**Fr. Conceicao Rodrigues College Of Engineering**

Father Agnel Ashram, Bandstand, Bandra-west, Mumbai-50

Department of Production Engineering

T.E. (Production) (Semester VI)  (2020-2021)

**Lecture Plan**

**Subject: Rapid Proto-typing and Manufacturing Credits - 3**

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|  | Syllabus | Hours |
| 1 | **Introduction to Rapid Prototyping (RP) and Additive Manufacturing (AM)** Prototype Fundamentals, Historical Development, Fundamentals of Rapid Prototyping, Advantages of Rapid Prototyping, Commonly Used Terms, Additive Manufacturing (AM) Definition, Applications of AM parts, The Generic AM process, Why use the term Additive Manufacturing, The Benefits of AM, Distinction Between AM and CNC Machining Other Related Technologies: Reverse Engineering, CAE, Haptic based CAD. Classifications of AM / RP System: Liquid polymer Systems, Discrete Particle Systems, Molten Material Systems, Solid Sheet Systems New AM Classification Schemes as per ASTM F42 and ISO TC 261: Vat photo polymerization, Powder bed fusion, Material extrusion, Material jetting, Binder jetting, Sheet lamination and Directed energy deposition.  | 06 |
| 2 | **Additive Manufacturing / Rapid Prototyping Systems** Vat Photo Polymerization based AM / RP Systems: Principle of operation, Process, materials advantages, disadvantages, and applications of 3D Systems’ stereo lithography (SLA), CMET’S Solid Object Ultraviolet-Laser Printer (SOUP). 2.1 Powder Bed Fusion based AM / RP Systems: Principle of operation, Process, materials, advantages, disadvantages, and applications of 3D Systems’ Selective Laser Sintering (SLS), EOS’s EOSINT Systems, ARCAM’s Electron Beam Melting (EBM). 2.2 Material Extrusion based AM / RP Systems: Principle of operation, Process, advantages, disadvantages and applications of STRATASYS’ Fused Deposition Modeling (FDM). 2.3 Material Jetting based AM / RP Systems: Principle of operation, Process, advantages, disadvantages and applications of 3D Systems’ Multi-jet Modeling System (MJM). 2.4 Binder Jetting based AM / RP Systems: Binder jetting principle, materials, Z Corporation’s Three Dimensional Printing (3DP) machine, process benefits and drawbacks. 2.5 Sheet lamination based AM / RP Systems: Principle of operation, Process, materials, advantages, disadvantages, and applications of CUBIC Technologies Laminated Object Manufacturing (LOM), CAM-LEM’s (Computer Aided Manufacturing of Laminated Engineering Materials) CL 100. 2.6 Directed Energy Deposition based AM / RP Systems: Principle of operation, Process, materials, advantages, disadvantages, and applications of OPTOMEC’s Laser Engineered Net Shaping (LENS).  | 10 |
| 3 | **Direct Digital Manufacturing** Concept of Direct Digital Manufacturing (DDM), Application Case Studies, DDM Drivers 3.3 Manufacturing Versus Prototyping 3.4 Cost Estimation: Cost Model, Build Time Model 3.5 Life-Cycle Costing 3.6 Future of DDM  | 05 |
| 4 | **Design for Additive Manufacturing** 4.1 AM Unique Capabilities: Shape Complexity, Hierarchical Complexity, Functional Complexity, Material Complexity. 4.2 Core DFAM Concepts and Objectives: Complex Geometry, Integrated Assemblies, Customized Geometry, Multifunctional Designs, Elimination of Conventional DFM Constraints  | 05 |
| 5 | **Rapid Tooling and Reverse Engineering** 5.1 Introduction to Rapid Tooling, Indirect Rapid Tooling Processes, Direct Rapid Tooling Processes, Emerging Trends in Rapid Tooling 5.2 Reverse Engineering (RE): Introduction, RE generic process, RE hardware and software, Integration of RE and RP for Layer-based Model Generation, Applications and case studies of RE in automotive, aerospace and medical device industry, Barriers for adopting RE.  | 07 |
| 6 | **Digital Manufacturing** 6.1 Definition of digital manufacturing, Digital manufacturing idea taking control for center, Digital manufacturing idea taking design for center, Digital manufacturing idea taking management as its center, The 10 disruptive principles of digital manufacturing processes. 6.2 Key Technologies of Digital Manufacturing: Various Digital Technologies in Product Life Cycle, Resource and Environment, Management, Control and Product Recognition.  | 08 |

**Reference Books:**

1. *Fundamentals of Digital Manufacturing Science*, Zude Zhou, Shane (Shengquan) Xie, Dejun Chen, Springer, 2012.

2. *Rapid Manufacturing: An Industrial Revolution for the Digital Age,* N. Hopkinson, R.J.M. Hague and P.M. Dickens (Eds.), John Wiley & Sons, 2006.

3. *Rapid Tooling: Technologies and Industrial Applications*, Peter D. Hilton and Paul F. Jacobs (Eds.), Marcel Dekker, 2000.

4. *Collaborative Design and Planning for Digital Manufacturing* Lihui Wang, Andrew Y.C. Nee. (Eds.)*,* Springer, 2009.

5. *Rapid Prototyping Principles and Applications*, Chua C.K., Leong K.F., and Lim C.S 2nd Edition, World Scientific, 2003.

6. *Additive Manufacturing Technologies*, Ian Gibson, D.W. Rosen, and B. Stucker, 2nd Edition, Springer, 2015.

7. *Rapid Prototyping Theory and Practice*, Ali Kamrani, and Emad Abouel Nasr (Eds.), Springer, 2006.

8. *Understanding Additive Manufacturing*, Andreas Gebhardt, Hanser, 2011.

9. *Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling*, D. T. Pham and S.S. Dimov, Springer, 2001.

10. *Rapid Prototyping Technology Selection and Application*, Kenneth G. Cooper, Marcel Dekker Inc, 2001.

*11. Reverse Engineering: An Industrial Perspective,* Vinesh Raja and Kiran J. Fernandes (Eds.), *Springer*, 2008.

Lesson Plan

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| L. No. | Date | Lecture | Mode |
| 1 | 25/1 | Introduction to RMP | Google Classroom and PPT |
| 2 | 27/1 | Prototype Fundamentals, Historical Development, Fundamentals of Rapid Prototyping, Advantages of Rapid Prototyping, | Google Classroom and PPT |
| 3 | 29/1 | Commonly Used Terms, Additive Manufacturing (AM) Definition, Applications of AM parts, The Generic AM process | Google Classroom and PPT |
| 4 | 1/2 | Classifications of AM / RP System | Google Classroom and PPT |
| 5 | 3/2 | Additive Manufacturing / Rapid Prototyping Systems  | Google Classroom and PPT |
| 6 | 5/2 | Vat Photo Polymerization based AM / RP Systems | Google Classroom and PPT |
| 7 | 8/2 | Powder Bed Fusion based AM / RP Systems | Google Classroom and PPT |
| 8 | 10/2 | Material Extrusion based AM / RP Systems | Google Classroom and PPT |
| 9 | 12/2 | Binder Jetting based AM / RP Systems | Google Classroom and PPT |
| 10 | 15/2 | Sheet lamination based AM / RP Systems | Google Classroom and PPT |
| 11 | 17/2 | Directed Energy Deposition based AM / RP Systems | Google Classroom and PPT |
| 12 | 22/2 | Concept of Direct Digital Manufacturing (DDM), Application Case Studies,  | Google Classroom and PPT |
| 13 | 24/2 | DDM Drivers, Manufacturing Versus Prototyping | Google Classroom and PPT |
| 14 | 26/2 | Cost Estimation: Cost Model, Build Time Model ,Life-Cycle Costing | Google Classroom and PPT |
| 15 | 1/3 | AM Unique Capabilities: Shape Complexity, Hierarchical Complexity,  | Google Classroom and PPT |
| 16 | 3/3 | AM Unique Capabilities: Functional Complexity, Material Complexity. | Google Classroom and PPT |
| 17 | 5/3 | Core DFAM Concepts and Objectives: Complex Geometry,  | Google Classroom and PPT |
| 18 | 8/3 | Core DFAM Concepts and Objectives: Integrated Assemblies,  | Google Classroom and PPT |
| 19 | 10/3 | , Core DFAM Concepts and Objectives: Customized Geometry,  | Google Classroom and PPT |
| 20 | 12/3 | Core DFAM Concepts and Objectives: Multifunctional Designs,  | Google Classroom and PPT |
| 21 | 15/3 | Core DFAM Concepts and ObjectivesElimination of Conventional DFM Constraints | Google Classroom and PPT |
| 22 | 17/3 | Introduction to Rapid Tooling, Indirect Rapid Tooling Processes, Direct Rapid Tooling Processes,  | Google Classroom and PPT |
| 23 | 19/3 | Emerging Trends in Rapid Tooling | Google Classroom and PPT |
| 24 | 22/3 | Introduction, RE generic process, RE hardware and software | Google Classroom and PPT |
| 25 | 24/3 |  Integration of RE and RP for Layer-based Model Generation,  | Google Classroom and PPT |
| 26 | 26/3 | RE Applications | Google Classroom and PPT |
| 27 | 31/3 | Definition of digital manufacturing, Digital manufacturing idea taking control for center,  | Google Classroom and PPT |
| 28 | 2/4 | The 10 disruptive principles of digital manufacturing processes | Google Classroom and PPT |
| 29 | 5/4 | Key Technologies of Digital Manufacturing: n. | Google Classroom and PPT |
| 30 | 7/4 | Various Digital Technologies in Product Life Cycle, Resource and Environment,  | Google Classroom and PPT |
| 31 | 9/4 | Management, Control and Product Recognition | Google Classroom and PPT |