SR UNIVERSITY

# M. TECH (ADVANCED MANUFACTURING SYSTEMS)
# MECHANICAL ENGINEERING

**(Applicable from the batch admitted during the 2026-27 Academic Year and onwards)**

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## *(RA26) COURSE STRUCTURE*

**M. TECH (ADVANCED MANUFACTURING SYSTEMS)**
**MECHANICAL ENGINEERING**
(Applicable from the batch admitted during 2026-27 Academic Year and onwards)

**L: Theory T: Tutorial P/D: Practical/Drawing C: Credits**
**CIE: Continuous Internal Evaluation SEE: Semester End Examination**

| I SEM | | | | | | |
|---|---|---|---|---|---|---|
| **S.No.** | **Course Code** | **Course** | **Hours / Week** | | | |
| | | | **L** | **T** | **P/D** | **C** |
| 1 | 26AMS302PC501 | Additive Manufacturing Processes | 3 | 0 | 2 | 4 |
| 2 | 26AMS302PC502 | Computer Aided Design Modeling | 3 | 0 | 2 | 4 |
| 3 | 26AMS302PC503 | Materials and Energy Sources for Additive Manufacturing | 3 | 0 | 2 | 4 |
| 4 | 26CAI206ES501 | AI Assisted Problem Solving Using Python | 2 | 0 | 6 | 5 |
| 5 | 26BUS400RM501 | Sustainability, Critical Thinking, Research Methodology and IPR | 4 | 0 | 0 | 4 |
| 6 | 26HUM302CR501 | Life Skills: Entrepreneurship, Language, Communication and Personality | 3 | 0 | 2 | 4 |
| | | **Total** | **18** | **0** | **14** | **25** |

| II SEM | | | | | | |
|---|---|---|---|---|---|---|
| **S.No.** | **Course Code** | **Course** | **Hours / Week** | | | |
| | | | **L** | **T** | **P/D** | **C** |
| 1 | 26AMS402PC504 | Design for Additive Manufacturing | 4 | 0 | 2 | 5 |
| 2 | 26AMS402PC505 | Material Characterization | 4 | 0 | 2 | 5 |
| 3 | 26AMS202PC506 | Automation & Robotics | 2 | 0 | 2 | 3 |
| 4 | 26AMS302PC507 | Mechanics of Composite Materials | 3 | 0 | 2 | 4 |
| 5 | 26AMS302PC508 | Computer Integrated Manufacturing | 3 | 0 | 2 | 4 |
| 6 | 26HUM204CR503 | Aptitude and Reasoning | 2 | 0 | 4 | 4 |
| | | **Total** | **18** | **0** | **14** | **25** |

| III SEM | | | | | | |
|---|---|---|---|---|---|---|
| **S.No.** | **Course Code** | **Course** | **Hours / Week** | | | |
| | | | **L** | **T** | **P/D** | **C** |
| 1 | 26AMS012PR601 | Capstone Project | 0 | 0 | 12 | 6 |
| 2 | | Program Elective-I | 3 | 0 | 0 | 3 |
| 3 | | Program Elective- II | 3 | 0 | 0 | 3 |
| 4 | | Open Elective | 3 | 0 | 0 | 3 |
| | | OR | | | | |
| | 26AMS030PR602 | Industrial Project/R&D Project/Industry Internship/Start-up/Externship | 0 | 0 | 0 | 15 |
| **Total** | | | **9** | **0** | **12** | **15** |

| IV SEM | | | | | | |
|---|---|---|---|---|---|---|
| **S.No.** | **Course Code** | **Course** | **Hours / Week** | | | |
| | | | **L** | **T** | **P/D** | **C** |
| 1 | 26AMS030PR603 | Major Project/Industrial Project/R&D Project/Industry Internship/Start-up/Externship | 0 | 0 | 30 | 15 |
| **Total** | | | | | | **15** |
| **Total Credits** | | | | | | **80** |

| Program Electives | | | | | | |
|---|---|---|---|---|---|---|
| **S.No.** | **Course Code** | **Program Electives I to II** | **Hours / Week** | | | |
| | | | **L** | **T** | **P/D** | **C** |
| 1 | 26AMS300PE601 | Sustainable Manufacturing | 3 | 0 | 0 | 3 |
| 2 | 26AMS300PE602 | Big Data Analytics for Manufacturing | 3 | 0 | 0 | 3 |
| 3 | 26AMS300PE603 | Engineering Smart Materials | 3 | 0 | 0 | 3 |
| 4 | 26AMS300PE604 | Finite Element Analysis | 3 | 0 | 0 | 3 |

| Open Electives | | | | | | |
|---|---|---|---|---|---|---|
| **S.No.** | **Course Code** | **Course** | **Hours / Week** | | | |
| | | | **L** | **R** | **P** | **C** |
| 1 | 26PEL300OE601 | Energy Systems and Management | 3 | 0 | 0 | 3 |
| 2 | 26PEL300OE602 | Renewable Energy Technologies | 3 | 0 | 0 | 3 |
| 3 | 26CAI300OE603 | Cyber Laws | 3 | 0 | 0 | 3 |
| 4 | 26CAI300OE604 | Block Chain Technology | 3 | 0 | 0 | 3 |
| 5 | 26AMS300OE605 | Operations Research | 3 | 0 | 0 | 3 |
| 6 | 26AMS300OE606 | 3D Printing | 3 | 0 | 0 | 3 |
| 7 | 26ECE300OE607 | Internet of Things and IIoT | 3 | 0 | 0 | 3 |
| 8 | 26ECE300OE608 | Computer vision | 3 | 0 | 0 | 3 |
| 9 | 26CTM300OE609 | Disaster Management | 3 | 0 | 0 | 3 |
| 10 | 26CTM300OE610 | Smart Cities | 3 | 0 | 0 | 3 |

# DETAILED SYLLABUS

| (26AMS302PC501) ADDITIVE MANUFACTURING PROCESSES | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | - | 2 | 4 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT-I: Introduction to Additive Manufacturing (5 Lectures)**

1. Introduction to Manufacturing Paradigms
2. Evolution of Additive Manufacturing
3. Distinction between AM and CNC Machining
4. Advantages and Limitations of AM
5. Industrial Adoption & Future Scope

**UNIT-II: Classification of AM Processes – Liquid-Based Systems (7 Lectures)**

6. Overview of AM Process Classifications
7. Stereolithography Apparatus (SLA): Introduction
8. SLA: Process, Photopolymers, and Photo Polymerization
9. SLA: Working Principle and Layering Technology
10. SLA: Applications, Advantages & Disadvantages
11. SLA: Case Studies and Interactive Discussion
12. Solid Ground Curing (SGC): Process & Principle
13. SGC: Applications, Advantages, Disadvantages, Case Studies

**UNIT-III: Solid-Based Systems (8 Lectures)**

14. Introduction to Solid-Based Systems
15. Laminated Object Manufacturing (LOM): Models & Setup
16. LOM: Process, Working Principle
17. LOM: Applications, Advantages, Disadvantages, Case Studies
18. Fused Deposition Modeling (FDM): Introduction & Setup
19. FDM: Process and Working Principle
20. FDM: Applications, Advantages, Disadvantages
21. FDM: Case Studies + Practical Demonstration

**UNIT-IV: Powder-Based Systems (8 Lectures)**

22. Introduction to Powder-Based Systems
23. Selective Laser Sintering (SLS): Models & System Setup
24. SLS: Process & Working Principle
25. SLS: Applications, Advantages & Disadvantages
26. SLS: Case Studies & Industry Examples
27. Three-Dimensional Printing (3DP): Introduction & Setup
28. 3DP: Process, Working Principle
29. 3DP: Applications, Advantages, Disadvantages, Case Studies

**UNIT-V**: AM Applications and Industry Use Cases (8 Lectures)
30. Functional Models and Prototypes
31. Patterns for Investment and Vacuum Casting
32. Medical Models and Bio-Engineering Applications
33. Art, Architecture, and Creative Industries
34. Engineering Models, Rapid Tooling, and Jigs
35. Advanced Applications: Bi-metallics, Re-manufacturing, New Materials
36. Application Examples: Aerospace, Defence, Automotive, Biomedical

**STUDIO WORK / LABORATORY EXPERIMENTS / HANDS-ON ACTIVITY:**

1. Introduction to 3D Printing and CAD Design Tools
2. Intermediate 3D Modelling for Functional Prototypes
3. STL File Handling and Introduction to Slicing Software
4. Build Setup & Tool Path Generation
5. Exploring Cura Slicing Software
6. Material and Parameter Study
7. G-Code Interpretation and Machine Setup
8. FDM Machine Operation & Printing
9. Print Larger Part & Evaluate Parameters
10. Post-Processing Techniques
11. Biomedical Application - CT/MRI to STL
12. Final Project / Evaluation

**LEARNINGRESOURCES**

**TEXT BOOKS:**
1. Gibson, I., Rosen, D. W., & Stucker, B. (2015). Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing (2nd ed.). Springer.
2. Horvath, J., & Cameron, R. (2020). Mastering 3D printing: A guide to modeling, printing, and prototyping (2nd ed.). Apress.

**REFERENCE BOOKS:**
1. Andrade, C. (2022). 3D printing step by step: 3D design tutorials and common mistakes in 3D printing with solutions (1st ed.). Notion Press.
2. Randall, M. D. (2022). 3D printer: A complete 3D printing guide (1st ed.). Oas-Global Press.

| (26AMS302PC502) COMPUTER AIDED DESIGN MODELING | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 2 | 4 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT I:Introduction to CAD**

1. Fundamentals of Computer-Aided Design
2. Advantages and applications of CAD in mechanical engineering
3. Introduction to parametric modeling
4. Concepts of feature-based design
5. Overview of generative design and its applications
6. 2D Sketching – Tools and workspace overview
7. Applying geometric constraints in sketches

**UNIT II: 3D Part Modeling**

8. Introduction to 3D part modeling environments
9. Creating basic 3D features: Extrude
10. Revolve feature and its uses
11. Creating rounds and chamfers in 3D models
12. Hole feature types and placement
13. Draft and shell features in part modeling
14. Sweep operation for creating complex shapes
15. Variable section sweep – concept and execution
16. Blend feature and its use in design transitions
17. Pattern creation: linear, circular, and mirror
18. Applying combined features in part design

**UNIT III: Assembly Modeling**

19. Introduction to assembly modeling
20. Applying constraints in assemblies
21. Creating subassemblies and hierarchical assemblies
22. Creating exploded views and animations
23. Working with family tables in assemblies
24. Introduction to layouts in CAD software
25. Checking assembly interferences and motion simulation

**UNIT IV: Technical Drawings**

26. Creating detailed part drawings
27. Generating assembly drawings with BOM
28. Isometric and orthographic projections
29. Applying dimensions and annotations
30. Introduction to Geometric Dimensioning and Tolerancing (GD&T)

**UNIT V: Preprocessing for AM and CNC**

31. CAD model preprocessing steps for AM
32. Converting CAD models to STL format
33. Diagnosing and correcting STL file errors
34. Support structure generation for AM
35. Slicing models for 3D printing
36. Introduction to CNC toolpath and G-code generation

**LAB**

1. Introduction to AutoCAD workspace and basic 2D sketching
2. Practicing constraints and parametric design in 2D
3. Creating 3D parts using extrude and revolve in Fusion 360
4. Applying rounds, chamfers, and shell features in Creo
5. Sweep and blend operations in PTC Creo
6. Using hole, pattern, and draft tools in Fusion 360
7. Modeling assemblies and applying constraints in Creo
8. Creating exploded views and motion simulation in Fusion 360
9. Generating part and assembly drawings with annotations
10. GD&T applications and practice on part drawings
11. STL conversion and error checking for 3D printing
12. CNC code generation using Creo or Fusion 360 post-processing tools

**TEXTBOOKS:**

1. Olaf Diegel, Axel Nordin, Damien Motte, A Practical Guide to Design for Additive Manufacturing , Springer Series in Advanced Manufacturing 2019.
2. A Zimmers and P. Groover, “CAD/AM”, PE/PHI, 1st Ed. Re-printed 2025.

**REFERENCE BOOKS:**

1. Martin Leary, Design for Additive Manufacturing, Elsevier 2019.
2. Ibrahim Zeid, “CAD/CAM Theory and Practice”, TMH, 2nd Ed 2009

**MOOC COURSES:**

1. https://www.youtube.com/watch?v=TgYkBMmuRW8&pp=ygUbYXNzZW1ibHkgZHJhd2luZyB1c2luZyBjcmVv
2. https://www.youtube.com/watch?v=YcuMTrCLoJ8

| (26AMS302PC503) MATERIALS AND ENERGY SOURCES FOR ADDITIVE MANUFACTURING | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 2 | 4 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT I- Introduction and Materials for Additive Manufacturing (7 Sessions)**

1. Introduction to Additive Manufacturing – History, evolution, and importance.
2. Energy sources for material processing – overview and classification.
3. Detailed classification of energy sources and their applications in AM.
4. Materials for AM – atomic structure and bonding fundamentals.
5. Nature of polymers – thermoplastics vs. thermosetting polymers and their behavior in AM.
6. Polymerization types, polymer properties, and degradation mechanisms.
7. Metal and ceramic powders – production, compaction, sintering, composites, and Functionally Graded Materials (FGMs).

**UNIT II- Laser Beam (7 Sessions)**

8. Fundamentals of lasers – introduction, electromagnetic radiation, and energy levels.
9. Interaction of radiation with matter – absorption, reflection, and transmission mechanisms.
10. Generation of laser beam – spontaneous and stimulated emission, population inversion, etc.
11. Properties of laser light – coherence, divergence, line width, radiance, focusing, and power.
12. Types of lasers used in manufacturing – $CO_2$, Nd:YAG, fiber, and diode lasers.
13. Laser optics – light beam deflectors, Q-switches, optical isolators, beam profilers, beam homogenizers.
14. Laser–material interaction and industrial applications (cutting, welding, cladding, marking, etc.).

**UNIT III- Laser Additive Manufacturing (AM) (8 Sessions)**

15. Introduction to Laser Additive Manufacturing (AM) – classification and processing philosophy.
16. Metallurgical mechanisms in laser AM processes – melting, solidification, and microstructure formation.
17. Laser sintering (LS) and laser melting (LM) – process principles and operational details.
18. Laser Metal Deposition (LMD) – working principle, process parameters, and advantages.
19. Materials used in laser AM – pure metals, alloys, and multi-component powders.
20. Metal Matrix Composites (MMCs) in AM – process control and performance aspects.
21. Physical aspects and design strategies of materials for AM – powder flowability, layer thickness, scanning.
22. Microstructural and mechanical properties of AM parts – structure-property stability and performance.

**UNIT IV- Electron Beam (7 Sessions)**

23. Introduction to electron beam technology – principles, wave, and particle behavior.
24. Constructive and destructive interference – basics of electron wave properties.
25. Generation of electron beam – electron gun, cathode, anode, control electrode, focusing lens, deflection system.
26. Key parameters – accelerating voltage, beam current, power density, focal position, beam speed, and deflection.
27. Process effects – vapor and liquid phases, heat-affected zone, and internal thermal stresses.
28. Electron beam–material interactions and comparison with laser-based processes.
29. Applications of electron beam technology in manufacturing and materials research.

**UNIT V- Electron Beam Technology in AM, Plasma Arc, and Other Sources (7 Sessions)**

30. Electron Beam Technology in AM – powder bed fusion and electron beam melting (EBM).
31. Powder metallurgy requirements for EBM – material and process considerations.
32. Powder manufacturing methods – gas atomization, induction plasma atomization, Armstrong process, hydride-dehydride.
33. Powder characterization, parameter development, build setup, and process sequence in EBM.
34. Plasma arc technology – introduction, basic properties, and plasma production.
35. Plasma–material interaction, applications, and comparison with laser/electron beam processes.
36. Other emerging sources – ultrasonic, hybrid energy systems, and review of latest literature in AM.

**LAB EXPERIMENTS:-**

1. Identification of Thermoplastics and Thermosetting Polymers
2. Compaction of Metal or Ceramic Powders Using a Hydraulic Press
3. Sintering of Powder Compacts in a Muffle Furnace
4. Tensile Testing of Polymer Samples
5. Laser Beam Deflection Using Mirrors and Lenses
6. Laser Engraving on Metal, Wood, and Polymer Surfaces
7. 3D Printing of a Simple Part Using FDM Technology
8. Effect of Build Orientation on Mechanical Properties of 3D Printed Parts
9. Demonstration of Vacuum Creation for Electron Beam Processing
10. Observation of Electron Beam Welding Process (Demo/Video)
11. Powder Flowability Test Using Funnel Flow Method
12. Plasma Cutting or Surface Hardening Demonstration

**LEARNING RESOURCES**

**TEXT BOOKS:**

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing by Ian Gibson, David Rosen, Brent Stucker, Mahyar Khorasani, 3rd Edition (2021).
2. Materials for Additive Manufacturing by Lorenzo Donati, Roberto Montanari, 1st Edition (2021)

**REFERENCE BOOKS**

1. Green manufacturing: fundamentals and applications by David A. Dornfeld. Springer Science &Business Media, 2012.
2. Sustainable Manufacturing: Shaping Global Value Creation by Günther Seliger, Springer, 2017.

**USEFUL LINKS**

1. https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SPR1616.pdf
2. https://www.diva-portal.org/smash/get/diva2:1676285/FULLTEXT01.pdf

| (26CAI206ES501)<br>AI ASSISTED PROBLEM SOLVING USING PYTHON | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 2 | 0 | 6 | 5 |
| Course type | Program Core | Pre-requisite | | | | |

**Course Outcomes:**

At the end of the course, the student will be able to:

**CO1:** Understand the fundamentals of Artificial Intelligence and Python programming environment.

**CO2:** Apply search strategies and problem-solving techniques using Python.

**CO3:** Perform data manipulation, visualization, and implement basic machine learning models.

**CO4:** Apply knowledge representation, NLP, and AI tools for real-world applications and project development.

**UNIT I - Introduction to AI & Python Programming**

1. Definition, History, Types, And Applications of AI.
2. Python Basics: Data Types.
3. Control Structures.
4. Functions, I/O.
5. Setting Up the Development Environment: Jupyter, Anaconda.

**UNIT II**

6. Problem Solving and Search Strategies.
7. State Space Representation, Uninformed Search.
8. BFS, DFS.
9. Informed Search: Greedy, A*, heuristics.
10. Introduction to the Minimax Algorithm.

**UNIT III**

11. Data Handling and Machine Learning Basics.
12. Data Manipulation using Numpy and Pandas.
13. Data Visualization with Matplotlib and Seaborn.
14. Introduction to Supervised and Unsupervised Learning.
15. Regression, Classification.
16. Clustering Techniques.
17. Model Evaluation Metrics: Accuracy, Confusion Matrix.

**UNIT IV**

18. Knowledge Representation & Natural Language Processing.
19. Logic: Propositional and Predicate.
20. Rule-Based Systems and Inference Engines.
21. NLP Basics: Tokenization, Stemming, TF-IDF.

**UNIT V**

22. AI Applications and Capstone Project.
23. Real-World AI Applications in Various Domains, Ethical Considerations in AI.
24. AI Project Lifecycle: Problem Identification To Solution Deployment, Basics of Model Deployment Using Flask Or Streamlit.

**LAB**

1. Environment Setup -Install and Configure Github Copilot, Tabnine, and OpenAI API. VS Code, JetBrains IDE, Jupyter Notebook.
2. Prompt-Based Code Generation – Basics.
3. Generate Basic Programs (E.G., Calculator, Temperature Converter) using Single-Line Prompts -Prompt Engineering – Advanced.
4. Generate Functions using Zero-Shot, One-Shot, and Few-Shot Prompting Techniques.
5. Example: Generate Recursion-Based and Iteration-Based Solutions - AI-Based Code Auto Completion.
6. Use Copilot to Auto-Complete Classes, Loops, And Conditionals In Python/Java/C++.
7. AI-Powered Error Debugging.
8. Provide A Buggy Code to ChatGPT or Copilot and Fix Errors.
9. Example: Debug a Login System with Validation Flaws.
10. Data Structure Implementation via AI.
11. Generate Code for Stack, Queue, Linked List, And Tree Using AI Prompts.
12. Algorithm Implementation Using AI
13. Implement Sorting and Searching Algorithms (Bubble, Merge, And Binary Search).
14. Code Refactoring with AI Suggestions.
15. Improve Legacy Code Using Copilot's Suggestions for Better Performance and Readability.
16. Real-Time Test Case Generation
17. Generate UNIT Tests Using AI Tools for Given Functions/Modules.
18. Documentation And Code Comments Generation.
19. Automatically Generate Docstrings, Markdown Documentation, and Inline Comments Using AI.
20. Chatbot Development Using AI Suggestions.
21. Build A Simple Chatbot Using AI-Assisted Logic Flow and Conversation Handling.
22. Project Skeleton Creation Using AI - Generate Project Structure for Applications (E.G., E-Commerce, Student Management) Using AI.
23. Code Optimization Using AI.
24. Optimize Nested Loops, Remove Redundant Lines, and Enhance Time Complexity.
25. Front-End Web App Generation Using AI.
26. Use AI To Generate HTML/CSS/JS Code for a Basic Landing Page or Portfolio.
27. Backend API Design Using AI.
28. Auto-Generate REST API Boilerplate (Node.js, Flask, Django) Using Prompts.
29. AI-Powered SQL Query Generator.
30. Generate Complex SQL Queries and Database Schema Using Natural Language Prompts.
31. Code Translation Using AI.
32. Convert Code Between Languages (Python ⇌ Java ⇌ C++) Using ChatGPT/Copilot.

33. AI For Code Review.
34. Perform Code Reviews Using AI - Highlight Security Issues, Inefficiencies, And Suggest Improvements.
35. AI-Driven Data Analysis.
36. Use AI To Generate Python Scripts for Data Cleaning and Preprocessing.

**TEXT BOOKS:**

1. Leo Porter (Author), Daniel Zingaro (Author), "Learn Ai-assisted Python Programming", 2024.
2. Tom Taulli, "Ai-Assisted Programming Better Planning, Coding, Testing, and Deployment, 2024.

**REFERENCES BOOKS:**

Sebastian Raschka, "Python Machine Learning, Edition", 2019.

| (26BUS400RM501) SUSTAINABILITY, CRITICAL THINKING, RESEARCH METHODOLOGY AND IPR | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 4 | 0 | 0 | 4 |
| Course type | Program Core | Pre-requisite | | | | |

**COURSE OUTCOMES**

At the end of course, the students will be able to identify appropriate research topics
CO1 :Select and define appropriate research problem and parameters
CO2: Prepare a project proposal (to undertake a project)

**UNIT I: Foundations of Research Methodology**

1. Meaning, objectives, and scope of research.
2. Importance of scientific research in decision making.
3. Characteristics and significance of good research.
4. Types of research: basic, applied, descriptive, analytical, and exploratory.
5. Steps in the research process.
6. Identification and formulation of research problem.
7. Hypothesis: meaning, types, and formulation.
8. Research designs: exploratory, descriptive, and experimental.
9. Importance of a well-structured research design.

**UNIT II: Measurement, Data Collection, and Sampling Techniques**

10. Measurement in research: concept and types of scales.
11. Data collection: primary and secondary data sources.
12. Questionnaire design and interview techniques.
13. Reliability and validity in data collection instruments.
14. Sampling fundamentals: population, sample, and sampling frame.
15. Probability and non-probability sampling methods.
16. Determination of sample size and sampling errors.
17. Scaling techniques: nominal, ordinal, interval, and ratio scales.
18. Data processing: editing, coding, classification, and tabulation.

**UNIT III: Data Analysis – I**

19. Introduction to data analysis and hypothesis testing.
20. Parametric tests: Z-test – concept and applications.
21. Parametric tests: t-test – independent and paired samples.
22. F-test and analysis of variance (ANOVA).
23. Chi-square test: goodness of fit and test of independence.
24. Non-parametric tests: concept and applications.
25. Sign test and run test.
26. Kruskal–Wallis test for multiple samples.
27. Interpretation and presentation of statistical results.

**UNIT IV: Data Analysis – II, SPSS, and Report Writing**

28. Factor analysis: concepts and extraction techniques.
29. Multiple regression analysis: model building and validation.
30. Discriminant analysis and its applications.
31. Using SPSS: data entry, coding, and variable setup.
32. Practical SPSS exercises: frequencies, charts, and graphs.
33. Hypothesis testing in SPSS: t-test, ANOVA, and chi-square.
34. Reliability and correlation analysis using SPSS.
35. Research report writing: structure, types, and formatting.
36. Ethical issues and presentation of research findings.

**UNIT V: Intellectual Property Rights (IPR) and Patents**

37. Meaning, nature, and origin of property and intellectual property.
38. TRIPS and WTO provisions on intellectual property rights.
39. Types of IPR: patent, copyright, trademark, design, and trade secret.
40. Geographical indications, plant varieties, and traditional knowledge.
41. Patent law: definition, scope, and types of patents.
42. Inventions not patentable and registration procedures.
43. Rights, duties, assignment, and licensing of patents.
44. Restoration, revocation, and infringement of patents.
45. Copyright: meaning, types, and registration process.
46. Assignment, licensing, and duration of copyright.
47. Copyright infringement and remedies.
48. Copyright issues in software and digital works.

**TEXT BOOKS:**

**1.** Stuart Melville and Wayne Goddard, Research methodology: an introduction for science & Engineering students'
**2.** Wayne Goddard and Stuart Melville, Research Methodology: An Introduction'.

**REFERENCE BOOKS:**

**1.** Paneersevam, Research Methodology, PHI.
**2.** Dr. B.L.Wadehra, Law relating to Intellectual Property, Universal Law Publishing Co.

| **(26HUM302CR501)**<br>**LIFE SKILLS: ENTREPRENEURSHIP, LANGUAGE, COMMUNICATION AND PERSONALITY** | | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 2 | 4 |
| Course type | Program Core | Pre-requisite | | | | |

| (26AMS402PC504) DESIGN FOR ADDITIVE MANUFACTURING | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 4 | 0 | 2 | 5 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT I: Introduction to Design for Additive Manufacturing**

1. Motivation for DFAM: Industry trends, innovation through AM
2. Overview of DFMA and DFAM concepts: Objectives, evolution
3. Unique capabilities of AM compared to traditional manufacturing
4. Exploring design freedoms: Complexity without cost penalty
5. Introduction to design tools used in AM (Fusion 360, Netfabb, etc.)
6. Part orientation strategies: Influence on quality, strength, and supports
7. Support removal considerations in the design phase
8. Hollowing parts for weight reduction and material savings
9. Incorporation of undercuts, complex geometries, and interlocking features
10. Assembly simplification and feature integration (markings, numbers, tags)

**UNIT II: Process Fundamentals and Material Properties**

11. Understanding AM build volume limitations
12. Process-influencing factors: Machine, material, environment
13. Thermal processes: Heat transfer, solidification, cooling behavior
14. Layer-by-layer fabrication: Effects on microstructure and properties
15. Build orientation: Trade-offs in strength, surface finish, and time
16. Shrinkage, warpage, and distortion during printing
17. Surface finish quality and enhancement strategies
18. Support structures: Design, function, and challenges
19. Material properties: Overview of AM-compatible powders
20. Suitability of materials for different applications (polymers, metals, ceramics)

**UNIT III: Rapid Tooling Equipment**

21. Introduction to rapid tooling: Importance and need
22. Classification: Direct vs Indirect rapid tooling
23. Direct tooling methods (e.g., Direct metal laser sintering)
24. Indirect tooling methods (e.g., AM-based molds, soft tooling)
25. Applications in injection molding, die casting, stamping
26. Case studies in automotive and biomedical industries

**UNIT IV: Design for AM - Polymer and Metal Processes**

27. Introduction to design considerations for polymer AM
28. Material extrusion (FDM/FFF): Wall thickness, bridging, overhangs
29. Polymer powder bed fusion (SLS): Nesting, shrinkage, tolerances
30. Vat photopolymerization (SLA/DLP): Resins, support strategies
31. Case studies and sample part analysis (polymer-based)
32. Hands-on design activity using slicing software for polymer AM

33. Overview of design considerations for metal AM
34. Laser powder bed fusion (LPBF): Thermal stress, support, overhangs
35. Electron beam melting (EBM): Powder spreading, cooling rates
36. Metal binder jetting: Sintering shrinkage, orientation
37. Functional design features for metal parts (lattices, channels)
38. Case studies in aerospace, biomedical, tooling applications

**UNIT V: Pre-processing and Post-processing in AM**

39. STL file generation and conversion from CAD
40. STL file errors and diagnostics (holes, flipped normals)
41. Build orientation and transformation operations
42. Support generation and slicing overview (Cura, Netfabb, Materialise)
43. Material preparation and pre-heating strategies for powder systems
44. Post-processing goals and classification
45. Support removal techniques: Manual and automated
46. Heat treatment and HIP for metals
47. Surface finishing: Media blasting, polishing, EDM, CNC
48. Micro-machining and high-precision finishing for functional parts

**STUDIO WORK / LABORATORY EXPERIMENTS / HANDS ON ACTIVITY:**

**List of Experiments for MSAM Lab**

1: CAD Modeling and STL File Generation
2: STL File Inspection and Manipulation
3: STL File Reading and Slicing Using Cura Software
4: MATLAB Routine for Reading STL Files
5: MATLAB Routine for Orientation Adjustment
6: MATLAB Routine for Uniform Slicing of STL File
7: Introduction to Topology Optimization using Ansys Additive Suite
8: Topology Optimization of a Brake Pedal
9: Topology Optimization of a Throttle Pedal
10: Optimization of a Spanner with 25% Mass Reduction
11: Optimization of an L-Bracket with 65% Mass Reduction
12: Final Integration and Report Presentation

**LEARNINGRESOURCES**

**TEXTBOOKS**

1. Diegel, O., Nordin, A., & Motte, D. (2020). A practical guide to design for additive manufacturing (p. 226). New York, NY, USA: Springer.
2. Gibson, I., Rosen, D. W., & Stucker, B. (2015). Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing (2nd ed.). Springer.

**REFERENCEBOOKS**

1. Gibson, I., Rosen, D., Stucker, B., Khorasani, M., Rosen, D., Stucker, B., & Khorasani, M. (2021). Additive manufacturing technologies (Vol. 17, pp. 160-186). Cham, Switzerland: Springer.
2. Hilton, P. (2000). Rapid tooling: technologies and industrial applications. CRC press.

**USEFUL LINKS**

1. https://www.alphaprecisionpm.com/blog/design-for-additive-manufacturing
2. https://www.makeuseof.com/how-to-design-for-additive-manufacturing/

| (26AMS402PC505) MATERIAL CHARACTERIZATION | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 4 | 0 | 2 | 5 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT I: Optical Microscopy**

1. Fundamentals of light interaction with materials
2. Resolution, magnification, and numerical aperture in optics
3. Bright field microscopy: working principle and applications
4. Dark field microscopy: contrast enhancement in transparent materials
5. Phase contrast microscopy: observing phase variations
6. Differential interference contrast (DIC) microscopy
7. Polarized light microscopy and grain structure analysis
8. Sample preparation for optical microscopy (metals and alloys)
9. Applications of optical microscopy in material science

**UNIT II: Scanning Electron Microscopy**

10. Introduction to electron microscopy: SEM basics
11. Electron source types and working principle
12. Vacuum systems and electron beam interactions
13. Electromagnetic lenses and scanning coils
14. Secondary electron imaging: surface topography
15. Backscattered electron imaging: atomic number contrast
16. Working of detectors and image acquisition
17. Energy dispersive spectroscopy (EDS): principle and setup
18. X-ray mapping and qualitative analysis using EDS
19. Applications of SEM in failure analysis and microstructural studies

**UNIT III: X-ray Scattering and Diffraction**

20. X-ray generation and safety precautions
21. Bragg’s law and conditions for diffraction
22. X-ray diffraction instrumentation and setup
23. Powder diffraction techniques and sample prep
24. Phase identification using standard diffraction data
25. Scherrer’s equation for crystallite size estimation
26. Effect of lattice strain on diffraction peak broadening
27. Residual stress measurement using diffraction
28. Quantitative phase analysis in multi-phase materials
29. Applications of XRD in structural characterization

**UNIT IV: X-ray Scattering and Diffraction**

30. Introduction to TEM and comparison with SEM
31. Electron diffraction and reciprocal lattice concepts
32. Construction and operation of TEM

33. Bright field and dark field imaging in TEM
34. High-resolution TEM (HRTEM) for atomic scale imaging
35. SAED (Selected Area Electron Diffraction) pattern analysis
36. TEM sample preparation methods (mechanical, ion milling)
37. Contrast mechanisms in TEM: mass-thickness and diffraction
38. Electron energy loss spectroscopy (EELS) basics
39. Applications of TEM in nanomaterials and defect analysis

**UNIT V: Mechanical Testing of Materials**

40. Overview of mechanical testing and test standards
41. Stress-strain curve and tensile testing procedure
42. True stress and true strain: material deformation analysis
43. Tensile testing machines and extensometers
44. Flexural testing: setup and analysis
45. Impact testing: Charpy and Izod methods
46. Hardness testing: Brinell and Rockwell methods
47. Vickers and Microhardness testing techniques
48. Interpretation of mechanical test data and applications

**LAB**

1. Sample polishing and etching for optical microscopy
2. Grain size measurement using optical microscope
3. Surface analysis of metals using SEM
4. Microstructure imaging and interpretation in SEM
5. SEM-EDS analysis for elemental identification
6. XRD pattern acquisition for powder samples
7. Phase identification from XRD data using databases
8. Crystallite size estimation using Scherrer equation
9. Demonstration and virtual analysis of TEM images
10. Interpretation of SAED patterns in TEM
11. Tensile testing of mild steel and stress-strain analysis
12. Hardness testing of various materials (Brinell, Rockwell, Vickers)

**TEXT BOOKS**

1. Prof. Yang Leng, “Materials Characterization: Introduction to Microscopic and Spectroscopic Methods”, Second Edition. Wiley-VCH, Year: 2013.
2. Larry Horath, “Fundamentals of Materials Science for Technologists: Properties, Testing, and Laboratory Exercises”, Waveland Press, 2019.

**REFERENCE BOOKS**

1. P. K. Mitra, “Characterization of Materials” PHI, 2016.
2. Transmission Electron Microscopy: A Textbook for Materials Science" by David B. Williams & C. Barry Carter, 3rd Edition, 2021

| (26AMS202PC506) AUTOMATION & ROBOTICS | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 2 | 0 | 2 | 3 |
| Course type | Program Core | Pre-requisite | | | | |

## UNIT-I. Automated Manufacturing Systems

1. Introduction to Automation – Fixed, Programmable, Flexible Automation
2. Basic Elements of Automated Systems (Program & Control)
3. Advanced Automation Functions & Levels of Automation
4. Industrial Control Systems (Process vs. Discrete Manufacturing)
5. Continuous & Discrete Control, Low-Cost Automation
6. Economic & Social Aspects of Automation
7. Transfer Lines – Fundamentals, Configurations, Mechanisms
8. Analysis of Transfer Lines (With/Without Storage Buffers)

## UNIT-II. Assembly Automation

9. Types of configurations of Assembly Automation
10. Parts Delivery – Vibratory/Non-Vibratory Feeding Devices
11. Feeding Rate Calculations & Cycle Time Analysis
12. Single-Station & Partially Automated Assembly Systems
13. Product Design for Automated Assembly
14. Case Studies & Problem-Solving (Assembly Automation)

## UNIT-III. Fundamentals of Industrial Robots

15. Introduction to Industrial Robots – Specifications & Characteristics
16. Robot Components & Configurations
17. Selection Criteria & Industrial Applications
18. Robotic Control Systems – Drives & Actuators
19. Power Transmission & Robot Controllers
20. Dynamic Properties – Stability, Resolution, Accuracy
21. Repeatability, Compliance, and Performance Metrics
22. Basics of Robot Kinematics

## UNIT-IV. Robotic End Effectors & Sensors

23. Transducers & Sensors in Robotics – Classification
24. Tactile (Touch) Sensors & Proximity/Range Sensors
25. Force & Torque Sensing in Robotics
26. End Effectors – Types, Grippers, Process Tools
27. Robot-End Effector Interface & Compliance (Active/Passive)
28. Gripper Selection & Design Principles
29. Sensor Integration & Gripper Testing

### UNIT-V. Robot Programming & Applications

30. Robot Programming – Lead-Through Method
31. Defining Positions in Space & Motion Interpolation
32. Branching & Textual Robot Programming Languages
33. Robot Applications – Material Transfer & Machine Loading
34. Processing Operations & Inspection Automation
35. Robot Cell Design & Control Strategies
36. Recent Trends & Special Applications

**EXPERIMENTS**

1. Demonstrate basic differences and practical models of Fixed, Programmable, and Flexible Automation Systems
2. Simulation of an Automated Manufacturing Line using FlexSim, Tecnomatix, or Arena to simulate control systems.
3. Implement both control types using PLCs or microcontrollers.
4. Analysis of a Transfer Line with and without Buffers
5. Design and Testing of Vibratory Bowl Feeder to analyze feeding efficiency and orientation capability.
6. Feeding Rate and Cycle Time Calculation for Assembly Station
7. Demonstration of a Single Station Automated Assembly System
8. Programming of an Industrial Robot Arm using software simulators like RoboDK or V-REP (CoppeliaSim).
9. Robot Component Identification and Configuration Mapping
10. Motion Accuracy, Repeatability, and Compliance Testing in automation.
11. Lead-Through Robot Programming Using Simulators or Physical Robots
12. Textual Programming for Industrial Robot Using a Language Like RAPID/URScript/Python

**LEARNINGRESOURCES**

TEXT BOOKS.

1. **Groover, M.P.** (2022), *Automation, Production Systems, and Computer-Integrated Manufacturing*, 7th Edition, Pearson Education.
2. **Niku, Saeed B.** (2020), *Introduction to Robotics. Analysis, Control, Applications*, 3rd Edition, Wiley.

**REFERENCE BOOKS.**

1. **Saha, S. K. (2024),** *Introduction to Robotics*, 3rd Edition, McGraw-Hill Education (India), ISBN. 978-9355326461
2. **Kurfess, Thomas R. (2004),** *Robotics and Automation Handbook*, 1st Edition, CRC Press, ISBN. 978-0849318047

**USEFUL LINKS**

1. https://nptel.ac.in/courses/112101098
2. https://www.coursera.org/learn/robotics-process-automation-for-smart-manufacturing

| (26AMS302PC507) MECHANICS OF COMPOSITE MATERIALS | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 2 | 4 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT-I: Introduction to Composite Materials**

1. **Definition of Composite Materials** – Components (Fiber, Matrix), Key Terms.
2. **Types of Fibers** – Glass, Carbon, Aramid, Natural Fibers.
3. **Raw Fiber Properties** – Tensile Strength, Modulus, Density, Thermal Stability.
4. **Types of Matrix** – Thermosets (Epoxy, Polyester), Thermoplastics (PEEK, Nylon).
5. **Prepegs, Fillers, and Additives** – Roles of Coupling Agents, Nanofillers.
6. **Advantages & Applications** – Weight Savings, Corrosion Resistance, Aerospace/Automotive Case Studies.

**UNIT-II: Basics of Composites**

7. **Mechanical Behavior of Composites** – Anisotropy, Homogenization.
8. **Lamina vs. Laminate** – Definitions, Role in Layered Structures.
9. **Micromechanics Fundamentals** – Rule of Mixtures (ROM) for Stiffness.
10. **Strength Prediction** – Fiber-Matrix Load Transfer, Critical Fiber Length.
11. **Stress/Strain in Composites** – Isotropic vs. Anisotropic Response.
12. **Practical Demo** – Tensile Testing of a Unidirectional Lamina.

**UNIT-III: Properties of Composites**

13. **Volume/Weight Fractions** – Calculations, Experimental Methods (Burn-off Test).
14. **Longitudinal Strength & Stiffness** – ROM Derivation, Fiber Dominance.
15. **Transverse Modulus** – Matrix Dominance, Halpin-Tsai Equations.
16. **In-Plane Shear Modulus** – Shear Lag Analysis.
17. **Poisson's Ratio** – Anisotropic Effects.
18. **Stress-Strain Relationships** – Generalized Hooke's Law for Orthotropic Materials.
19. **Engineering Constants** – E1,E2,G12,$\nu$12$E$1,$E$2,$G$12,$\nu$12.
20. **Thin Lamina Stress-Strain** – Plane Stress Assumptions, Compliance Matrix.

**UNIT-IV: Laminated Composites**

21. **Laminate Basics** – Stacking Sequence, Ply Orientation.
22. **Classical Lamination Theory (CLT)** – Key Assumptions.
23. **Strain-Displacement** – Kirchhoff Plate Theory.
24. **Stress-Strain in Laminates** – ABD Matrix (Extensional/Bending Coupling).
25. **Equilibrium Equations** – Force/Moment Resultants.
26. **Laminate Stiffness** – Symmetric vs. Unsymmetric Layups.
27. **Lamina Stresses/Strains** – Ply-by-Ply Analysis.
28. **Laminate Types** – Balanced, Anti-symmetric, Quasi-Isotropic.

**UNIT-V: Failure Theories**

29. **Micromechanics of Failure** – Fiber Breakage, Matrix Cracking, Debonding.
30. **Anisotropic Strength** – Directional Dependency.
31. **Maximum Stress Theory** – Criteria for Fiber/Matrix Failure.
32. **Maximum Strain Theory** – Strain-Based Limits.
33. **Tsai-Hill Theory** – Interactive Failure Criterion.
34. **Tsai-Wu Theory** – Tensor Polynomial Approach.
35. **Shear Strength Importance** – Interlaminar Shear Stress (ILSS).
36. **Case Studies** – Real-World Failures (e.g., Aircraft Wing Delamination).

**LAB SYLLABUs**

1. Identification and Classification of Composite Materials
2. Tensile Testing of Fiber Samples
3. Fabrication of Composite Laminates by Hand Lay-Up Method
4. Micromechanical Analysis: Rule of Mixtures Validation
5. Volume and Weight Fraction Determination (Burn-Off Test)
6. Tensile Testing of Laminated Composites.
7. Flexural Testing of Composite Beams
8. Shear Testing of Composites (ILSS)
9. Thermal Analysis (TGA/DSC) of Composite Samples
10. Simulation of Laminate Behavior using MATLAB or ANSYS
11. Failure Mode Analysis in Composite Laminates
12. Study of Real-World Composite Failures

**LEARNINGRESOURCES**

**TEXTBOOKS**

1. Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", Universities Press, 7th Edition 2022.
2. Robert M Jones, "Mechanics of Composite Materials", CRC Press, 5th Ed., 2015.

**REFERENCEBOOKS**

1. RC Hibbeler, "Mechanics of Composite Materials and Structures", Universities Press, 7th Ed., 2021.
2. Ever J. Barbero, "Introduction to Composite Materials Design", CRC Press, 5th Edition, 2022.

**USEFUL LINKS**

1. https://sarrami.iut.ac.ir/sites/sarrami.iut.ac.ir/files/files_course/01mechanics_of_composite_materials_sbookfi.org_.pdf
2. http://www.eng.usf.edu/~kaw/compositesOCW/

| (26AMS302PC508) COMPUTER INTEGRATED MANUFACTURING | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 2 | 4 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT I: Introduction to CIM**

1. Origin and Evolution of CIM
2. Changing Manufacturing and Management Scenes
3. External Communication in CIM
4. Islands of Automation – Concept and Examples
5. Dedicated vs. Open Systems in CIM
6. Manufacturing Automation Protocol (MAP)
7. Overview of Product-Related Activities in a Company

**UNIT II: Group Technology & Computer Aided Process Planning**

8. History and Role of Group Technology (GT) in CAD/CAM
9. Part Families – Concept and Importance
10. Classification and Coding Systems – OPITZ, DCLASS, MICLASS
11. Facility Design using GT
12. Benefits of GT & Introduction to Cellular Manufacturing
13. Process Planning in CAD/CAM Integration
14. Computer-Aided Process Planning (CAPP) – Types and Approach

**UNIT-III: Shop Floor Control**

15. Phases of Shop Floor Control
16. Factory Data Collection System Overview
17. Automatic Identification Methods
18. Barcode Technologies – Working and Applications
19. RFID Technologies – Principles and Use Cases
20. Automated Data Collection Systems – Integration Aspects
21. Integrating Manufacturing with Business Functions

**UNIT-IV**: **CIM Implementation & Data Communication**

22. CIM in Company Strategy
23. System Modeling Tools – Overview
24. IDEF Modeling Techniques
25. Activity Cycle Diagrams & CIMOSA
26. Manufacturing Enterprise Wheel & CIM Architectures
27. CIM Implementation Software
28. LANs – Topologies, Management, and Installations

**UNIT-V: Open Systems and Databases for CIM**

29. Open Systems and OSI Model
30. MAP/TOP – Manufacturing & Technical Office Protocols

31. Database Fundamentals for CIM
32. Architecture of Database Systems
33. Data Modeling and Associations
34. Relational Databases – Operators and Use
35. Advantages of Databases in CIM Environment
36. Case study

**LAB**

1. Manual programming for CNC turning/Milling
2. CAD/CAM based part programming using CNC controller simulator
3. Demonstrate automatic feature recognition using CAM software
4. CNC tool path verification and optimization using digital manufacturing software
5. Modeling and simulation of CIM system using software
6. Simulation on flexible manufacturing system
7. Modeling Automated Storage/Retrieval Systems in manufacturing industry
8. Identify product with Barcode, RFID etc. by using Flexsim software
9. Modeling partially automated flow line with AGV by using Flexsim software
10. Modeling fully automated flow line with AGV by using Flexsim software
11. Demonstrate factory shop floor data collection method
12. Virtual reality simulation of digital manufacturing machinery and factory

**TEXTBOOKS**

1. Mikell.P. Groover "Automation, Production Systems and computer integrated manufacturing", Pearson Education 2008.
2. R.B.Patil,Pankaj.D,Dr.F.B.sayyad, "Computer Integrated Manufacturing System", SPPU,2023

**REFERENCE BOOKS**

1. Ranky, Paul G., "Computer Integrated Manufacturing", Prentice Hall International, 2010.
2 Dr.V.Jaya Kumar,Dr.H.S.Masooth "Computer Integrated Design and Manufacturing", Lakshmi Publications, 2021.

**USEFUL LINKS**

1. https://onlinecourses.nptel.ac.in/noc22_me10/preview
2 https://elearn.nptel.ac.in/shop/nptel/computer-integrated-manufacturing/?v=c86ee0d9d7ed

## PROGRAM ELECTIVES: I TO II

| (26AMS300PE601) SUSTAINABLE MANUFACTURING | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT I: Introduction to Sustainability and Manufacturing Processes**

1. **Concept of Sustainability in Manufacturing** - Definition, key principles, and significance.
2. **Sustainable Manufacturing Operations** - Overview of sustainable manufacturing practices.
3. **Manufacturing Processes and Sustainability** - Integration of sustainability in various processes.
4. **Sustainable Manufacturing Practices** - Best practices for reducing environmental impact.
5. **Case Studies on Sustainable Manufacturing** - Examples of real-world applications.
6. **Introduction to Green Manufacturing** - Importance and benefits.
7. **Waste Reduction and Circular Economy** - Strategies for sustainability.

**UNIT II: Simulation and Digital Modeling for Sustainable Manufacturing**

8. **Introduction to Manufacturing Simulation** - Importance and applications.
9. **Simulation Model Development** - Key components and structure.
10. **Verification and Validation of Simulation Models** - Ensuring accuracy and reliability.
11. **Output Analysis in Manufacturing Simulation** - Data interpretation and decision-making.
12. **Optimization Techniques in Simulation** - Improving efficiency and sustainability.
13. **Basics of Factory Simulation** - Concept, need, and applications.
14. **Building Simulation Models for Factories** - Key steps and tools.
15. **Digital Twin in Sustainable Manufacturing** - Integration of real-time data.
16. **Factory Simulation Case Studies** - Successful implementations.

**UNIT III: Life Cycle Assessment (LCA) and Sustainability Strategies**

17. **Introduction to Life Cycle Analysis (LCA)** - Concepts and methodologies.
18. **LCA Phases and Methodology** - Inventory analysis, impact assessment, and interpretation.
19. **Sustainability Frameworks in Manufacturing** - Approaches to integrating sustainability.
20. **Carbon Footprint and Environmental Impact Assessment** - Measuring sustainability performance.
21. **LCA Case Studies and Applications** - Practical implementation in industry.
22. **Sustainable Supply Chain Management** - Green logistics and resource optimization.
23. **Sustainability Metrics and Performance Indicators** - Measuring and improving performance.
24. **Regulatory Frameworks and Standards** - Compliance and best practices.

**UNIT IV: Productivity, Energy Efficiency, and Smart Factories**

25. **Balancing Productivity and Sustainability** - Challenges and solutions.
26. **Lean Manufacturing and Sustainability** - Principles and implementation.
27. **Energy Efficiency in Manufacturing** - Strategies for reducing energy consumption.
28. **Integration of Renewable Energy in Factories** - Solar, wind, and bioenergy applications.

29. **Green Manufacturing in Industry 4.0** - Role of advanced technologies.
30. **Energy Audits and Sustainability Assessment** - Evaluation techniques.
31. **Real-World Case Studies on Green Factories** - Industry examples.

**UNIT V: Laboratory Demonstrations and Developing a Green Smart Factory**

32. **Lab Demonstration on Sustainable Processes** - Practical applications.
33. **Introduction to Renewable Energy in Manufacturing** - Types and benefits.
34. **Developing a Green Smart Factory** - Key elements and strategies.
35. **Human-Machine Collaboration in Smart Factories** - Enhancing sustainability and efficiency.
36. **Future Trends in Sustainable Manufacturing** - Emerging innovations and best practices.

## LEARNING RESOURCES

### TEXT BOOKS:

1. Sustainable Manufacturing: Concepts, Tools, Methods and Case Studies" by R. Vinodh, Routledge, 2021.
2. Sustainable Manufacturing Systems: An Energy Perspective" by R. Saidur and N.A. Rahim, Wiley-IEEE Press, 2020

### REFERENCE BOOKS

1. Greenmanufacturing:fundamentalsandapplications by David A. Dornfeld.SpringerScience &BusinessMedia,2012.
2. Sustainable Manufacturing: Shaping Global Value Creationby Günther Seliger, Springer, 2017.

| (26AMS300PE602)<br>BIG DATA ANALYTICS FOR MANUFACTURING | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT-I: Big Data in Manufacturing**

1. Overview of digital transformation in manufacturing.
2. Key drivers: IoT, AI, and cyber-physical systems.
3. Big Data Fundamentals
4. 4 Vs (Volume, Velocity, Variety, Veracity)
5. Data Pipelines & Preprocessing
6. Data collection, cleaning, and feature engineering.

**UNIT-II: Machine Learning for Manufacturing**

7. Supervised Learning I -Regression
8. Predictive maintenance models -RUL estimation
9. Supervised Learning II - Classification
10. Defect detection using SVM/Random Forests.

**UNIT-III: Machine Learning for Manufacturing**

11. Unsupervised Learning
12. Clustering for process optimization K-means
13. Time-Series Analysis
14. LSTM for equipment health monitoring.

**UNIT-IV: Industrial IoT & Edge Computing**

15. IIoT Architecture
16. Sensor networks, protocols
17. Edge vs. Cloud Analytics
18. Real-time processing with Apache Kafka/Flink.

**UNIT-V: Advanced Analytics & Optimization**

19. Digital Twins
20. Simulation-driven analytics (ANSYS, MATLAB)
21. Prescriptive Analytics
22. Linear programming for production scheduling.
23. Reinforcement Learning
24. Dynamic process control

**LEARNINGRESOURCES**

**TEXTBOOKS**

1. Arun et.al."Internet of Things and Big Data Analytics-Based Manufacturing", 1st Ed., Taylor and Francis, Publisher, 2025.
2. EMC Education Services, "Data Science & Big Data Analytics", Wiley, 1st Ed., 2015.

**REFERENCEBOOKS**

1. O'Reilly Radar Team, "Big Data Now: Current Perspectives from O'Reilly Radar", O'Reilly Media, 1st Ed., 2011.
2. Sid Khanna, "BIG DATA IN MANUFACTURING: A Practical Introductory Guide to starting your Big Data journey",1st Ed., 2017.

**USEFUL LINKS**

1. https://appinventiv.com/blog/big-data-in-manufacturing/amp/
2. https://tulip.co/blog/big-data-for-manufacturing/

| (26AMS300PE603) ENGINEERING SMART MATERIALS | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT I: Fundamentals of Smart Materials**

1: Introduction to Conventional Materials: Metals, Ceramics, and Polymers – Classification and Properties
2: Introduction to Smart Materials – Definitions, Importance, and Classification
3: Components of a Smart System: Functional Elements, Sensing-Actuation Mechanisms
4: Types of Smart Materials I – Piezoelectric, Electrostrictive, Magnetostrictive, Magnetoelectric
5: Types of Smart Materials II – Magneto/Electro-rheological Fluids, Shape Memory Alloys, Applications and Case Studies

**UNIT II: Processing and Fabrication Techniques**

6: Overview of Processing Techniques for Smart Materials
7: Semiconductor Fabrication and Ceramic Processing Techniques
8: Polymer Synthesis – UV Curing and Metallization of Smart Structures
9: Composite Material Fabrication, Microstructural Control, and Multiscale Processing

**UNIT III: Smart Sensors and Sensing Mechanisms**

10: Introduction to Smart Sensors – Definitions and Characteristics
11: Sensor Types I – Conductometric, Capacitive, and Piezoelectric
12: Sensor Types II – Magnetostrictive, Piezoresistive, Optical, Resonant, CNT, and Polymer-Based
13: Emerging Sensors – Ferroelectric, LCE-based, and Multifunctional; Application Case Studies

**UNIT IV: Smart Actuators and Adaptive Systems**

14: Fundamentals of Smart Actuation – Principles and Examples
15: Actuation Types – Electrostatic, Electromagnetic, Electrodynamic
16: Advanced Actuators – Piezoelectric, Electrostrictive, Magnetostrictive, Electrothermal
17: Performance Comparison; Micro/Nano Actuators and Multiferroic Systems

**UNIT V: IoT Integration and Intelligent Smart Systems**

18: IoT in Smart Composites – System Architecture and Embedded Sensing
19: IoT Communication Protocols – Wi-Fi, BLE, Zigbee, LoRa
20: Wireless Data Acquisition, Edge Computing, and Real-Time Control
21: Applications – Structural Health Monitoring, Healthcare, Industrial Automation
22: Machine Learning for Smart Material Systems – Introduction and Behavior Prediction
23: Digital Twins – Concept, Manufacturing Use Cases, IoT Integration
24: Future Trends – Autonomous Systems, Smart Infrastructure, Sustainability Aspects

**LEARNING RESOURCES**

**TEXTBOOKS:**

1. *Smart materials and structures* by Gandhi, M. V., & Thompson, B. S**.** 7th edition (2020). Springer.
2. Fundamentals of Smart Materials, Mohsen Shahinpoor , Royal Society of Chemistry, 1st edition, 2020

**REFERENCE BOOKS:**

1. Smart Structures, P. Gauenzi, Wiley, 2009.
2. Handbook of Smart Materials, Technologies, and Devices, Chaudhery Mustansar Hussain, Paolo Di Sia, Springer, 1st edition ,2022

**USEFUL LINKS**

1. https://www.slideshare.net/sureshdaravath/shape-memory-alloys-71483726
2. https://www.slideshare.net/deepika46/smart-materials-39205546

| (26AMS300PE604) FINITE ELEMENT ANALYSIS | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | - | - | 3 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT I: Introduction to FEM**

1. Fundamentals of FEM
2. Comparison of FEM with Other Methods and Basic Concepts
3. Meshing in FEM
4. FEM Formulation and Errors

**UNIT II: Methods of finite element analysis**

5. Introduction to Variational Methods
6. Rayleigh-Ritz Method
7. Method of Weighted Residuals (MWR) - Basics
8. Method of Weighted Residuals (MWR) - Detailed Study
9. Assembly Process in FEM
10. Implementation of Boundary Conditions for 1D/2D/3D elements

**UNIT III: One-dimensional problems of FEM**

11. Introduction to 1D Finite Element Problems
12. Finite Element Analysis of Bars
13. Plane Trusses – Fundamentals, Displacement & Stress Analysis
14. Buckling Analysis using FEM
15. Analysis of Thin Plates & Composite Slabs
16. 1D Heat Conduction Problems

**UNIT IV: 2-D and 3D problems of FEM**

17. Introduction to 2D and 3D FEM Problems
18. Stress Computation in Axisymmetric Loading
19. FEM Applications in Fluid Mechanics
20. 2D and 3D Heat Conduction Problems

**UNIT V: Advanced topics of FEM**

21. Failure Analysis Using FEM
22. Time Integration Methods
23. Nonlinear FEM Formulations
24. Multi-Physics Coupling in FEM

**TEXTBOOKS**

1. S. S. Rao. “The Finite Element Methods in Engineering”, Elsevier, 9th edition, 2021.
2. O.C. Zienkiewicz, R.L. Taylor, D.D. Fox ."The Finite Element Method: Its Basis and Fundamentals".Butterworth-Heinemann Ltd; 10th edition (2 October 2020).

**REFERENCE BOOKS**

1. J.N.Reddy, “An Introduction to Finite Element Methods”, McGraw Hill, 7th Ed., 2020.
2. Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith, Ted G. Byrom. “The Finite Element Method for Engineers".Wiley-Interscience; 9th edition (9 November 2021).

## OPEN ELECTIVES

| **(26PEL300OE601)**<br>**ENERGY SYSTEMS AND MANAGEMENT** | | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Open Elective | Pre-requisite | | | | |

| (26PEL300OE602) RENEWABLE ENERGY TECHNOLOGIES | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Open Elective | Pre-requisite | | | | |

## UNIT I Energy Sources Classification

1. Global energy landscape - an overview of energy sources
2. Classification of energy - conventional vs. non-conventional
3. Distinguishing renewable and non-renewable energy resources
4. Prospects and perspectives for non-conventional energy
5. Comparative advantages of renewable energy technologies
6. Key renewable sources - solar, wind, and biomass
7. Ocean and earth energy - OTEC and geothermal systems
8. Advanced conversion - fuel cells, MHD, thermionic and thermo-electric power

## Unit II Solar Energy Fundamentals

9. Solar radiation fundamentals - the solar constant and extraterrestrial radiation
10. Solar geometry - understanding sun-earth angles
11. Defining time and day length in solar energy applications
12. Techniques and instrumentation for solar radiation measurement
13. Calculating solar radiation on inclined surfaces
14. Interpreting and utilizing solar radiation data and charts

## UNIT III Wind Energy Fundamentals

15. Assessing wind as a viable energy resource
16. Characterization and analysis of wind data
17. Principles of horizontal axis wind turbines
18. Principles of vertical axis wind turbines

## UNIT IV Biomass Energy Conversion

19. Biomass resources and potential
20. Characterizing biofuels - properties and energy content
21. Biomass conversion pathways: thermal, chemical, biological
22. Anaerobic digestion processes for biogas production
23. Principles of aerobic digestion in biomass treatment
24. Key factors affecting bio-digestion performance
25. Design and types of biogas plants
26. Strategies for effective biogas collection and utilization
27. Biomass gasification technology: principles and gasifier types
28. Thermal applications and development issues of gasifiers
29. Integration of producer gas with internal combustion engines

## UNIT V Other Non-Conventional Energy Sources

30. Geothermal energy - resource assessment, sources, and system characteristics
31. Fuel cell technology - operating principles and classification
32. Performance analysis of fuel cells - efficiency and polarization
33. Magneto-hydrodynamic power generation
34. Mhd systems - open and closed cycle configurations and materials
35. Harnessing energy from thermonuclear fusion: concepts and challenges
36. Emerging sources for sustainable use

## TEXT BOOKS

1. Da Rosa, Aldo Vieira, and Juan Carlos Ordonez. Fundamentals of Renewable Energy Processes. Academic Press, 2021.
2. Kathiresh, M., et al., editors. Integration of Renewable Energy Sources with Smart Grid. John Wiley & Sons, 2021.

## REFERENCE BOOKS

1. Kothari, D. P., et al. Renewable Energy Sources and Emerging Technologies. 2021.
2. Twidell, John. Renewable Energy Resources. Routledge, 2021.

| **(26CAI300OE603)**<br>**CYBER LAWS** | | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Open Elective | Pre-requisite | | | | |

| (26CAI300OE604) BLOCK CHAIN TECHNOLOGY | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Open Elective | Pre-requisite | | | | |

## UNIT I: – Foundations of Blockchain

1. Blockchain and Distributed Ledger Technology (DLT)
2. Types of Distributed Ledgers
3. Hashing and Merkle Trees
4. Public Key Cryptography
5. Digital Signatures
6. Proof of Work (PoW)
7. Proof of Stake (PoS)
8. Advanced Consensus (PBFT, DPoS, PoA)

## UNIT II – Bitcoin and Early Blockchain Concepts

9. Bitcoin Architecture Overview
10. Bitcoin Transactions and UTXO Model
11. Bitcoin Mining and Block Structure
12. Bitcoin Network and Nodes
13. Bitcoin Scripting Basics
14. Bitcoin Wallets and Key Management
15. Early Blockchain Use Cases

## UNIT III – Ethereum and EVM Architecture

16. Ethereum and EVM
17. Accounts, Gas, and Transactions
18. Solidity Structure and Syntax
19. Data Types and State Variables
20. Functions, Modifiers, and Events
21. Solidity Inheritance and Interfaces
22. Solidity Libraries

## UNIT IV – Smart Contracts and Token Standards

23. Smart Contract Development Lifecycle
24. Smart Contract Deployment
25. ERC20 Token Standard
26. ERC721 Token Standard (NFTs)
27. Smart Contract Security Vulnerabilities
28. Secure Coding Best Practices
29. dApps Architecture

## UNIT V – dApp Ecosystem, DeFi & Advanced Blockchain

30. Web3.js / Ethers.js Integration
31. Wallet Integration (MetaMask)
32. Decentralized Storage (IPFS)
33. Oracle Networks
34. Decentralized Finance (DeFi)
35. Decentralized Autonomous Organizations (DAOs)
36. Layer 2 Scaling and Interoperability

## TEXT BOOKS

1. Imran Bashir, Mastering Blockchain, 4th Edition, Packt Publishing, 2024. O'Reilly
2. Ramchandra Sharad Mangrulkar and Pallavi Vijay Chavan, Blockchain Essentials: Core Concepts and Implementations, Apress, 2024. SpringerLink
3. Andreas M. Antonopoulos and Gavin Wood, Mastering Ethereum: Building Smart Contracts and dApps, O'Reilly Media, 2023.

## REFERENCE BOOKS

4. Nick Vyas, Aljosja Beije, and Bhaskar Krishnamachari, Blockchain and the Supply Chain: Concepts, Strategies and Practical Applications, Kogan Page, 2024. Zephyrnet
5. (Editors) Sushmita Ruj, Salil S. Kanhere, Mauro Conti, Blockchains: A Handbook on Fundamentals, Platforms and Applications, Springer, 2024. SpringerLink
6. Agustin Aguilar and Shermin Voshmgir, Blockchain Developer's Guide: Develop Decentralized Applications Using Python, Ethereum, and Solidity (2024 Edition – if available). learnblockchain101.com

(Optional additional reference) The Blockchain Technology for Secure and Smart Applications across Industry Verticals, Elsevier/Academic Press (latest edition).

| (26AMS300OE605) OPERATIONS RESEARCH | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Open Elective | Pre-requisite | | | | |

**UNIT I — Linear Programming Problem (06 Hours)**

Introduction to Operations Research; Linear Programming; mathematical formulation; graphical method; simplex method; penalty methods — Big-M method and Two-Phase method.

**UNIT II — Transportation and Assignment (05 Hours)**

Introduction; formulation; solution of the transportation problem (minimization and maximization) — Northwest Corner rule, row minima method, column minima method, Least Cost method, Vogel's Approximation Method; optimality test — MODI method. Assignment problems — applications, minimization and maximization; Travelling Salesman Problem.

**UNIT III — Sequencing and Replacement Models (09 Hours)**

Sequencing — introduction, flow-shop sequencing, n jobs through two machines, n jobs through three machines, job shop sequencing, two jobs through 'm' machines. Replacement Models — introduction; replacement of items that deteriorate with time (when money value is not counted and when counted); replacement of items that fail completely; group replacement.

**UNIT IV — Game Theory and Queuing Models (10 Hours)**

Game theory — competitive games, useful terminology, rules for game theory, two-person zero-sum game, property of dominance, graphical solution, algebraic method. Queuing Models — Poisson arrivals and exponential service times, single-channel and multi-channel models. Simulation — basic concepts, advantages and disadvantages, random number generation, Monte Carlo simulation applied to queuing problems.

**UNIT V — Project Management (06 Hours)**

Introduction; phases of project management; construction of network diagrams; Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT); crashing of project network.

**TEXTBOOKS**

1. S. D. Sharma, "Operations Research", 20th ed., Kedar Nath Ram Nath Publishers, 2019.
2. J. K. Sharma, "Operations Research: Theory and Applications", 6th ed., Trinity Press, 2022.

**REFERENCE BOOKS**

1. R. Panneerselvam, "Operations Research", 2nd ed., PHI Learning, 2023.2. A. D. Belegundu and T. R. Chandrupatla, "Optimization Concepts and Applications in Engineering", 3rd ed., Cambridge University Press, 2022.

**MOOC COURSES / ONLINE LEARNING RESOURCES (Reference to the Course):**

1. Fundamentals of Operations Research – NPTEL: https://onlinecourses.nptel.ac.in/noc22_ma48/preview
2. Operations Research (Modeling) – Coursera: https://www.coursera.org/learn/operations-research-modeling

| (26AMS300OE606)<br>3D PRINTING | | | L | T | P | C |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Program Core | Pre-requisite | | | | |

**UNIT I: Introduction, Data Formats & Software**

1. Introduction to Prototyping and Historical Development
2. Fundamentals of 3D Printing & Process Chain
3. Advantages and Limitations of 3D Printing
4. Classification of 3D Printing Systems
5. STL File Format and Common Problems
6. Repairing STL Files and Introduction to New Formats
7. Overview of RP Software: Magics, Mimics, Rhino, and Others

**UNIT II: Liquid-Based Systems**

8. Introduction to Liquid-Based Systems: SLA & SGC
9. Stereolithography Apparatus (SLA): Principle and Process
10. SLA: Pre-build, Part-building & Post-build Processes
11. SLA: Photo-polymerization, Recoating Issues & Materials
12. SLA: Part Quality, Process Planning & Case Studies
13. Solid Ground Curing (SGC): Principle and Process Flow
14. SGC: Advantages, Disadvantages & Applications
15. SGC: Industrial Case Studies

**UNIT III: Solid-Based Systems**

16. Introduction to Solid-Based Systems: LOM & FDM
17. Laminated Object Manufacturing (LOM): Working Principle
18. LOM: Process Flow, Materials & Applications
19. LOM: Advantages, Disadvantages & Case Studies
20. Fused Deposition Modeling (FDM): Principle and Process
21. FDM: Materials, Specifications & Quality Aspects
22. FDM: Applications, Advantages & Limitations
23. FDM: Industrial Case Studies

**UNIT IV: Powder-Based Systems**

24. Introduction to Powder-Based Systems: SLS & 3DP
25. Selective Laser Sintering (SLS): Working Principle
26. SLS: Materials, Applications & Advantages
27. SLS: Limitations and Case Studies
28. Three-Dimensional Printing (3DP): Principle and Process
29. 3DP: Applications, Materials & Limitations
30. 3DP: Case Studies in Different Industries

**UNIT V: Applications of 3D Printing**

31. Applications in Engineering Design, Analysis & Planning
32. Applications in Aerospace and Automotive Industry
33. Applications in Jewellery, Coins, GIS & Architecture
34. Medical Applications: Surgery Planning & Implants
35. Medical Devices, Forensics & Bioengineering Applications
36. Visualization of Biomolecular Models & Future Trends

**LEARNINGRESOURCES**

**TEXT BOOKS:**

1. Gibson, I., Rosen, D. W., & Stucker, B. (2015). *Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing* (2nd ed.). Springer.
2. Horvath, J., & Cameron, R. (2020). *Mastering 3D printing: A guide to modeling, printing, and prototyping* (2nd ed.). Apress.

**REFERENCE BOOKS:**

1. Andrade, C. (2022). *3D printing step by step: 3D design tutorials and common mistakes in 3D printing with solutions* (1st ed.). Notion Press.
2. Randall, M. D. (2022). *3D printer: A complete 3D printing guide* (1st ed.). Oas-Global Press.

**USEFUL LINKS**

1. https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SPR1616.pdf
2. https://www.diva-portal.org/smash/get/diva2:1676285/FULLTEXT01.pdf

| **(26ECE300OE607)**<br>**INTERNET OF THINGS AND IIoT** | | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Open Elective | Pre-requisite | | | | |

| **(26ECE300OE608)**<br>**COMPUTER VISION** | | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Open Elective | Pre-requisite | | | | |

| **(26CTM300OE609)**<br>**DISASTER MANAGEMENT** | | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Open Elective | Pre-requisite | | | | |

| **(26CTM300OE610)**<br>**SMART CITIES** | | | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|---|
| | | | 3 | 0 | 0 | 3 |
| Course type | Open Elective | Pre-requisite | | | | |