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Ref No:

Sri krishna Institute of Technology, Bangalore

COURSE PLAN
Academic Year 2019-2020

Program:	B E – Mechanical Engineering
Semester :	8
Course Code:	15ME82
Course Title:	Adittive Manufacturing
Credit / L-T-P:	4 / 4-0-0
Total Contact Hours:	50
Course Plan Author:	Mr.PRAMOD S N / Mr.SHANKAREGOWDA K C

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Note : Remove “Table of Content” before including in CP Book
Each Course Plan shall be printed and made into a book with cover page
Blooms Level in all sections match with A.2, only if you plan to teach / learn at higher levels

15ME82 : ADDITIVE MANUFACTURING

A. COURSE INFORMATION

1. Course Overview

Degree:	BE	Program:	ME
Year / Semester :	4/VIII	Academic Year:	2019-2020
Course Title:	Additive Manufacturing	Course Code:	15ME82
Credit / L-T-P:	4/4-0-0	SEE Duration:	180 Minutes
Total Contact Hours:	50	SEE Marks:	80Marks
CIA Marks:	20	Assignment	1 / Module
Course Plan Author:	Mr. SHANKAREGOWDA K C	Sign	Dt:
Checked By:	Mr. PRAMOD S N	Sign	Dt:

2. Course Content

Module	Module Content	Teaching Hours	Module Concepts	Blooms Level
1	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 mterial 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, challengesof 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,defence, automobile, Bio-medical and general engineering industries	10	Additive manufacturing	L1,L2
2	System Drives and devices: Hydraulic and pneumatic motors and their features,Electrical motors AC/DC and their featuresActuators: Electrical Actuators; Solenoids, Relays, Diodes, Thyristors, Triacs, Hydraulicand Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectricactuators, Shape memory alloys.	08	Drives and Actuators	L2,L3
3	POLYMERS & POWDER METALLURGY Basic Concepts: Introduction to Polymers used for additive manufacturing: polyamide,PF resin, polyesters etc. Classification of polymers, Concept of functionality, HoursPolydispersity 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 ofpolymers, Polymer processing techniquesGeneral Concepts: Introduction and History of Powder Metallurgy (PM), Present andFuture Trends of PMPowder Production	12	Material processing	L2,L3

	Techniques:Different Mechanical and Chemical methods,Atomisation of Powder, other emergingprocesses.Characterization Techniques:Particle Size & Shape Distribution, Electron Microscopy of Powder, InterparticleFriction, Compression ability, Powder Structure, Chemical CharacterizationMicrostructure Control in Powder: Importance of Microstructure Study,Microstructures of Powder by Different techniquesPowder Shaping: Particle Packing Modifications, Lubricants & Binders, PowderCompaction & 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 PhaseSintering Modern Sintering Techniques, Physical & Mechanical Properties Evaluation,Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis ofSintered ComponentsApplication of Powder Metallurgy: Filters, Tungsten Filaments, Self-LubricatingBearings, Porous Materials, Biomaterials etc.			
4	NANO MATERIALS & CHARACTERIZATION TECHNIQUES: Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in NanotechnologyNano-materials Synthesis and Processing: Methods forcreating Nanostructures;Processes for producing ultrafine powders- Mechanical grinding; Wet ChemicalSynthesis 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, 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, ImagingModes, Applications, Limitations.Atomic Force Microscopy (AFM) - basic principles,instrumentation, operational modes, Applications, Limitations. Electron Probe MicroAnalyzer (EPMA) - Introduction, Sample preparation, Working procedure, Applications,Limitations.	10	Nano concept	L2,L3
5	MANUFACTURING CONTROL AND AUTOMATION 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 andintroduction, Manual part programming: Basic (Drilling, milling, turning etc.), Specialpart 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 ofAutomations, introduction to automation productivityControl Technologies in Automation: Industrial control system. Process industry vsdiscrete manufacturing industries. Continuous vs discrete control. Continuous	10	Automation	L2,L3

	processand its forms. Other control system components			

3. Course Material

Module	Details	Available
	Reference books	
1	Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003.	In Lib,In dept lib
2	G Odian Principles of Polymerization, Wiley Inerscience John Wiley and Sons, 4th edition, 2005	In Lib,In dept lib
3	Mark James Jackson, Microfabrication and Nanomanufacturing, CRC Press, 2005.	In Lib,In dept lib
	Reference books	
4	Powder Metallurgy Technology, Cambridge International Science Publishing, 2002.	In Lib,In dept lib
5	P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.	In Lib,In dept lib
	Mikell P Groover, Automation, Production Systems and Computer Integrated Manufacturing, 3rd Edition, Prentice Hall Inc., New Delhi, 2007	In Lib,In dept lib
	Others (Web, Video, Simulation, Notes etc.)	
	• **https://www.youtube.com/watch?v=kKQ5KwFwW_s** • **https://www.youtube.com/watch?v=_mhN1d768o8** • **https://www.youtube.com/watch?v=bopz6b3-CTU**	

4. Course Prerequisites

SNo	Course Code	Course Name	Module / Topic / Description	Sem	Remarks	Blooms Level
1	15ME62	Computer integrated manufacturing	MANUFACTURING CONTROL AND AUTOMATION	6		L2
2	15ME72	Fluid power system	System Drives and devices	7		L2

Note: If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

B. OBE PARAMETERS

1. Course Outcomes

#	COs	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
15ME82.1	Student should able to understand Concept of additive manufacturing and post processing of AM	10	Additive manufacturing	Chalk and board	Assignment , Unit test and CIA	L2 Understand
15ME82.2	Student should able to understand Systems of drives, actuators and its types.	08	Drives	Chalk and board	Assignment , Unit test and CIA	L2 Understand
15ME82.3	Student should able to understand power metallurgy technique and micro structure of power in various methods.	12	Micro structure	Chalk and board	Assignment , Unit test and CIA	L2 Understand
15ME8	Student should able to understand	10	Nano	Chalk	Assignment ,	L2

2.4	Concept of nano technology and optical microscopy.		technology	and board	Unit test and CIA	Underst and
15ME82.5	Student should able to understand automation and control techniques.	10	Automation	Chalk and board	Assignment , Unit test and CIA	L2 Underst and
-	**Total**	**50**	-	-	-	-

Note: Identify a max of 2 Concepts per Module. Write 1 CO per concept.

2. Course Applications

SNo	Application Area	CO	Level
1	Manufacturing.	CO1	L2
2	Drivers and actuators,CNC.	CO1	L2
3	Material processing.	CO3	L2
4	Nano technology	CO2	L2
5	Automation	CO3	L2

Note: Write 1 or 2 applications per CO.

3. Articulation Matrix

(CO – PO MAPPING)

-	Course Outcomes	Program Outcomes												
#	COs	PO1	PO2	PO3	PO4	PO5	PO 6	PO7	PO8	PO9	PO1 0	PO1 1	PO1 2	Level
15ME82.1	Student should able to understand Concept of additive manufacturing and post processing of AM	√	-	-	-	-	-	-	-	-	-	-	-	L2
15ME82.2	Student should able to understand Systems of drives, actuators and its types.	√	-	-	-	-	-	-	-	-	-	-	-	L2
15ME82.3	Student should able to understand power metallurgy technique and micro structure of power in various methods.	√	-	-	-	-	-	-	-	-	-	-	-	L2
15ME82.4	Student should able to understand Concept of nano technology and optical microscopy.	√	-	-	-	-	-	-	-	-	-	-	-	L2
15ME82.5	Student should able to understand automation and control techniques.	√	-	-	-	-	-	-	-	-	-	-	-	L2
Note: Mention the mapping strength as 1, 2, or 3														

4. Mapping Justification

Mapping		Justification	Mapping Level
CO	**PO**	**-**	**-**
CO1	PO1	Apply the knowledge of additive manufacturing	L2
CO1	PO2	Since it is basic science -No mapping	L2

ME
Prepared by Checked by Approved

CO1	PO3	Atudents will not be Designing/developing of solution-No mapping	L2
CO1	PO4	Since no conduction on investigations of complex Problems-No mapping	L2
CO1	PO5	No Modern tools are used -No mapping	L2
CO1	PO6	No inpact on engineers and society-No mapping	L2
CO1	PO7	Will not be affected on environment and sustainability-No mapping	L2
CO1	PO8	Since the study is limited to basics -No mapping	L2
CO1	PO9	Will not be working either Individual nor team work-No mapping	L2
CO1	PO10	NO instruction will be given -No mapping	L2
CO1	PO11	No application of management and finance principles involved -No mapping	L2
CO1	PO12	Due to change in technology-No mapping	L2
CO2	PO1	Apply the knowledge of different AM processing	L2
CO2	PO2	Since it is basic science -No mapping	L2
CO2	PO3	Students will not be Designing/developing of solution-No mapping	L2
CO2	PO4	Since no conduction on investigations of complex Problems-No mapping	L2
CO2	PO5	No Modern tools are used -No mapping	L2
CO2	PO6	Impact on engineers and society through improved productivity and efficiency	L2
CO2	PO7	Will not be affected on environment and sustainability-No mapping	L2
CO2	PO8	Since the study is limited to basics -No mapping	L2
CO2	PO9	Will not be working either Individual nor team work-No mapping	L2
CO2	PO10	NO instruction will be given -No mapping	L2
CO2	PO11	No application of management and finance principles involved -No mapping	L2
CO2	PO12	Due to change in technology-No mapping	L2
CO3	PO1	Apply the knowledge of drives in machines	L2
CO3	PO2	Since it is basic science -No mapping	L2
CO3	PO3	Students will not be Designing/developing of solution-No mapping	L2
CO3	PO4	Since no conduction on investigations of complex Problems-No mapping	L2
CO3	PO5	No Modern tools are used -No mapping	L2
CO3	PO6	Impact on engineers and society through improved productivity and efficiency	L2
CO3	PO7	Will affect on environment and sustainability in utilizing resources	L2
CO3	PO8	Since the study is limited to basics -No mapping	L2
CO3	PO9	Will not be working either Individual nor team work-No mapping	L2
CO3	PO10	NO instruction will be given -No mapping	L2
CO3	PO11	No application of management and finance principles involved -No mapping	L2
CO3	PO12	Due to change in technology-No mapping	L2
CO4	PO1	Apply the knowledge of actuators in machines	L2
CO4	PO2	Since it is basic science -No mapping	L2
CO4	PO3	Students will not be Designing/developing of solution-No mapping	L2
CO4	PO4	Since no conduction on investigations of complex Problems-No mapping	L2
CO4	PO5	No Modern tools are used -No mapping	L2
CO4	PO6	Impact on engineers and society through improved driving mechanism	L2
CO4	PO7	Will affect on environment and sustainability in automation	L2

CO4	PO8	Since the study is limited to basics -No mapping	L2
CO4	PO9	Will not be working either Individual nor team work-No mapping	L2
CO4	PO10	NO instruction will be given -No mapping	L2
CO4	PO11	No application of management and finance principles involved -No mapping	L2
CO4	PO12	Due to change in technology-No mapping	L2
CO5	PO1	To know the knowledge of polymers and powder metallurgy	L2
CO5	PO2	Since it is basic science -No mapping	L2
CO5	PO3	Students will not be Designing/developing of solution-No mapping	L2
CO5	PO4	Since no conduction on investigations of complex Problems-No mapping	L2
CO5	PO5	Modern tools are used	L2
CO5	PO6	Impact on engineers and society through improved processing methods	L2
CO5	PO7	Will not be affected on environment and sustainability-No mapping	L2
CO5	PO8	Since the study is limited to basics -No mapping	L2
CO5	PO9	Will not be working either Individual nor team work-No mapping	L2
CO5	PO10	NO instruction will be given -No mapping	L2
CO5	PO11	No application of management and finance principles involved -No mapping	L2
CO5	PO12	Due to change in technology-No mapping	L2

Note: Write justification for each CO-PO mapping.

5. Curricular Gap and Content

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					

Note: Write Gap topics from A.4 and add others also.

6. Content Beyond Syllabus

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					

Note: Anything not covered above is included here.

C. COURSE ASSESSMENT

1. Course Coverage

Module #	Title	Teaching Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Introduction to additive manufacturing	10	2	-	-	1	-	-	CO1, CO1	L1, L2
2	System drives and actuators	08	2	-	-		-	-	CO3, CO2	L1, L2
3	Polymers and metallurgy	12	-	2	-	1	-	-	CO3, CO3	L1, L2
4	Nano materials	10	-	2	-		-	-	CO4, C08	L1, L2

5	Manufacturing control and manufacturing	10	-	-	4	1	-		CO5, CO5	L1, L2
-	**Total**	**50**	**4**	**4**	**4**	**3**	**-**	**-**	**-**	**-**

Note: Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

2. Continuous Internal Assessment (CIA)

Evaluation	Weightage in Marks	CO	Levels
CIA Exam – 1	15	CO1, CO1, CO3, CO2	L1,L2
CIA Exam – 2	15	CO3, CO3, CO4, C08	L1,L2
CIA Exam – 3	15	CO5,CO5	L1,L2
Assignment - 1	05	CO1, CO1, CO3, CO2	L1,L2
Assignment - 2	05	CO3, CO3, CO4, C08	L1,L2
Assignment - 3	05	CO5,CO5	L1,L2
Seminar - 1			
Other Activities – define – Slip test			
Final CIA Marks	**20**	**-**	**-**

Note : Blooms Level in last column shall match with A.2 above.

D1. TEACHING PLAN - 1

Module - 1

Title:	Introduction Additive Manufacturing	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Understand concept of additive manufacturing.	CO1	L2
2	Identify types,limitation and applications of AM.	CO1	L2
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	Introduction to Additive Manufacturing: Introduction to AM, AM evolution.	C01	L2
2	Distinction between AM & CNC machining, Advantages of AM, AM process chain.	C01	L2
3	Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation.	C01	L2
4	Machine setup, build , removal and clean up, post processing.	C01	L2
5	Classification of AM processes: Liquid polymer system, Discrete particle system.	C01	L2
6	Property enhancements using non-thermal and thermal techniques.	C01	L2
7	accuracy improvement, aesthetic improvement, preparation for use as a pattern.	C01	L2
8	Post processing of AM parts: Support material removal, surface texture improvement.	C01	L2
9	Molten material systems and Solid sheet system.	C01	L2
10	Application examples for Aerospace,defence, automobile, Bio-medical and general engineering industries.	C01	L2
c	**Application Areas**	**CO**	**Level**
1	Manufacturing.	CO1	L2

2	Rapid prototyping.	CO1	L2
d	**Review Questions**	-	-
1	Define additive manufacturing. Explain the evolution of additive manufacturing.	CO1	L2
2	Distinguish between CNC and additive manufacturing.	CO1	L2
3	Give the classification OF additive manufacturing.	CO1	L2
4	Explain the guidelines of process selection.	CO1	L2
5	What are the prerequisites of post processing of additive manufactured parts.	CO1	L2
6	Explain liquid polymer system	CO1	L2
7	Explain with a neat sketch molten material system	CO1	L2
8	List the application of additive manufacturing	CO1	L2
9	What is do you mean by Re-manufacturing ?	CO1	L2
10	What do you mean by engineering analysis models?	CO1	L2
e	**Experiences**	-	-
1			
2			

Module – 2

Title:	System drives and devices	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Understand the various drives and its mechanism.	CO2	L2
2	Understand the different actuators,its types.	CO2	L2
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	System Drives and devices: Hydraulic and pneumatic motors and their features.	CO2	L2
2	Electrical motors AC/DC and their features.	CO2	L2
3	Actuators: Electrical Actuators.	CO2	L2
4	Hydraulic and Pneumatic actuators.	CO2	L2
5	Design of Hydraulic and Pneumatic circuits.	CO2	L2
6	Piezoelectric actuators.	CO2	L2
7	Solenoids, Relays, Diodes, Thyristors, Triacs.	CO2	L2
8	Shape memory alloys.	CO2	L2
c	**Application Areas**	**CO**	**Level**
1	CNC.	CO2	L2
2	Automation.	CO2	L2
d	**Review Questions**	-	-
1	What is the difference between hydraulics and pneumatic motors?	CO2	L2
2	What are the salient features of AC/DC motors?	CO2	L2
3	What do you mean by actuators?List the types of actuators	CO2	L2
4	Explain the working of thyristors and triacs ?	CO2	L2
5	What are the design parameters while building a hydraulics and	CO2	L2

	pneumatic circuit?		
6	What do you mean by piezoelectric materials actuators?	CO2	L2
7	What are the features of shape memory alloy?	CO2	L2
8	Give the classification of actuators.	CO2	L2
9	With a neat sketch solenoid actuator.	CO2	L2
10	With a neat sketch relay and diode actuator.	CO2	L2
e	**Experiences**	-	-
1			
2			

E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:	15ME82	Sem:	VIII	Marks:	15	Time:	75 minutes
Course:	Additive Manufacturing						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Define additive manufacturing. Explain the evolution of additive manufacturing.	5	CO1	L2
	b	Distinguish between CNC and additive manufacturing.	6	CO1	L2
	c	Give the classification OF additive manufacturing.	4	CO1	L2
		OR			
2	a	Explain with a neat sketch molten material system	4	CO1	L2
	b	List the application of additive manufacturing	4	CO1	L2
	c	What is do you mean by Re-manufacturing ?	7	CO1	L2
3	a	Explain the working of thyristors and triacs ?	5	CO2	L2
	b	What are the design parameters while building a hydraulics and pneumatic circuit?	6	CO2	L2
	c	What do you mean by piezoelectric materials actuators?	4	CO2	L2
		OR			
4	a	What are the features of shape memory alloy?	5	CO2	L2
	b	Give the classification of actuators.	5	CO2	L2
	c	With a neat sketch solenoid actuator.	5	CO2	L2

b. Assignment -1

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15ME82	Sem:	VIII	Marks:	5	Time:	90 – 120 minutes
Course:	Additive manufacturing						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	**USN**	**Assignment Description**	**Marks**	**CO**	**Level**
1		Introduction to Additive Manufacturing: Introduction to AM, AM evolution.	5	CO1	L2
2		Distinction between AM & CNC machining, Advantages of AM, AM process chain.	5	CO1	L2
3		Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation.	5	CO1	L2
4		Machine setup, build , removal and clean up, post processing.	5	CO1	L2

5		Classification of AM processes: Liquid polymer system, Discrete particle system.	5	CO1	L2
6		Property enhancements using non-thermal and thermal techniques.	5	CO1	L2
7		accuracy improvement, aesthetic improvement, preparation for use as a pattern.	5	CO1	L2
8		Post processing of AM parts: Support material removal, surface texture improvement.	5	CO1	L2
9		Molten material systems and Solid sheet system.	5	CO1	L2
10		Application examples for Aerospace,defence, automobile, Bio-medical and general engineering industries.			
11		What is the difference between hydraulics and pneumatic motors?	5	CO1	L2
12		What are the salient features of AC/DC motors?	5	CO2	L2
13		What do you mean by actuators?List the types of actuators	5	CO2	L2
14		Explain the working of thyristors and triacs ?	5	CO2	L2
15		What are the design parameters while building a hydraulics and pneumatic circuit?	5	CO2	L2
16		What do you mean by piezoelectric materials actuators?	5	CO2	L2
17		What are the features of shape memory alloy?	5	CO2	L2
18		Give the classification of actuators.	5	CO2	L2
19		With a neat sketch solenoid actuator.	5	CO2	L2
20		With a neat sketch relay and diode actuator.	5	CO2	L2
21		What is the difference between hydraulics and pneumatic motors?	5	CO2	L2

D2. TEACHING PLAN - 2

Module – 3

Title:	Polymers and power metallurgy	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Understand the various polymer materials	CO3	L2
2	Micro structure and characterization of polymer materials	CO3	L3
b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**
1	Basic Concepts: Introduction to Polymers used for additive manufacturing.	CO3	L2
2	polyamide,PF resin, polyesters etc.	CO3	L2
3	Classification of polymers, Concept of functionality.	CO3	L2
4	Characterization Techniques:Particle Size & Shape Distribution.	CO3	L2
5	Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD].	CO3	L2
6	Powder Production Techniques: Different Mechanical and Chemical methods,Atomization of Powder, other emerging processes.	CO3	L2
7	Electron Microscopy of Powder, InterparticleFriction, Compression ability, Powder Structure, Chemical Characterization.	CO3	L2
8	Microstructure Control in Powder: Importance of Microstructure Study,Microstructures of Powder by Different techniques.	CO3	L2
9	Powder Shaping: Particle Packing Modifications, Lubricants & Binders.	CO3	L2
10	Powder Compaction & Process Variables, Pressure & Density Distribution during Compaction,Isotactic.	CO3	L2

11	Pressing, Injection Moulding, Powder Extrusion, Slip Casting, Tape Casting.	CO3	L2
12	Application of Powder Metallurgy: Filters, Tungsten Filaments, Self-Lubricating Bearings, Porous Materials, Biomaterials etc.	CO3	L2
c	**Application Areas**	**CO**	**Level**
1	Polymerisation process.	CO3	L2
2	Moulding.	CO3	L3
d	**Review Questions**	-	-
1	What are the different polymers used in additive manufacturing?	CO3	L2
2	Give the classification polymers	CO3	L2
3	What are the different polymers processing methods?	CO3	L2
4	Explain with a neat wet spinning.	CO3	L2
5	Explain with a neat Dry spinning	CO3	L2
6	What are the compatibility issues with polymers?	CO3	L2
7	What is the future trend of power metallurgy?	CO3	L2
8	What are the different powder production technique?	CO3	L2
9	What do you mean by micro structure control in powder?	CO3	L2
10	Explain with a neat sketch any two sistering process.	CO3	L2
e	**Experiences**	-	-
1			
2			

Module – 4

Title:	**Nano materials and characterization**	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Understand the concept of nano materials.	CO4	L2
2	Analyses and recognize the materials.	CO4	L3
b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**
1	NANO MATERIALS & CHARACTERIZATION TECHNIQUES: Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in NanotechnologyNano-materials	CO4	L2
2	Synthesis and Processing: Methods for creating Nanostructures;Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical	CO4	L2
3	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).	CO4	L2
4	Optical Microscopy - principles, Imaging Modes, Applications, Limitations.Scanning Limitations.	CO4	L2
5	Electron Microscopy (SEM) - principles, Imaging Modes, Applications,Limitations.	CO4	L2
6	Transmission Electron Microscopy (TEM) - principles, Imaging Modes.	CO4	L2
7	Limitations.X- Ray Diffraction (XRD) - principles,Imaging	CO4	L2

	Modes,Applications, Limitations.		
8	Scanning Probe Microscopy (SPM) - principles, ImagingModes, Applications.	CO4	L2
9	Limitations.Electron Probe MicroAnalyzer (EPMA) - Introduction, Sample preparation, Working procedure, Applications,Limitations.	CO4	L2
10	Atomic Force Microscopy (AFM) - basic principles,instrumentation, operational modes, Applications.	CO4	L2
c	**Application Areas**	**CO**	**Level**
1	Material processing	CO4	L2
2	Research domain	CO4	L2
d	**Review Questions**	-	-
1	What are importance of nano technology,Explain the emergence of nano technology.	CO4	L2
2	What are the different processes involved of nano materials ?	CO4	L2
3	Explain with a neat sketch Gas phased synthesis of nano materials	CO4	L2
4	Explain with a neat sketch flam assisted ultra spray pyrolysis	CO4	L2
5	What do mean by optical microscopy and explain the principles behind it.	CO4	L2
6	What do you mean by scanning electron microscope and explain the working principle.	CO4	L2
7	Explain with a neat sketch XRD.		
8	Explain with a neat sketch SPM.	CO4	L2
9	Explain with a neat sketch AFM.	CO4	L2
10	Explain with a neat sketch EPMA.	CO4	L2
e	**Experiences**	-	-
1			
2			
3			
4			
5			

E2. CIA EXAM – 2

a. Model Question Paper - 2

Crs Code:	15ME82	Sem:	VIII	Marks:	15	Time:	75 minutes		
Course:	Additive manufacturing								
-	**-**	**Note: Answer any 2 questions, each carry equal marks.**					**Marks**	**CO**	**Level**
1	a	What are the different powder production technique?					5	CO3	L2
	b	What do you mean by micro structure control in powder?					5	CO3	L2
	c	Explain with a neat sketch any two sistering process.					5	CO3	L2
		OR							
2	a	What are the compatibility issues with polymers?					5	CO3	L2
	b	What is the future trend of power metallurgy?					5	CO3	L2
	c	What are the different powder production technique?					5	CO3	L2
3	a	What are importance of nano technology,Explain the emergence of nano technology.					5	CO4	L2
	b	What are the different processes involved of nano materials ?					5	CO4	L2
	c	Explain with a neat sketch Gas phased synthesis of nano materials					5	CO4	L2
		OR							
4	a	Explain with a neat sketch EPMA					5	CO4	L2
	b	What do mean by optical microscopy and explain the principles behind it.					5	CO4	L2

	c	What do you mean by scanning electron microscope and explain the working principle.	5	CO4	L2

b. Assignment – 2

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15ME82	Sem:	VIII	Marks:	05	Time:	75 minutes
Course:	Additive manufacturing						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1		What are the different polymers used in additive manufacturing?	5	CO3	L2
2		Give the classification polymers.	5	CO3	L2
3		What are the different polymers processing methods?	5	CO3	L2
4		Explain with a neat wet spinning.	5	CO3	L2
5		Explain with a neat Dry spinning.	5	CO3	L2
6		What are the compatibility issues with polymers?	5	CO3	L2
7		What is the future trend of power metallurgy?	5	CO3	L2
8		What are the different powder production technique?	5	CO3	L2
9		What do you mean by micro structure control in powder?	5	CO3	L2
10		Explain with a neat sketch any two sistering process.			
11		What are importance of nano technology,Explain the emergence of nano technology.	5	CO3	L3
12		What are the different processes involved of nano materials ?	5	CO4	L2
13		Explain with a neat sketch Gas phased synthesis of nano materials.	5	CO4	L2
14		Explain with a neat sketch flam assisted ultra spray pyrolysis.	5	CO4	L2
15		What do mean by optical microscopy and explain the principles behind it.	5	CO4	L2
16		What do you mean by scanning electron microscope and explain the working principle.	5	CO4	L2
17		Explain with a neat sketch XRD.	5	CO4	L3
18		Explain with a neat sketch SPM.	5	CO4	L3
19		Explain with a neat sketch AFM.	5	CO4	L2
20		Explain with a neat sketch EPMA	5	CO4	L2
21		What are importance of nano technology,Explain the emergence of nano technology.	5	CO4	L2

D3. TEACHING PLAN - 3

Module – 5

Title:	**Manufacturing control and automation**	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
		-	**Level**
1	Students will be able to understand CNC	CO5	L2
2	Students will be able to apply automation to different process	CO5	L2
b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**
1	CNC technology - An overview: Introduction to NC/CNC/DNC machine tools,Classification of NC /CNC machine tools, introduction	CO5	L2

2	Advantage, disadvantages of NC /CNC machine tools, Application of NC/CNC Part programming: CNC programming	CO5	L2
3	Manual part programming: Basic (Drilling, milling, turning etc.),	CO5	L2
4	Programs on drilling,milling and turning	CO5	L2
5	Special part programming, Advanced part programming, Computer aided part programming(APT)	CO5	L2
6	Introduction: Automation in production system principles and strategies of automation,basic Elements of an automated system	CO5	L2
7	Advanced Automation functions.	CO5	L2
8	Levels of Automations, introduction to automation productivity Control Technologies	CO5	L2
9	Automation: Industrial control system. Process industry vs discrete manufacturing industries.	CO5	L2
10	Continuous vs discrete control. Continuous process and its forms. Other control system components.	CO5	L2
c	**Application Areas**		
1	CNC	CO5	L2
2	Automation	CO5	L2
d	**Review Questions**		
1	What do you mean by NC, CNC, and DNC.	CO5	L2
2	Give the classification CNC machine tools	CO5	L2
3	List the advantages and dis-advantages also its applications of CNC	CO5	L2
4	What do you mean by part programming and special part programming?	CO5	L2
5	Explain the computer aided programming?	CO5	L2
6	What do you mean by automation? List the different types.	CO5	L2
7	What are the strategies of automations	CO5	L2
8	Explain the different elements of automation .	CO5	L2
9	Explain the different levels of automation.	CO5	L2
10	What is the principles of automated systems	CO5	L2
11	What do you mean by industrial control systems?	CO5	L2
12	What is the difference between process industries and discrete manufacturing industries?	CO5	L2
13	What are the different continuous process in control technologies	CO5	L2
14	What do you mean by automation productivity.	CO5	L2
e	**Experiences**	-	-
1			
2			

E3. CIA EXAM – 3

a. Model Question Paper - 3

Crs Code:	15ME82	Sem:	VIII	Marks:	15	Time:	75 minutes
Course:	Additive manufacturing						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Explain the computer aided programming?	7	CO5	L2
	b	What do you mean by automation? List the different types.	8	CO5	L2
		OR			
2	a	What do you mean by NC, CNC, and DNC.	7	CO5	L2
	b	Give the classification CNC machine tools	8	CO5	L2
3	a	What do you mean by industrial control systems?	7	CO5	L2
	b	What is the difference between process industries and discrete manufacturing industries?	8	CO5	L2

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Prepared by Checked by Approved

		OR			
4	a	What is the difference between process industries and discrete manufacturing industries?	8	CO5	L2
	b	What are the different continuous process in control technologies	7	CO5	L2

b. Assignment – 3

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15ME82	Sem:	I	Marks:	5	Time:	90 – 120 minutes
Course:	Additive manufacturing						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1		What do you mean by NC, CNC, and DNC.	5	CO5	L2
2		Give the classification CNC machine tools	5	CO5	L2
3		List the advantages and dis-advantages also its applications of CNC	5	CO5	L2
4		What do you mean by part programming and special part programming?	5	CO5	L2
5		Explain the computer aided programming?	5	CO5	L2
6		What do you mean by automation? List the different types.	5	CO5	L2
7		What are the strategies of automations	5	CO5	L2
8		Explain the different elements of automation .	5	CO5	L2
9		Explain the different levels of automation.	5	CO5	L2
10		What is the principles of automated systems	5	CO5	L2
11		What do you mean by industrial control systems?	5	CO5	L2
12		What is the difference between process industries and discrete manufacturing industries?	5	CO5	L2
13		What are the different continuous process in control technologies	5	CO5	L2
14		What do you mean by automation productivity.	5	CO5	L2

F. EXAM PREPARATION

1. University Model Question Paper

Course:	Additive manufacturing					Month / Year	May /2018
Crs Code:	15ME82	Sem:	VIII	Marks:	80	Time:	180 minutes

-	Note	Answer all FIVE full questions. All questions carry equal marks.	Marks	CO	Level
1	a	Explain Property enhancements using non-thermal and thermal techniques.	7	CO1	L2
	b	Explain accuracy improvement, aesthetic improvement, preparation for use as a pattern.	9	CO1	L2
		OR			
-	a	ExplainPost processing of AM parts, Support material removal, surface texture improvement.	10	CO1	L2
	b	Write the classification of AM processes, Liquid polymer system, Discrete particle system.	6	CO1	L2
2	a	Explain the working of thyristors and triacs ?	8	CO2	L2
	b	What are the design parameters while building a hydraulics and pneumatic circuit?	8	CO2	L2
		OR			
-	a	What are the salient features of AC/DC motors?	8	CO2	L2
	b	What do you mean by actuators?List the types of actuators	8	CO2	L2

3	a	Explain Electron Microscopy of Powder, Inter particle Friction, Compression ability, Powder Structure, Chemical Characterization.	10	CO3	L2
	b	Write note Microstructure Control in Powder: Importance of Microstructure Study,Microstructures of Powder by Different techniques.	6	CO3	L2
		OR			
-	a	Explain Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD].	12	CO3	L2
	b	ExplainPowder Production Techniques, Different Mechanical and Chemical methods,Atomization of Powder, other emerging processes.	4	CO3	L2
4	a	What do you mean by scanning electron microscope and explain the working principle.	8	CO4	L2
	b	Explain with a neat sketch XRD.	8	CO4	L2
		OR			
-	a	Explain with a neat sketch flam assisted ultra spray pyrolysis	6	CO4	L2
	b	What do mean by optical microscopy and explain the principles behind it.	10	CO4	L2
5	a	What is the principles of automated systems	7	CO5	L2
	b	What do you mean by industrial control systems?	9	CO5	L2
		OR			
	a	Explain the different elements of automation .	8	CO5	L2
	b	Explain the different levels of automation.	8	CO5	L2

2. SEE Important Questions

Course:	Additive manufacturing					Month / Year	May /2018	
Crs Code:	15ME82	Sem:	VIII	Marks:	80	Time:	180 minutes	
	Note	Answer all FIVE full questions. All questions carry equal marks.				-	-	
Module	Qno.	Important Question				**Marks**	**CO**	**Year**
1	1	Write the classification of AM processes: Liquid polymer system, Discrete particle system.					CO1	
	2	ExplainProperty enhancements using non-thermal and thermal techniques.					CO1	
	3	Explain accuracy improvement, aesthetic improvement, preparation for use as a pattern.					CO1	
	4	Explain Post processing of AM parts, Support material removal, surface texture improvement.					CO1	
2	1	What are the salient features of AC/DC motors?					CO2	
	2	What do you mean by actuators?List the types of actuators					CO2	
	3	Explain the working of thyristors and triacs ?					CO2	
	4	What are the design parameters while building a hydraulics and pneumatic circuit?					CO2	
3	1	Explain Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD].					CO3	
	2	Explain Powder Production Techniques: Different Mechanical and Chemical methods,Atomization of Powder, other emerging processes.					CO3	
	3	Explain Electron Microscopy of Powder, Inter particle Friction, Compression ability, Powder Structure, Chemical Characterization.					CO3	
	4	Explain Microstructure Control in Powder: Importance of Microstructure Study,Microstructures of Powder by Different techniques.					CO3	

4	1	Explain with a neat sketch flam assisted ultra spray pyrolysis		CO4	
	2	What do mean by optical microscopy and explain the principles behind it.		CO4	
	3	What do you mean by scanning electron microscope and explain the working principle.		CO4	
	4	Explain with a neat sketch XRD.		CO4	
5	1	Explain the different elements of automation .		CO5	
	2	Explain the different levels of automation.		CO5	
	3	What is the principles of automated systems		CO5	
	4	What do you mean by industrial control systems?		CO5	

G. Content to Course Outcomes

1. TLPA Parameters

Table 1: TLPA – Example Course

Module-#	Course Content or Syllabus (Split module content into 2 parts which have similar concepts)	Content Teaching Hours	Blooms' Learning Levels for Content	Final Blooms' Level	Identified Action Verbs for Learning	Instruction Methods for Learning	Assessment Methods to Measure Learning
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	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 mterial 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, challengesof 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,defence, automobile, Bio-medical and general engineering industries	10	L2	L2	Understand	Chalk and Board	Assignment -1
2	System Drives and devices: Hydraulic and pneumatic motors and their	8	L2	L2	Understand	Chalk and	Assignment -1

	features,Electrical motors AC/DC and their featuresActuators: Electrical Actuators; Solenoids, Relays, Diodes, Thyristors, Triacs, Hydraulicand Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectricactuators, Shape memory alloys.					Talk	
3	POLYMERS & POWDER METALLURGY Basic Concepts: Introduction to Polymers used for additive manufacturing: polyamide,PF resin, polyesters etc. Classification of polymers, Concept of functionality, Hours Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD]Polymer Processing: Methods of spinning for additive manufacturing: Wet spinning,Dry spinning. Bio polymers, Compatibility issues with polymers. Moulding and casting of polymers, Polymer processing techniques General Concepts: Introduction and History of Powder Metallurgy (PM), Present andFuture 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 Micro structure Study, Micro structures 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 PhaseSintering Modern Sintering Techniques, Physical & Mechanical Properties Evaluation,Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis ofSintered ComponentsApplication of Powder Metallurgy: Filters, Tungsten Filaments, Self-LubricatingBearings, Porous Materials, Biomaterials etc.	12	L2	L2	Understand	Chalk and Board	Assignment -1
4	NANO MATERIALS & CHARACTERIZATION TECHNIQUES: Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in NanotechnologyNano-materials Synthesis and Processing: Methods forcreating	10	L2	L2	Understand	Chalk and Board	Assignment -1

	Nanostructures;Processes for producing ultrafine powders- Mechanical grinding; Wet ChemicalSynthesis 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, 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, ImagingModes, Applications, Limitations.Atomic Force Microscopy (AFM) - basic principles,instrumentation, operational modes, Applications, Limitations. Electron Probe MicroAnalyzer (EPMA) - Introduction, Sample preparation, Working procedure, Applications,Limitations.						
5	MANUFACTURING CONTROL AND AUTOMATION 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 andintroduction, Manual part programming: Basic (Drilling, milling, turning etc.), Specialpart 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 ofAutomations, introduction to automation productivityControl Technologies in Automation: Industrial control system. Process industry vsdiscrete manufacturing industries. Continuous vs discrete control. Continuous processand its forms. Other control system components	10	L2	L2	Understand	Chalk and Board	Assignment -2

2. Concepts and Outcomes:

Table 2: Concept to Outcome – Example Course

Module	Learning or Outcome	Identified Concepts	Final Concept	Concept Justification	CO Components (1.Action Verb,	Course Outcome

e-#	from study of the Content or Syllabus	from Content		(What all Learning Happened from the study of Content / Syllabus. A short word for learning or outcome)	2.Knowledge, 3.Condition / Methodology, 4.Benchmark)	**Student Should be able to ...**
A	*I*	*J*	*K*	*L*	*M*	*N*
1	Student should able to understand Concept of additive manufacturing and post processing of AM	additive manufacturing	Process	Comprehend the Process of additive manufacturing	- Understand method of additive manufacturing	Understand the Process of additive manufacturing
2	Student should able to understand Systems of drives, actuators and its types.	actuators	working	Understanding working principle	Understand actuator working principle	Understand concept actuator working.
3	Student should able to understand power metallurgy technique and micro structure of power in various methods.	power metallurgy	micro structure	Have knowledge of metallurgy	Understand features of micro structure	Understand micro structure of power in various methods
4	Student should able to understand Concept of nano technology and optical microscopy.	optical microscopy.	nano technology	Understand the technology	Comprehend the nano technology	Understand the nano technology and optical microscopy
5	Student should able to understand automation and control techniques.	automation	Control	Explain the working of automation and control techniques	Understand different techniques.	Understand the different automation and control techniques.