CMR Institute of Technology, Bangalore			
Department: Mechanical Engineering			
Semester: 08	Section(s): B		
Subject: ADDITIVE MANUFACTURING		21ME73	Lectures/week: 04
Course Instructor(s): Dr. Sagar M Baligidad			
Course duration: September-2024 – December-2024			

Course Objectives:

1. Understand the additive manufacturing process, polymerization and powder metallurgy process
2. Understand characterization techniques in additive manufacturing.
3. Acquire knowledge on CNC and Automation

Class No.	Chapter Title / Reference Literature	Topic	Percentage of portion covered	
			Reference	Cumulative
1-10	**MODULE -1** **TB1: 1.2, 1.3, 2.1** **TB2 : 1.1, 1.3, 1.6** **RB1: 1.1, 1.3**	**Introduction to Additive Manufacturing:** Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages of AM, AM process chain: Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build , removal and clean up, post processing. **Classification of AM processes:** Liquid polymer system, Discrete particle system, Molten material systems and Solid sheet system. Post processing of AM parts: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques. **Guidelines for process selection:** Introduction, selection methods for a part, challenges of selection. **AM Applications:** Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries	20%	20%
11-18	**MODULE -2** **TB2: 2.2, 2.4, 3.2** **RB1 : 2.2, 2.6, 4.1** **RB3: 2.1, 2.5, 3.5, 3.6**	**System Drives and devices:** Hydraulic and pneumatic motors and their features, Electrical motors AC/DC and their features **Actuators**: Electrical Actuators; Solenoids, Relays, Diodes, Thyristors, Triacs, Hydraulic	16%	36%

		and Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectric actuators, Shape memory alloys.		
19-30	**MODULE -3** POLYMERS & POWDER METALLURGY **TB1: 4.1, 4.2, 4.6** **TB2 : 3.5, 3.7, 4.1** **TB3: 3.4, 4.2, 4.3, 4.4**	**Basic Concepts:** Introduction to Polymers used for additive manufacturing: polyamide, PF resin, polyesters etc. Classification of polymers, Concept of functionality, Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD], Polymer Processing: Methods of spinning for additive manufacturing: Wet spinning, Dry spinning. Biopolymers, Compatibility issues with polymers. Moulding and casting of polymers, Polymer processing techniques **General Concepts:** Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM **Powder Production Techniques:** Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes. **Characterization Techniques:** Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle Friction, Compression ability, Powder Structure, Chemical Characterization **Microstructure Control in Powder:** Importance of Microstructure Study, Microstructures of Powder by Different techniques **Powder Shaping:** Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process Variables, Pressure & Density Distribution during Compaction, Isotactic Pressing, Injection Moulding, Powder Extrusion, Slip Casting, Tape Casting. **Sintering:** Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering Modern Sintering Techniques, Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis of Sintered Components Application of Powder Metallurgy: Filters, Tungsten Filaments, Self-Lubricating Bearings, Porous Materials, Biomaterials etc.	24%	60%
31-40	**MODULE -4** NANO MATERIALS & CHARACTERIZATION TECHNIQUES: **TB2: 5.1, 5.3, 5.4** **TB3 : 4.2, 4.5, 5.1** **TB4: 4.3, 4.6, 4.7**	**Introduction:** Importance of Nano-technology, Emergence of Nanotechnology, Bottom up and Top-down approaches, challenges in Nanotechnology **Nano-materials Synthesis and Processing:** Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical Synthesis of Nano-materials- sol-gel process; Gas Phase synthesis of Nano-materials- Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation(CVC). **Optical Microscopy** - principles, Imaging Modes, Applications, Limitations. Scanning Electron Microscopy (SEM) - principles, Imaging Modes,	20%	80%

		Applications, Limitations. Transmission Electron Microscopy (TEM) - principles, Imaging Modes, Applications, Limitations, X-Ray Diffraction (XRD) - principles, Imaging Modes, Applications, Limitations. Scanning Probe Microscopy (SPM) - principles, Imaging Modes, Applications, Limitations. Atomic Force Microscopy (AFM) – basic principles, instrumentation, operational modes, Applications, Limitations. Electron Probe Micro Analyzer (EPMA) - Introduction, Sample preparation, Working procedure, Applications, Limitations.		
41-50	**MODULE -5** MANUFACTURING CONTROL AND AUTOMATION **TB1: 6.2, 6.4, 6.5, 7.3** **TB3 : 6.1, 6.3, 6.5** **RB3: 14.3, 14.4, 15.2**	CNC technology - An overview: Introduction to NC/CNC/DNC machine tools, Classification of NC /CNC machine tools, Advantage, disadvantages of NC /CNC machine tools, Application of NC/CNC Part programming: CNC programming and introduction, Manual part programming: Basic (Drilling, milling, turning etc.), Special part programming, Advanced part programming, Computer aided part programming (APT), **Introduction:** Automation in production system principles and strategies of automation, basic Elements of an automated system. Advanced Automation functions. Levels of Automations, introduction to automation productivity **Control Technologies in Automation:** Industrial control system. Process industry vs discrete manufacturing industries. Continuous vs discrete control. Continuous process and its forms. Other control system components.	20%	100%

Syllabus for Sessionals:

Sessional No.	Syllabus
T1	Class No. 01 – 21
T2	Class No. 22 – 40
Improvement test	Class No. 41 - 50

Book Type	Code	Author and Title	Publication Details
Text Book	TB1	Rapid prototyping- principles and applications By Chee Kai Chua- Kah Fai Leong- Chu Sing Lim	World scientific publishing Co.Pvt. Ltd, 2nd Edition 2004
Text Book	TB2	Principles of Polymerization, by G Odian	Wiley Inerscience John Wiley and Sons, 4th edition, 2005
Text Book	TB3	Automation, Production Systems and Computer Integrated Manufacturing, by Mikell P Groover,	3rd Edition, Prentice Hall Inc., New Delhi, 2007
Text Book	TB4	P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.	Ph Learning Private Ltd, 4th Edition, 2015

Course Outcomes:

1. Understand the different processes of Additive Manufacturing. using Polymer, Powder and Nano materials manufacturing.
2. Analyse the different characterization techniques.
3. Describe the various NC, CNC machine programing and Automation techniques.

Course Outcomes		Modules covered	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	Understand the different processes of Additive Manufacturing. using Polymer, Powder and Nano materials manufacturing	**1,3**	2	1	-		1	1	-	-	-	-	-	-		1	1	1
CO2	Analyses of the different characterization techniques	**2,4**	2	1	-	-	1	1	-	-	-	-	-	-		1	1	1
CO3	Describe the various NC, CNC machine programing and Automation techniques	**5**	2	1	-	2	1	1	-	-	-	-	-	-	-	1	1	1

Appendix

Table 01: Cognitive Levels

Cognitive Levels	
Cognitive level	**Revised Blooms Taxonomy Keywords**
L1	List, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.
L2	summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
L3	Apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover.
L4	Analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer.
L5	Assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize.

Table 02: Program Outcomes (PO) and Program Specific Outcomes (PSO)

Program Outcomes (PO), Program Specific Outcomes (PSO)	
PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
PSO1	Apply knowledge of engineering graphics and machine drawing to read, interpret and create engineering drawings and models.
PSO2	Apply principles of physics, knowledge of material properties and strength, manufacturing methods, design codes and standards and best practices to design, analyze and develop solutions in engineering.
PSO3	Contribute to project teams in the core and associated domains by using modern tools for drafting, modelling, analyzing and simulation.
PSO4	Identify and articulate industrial problems and solve with the use of management tools for optimum solutions and realistic outcomes.

Table 03: Correlation Levels

Correlation Levels	
0	No Correlation
1	Slight/Low
2	Moderate/ Medium
3	Substantial/ High

Signature with date:	**Course Instructor**	**HOD**