DHANALAKSHMI SRINIVASAN ENGINEERING COLLEGE
(AUTONOMOUS)
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PERAMBALUR-621212, TAMILNADU, INDIA.
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COURSE MATERIALS

Course Code/Name	**P23CCT23 / ADDITIVE MANUFACTURING AND TOOLING**			
Year/ Department	II / CAD/CAM			
Credits Details	L: 3	T: 0	P: 0	C: 3
Total Contact Hours Required	45			

Syllabus:

UNIT I/ INTRODUCTION	**No. of Periods : 9**
Need-DevelopmentofAMsystems–AMprocesschain-ImpactofAMonProductDevelopment- Virtual Prototyping- Rapid Tooling – RP to AM -Classification of AM processes-Benefits- Applications.	
UNIT II/ CAD & REVERSE ENGINEERING	**No. of Periods : 9**
Basic concept- Digitization techniques – Model reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data requirements – Geometric modeling techniques: Wire frame, surface and solid modeling data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation-Software for AM- Case studies.	
UNIT III/ LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS	**No. of Periods : 9**
Stereo lithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, part quality and process planning, recoating issues, materials, advantages, limitations and applications. Solid Ground Curing (SGC): working principle, process, strengths, weaknesses and applications. Fused deposition Modeling (FDM): Principle, details of processes, process variables, types, products, materials and applications. Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.	
UNIT IV/ POWDER BASED ADDITIVE MANUFACTURING SYSTEMS	**No. of Periods : 9**
Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications– Case Studies.	

UNIT V/ TOOLING	**No. of Periods : 9**
Classification, Soft tooling, Production tooling, Bridge tooling, direct and indirect tooling, Fabrication processes, Applications Case studies automotive, aerospace and electronics industries	

Objective:

- To know the principle methods, areas of usage, possibilities and limitations as well as environmental effects of the Additive Manufacturing technologies
- To be familiar with the characteristics of the different materials those are used in Additive Manufacturing

Text Book:

T1:. Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third Edition, World Scientific Publishers, 2010.
T2: Gebhardt A., "Rapid prototyping", Hanser Gardener Publications, 2003.

Reference Book:

R1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications : A tool box for prototype development", CRC Press, 2007.
R2. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.
R3. Hilton P.D. and Jacobs P.F., "Rapid Tooling: Technologies and Industrial Applications", CRC press, 2000.

Website:

W1 : https://www.coursera.org/learn/introduction-to-additive-manufacturing-processes?utm_source=chatgpt.com
W2 : https://github.com/leahgaeta/Additive- Manufacturing /blob/ master/ Additive% 20Data %20 Workflow.
W3 : https://youtu.be/t7yv4gSnNkE?t=145

Online Mode of Study (if Any):

- https://slideplayer.com/slide/12100592/

UNIT I – INTRODUCTION

1. **Define Additive Manufacturing.** *(AU Nov/Dec 2021)*

   ➤ Process of building 3D objects layer by layer from a digital file.

2. **List two advantages of AM.** *(AU Apr/May 2022)*

   ➤ (i) Reduced material waste, (ii) Complex geometry fabrication.

3. **State two limitations of AM.**

   ➤ (i) Slow build rate, (ii) Limited material availability.

4. **Why is AM required in modern manufacturing?** *(AU Nov/Dec 2021)*

   ➤ Enables rapid prototyping, design flexibility, and mass customization.

5. **What is rapid prototyping?** *(AU Nov/Dec 2022)*

   ➤ Quick fabrication of a scale model using AM from CAD data.

6. **Mention any two applications of AM.** *(AU Apr/May 2023)*

   ➤ (i) Biomedical implants, (ii) Automotive prototyping.

7. **What are the stages of AM process chain?**

   ➤ CAD modeling → STL conversion → Slicing → Printing → Post-processing.

8. **List two product development benefits of AM.**

   ➤ (i) Shorter time-to-market, (ii) Early design validation.

9. **What is tooling in AM?** *(AU Apr/May 2022)*

   ➤ Using AM to create molds, dies, jigs, or fixtures.

10. **List any two types of AM classifications.** *(AU Nov/Dec 2023)*

    ➤ Material extrusion, Powder bed fusion.

11. **What are photopolymers?**

    ➤ Light-sensitive resins used in SLA process.

12. **Mention any two AM file formats.**

    ➤ STL, OBJ.

13. **What is additive layer manufacturing?** *(AU Nov/Dec 2023)*

    ➤ Manufacturing technique that builds parts layer-by-layer.

14. **Differentiate between traditional and additive manufacturing.**

    ➤ Traditional: subtractive; AM: additive, builds parts from nothing.

15. **What is net shape manufacturing?** *(AU Apr/May 2022)*

    ➤ Producing parts with final dimensions without machining.

UNIT II – CAD & REVERSE ENGINEERING

1. **What is CAD in AM?** *(AU Apr/May 2022)*

   ➤ Software used to create 3D models for AM.

2. **Define reverse engineering.** *(AU Nov/Dec 2023)*

   ➤ Converting physical parts into digital models using scanning.

3. **List two digitization techniques.**

   ➤ Laser scanning, CT scanning.

4. **What is STL file?** *(AU Apr/May 2022)*

   ➤ A file format that stores 3D model as a mesh of triangles.

5. **What is the purpose of slicing in AM?** *(AU Apr/May 2023)*

   ➤ Converts 3D model into layers for printing.

6. **State the role of part orientation.** *(AU Nov/Dec 2022)*

   ➤ Affects surface finish, strength, and support material usage.

7. **Mention any two software tools used in AM.** *(AU Nov/Dec 2021)*

   ➤ MIMICS, MAGICS.

8. **Define toolpath generation.**

   ➤ Defines the path for deposition of material in each layer.

9. **What is tessellation in AM?**

   ➤ Converting 3D surfaces into triangles for STL format.

10. **List two challenges in reverse engineering.** *(AU Apr/May 2023)*

    ➤ Incomplete data capture, complex surface modeling.

11. **What is voxel model in AM?**

    ➤ A 3D model represented using volume pixels (voxels).

12. **What is mesh repair?** *(AU Apr/May 2022)*

    ➤ Fixing STL file issues like holes or inverted normals.

13. **What is support generation?**

    ➤ Creating additional structures to support overhanging parts.

14. **What is the function of MAGICS software?** *(AU Nov/Dec 2022)*

    ➤ STL file editing, slicing, and build optimization.

15. **What is model reconstruction?**

    ➤ Generating 3D models from scanned point cloud data.

UNIT III – LIQUID & SOLID BASED SYSTEMS

1. **What is SLA?** *(AU Nov/Dec 2022)*

   ➤ A resin-based AM process using UV laser to solidify layers.

2. **List two advantages of SLA.** *(AU Apr/May 2022)*

   ➤ High accuracy, Smooth surface finish.

3. **Define FDM.** *(AU Nov/Dec 2023)*

   ➤ A process that extrudes thermoplastic filaments to build parts.

4. **Mention two FDM materials.** *(AU Apr/May 2022)*

   ➤ ABS, PLA.

5. **What is LOM?** *(AU Nov/Dec 2022)*

   ➤ Laminated Object Manufacturing uses paper/plastic sheets to build parts.

6. **List two limitations of FDM.**

   ➤ Poor surface finish, Slow build speed.

7. **What is recoating in SLA?**

   ➤ Applying a new resin layer after each laser curing step.

8. **Define raster path in FDM.**

   ➤ Path followed by extruder to lay material layer-wise.

9. **Compare SLA and FDM.** *(AU Nov/Dec 2022)*

   ➤ SLA: resin-based, high detail; FDM: thermoplastic, cost-effective.

10. **List one application of LOM.**

    ➤ Architectural modeling.

11. **What is UV curing?**

    ➤ Hardening of liquid resin by ultraviolet light.

12. **What are thermoplastics?** *(AU Apr/May 2023)*

    ➤ Plastics that soften with heat and solidify on cooling.

13. **Why is support material needed in FDM?**

    ➤ To hold overhangs and bridges during printing.

14. **What is heated build chamber in FDM?**

    ➤ Maintains constant temperature to reduce warping.

15. **What is slicing software used in SLA?**

    ➤ PreForm (for Formlabs SLA printers).

UNIT IV – POWDER BASED SYSTEMS

1. **Define SLS.** *(AU Apr/May 2023)*

   ➤ Uses a laser to sinter powdered material layer-by-layer.

2. **List two materials used in SLS.** *(AU Nov/Dec 2023)*

   ➤ Nylon, Polyamide.

3. **State one application of SLS.**

   ➤ Functional plastic prototypes.

4. **What is 3DP in powder-based AM?** *(AU Apr/May 2023)*

   ➤ Inkjet heads selectively bind powder using a liquid binder.

5. **What is the working principle of LENS?**

   ➤ Laser melts powder fed through a nozzle to create metal parts.

6. **Compare SLS and 3DP.** *(AU Nov/Dec 2023)*

   ➤ SLS uses laser sintering; 3DP uses binder jetting.

7. **What is sintering?**

   ➤ Heating material below melting point to bond particles.

8. **Define EBM.** *(AU Apr/May 2023)*

   ➤ Electron Beam Melting uses electron beams to melt powder in vacuum.

9. **What is powder bed fusion?** *(AU Nov/Dec 2022)*

   ➢ Laser or electron beam fuses powder in a bed layer by layer.

10. **List two advantages of LENS.**

    ➢ Precise metal part fabrication, Repair of existing parts.

11. **State two challenges in EBM.**

    ➢ High cost, Need for vacuum environment.

12. **Mention one industrial application of LENS.**

    ➢ Turbine blade repair.

13. **List one limitation of SLS.**

    ➢ Surface roughness due to powder particles.

14. **What is the role of binder in 3DP?**

    ➢ Binds the powder particles into solid form.

15. **Why is post-processing important in SLS?**

    ➢ To remove loose powder and improve surface finish.

UNIT V – TOOLING

1. **What is bio-additive manufacturing?** *(AU Nov/Dec 2023)*

   ➢ Fabrication of biological/medical components using AM.

2. **Define prosthesis.** *(AU Apr/May 2024)*

   ➢ An artificial device replacing a missing body part.

3. **What is CATE?** *(AU Nov/Dec 2023)*

   ➢ Computer-Aided Tissue Engineering integrates CAD and tissue growth.

4. **Mention one biocompatible material.**

   ➢ Titanium alloy.

5. **What is patient-specific implant?** *(AU Apr/May 2024)*

   ➢ Customized implants designed using CT/MRI data.

6. **List one AM technique for prosthetic limbs.**

   ➢ FDM.

7. **What is a scaffold in tissue engineering?** *(AU Nov/Dec 2023)*

   ➢ 3D framework supporting cell growth and tissue formation.

8. **Give an example of bio-AM case study.**

   ➢ 3D printed skull implant for trauma patient.

9. **What is organ printing?** *(AU Apr/May 2023)*

   ➢ Layer-by-layer deposition of cells to form organ-like structures.

10. **Mention two applications of bio-AM.**

    ➢ Dental crowns, Bone scaffolds.

11. **What is a CT scan used for in medical AM?**

    ➢ To acquire patient geometry for customized modeling.

12. **Why is sterilization important in medical AM?**

    ➢ To ensure the safety and cleanliness of implants.

13. **What is 3D bioprinting?** *(AU Nov/Dec 2023)*

    ➢ Printing structures with living cells for tissue regeneration.

14. **Mention one limitation of bio-AM.**

    ➢ Limited vascularization in printed tissues.

15. **What is regenerative medicine?**

    ➢ Medical field focused on regenerating damaged tissues/organs.

ADDITIVE MANUFACTURING

UNIT 1

INTRODUCTION

Part – A

1. What is additive manufacturing?

2. What is STL file?
3. What are the advantages of RP?
4. Write a note on product development by AM?
5. What is Rapid Tooling?
6. What are the applications of AM?
7. What is the need of Am in current Scenario?

8. What is AM process chain?

9.What is Rapid Prototyping?
10. What is a 3D printer?
11.What is Virtual prototyping?
12. What are the benefits of AM?
13. Classify the AM process?
14. Write the merits of virtual prototyping.

15. What are basic requirements of product development?
16. What are the merits of product development?
17. What are the inputs required for product development?
18. What are the benefits of rapid tooling?
19. What are the applications of rapid tooling?
20. What are the limitations of AM?

Part – B

1. Explain the transition of RP to Am.
2. Classify and explain the AM process.
3. Write a note on the need and development of AM systems.
4. Write a note on the impact of AM on product development.

5. Write a note on a) Virtual prototyping b) Rapid Tooling
6. Explain how AM has influenced the 3D printing technology.
7. Explain the Am process chain.

8. Write a note on the benefits and applications of AM.
9. Explain the transition of RP to Am

10. Write a note on the benefits and applications of AM.

UNIT 2

REVERSE ENGINEERING AND CAD MODELING:

Part – A

1. What is reverse engineering?
2. What is geometric modeling?
3. What is model reconstruction?
4. What is additive manufacturing?

5. What is data processing?
6. Classify the digitization techniques
7. What is wire frame modeling?
8. Mention few data formats
9. What is data interfacing?.

10. Brief about part orientation?
11. Why support generation, is needed?
12. Brief about Support structure design?
13. What is Model Slicing?
14. What are the softwares used for Tool path generation
15. What are the softwares currently used for AM?
16. What are the limitations of Tool path generation?
17. What are the advantages of Part orientation?
18. what is surface modeling?
19. what is solid modeling?
20. Mention the applications of modeling.

Part – B

1. Explain about data formats and data interfacing.
2. What is part orientation? Explain with illustrations.

3. Explain the need of support generation with flow charts.
4. What are the steps involved in model slicing?
5. Discuss various aspects of tool path generation

6. Write a note on a) Virtual prototyping b) Rapid Tooling
7. Explain the concept of reverse engineering?
8. Explain in detail data processing for RP.
9. Explain the geometric modeling techniques?

10. What are the techniques used in Tool path generation?

UNIT 3

LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS

Part – A

1. What is SLA?
2. Why pre-build process is required in SLA?
3. What are part-building steps in SLA?
4. What are the steps in post-build processes?
5. What is photo polymerization in SLA?
6. What is the role of process planning in SLA?

7. What is SGC?
8. What are the strengths of SGC?
9. What are the weaknesses of SGC?

10. What are the applications of SGC?
11. What is FDM?
12. Brief the FDM process.
13. What are process variables in FDM?
14. Mention the products of FDM?
15. What are the limitations of FDM?
16. What is LOM?
17. Brief the LOM process.
18. What are the limitations of FDM?
19. What are the recoating issues in SLA?
20. What are the applications of FDM?

Part – B

1. Explain the working principle of SLA.

2. What are the part building and post building process involved in SLA?
3. Explain the recoating issues in SLA?
4. Explain the working principle of SGC.
5. Brief about strength, Weakness and applications of SGC?
6. Explain the working principle of FDM.

7. Explain the process variables of FDM.
8. Explain the working principle of LOM.
9. What are the steps in pre build and post-build process for LOM?

10. Compare the liquid based and solid based AM systems.

Unit 4

POWDER BASED ADDITIVE MANUFACTURING SYSTEMS

Part A

1. What is LENS?
2. What are the materials used in LENS?
3. What is SLS?

4. What are the advantages and limitations of LENS?
5. What are the advantages and limitations of SLS?
6. What are the materials used in SLS?
7. Brief the post processing types of SLS.
8. Why surface deviation occurs in SLS?
9. Why is accuracy important in SLS

10. What are the applications of SLS?
11. Brief the post processing types of LENS.
12. Why surface deviation occurs in LENS?
13. Why is accuracy important in LENS?
14. What are the applications of LENS?
15. Why case studies are analyzed for sintering?
16. What is direct SLS?
17. What is indirect SLS?
18. Mention the merits of direct SLS.
19. Mention the merits of indirect SLS.
20. What are the applications of direct SLS

Part B

1. What is LENS? Explain the same.
2. What are the processing techniques used in LENS?
3. What is SLS? Explain the same.

4. What are the advantages and limitations of LENS? Explain with examples
5. Explain the applications of SLS and its processing techniques.

6. Brief the post processing types of LENS. Explain each with suitable example.

7. Explain the effect of surface deviation in LENS?
8. What is indirect SLS and direct SLS. Explain the same.
9. Mention the post processing techniques of direct SLS.

10. Mention the post processing techniques of direct SLS.

UNIT 5
OTHER ADDITIVE MANUFACTURING SYSTEMS
PartA

1. Brief the material system of 3DP.

2. Brief solid, liquid and powder based system of 3DP.
3. What is SDM?
4. What is 3DP?
5. What is the principle of 3DP?
6. What are the strength and weakness of 3DP?
7. What are the applications of 3DP?

8. What is BPM?
9. What is EBM?

10. What is SLM?
11. Brief the physics of 3DP.
12. What are the types of 3DP?
13. Brief the process capabilities of 3DP.
14. What are the applications of EDM?
15. What are the applications of SDM?
16. What are the merits of EDM?
17. What are the merits of SLM?
18. What are the demerits of EDM?
19. What are the demerits of SDM?
20. What are the merits of 3DP

Part B

1. Explain the working principle of 3DP
2. Compare solid, liquid and powder based system of 3DP.
3. Explain the working principle of SDM
4. Explain Ballistic Particle Manufacturing (BPM)
5. Discuss few case studies of 3DP.
6. Explain Electron Beam Melting.

7. Differentiate between SDM and EBM.
8. Brief the post processing in SDM.
9. Brief the post processing in EBM.
10. (a) Explain the advantages of SLM and EBM.

(b)Brief the pre and post processing in BPM