND PRINT OPTIMIZATION	[9 hours]
Introduction to Slicing Software – STL and 3MF File Formats – Build Orientation – Layer Height Selection – Infill Patterns – Support Generation – Shell Thickness – Printing Speed – Temperature Settings – G-Code Generation – Print Simulation – Build Time Estimation – Material Consumption Analysis – Print Quality Optimization – Troubleshooting Common Printing Issues.	

UNIT V- CAD AND ADDITIVE MANUFACTURING APPLICATIONS IN SMART ENGINEERING SYSTEMS	[9 hours]
Biomedical Product Design – Prosthetics and Orthotics – Wearable Devices – Robotics Components – Electronics Enclosures – IoT Device Housings – Drone Structures – Smart Agriculture Components – Customized Consumer Products – Sustainable Product Design – AI-Assisted Generative Design – Digital Twin Integration – Engineering Case Studies and Product Innovation.	

Course outcomes:

On completion of the course, the student will have the ability to:

CO1	Develop accurate 3D parametric models and assemblies using CAD software for engineering applications.	K3
CO2	Apply Design for Additive Manufacturing (DfAM) principles to optimize products for additive manufacturing processes.	K3
CO3	Generate printable digital models by performing model validation, mesh optimization, slicing, and build preparation.	K3
CO4	Analyze design alternatives using topology optimization and lightweight design techniques for improved product performance.	K4
CO5	Design innovative prototypes for multidisciplinary engineering applications using CAD and additive manufacturing tools.	K5

COs and POs Mapping:

CO NO	Course Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	3	-	-	-	-	-	-	1
CO2	3	3	3	1	2	-	2	-	-	-	-	1
CO3	2	2	2	2	3	-	1	-	-	-	-	2
CO4	2	3	2	3	2	-	2	-	-	-	1	2
CO5	3	3	3	2	3	1	2	-	2	2	1	3

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

Component	Type of assessment	Max Marks	Reduced Marks	Total	Final marks
Continuous Internal Examination (CIE)	CIE – I	100	60	100	40
	CIE – II	100			
	Skill Assessment – I	40	40		
	Skill Assessment - II	40			
End Semester Examination (ESE)	Theory Exam	100	60	60	60
				Total	100

End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

Text Books:

1. Chee Kai Chua and Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications, 5th Edition, World Scientific, 2023.
2. Ian Gibson, David Rosen and Brent Stucker, Additive Manufacturing Technologies, 3rd Edition, Springer, 2021.
3. Sham Tickoo, Autodesk Fusion 360 for Designers, CADCIM Technologies, Latest Edition.

Reference Books:

1. Andreas Gebhardt and Jan-Steffen Hötter, Additive Manufacturing: 3D Printing for Prototyping and Manufacturing, Hanser Publications.
2. Milan Brandt (Ed.), Laser Additive Manufacturing: Materials, Design, Technologies and Applications, Woodhead Publishing.

3. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson.
4. John M. Jordan, 3D Printing, MIT Press Essential Knowledge Series.
5. Lihui Wang and Kai Ding, Cloud-Based Cyber-Physical Systems in Manufacturing, Springer.

Suggested Skill Activities:

Students shall complete the following laboratory and skill-oriented activities.

1. Develop 2D sketches and parametric 3D models using CAD software.
2. Create assemblies with appropriate mating constraints.
3. Design products following Design for Additive Manufacturing (DfAM) principles.
4. Perform topology optimization for lightweight engineering components.
5. Generate STL files and repair mesh defects.
6. Prepare printable models using Cura or PrusaSlicer.
7. Optimize print orientation, support structures, and slicing parameters.
8. Develop customized enclosures for IoT or embedded systems.
9. Design and fabricate a functional engineering prototype using 3D printing.
10. Complete a mini project on product development for a smart engineering application.

Course Code:	24 3D 601	Course Title:	MATERIALS, PROCESSES AND QUALITY CONTROL IN 3D PRINTING
Credits:	**3**	**L – T – P**	**3 – 0 – 0**

Course objectives:

The course enables the students to:

- Understand the characteristics of materials used in additive manufacturing and their suitability for different engineering applications.
- Explain the working principles, capabilities, and limitations of various 3D printing processes used in product development and manufacturing.
- Apply appropriate material selection and process parameters to produce high-quality 3D printed components.
- Analyze defects, testing methods, quality assurance techniques, and post-processing operations in additive manufacturing.
- Design quality-oriented additive manufacturing workflows for biomedical, electronics, robotics, aerospace, agriculture, and smart manufacturing applications.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Interactive Lectures with Industrial Case Studies
2. Demonstration of Industrial and Desktop 3D Printing Systems
3. Hands-on Laboratory Sessions
4. Material Characterization and Testing Exercises
5. Project-Based Learning
6. Problem-Based Learning
7. Flipped Classroom
8. Industry Expert Lectures
9. Collaborative Design and Testing Activities
10. Mini Projects and Technical Presentations

UNIT I – MATERIALS FOR ADDITIVE MANUFACTURING	[9 hours]
Introduction to Additive Manufacturing Materials – Material Selection Criteria – Thermoplastics (PLA, ABS, PETG, Nylon, TPU, ASA) – Photopolymer Resins – Metal Powders – Ceramic Materials – Composite Materials – Carbon Fiber and Glass Fiber Reinforced Materials – Biomaterials and Biocompatible Polymers – Recycled and Sustainable Materials – Material Properties – Applications in Biomedical, Electronics, Robotics, Aerospace, Agriculture, and Consumer Products.	

UNIT II – ADDITIVE MANUFACTURING PROCESSES	[9 hours]
Classification of Additive Manufacturing Processes – Material Extrusion (FDM/FFF) – Vat Photopolymerization (SLA, DLP) – Powder Bed Fusion (SLS, SLM) – Binder Jetting – Material Jetting – Directed Energy Deposition (DED) – Sheet Lamination – Process Selection Criteria – Machine Components – Build Orientation – Support Structures – Printing Parameters – Industrial Applications and Process Comparison.	

UNIT III – PROCESS OPTIMIZATION AND POST-PROCESSING	[9 hours]
Process Planning – Layer Height Optimization – Infill Density and Patterns – Print Speed – Nozzle and Bed Temperature – Cooling Control – Build Plate Adhesion – Support Removal – Surface Finishing – Sanding and Polishing – Chemical Smoothing – Heat Treatment – UV Curing – Assembly Techniques – Process Optimization for Functional Prototypes and End-Use Products.	

UNIT IV- QUALITY CONTROL, TESTING AND INSPECTION	[9 hours]
Quality Assurance in Additive Manufacturing – Dimensional Accuracy – Surface Roughness – Mechanical Testing – Tensile, Compression and Flexural Testing – Hardness Testing – Non-Destructive Testing (NDT) Concepts – Visual Inspection – Defect Identification – Porosity – Warping – Delamination – Layer Separation – Process Monitoring – Statistical Quality Control – Standards and Certification in Additive Manufacturing.	

UNIT V- ADVANCED MATERIALS AND INDUSTRIAL APPLICATIONS OF 3D PRINTING	[9 hours]
Multi-Material 3D Printing – Functional Materials – Conductive Materials – Flexible Materials – Smart Materials – 4D Printing Concepts – Biomedical Implants and Prosthetics – Electronics Packaging – Robotics Components – Automotive and Aerospace Parts – Precision Agriculture Tools – Sustainable Manufacturing – AI-Based Process Monitoring – Digital Twin for Quality Control – Engineering Case Studies.	

Course outcomes:
On completion of the course, the student will have the ability to:

CO1	Select suitable materials and additive manufacturing processes for engineering products based on functional and performance requirements.	K3
CO2	Apply appropriate process parameters to fabricate high-quality 3D printed components with improved dimensional accuracy and surface finish.	K3
CO3	Analyze defects in additively manufactured parts and recommend suitable quality control and post-processing techniques.	K4
CO4	Evaluate the mechanical, thermal, and functional performance of 3D printed components using standard testing and inspection methods.	K5
CO5	Develop quality-assured additive manufacturing solutions for healthcare, electronics, robotics, agriculture, and smart manufacturing applications.	K5

COs and POs Mapping:

CO NO	Course Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	2	-	1	-	-	-	-	1
CO2	3	2	3	2	3	-	1	-	-	-	-	1
CO3	2	3	2	3	2	-	2	-	-	-	1	2
CO4	2	3	2	3	2	1	2	-	-	-	2	2
CO5	3	3	3	2	3	2	3	-	2	2	2	3

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

Component	Type of assessment	Max Marks	Reduced Marks	Total	Final marks
Continuous Internal Examination (CIE)	CIE – I	100	60	100	40
	CIE – II	100			
	Skill Assessment – I	40	40		
	Skill Assessment - II	40			
End Semester Examination (ESE)	Theory Exam	100	60	60	60
				Total	100

End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

Text Books:

1. Ian Gibson, David Rosen and Brent Stucker, Additive Manufacturing Technologies, 3rd Edition, Springer, 2021.
2. Chee Kai Chua and Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications, 5th Edition, World Scientific, 2023.
3. Andreas Gebhardt and Jan-Steffen Hötter, Additive Manufacturing: 3D Printing for Prototyping and Manufacturing, Hanser Publications, 2016.

Reference Books:

1. Milan Brandt (Ed.), Laser Additive Manufacturing: Materials, Design, Technologies and Applications, Woodhead Publishing.
2. Richard Leach, Fundamentals of Engineering Metrology, CRC Press.
3. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson.
4. Lihui Wang and Kai Ding, Cloud-Based Cyber-Physical Systems in Manufacturing, Springer.
5. ASTM International, ASTM F42 Standards for Additive Manufacturing Technologies (Reference Standard).

Suggested Skill Activities:

Students shall complete the following laboratory and skill-oriented activities.

1. Identify and compare materials used in additive manufacturing.
2. Select suitable materials for specific engineering applications.
3. Optimize print parameters to improve part quality.
4. Fabricate components using FDM and SLA printers.
5. Perform dimensional inspection using measuring instruments.
6. Evaluate surface finish and mechanical properties of printed parts.
7. Analyze common printing defects and recommend corrective actions.
8. Perform post-processing operations including support removal and surface finishing.
9. Prepare a quality assurance report for a 3D printed product.
10. Complete a mini project on process optimization and quality improvement for an engineering component.

Course Code:	24 3D 602	Course Title:	SMART ADDITIVE MANUFACTURING, AI AND DIGITAL TWIN
Credits:	3	L – T – P	3 – 0 – 0

Course objectives:

The course enables the students to:

- Understand the concepts of Smart Additive Manufacturing, Industry 4.0/5.0, Artificial Intelligence, and Digital Twin in modern manufacturing systems.
- Apply AI, Industrial Internet of Things (IIoT), cloud computing, and data analytics for intelligent monitoring and optimization of additive manufacturing processes.
- Develop Digital Twin models for simulation, process monitoring, predictive maintenance, and quality assurance in additive manufacturing.
- Analyze manufacturing data using AI techniques to improve productivity, product quality, resource utilization, and sustainability.
- Design intelligent additive manufacturing solutions integrating AI, Digital Twin, automation, and cloud technologies for multidisciplinary engineering applications.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Interactive Lectures with Industry 5.0 Case Studies
2. Demonstration of Smart Manufacturing Platforms
3. Hands-on Laboratory Sessions using AI and Data Analytics Tools
4. Simulation-Based Learning
5. Project-Based Learning
6. Problem-Based Learning
7. Flipped Classroom
8. Industry Expert Lectures
9. Collaborative Team Activities
10. Mini Projects and Technical Presentations

UNIT I – SMART ADDITIVE MANUFACTURING AND INDUSTRY 5.0	[9 hours]
Evolution of Manufacturing Systems – Industry 4.0 and Industry 5.0 – Smart Manufacturing Concepts – Digital Manufacturing Ecosystem – Smart Factory Architecture – Additive Manufacturing in Smart Factories – Cyber-Physical Systems (CPS) – Industrial Internet of Things (IIoT) – Intelligent Automation – Connected Manufacturing Systems – Sustainability and Circular Manufacturing – Applications of Smart Additive Manufacturing in Healthcare, Electronics, Robotics, Aerospace, Agriculture, and Consumer Products.	

UNIT II – AI AND DATA ANALYTICS FOR ADDITIVE MANUFACTURING	[9 hours]
Artificial Intelligence in Manufacturing – Machine Learning Fundamentals – Data Acquisition from 3D Printers – Manufacturing Data Analytics – Process Monitoring – Defect Detection using AI – Print Failure Prediction – Process Parameter Optimization – Predictive Quality Control – Computer Vision for Print Inspection – Explainable AI in Manufacturing – AI-Based Decision Support Systems.	

UNIT III – DIGITAL TWIN FOR ADDITIVE MANUFACTURING	[9 hours]
Introduction to Digital Twin – Physical and Virtual Models – Digital Thread – Digital Shadow – Digital Twin Architecture – Sensor Integration – Real-Time Data Synchronization – Simulation of Additive Manufacturing Processes – Virtual Commissioning – Process Optimization – Predictive Maintenance – Lifecycle Management – Digital Twin for Smart Production Systems.	

UNIT IV- CLOUD MANUFACTURING, IIoT AND INTELLIGENT AUTOMATION	[9 hours]
Cloud Manufacturing Concepts – Cloud-Based Additive Manufacturing Platforms – Industrial IoT Architecture – Smart Sensors – Edge Computing – Manufacturing Dashboards – Remote Printer Monitoring – Production Scheduling – Resource Optimization – Manufacturing Execution Systems (MES) – AI-Driven Workflow Automation – Cyber Security in Smart Manufacturing – Green Manufacturing Practices.	

UNIT V- SMART ADDITIVE MANUFACTURING APPLICATIONS IN ENGINEERING SYSTEMS	[9 hours]
Biomedical Device Manufacturing – Customized Prosthetics and Implants – Electronics and IoT Device Enclosures – Robotics Components – Aerospace Lightweight Structures – Smart Agricultural Equipment – Customized Consumer Products – Sustainable Manufacturing Solutions – Generative Design – Digital Supply Chain – Entrepreneurship in Additive Manufacturing – Engineering Case Studies and Emerging Trends.	

Course outcomes:
On completion of the course, the student will have the ability to:

CO1	Explain the principles of smart additive manufacturing and the role of AI, IIoT, and Digital Twin in intelligent production systems.	K2
CO2	Apply AI and data analytics techniques to monitor, optimize, and improve additive manufacturing processes.	K3
CO3	Develop Digital Twin models for real-time simulation, process monitoring, and predictive maintenance of 3D printing systems.	K6
CO4	Integrate cloud platforms, intelligent sensors, and IIoT technologies to enable connected and automated additive manufacturing.	K6
CO5	Design AI-enabled smart manufacturing solutions for healthcare, electronics, robotics, aerospace, agriculture, and sustainable product development.	K6

COs and POs Mapping:

CO NO	Course Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	2	-	1	-	-	-	-	1
CO2	3	3	2	2	3	-	2	-	-	-	1	2
CO3	2	3	3	3	3	-	2	-	1	1	2	3
CO4	2	3	3	2	3	1	2	-	2	2	2	3
CO5	3	3	3	2	3	2	3	-	2	2	2	3

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

Component	Type of assessment	Max Marks	Reduced Marks	Total	Final marks
Continuous Internal Examination (CIE)	CIE – I	100	60	100	40
	CIE – II	100			
	Skill Assessment – I	40	40		
	Skill Assessment - II	40			
End Semester Examination (ESE)	Theory Exam	100	60	60	60
				Total	100

End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

Text Books:

1. Ian Gibson, David Rosen and Brent Stucker, Additive Manufacturing Technologies, 3rd Edition, Springer, 2021.
2. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, 2nd Edition, Apress, 2024.
3. Michael Grieves and John Vickers, Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems, Springer.

Reference Books:

1. Milan Brandt (Ed.), Laser Additive Manufacturing: Materials, Design, Technologies and Applications, Woodhead Publishing.
2. Lihui Wang and Kai Ding, Cloud-Based Cyber-Physical Systems in Manufacturing, Springer.
3. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow, 3rd Edition, O'Reilly Media, 2023.
4. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson, 2020.
5. Chee Kai Chua and Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications, 5th Edition, World Scientific, 2023.

Suggested Skill Activities:

Students shall complete the following laboratory and skill-oriented activities.

1. Collect and analyze process data from a 3D printer using sensors or simulation.
2. Develop AI models to predict print defects or print failures.
3. Create a Digital Twin model for a 3D printing workflow using simulation software.
4. Design a dashboard for real-time monitoring of additive manufacturing processes.
5. Optimize printing parameters using AI-based data analysis.
6. Integrate cloud-based monitoring with a 3D printing system.
7. Develop a predictive maintenance model for a desktop 3D printer.
8. Perform computer vision-based quality inspection of printed components.
9. Evaluate sustainability metrics for additive manufacturing processes.
10. Complete a mini project on AI-enabled smart additive manufacturing for an engineering application.

Course Code:	24 3D 701	Course Title:	BIOMEDICAL, ELECTRONICS AND INDUSTRIAL APPLICATIONS OF 3D PRINTING
Credits:	**3**	**L – T – P**	**3 – 0 – 0**

Course objectives:

The course enables the students to:

- Understand the role of additive manufacturing in biomedical, electronics, industrial, and smart engineering applications.
- Apply 3D printing technologies for the design and fabrication of customized biomedical devices, electronic enclosures, industrial components, and functional prototypes.
- Analyze material selection, manufacturing processes, and regulatory requirements for specialized additive manufacturing applications.
- Integrate Artificial Intelligence, Digital Twin, and smart manufacturing concepts into advanced 3D printing applications.
- Design innovative and sustainable additive manufacturing solutions for healthcare, electronics, robotics, aerospace, agriculture, and consumer products.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Interactive Lectures with Industry Case Studies
2. Hands-on CAD and 3D Printing Laboratory Sessions
3. Demonstration of Biomedical and Industrial Applications
4. Project-Based Learning
5. Problem-Based Learning
6. Flipped Classroom
7. Product Design Workshops
8. Industry Expert Lectures
9. Collaborative Team Activities
10. Mini Projects and Technical Presentations

UNIT I – BIOMEDICAL APPLICATIONS OF 3D PRINTING	[9 hours]
Introduction to Biomedical Additive Manufacturing – Medical Imaging to 3D Models – Anatomical Models – Patient-Specific Implants – Prosthetics and Orthotics – Surgical Guides – Dental Applications – Hearing Aids – Tissue Engineering Fundamentals – Bioprinting Concepts – Biomaterials for Medical Applications – Regulatory and Ethical Considerations – Applications in Personalized Healthcare.	

UNIT II – ELECTRONICS, IoT AND ROBOTICS APPLICATIONS	[9 hours]
3D Printed Electronics – Electronic Enclosures – Printed Circuit Board (PCB) Prototyping Concepts – Sensor Housings – IoT Device Prototypes – Embedded System Casings – Wearable Electronics – Robotics Components – Drone Frames – Antenna Structures – Smart Device Prototyping – Rapid Product Development – Design Considerations for Functional Electronics.	

UNIT III – INDUSTRIAL AND ADVANCED MANUFACTURING APPLICATIONS	[9 hours]
Rapid Prototyping – Rapid Tooling – Production of Functional Parts – Lightweight Structures – Topology Optimization Applications – Aerospace Components – Automotive Components – Industrial Fixtures and Jigs – Spare Parts Manufacturing – Customized Industrial Products – Digital Supply Chain – On-Demand Manufacturing – Sustainable Manufacturing Practices.	

UNIT IV- AI, DIGITAL TWIN AND SMART PRODUCT DEVELOPMENT	[9 hours]
Artificial Intelligence in Product Design – Generative Design – AI-Based Process Optimization – Computer Vision for Quality Inspection – Digital Twin for Product Lifecycle Management – Cloud Manufacturing – Predictive Maintenance – Manufacturing Data Analytics – Industrial Internet of Things (IIoT) Integration – Smart Factory Applications – Sustainable Product Development – Entrepreneurship and Product Innovation.	

UNIT V- MULTIDISCIPLINARY APPLICATIONS OF 3D PRINTING	[9 hours]
3D Printing in Agriculture – Smart Irrigation Components – Food Printing Concepts – Consumer Product Development – Fashion and Wearable Products – Construction and Architecture Models – Educational Models – Renewable Energy Components – Assistive Technologies – Disaster Relief Applications – Circular Economy and Sustainable Manufacturing – Engineering Case Studies and Emerging Trends.	

Course outcomes:
On completion of the course, the student will have the ability to:

CO1	Apply additive manufacturing technologies to develop customized biomedical, electronic, and industrial products.	K3
CO2	Select appropriate materials, design methodologies, and fabrication processes for specialized 3D printing applications.	K3
CO3	Develop functional prototypes integrating 3D printing with embedded systems, IoT devices, and robotics.	K6
CO4	Analyze quality, performance, regulatory, and sustainability requirements of additively manufactured products.	K4
CO5	Design innovative multidisciplinary engineering solutions using AI-enabled additive manufacturing and digital manufacturing technologies.	K6

COs and POs Mapping:

CO NO	Course Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	3	2	2	-	1	-	-	2
CO2	3	3	2	1	3	-	2	-	-	-	1	2
CO3	2	3	3	2	3	1	2	-	2	2	1	3
CO4	2	3	2	3	2	2	3	-	-	1	2	2
CO5	3	3	3	2	3	2	3	-	2	2	2	3

Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

Component	Type of assessment	Max Marks	Reduced Marks	Total	Final marks
Continuous Internal Examination (CIE)	CIE – I	100	60	100	40
	CIE – II	100			
	Skill Assessment – I	40	40		
	Skill Assessment - II	40			
End Semester Examination (ESE)	Theory Exam	100	60	60	60
				Total	100

End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

Text Books:

1. Chee Kai Chua and Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications, 5th Edition, World Scientific, 2023.
2. Ian Gibson, David Rosen and Brent Stucker, Additive Manufacturing Technologies, 3rd Edition, Springer, 2021.
3. Andreas Gebhardt and Jan-Steffen Hötter, Additive Manufacturing: 3D Printing for Prototyping and Manufacturing, Hanser Publications.

Reference Books:

1. Milan Brandt (Ed.), Laser Additive Manufacturing: Materials, Design, Technologies and Applications, Woodhead Publishing.
2. Lihui Wang and Kai Ding, Cloud-Based Cyber-Physical Systems in Manufacturing, Springer.
3. John M. Jordan, 3D Printing, MIT Press Essential Knowledge Series.
4. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson.
5. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow, 3rd Edition, O'Reilly Media, 2023.

Suggested Skill Activities:

Students shall complete the following laboratory and skill-oriented activities.

1. Design and fabricate a customized biomedical assistive device.
2. Develop a 3D printed enclosure for an IoT or embedded system.
3. Design and print lightweight robotic components using CAD software.
4. Develop a prototype for an industrial fixture or assembly aid.
5. Perform topology optimization for a functional engineering product.
6. Create a Digital Twin model for a 3D printed product lifecycle.
7. Evaluate dimensional accuracy and functionality of biomedical or industrial prototypes.
8. Develop AI-assisted print quality inspection for fabricated parts.
9. Design a sustainable consumer product using additive manufacturing principles.
10. Complete a multidisciplinary mini project integrating 3D printing, AI, and smart manufacturing.

Course Code:	24 3D 702	Course Title:	3D PRINTING APPLICATIONS IN SMART ENGINEERING SYSTEMS
Credits:	3	L – T – P	1 – 0 – 4

Course objectives:

The course enables the students to:

- Apply additive manufacturing technologies to design and develop innovative engineering products for multidisciplinary applications.
- Integrate CAD, Design for Additive Manufacturing (DfAM), Artificial Intelligence, Digital Twin, and Industrial IoT technologies into smart product development.
- Develop functional prototypes using advanced 3D printing technologies, quality evaluation, and post-processing techniques.
- Analyze the performance, sustainability, cost, and manufacturability of 3D printed products for industrial and societal applications.
- Demonstrate professional competency by designing, fabricating, testing, and presenting industry-oriented additive manufacturing solutions for real-world engineering challenges.

Teaching-Learning Process:

Suggested strategies that teachers may use to effectively achieve the course outcomes:

1. Project-Based Learning
2. Design Thinking Methodology
3. Hands-on 3D Printing Laboratory Sessions
4. Product Innovation Workshops
5. Industry Case Studies
6. Simulation-Based Learning
7. Collaborative Team Projects
8. Industry Expert Lectures
9. Prototype Demonstration and Design Review
10. Capstone Project Presentation

UNIT I – SMART PRODUCT DESIGN AND DIGITAL MANUFACTURING	[9 hours]

Design Thinking for Product Innovation – Product Requirement Analysis – Design for Additive Manufacturing (DfAM) – Parametric Product Design – Reverse Engineering – Rapid Prototyping – Digital Manufacturing Workflow – AI-Assisted Product Design – Generative Design – Product Customization – Sustainable Design – Product Lifecycle Management.

UNIT II – SMART ADDITIVE MANUFACTURING SYSTEMS	[9 hours]
Smart Factory Concepts – Industrial Internet of Things (IIoT) – Connected 3D Printers – Cloud Manufacturing – Manufacturing Execution Systems (MES) – Real-Time Process Monitoring – Sensor Integration – AI-Based Process Optimization – Predictive Maintenance – Computer Vision-Based Quality Inspection – Cyber Security in Smart Manufacturing – Green Manufacturing Practices.	

UNIT III MULTIDISCIPLINARY APPLICATIONS OF 3D PRINTING	[9 hours]
Biomedical Devices and Prosthetics – Electronics Enclosures – IoT Device Prototypes – Robotics Components – Drone Structures – Aerospace Components – Renewable Energy Components – Agricultural Equipment – Smart Consumer Products – Educational Models – Assistive Technologies – Disaster Relief Products – Sustainable Manufacturing Applications.	

UNIT IV DIGITAL TWIN, QUALITY ASSURANCE AND PRODUCT OPTIMIZATION	[9 hours]
Digital Twin for Additive Manufacturing – Virtual Product Validation – Process Simulation – Manufacturing Data Analytics – Product Testing – Dimensional Inspection – Surface Quality Evaluation – Functional Testing – Reliability Assessment – Product Optimization – Life Cycle Assessment – Circular Economy – Engineering Standards – Commercialization of Additive Manufacturing Products.	

UNIT V- CAPSTONE PROJECT: 3D PRINTING SOLUTIONS FOR SMART ENGINEERING SYSTEMS	[9 hours]
Problem Identification – Product Requirement Specification – CAD Modelling – Material Selection – Design Optimization – Slicing and Build Preparation – Prototype Fabrication – Quality Inspection – Testing and Validation – AI-Based Performance Analysis – Technical Documentation – Cost Analysis – Product Demonstration – Project Presentation – Viva Voce.	

Course outcomes:

On completion of the course, the student will have the ability to:

CO1	Analyze engineering problems and identify suitable additive manufacturing technologies for product development.	K4
CO2	Develop innovative 3D printed products using CAD, DfAM, AI, and Digital Twin technologies.	K6
CO3	Implement smart manufacturing workflows by integrating additive manufacturing with Industrial IoT, cloud platforms, and data analytics.	K3
CO4	Evaluate the quality, functionality, sustainability, and performance of 3D printed engineering products using appropriate testing and optimization techniques.	K5
CO5	Design, fabricate, and demonstrate an industry-oriented 3D printed solution that addresses real-world engineering or societal needs.	K6

COs and POs Mapping:

CO NO	Course Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	1	-	-	-	-	2
CO2	3	3	3	2	3	1	2	-	2	2	1	3
CO3	2	2	3	2	3	1	2	-	2	2	2	2
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Level 3- Highly Mapped, Level 2- Moderately Mapped, Level 1- Low Mapped, Level 0- Not Mapped

Scheme of Evaluation:

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<tr><td>CIE – II</td><td>100</td></tr>
<tr><td>Skill Assessment – I</td><td>40</td><td rowspan="2">40</td></tr>
<tr><td>Skill Assessment - II</td><td>40</td></tr>
<tr><td>End Semester Examination (ESE)</td><td>Theory Exam</td><td>100</td><td>60</td><td>60</td><td>60</td></tr>
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End semester Examination: (QP PATTERN)

- Each unit consists of two 2 marks questions and one 16 marks question (either or).
- All the fifteen questions have to be answered.

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Reference Books:

1. Milan Brandt (Ed.), Laser Additive Manufacturing: Materials, Design, Technologies and Applications, Woodhead Publishing.
2. Lihui Wang and Kai Ding, Cloud-Based Cyber-Physical Systems in Manufacturing, Springer.
3. Michael Grieves and John Vickers, Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems, Springer.
4. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson.
5. John M. Jordan, 3D Printing, MIT Press Essential Knowledge Series.

Suggested Skill Activities:

Students shall complete the following laboratory and skill-oriented activities.

1. Design and fabricate a customized engineering product using CAD and 3D printing.
2. Perform Design for Additive Manufacturing (DfAM) optimization of an existing product.
3. Develop a Digital Twin model for a 3D printed product.
4. Implement AI-based defect detection for printed components using computer vision.
5. Integrate cloud-based monitoring for additive manufacturing processes.
6. Evaluate dimensional accuracy and mechanical performance of fabricated products.
7. Design sustainable products using recycled or eco-friendly materials.
8. Develop a functional IoT enclosure or robotics component using additive manufacturing.
9. Prepare a commercialization plan for a 3D printed product.
10. Present project outcomes through technical reports, prototypes, and demonstrations.

CAPSTONE PROJECT DOMAINS

Students shall undertake projects in any one of the following domains.

Computer Science / Artificial Intelligence / Information Technology

- AI-Based Print Quality Monitoring System
- Smart IoT Device Enclosure
- AI-Optimized Product Design
- Cloud-Based Additive Manufacturing Dashboard

Electrical and Electronics / Electronics and Communication

- Embedded System Enclosure
- Smart Sensor Housing
- PCB Assembly Fixtures
- Drone Frame and Electronics Mount

Biomedical Engineering

- Customized Prosthetic Devices
- Patient-Specific Anatomical Models
- Wearable Healthcare Devices
- Rehabilitation Assistive Equipment

Agricultural Engineering

- Precision Irrigation Components
- Agricultural Drone Accessories
- Smart Farm Sensor Mounts
- Livestock Monitoring Devices

Biotechnology / Chemical / Food Technology

- Laboratory Equipment Prototypes
- Microfluidic Device Prototypes
- Food Printing Demonstrators
- Customized Chemical Process Accessories

Multidisciplinary Projects

- Educational STEM Kits
- Robotics Components
- Smart Campus Assistive Devices
- Sustainable Consumer Products
- Disaster Relief Equipment
- Renewable Energy System Components