Fr. Conceicao Rodrigues College Of Engineering

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

Department of Production Engineering

T.E. (Production) (Semester VI) (2018-2019)

Lecture Plan

Subject: Rapid Prototyping and Digital Manufacturing **Credits - 4**

	SYLLABUS	
Module	**Contents**	**Hrs**
01	**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**
02	**Additive Manufacturing / Rapid Prototyping Systems** 2.1Vat 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). 2.2 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). 2.3 Material Extrusion based AM / RP Systems: Principle of operation, Process, advantages, disadvantages and applications of STRATASYS' Fused Deposition Modeling (FDM). 2.4 Material Jetting based AM / RP Systems: Principle of operation, Process, advantages, disadvantages and applications of 3D Systems' Multi-jet Modeling System (MJM). 2.5 Binder Jetting based AM / RP Systems: Binder jetting principle, materials, Z Corporation's Three Dimensional Printing (3DP) machine, process benefits and drawbacks. 2.6 Sheet lamination based AM / RP Systems: Principle of operation, Process, materials, advantages, disadvantages, and applications of CUBIC Technologies	**10**

	Laminated Object Manufacturing (LOM), CAM-LEM's (Computer Aided Manufacturing of Laminated Engineering Materials) CL 100. 2.7 Directed Energy Deposition based AM / RP Systems: Principle of operation, Process, materials, advantages, disadvantages, and applications of OPTOMEC's Laser Engineered Net Shaping (LENS).	
03	**Direct Digital Manufacturing** Concept of Direct Digital Manufacturing (DDM), Application Case Studies, DDM Drivers 3.1 Manufacturing Versus Prototyping 3.2 Cost Estimation: Cost Model, Build Time Model 3.3 Life-Cycle Costing 3.4 Future of DDM	**05**
04	**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**
05	**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**
06	**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**

Co No.	CO Statement
CO1	Demonstrate an importance of rapid prototyping/additive manufacturing techniques.
CO2	Design and develop of products using rapid manufacturing technology.
CO3	Design and develop of products using additive manufacturing technology
CO4	Illustrate the concept of Direct Digital Manufacturing.

CO5	Select appropriate Reverse engineering techniques for a particular case.
CO6	Select appropriate Rapid tooling techniques for a particular case.

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										1
CO2	3	2										1
CO3	3	2										1
CO4	3	2										1
CO5	3	2										1
CO6	3	2										1

Target = 2 for all COs

FINAL CO	**=**	**(0.8* Direct) + (0.2* Indirect)**

Direct	**CO1**	(0.6*UTest) +(0.4*Univ Exam)
	CO2	(0.6*UTest) +(0.4*Univ Exam)
	CO3	(0.6*UTest) +(0.4*Univ Exam)
	CO4	(0.6*UTest) +(0.4*Univ Exam)
	CO5	(0.6*UTest) +(0.4*Univ Exam)
	CO6	(0.6*UTest) +(0.4*Univ Exam)

Indirect	**CO1**	(1*Exit Survey)
	CO2	(1*Exit Survey)
	CO3	(1*Exit Survey)
	CO4	(1*Exit Survey)
	CO5	(1*Exit Survey)
	CO6	(1*Exit Survey)

LECTURE PLAN

Subject:	**RAPID PROTOTYPING AND DIGITAL MANUFACTURING**
Academic Year:	2018-19
Name of the Teacher:	Mrs. Jaya Goyal

Week No.	Topics	Module	Hours
Week 1 (01/01/19 – 04/01/19)	Course Objectives, Course Outcomes (COs), Textbook, Introduction, 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,	**1**	**3**
Week 2 (07/01/19 – 11/01/19)	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.	**1**	**3**
Week 3 (14/01/19 – 18/01/19)	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). 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**	**3**
Week 4 (21/01/19 – 25/01/19)	Material Extrusion based AM / RP Systems: Principle of operation, Process, advantages, disadvantages and applications of STRATASYS' Fused Deposition Modeling (FDM). Material Jetting based AM / RP Systems: Principle of operation, Process, advantages, disadvantages and applications of 3D Systems' Multi-jet Modeling System (MJM).	**2**	**3**

	Binder Jetting based AM / RP Systems: Binder jetting principle, materials, Z Corporation's Three Dimensional Printing (3DP) machine, process benefits and drawbacks.		
Week 5 (28/01/19 – 01/02/19)	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. Directed Energy Deposition based AM / RP Systems: Principle of operation, Process, materials, advantages, disadvantages, and applications of OPTOMEC's Laser Engineered Net Shaping (LENS).	**2**	**3**
Week 6 (04/02/19 – 08/02/19)	Concept of Direct Digital Manufacturing (DDM), Application Case Studies, DDM Drivers **Unit Test 1 (Feb 4, 5 and 6).**	**3**	**1**
Week 7 (11/02/19 – 15/02/19)	Manufacturing Versus Prototyping, Cost Estimation: Cost Model, Build Time Model **Euphoria (Feb 13, 14 and 15).**	**3**	**1**
Week 8 (18/02/19 – 22/02/19)	Life-Cycle Costing, Future of DDM , AM Unique Capabilities: Shape Complexity, Hierarchical Complexity, Functional Complexity, Material Complexity.	**3,4**	**3**
Week 9 (25/02/19 – 01/03/19)	Core DFAM Concepts and Objectives: Complex Geometry, Integrated Assemblies, Customized Geometry, Multifunctional Designs, Elimination of Conventional DFM Constraints	**4**	**3**
Week 10 (05/03/19 – 08/03/19)	Introduction to Rapid Tooling, Indirect Rapid Tooling Processes, Direct Rapid Tooling Processes, Emerging Trends in Rapid Tooling	**5**	**3**
Week 11 (11/03/19 – 15/03/19)	Reverse Engineering (RE): Introduction, RE generic process, RE hardware and software, Integration of RE and RP for Layer-based Model Generation, **Crescendo**	**5**	**2**
Week 12 (18/03/19 – 22/03/19)	Applications and case studies of RE in automotive, aerospace and medical device industry, Barriers for adopting RE. Definition of digital manufacturing, Digital manufacturing idea taking control for center,	**5, 6**	**3**
Week 13 (25/03/19 – 29/03/19)	Digital manufacturing idea taking design for center, Digital manufacturing idea taking management as its center, The 10 disruptive principles of digital manufacturing processes.	**6**	**3**

Week 14 (01/04/19 – 05/04/19)	Key Technologies of Digital Manufacturing: Various Digital Technologies in Product Life Cycle, Resource and Environment, Management, Control and Product Recognition.	**6**	**3**
Week 15 (08/04/19 – 12/04/19)	**Unit Test 2 (April 8, 9 and 10)**	**-**	**-**