SAMPLE TEMPLATEfor PCC/PEC/OEC

Semester- II

Advanced Materials Characterisation Techniques			
Course Code	**MMST201**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3;0;0;0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	04	Exam Hours	03

Course Learning objectives:

Learner shall familiarize about the different methods available to characterize the materials using different application and in failure analysis.

Module-1

Importance and the need for materials characterization;
X- ray diffraction -- Bragg's condition -- Laue treatment -- reciprocal lattice—intensity of diffracted beam -- crystal structure determination -- atomic scattering factor --geometrical structure factor for s.c, f.c.c and b.c.cc structures -- experimental methods – Laue, rotating crystal and powder photograph methods – estimation of stress, texture and other defects -- electron diffraction -- neutron diffraction.

8 Hrs

Teaching-Learning Process	Chalk and Talk method/ Power point presentation

Module-2

Particle size analysis techniques based on light scattering, Powder characterisation by microscopy techniques (light, electron), light scattering, gas adsorption (BET), Gas pycnometer for density measurement, and compositional analysis of powders by XRF and ICP techniques.

8 Hrs

Teaching-Learning Process	.Chalk and Talk method/ Power point presentation

Module-3

Metallography and microstructures, Principles of optical microscopy -resolution, magnification, depth of focus; electron diffraction, imaging (various contrasts), Cross-Sectional and fracture surface analysis of materials/coatings using FESEM, Crystal Identification through Selected area diffraction pattern (SADP) etc.

8 Hrs

Teaching-Learning Process	Chalk and Talk method/ Power point presentation

Module-4

Electron microscopy: Scanning electron microscopy (SEM), Instrumentation, Electron beam-specimen interaction, Specimen preparation, Energy dispersive spectroscopy (EDS) in electron microscopes; Transmission electron microscopy (TEM) - Basics of TEM, Electron sources, Specimen preparation, Image modes, Image contrast.8 Hrs

Teaching-Learning Process	Chalk and Talk method/ Power point presentation

Module-5

Tribology, Wear type and its Characterization, wear surface analysis, Tribometer, Friction, Low friction materials/coating etc. Instrumentation and principles of techniques used for thermal analysis, micro-thermal analysis, combined method of thermal analysis and their applications in materials characterization.

8 Hrs

Teaching-Learning Process	Chalk and Talk method/ Power point presentation

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. An Introduction to Materials Characterization, P. R. Khangaonkar; Penram Publishers, 2010.
2. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Yang Leng; 2nd ed., Wiley, 2013.
3. Scanning Electron Microscopy and X-Ray Microanalysis, Joseph Goldstein, Eric Lifshin, Charles E. Lyman, David C. Joy and Patrick Echlin; 3rd ed., Springer, 2003.
4. Physical Methods for Materials Characterisation, P.E.J.Flewitt, R.K.Wild ; Institute of Physics Publishing Ltd., 1994.
5. Thermal characterization of polymeric materials, Edith A. Turi (ed.), Academic Press, 1996.
6. Introduction to Polymer Rheology, Montgomery T. Shaw; Wiley, 2011.
7. Polymer Rheology and Processing, A.A. Collyer, Leszek A. Utracki; Springer, 1990.
8. Reference Books:
9. Structure of Materials: An Introduction to Crystallography, Diffraction and Symmetry, Marc De Graef, Michael E. McHenry; 2nd (ed.), Cambridge University Press, 2012.
10. Crystal Structure Determination, Werner Massa; 2nd (ed.), Springer, 2010.
11. Crystal Structure Analysis: Principles and Practice, Peter Main, William Clegg (ed.), Alexander J. Blake, Robert O. Gould , Vol 6, Oxford Science Publication, 2001.

Web links and Video Lectures (e-Resources):

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Skill Development Activities Suggested

Faculty can assign and supervise Project based assignment individually on any one/two of the topics given in the syllabus. Make sure that the students should acquire the fullest knowledge in the subject

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	To familiarize X-ray diffraction and neutron diffraction.	
CO2	To familiarize the analysis of particles by using different techniques	
CO3	To familiarize optical microscopy, diffraction pattern, FESEM.	
CO4	Analysis of surface deformities using different techniques	
CO5	To familiarize rheological and visco elastic properties measurement and analysis	

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**3**	**2**	**2**	**1**	**0**	**1**	**1**	**2**	**1**	**2**
CO2	**3**	**3**	**3**	**2**	**2**	**1**	**0**	**1**	**1**	**2**	**0**	**2**
CO3	**3**	**3**	**3**	**2**	**2**	**1**	**0**	**1**	**1**	**2**	**0**	**2**
CO4	**3**	**3**	**3**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**0**	**2**
CO5	**3**	**3**	**32**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**0**	**2**

SAMPLE TEMPLATEfor PCC/PEC/OEC

Course Code	**MMST202**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3;0;0;0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Explain the behavior of constituents in the composite materials
- Enlighten the students in different types of reinforcement
- Develop the student's skills in understanding the different manufacturing methods available for compositematerial.
- Illuminate the knowledge and analysis skills in applying basic laws in mechanics to the composite materials.

Module-1	
INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.	
Teaching-Learning Process	

Module-2	
REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.	
Teaching-Learning Process	.

Module-3	
Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.	
Teaching-Learning Process	

Module-4	
Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.	
Teaching-Learning Process	

Module-5	
Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.	
Teaching-Learning Process	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

3. Three Unit Tests each of **20 Marks**
4. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

6. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
7. The question paper will have ten full questions carrying equal marks.
8. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
9. Each full question will have a sub-question covering all the topics under a module.
10. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.
5. Mechanics of composite materials –Robert M Jones 1998
6.Mechanics of composite materials – Autar K Kaw 1997

Web links and Video Lectures (e-Resources):

1. https://youtu.be/AKhN-dBoBjM?list=PLHGmNPVOI3GElgoeCoescO3LRfErfmW0i
2. https://youtu.be/zmbS_TmNDP4?list=PLSGws_74K01-4rcWuB5BEATHSsOrBd1ye

Skill Development Activities Suggested

1.Individual projects on topics covered in class. Students will choose a real life problems related to the discussed topics and implement the solution by using techniques and strategies discussed in the class. For each project, students have to submit a report and present a seminar.

2. Assignments, Quiz and Industrial Visit on relevant topic of the course.

SAMPLE TEMPLATEfor PCC/PEC/OEC

Course outcome (Course Skill Set

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Apply the various processing and manufacturing techniques	
CO2	Apply the techniques and their characteristics/limitations of synthesis ofpolymers	
CO3	Evaluate the structure-processing-property relationship of metals and polymers.	
CO4	Analyze the basic issues involved in polymer blends, metal matrix composites and ceramic matrix composites	
CO5	Analyze the stress strain behaviour of the composites	

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**3**	**3**	**1**	**2**	**2**	**2**	**2**	**2**	**1**	**2**
CO2	**3**	**3**	**3**	**3**	**1**	**2**	**2**	**2**	**2**	**2**	**1**	**2**
CO3	**3**	**3**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	**2**	**1**	**2**
CO4	**3**	**3**	**3**	**3**	**1**	**2**	**2**	**2**	**1**	**2**	**1**	**2**
CO5	**3**	**3**	**3**	**2**	**1**	**2**	**0**	**2**	**2**	**2**	**1**	**2**

SAMPLE TEMPLATEfor PCC/PEC/OEC

Course Code	**Mechanical Behaviour of Metals**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	**MMST203**	SEE Marks	50
Total Hours of Pedagogy	3;0;0;0	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

Module-1	
Strength of materials- basic assumptions, elastic and plastic behaviour, stress–strain relationship for elastic behaviour, elements of plastic deformation of metallic materials Mohr‟s circle, yielding theories. Theory of plasticity: Elements of theory of plasticity, dislocation theory properties of dislocation, stress fields around dislocations, application of dislocation theory to work hardening, solid solution strengthening, grain boundary strengthening, dispersion hardening.	
Teaching-Learning Process	

Module-2	
Ductile and Brittle Fracture: Ductile and brittle fracture, Charpy and Izod testing, significance of DBTT, ECT, NDT and FATT; elements of fractography - Griffith‟s theory, LEFM– COD and J integral –determination of KIC, COD and J integral. Characteristics of fatigue failure: Initiation and propagation of fatigue cracks, factors affecting fatigue strength and methods of improving fatigue behaviour – testing analysis of fatigue data mechanics of fatigue crack propagation, corrosion fatigue.	
Teaching-Learning Process	.

Module-3	
Introduction to creep: - creep mechanisms, creep curve, variables affecting creep, accelerated creep testing, development of creep resistant alloys, Larsen Miller parameter – Manson Hafred parameter.	
Teaching-Learning Process	

Module-4	
Stages of failure analysis, classification and identification of various types of fracture.Overview of fracture mechanics, characteristics of ductile and brittle fracture. General concepts, fracture characteristics revealed by microscopy, factors affecting fatigue life Creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. Some case studies failures.	
Teaching-Learning Process	

Module-5	
Types of wear, analyzing wear failure. Corrosion failures- factors influencing corrosion failures, overview of various types of corrosion stress corrosion cracking, sources, characteristics of stress corrosion cracking. Procedure for analyzing stress corrosion cracking, various types of hydrogen damage failures. Causes of failure in forging; failure of iron and steel castings, improper heat treatment, stress concentration and service conditions. Failure of weldments - reasons for failure procedure for weld failure analysis.	
Teaching-Learning	

SAMPLE TEMPLATEfor PCC/PEC/OEC

Process	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

5. Three Unit Tests each of **20 Marks**
6. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**
CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

11. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
12. The question paper will have ten full questions carrying equal marks.
13. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
14. Each full question will have a sub-question covering all the topics under a module.

Suggested Learning Resources:

Books

1. Mechanical Behaviour of Materials (MCGRAW HILL SERIES IN MATERIALS SCIENCE AND ENGINEERING) Hardcover – Import, 1 Mar 1990 – Thomas Courtney.
2. Mechanical Behavior of Materials: Second Edition Front Cover Thomas H. Courtney Waveland Press, 16-Dec-2005 - Technology & Engineering.
3. Mechanical Metallurgy", Dieter G. E 3rd Edition, McGraw Hill, 1988.
4. Testing of Metallic Materials", Suryanarayana Prentice Hall India, 1979.
5. Structure and Properties of Materials", Rose R. M., Shepard L. A., Wulff J., Volume III, 4th Edition, John Wiley, 1984

Web links and Video Lectures (e-Resources):

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Skill Development Activities Suggested

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SAMPLE TEMPLATEfor PCC/PEC/OEC

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Leve
CO1	Understand the concept of mechanical behaviour of materials	
CO2	Analyse its characteristics failure and analyse the modes and stages of failure of failure	
CO3	Understand and analyse the failure analysis of creep	
CO4	Analyse the behaviour of fracture and its characteristics in various applications	
CO5	Understand the process and failure mechanism of the wear	

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**
CO2	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO3	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO4	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**1**	**2**	**0**	**2**
CO5	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**

Professional Elective 3

Thermodynamics and Phase diagrams			
Course Code	**MMST214A**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40H	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

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Module-1	
Solidification of metals, solidification of single crystals, metallic solid solutions, crystalline imperfections, rate process in solids, diffusion in metals. Numerical problems on above.	
Teaching-Learning Process	

Module-2	
Thermodynamics basic concepts (state variables, the first law, the enthalpy concept, heat capacity) The second law (reversible and irreversible processes, entropy, Gibbs energy, Hemholtz energy, Gibbs-Duhems equation, Maxwell's relationships)	
Teaching-Learning Process	.

Module-3	
Equilibrium conditions (chemical potential, driving force, the third law, Clausius-Clapeyrons equations, Thermodynamic application to materials: Ellingham diagrams; Electrochemistry: Porbaix diagrams; thermodynamics of solutions, construction and interpretation of 2 component phase diagrams.	
Teaching-Learning Process	

Module-4	
Phase Diagram– Gibbs's Phase rule – Interpretation of mass fractions using Lever's rule –Hume Rothery rules- Binary Iso-morphous system- Binary Eutectic alloy system (Lead-Tin System) –Binary Peritectic alloy system (Iron-Nickel System) – Invariant reactions	
Teaching-Learning Process	

Module-5	
Iron-Iron carbide phase diagram- Slow cooling of Hypo and hyper eutectoid steels – Temperature-Time-Transformation (TTT) and Continuous Cooling Transformation (CCT) Diagrams, Phase equilbria in ceramics	
Teaching-Learning Process	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

7. Three Unit Tests each of **20 Marks**
8. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

16. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
17. The question paper will have ten full questions carrying equal marks.
18. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
19. Each full question will have a sub-question covering all the topics under a module.
20. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

Introduction to the Thermodynamics of Materials, David R. Gaskell, 5th ed., CRC Press, 2008.

2. Phase Transformations in Metals and Alloys, Porter, Easterling; 3ed ed, CRC Press, 1991.

3. Thermodynamics in Materials Science, Robert DeHoff; 2nd ed, 2006.

4. Ceramic Materials: Science and Engineering, C. Barry Carter, M. Grant Norton; Springer, 2007

5. Fundamentals of Materials Science and Engineering, Willian F smith 5THEdn

Web links and Video Lectures (e-Resources):

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Skill Development Activities Suggested

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SAMPLE TEMPLATEfor PCC/PEC/OEC

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1		
CO2		
CO3		
CO4		
CO5		

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**
CO2	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO3	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO4	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**1**	**2**	**0**	**2**
CO5	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**

SAMPLE TEMPLATEfor PCC/PEC/OEC

Smart Materials and Structures			
Course Code	**MMST214B**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40H	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

Module-1	
Smart Structures: Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements Of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coercive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor. Beam Modelling: Beam Modelling with induced strain Rate effects, Inchworm Linear Motor Beam Modelling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectrical Applications.	
Teaching-Learning Process	

Module-2	
Shape memory Alloy: Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka‟s Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems. ER and MR Fluids: Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response. Post-Yield flow applications in Clatches, Dampers and Others.	
Teaching-Learning Process	.

Module-3	
Vibration Absorbers: series and Parallel Damped Vibrations (Over View), Active Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications. Control of Structures: Modelling, Control Strategies and Limitations, Active Structures in Practice.	
Teaching-Learning Process	

Module-4	
MEMS – Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration	
Teaching-Learning Process	

Module-5	
Devices: Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications.	
Teaching-Learning Process	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

9. Three Unit Tests each of **20 Marks**
10. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

21. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
22. The question paper will have ten full questions carrying equal marks.
23. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
24. Each full question will have a sub-question covering all the topics under a module.
25. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

12. An Introduction to Materials Characterization, P. R. Khangaonkar; Penram Publishers, 2010.
13. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Yang Leng; 2nd ed., Wiley, 2013.
14. Scanning Electron Microscopy and X-Ray Microanalysis, Joseph Goldstein, Eric Lifshin, Charles E. Lyman, David C. Joy and Patrick Echlin; 3rd ed., Springer, 2003.
15. Physical Methods for Materials Characterisation, P.E.J.Flewitt, R.K.Wild ; Institute of Physics Publishing Ltd., 1994.
16. Thermal characterization of polymeric materials, Edith A. Turi (ed.), Academic Press, 1996.
17. Introduction to Polymer Rheology, Montgomery T. Shaw; Wiley, 2011.
18. Polymer Rheology and Processing, A.A. Collyer, Leszek A. Utracki; Springer, 1990.
19. Reference Books:
20. Structure of Materials: An Introduction to Crystallography, Diffraction and Symmetry, Marc De Graef, Michael E. McHenry; 2nd (ed.), Cambridge University Press, 2012.
21. Crystal Structure Determination, Werner Massa; 2nd (ed.), Springer, 2010.
22. Crystal Structure Analysis: Principles and Practice, Peter Main, William Clegg (ed.), Alexander J. Blake, Robert O. Gould , Vol 6, Oxford Science Publication, 2001.

Web links and Video Lectures (e-Resources):

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SAMPLE TEMPLATEfor PCC/PEC/OEC

Skill Development Activities Suggested

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Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Understand the behaviour and applicability of various smart materials	
CO2	Design simple models for smart structures & materials	
CO3	Perform simulations of smart structures & materials application	
CO4	Conduct experiments to verify the predictions	
CO5	knowledge of sensors, actuators.	

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**
CO2	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO3	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO4	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**1**	**2**	**0**	**2**
CO5	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**

SAMPLE TEMPLATEfor PCC/PEC/OEC

Mechanical Behaviour of thin films			
Course Code	**MMST214C**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40H	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

-

Module-1	
Vacuum components and systems: Need for vacuum, ways to achieve vacuum, determination of vacuum, dry and vapour pumps, pressure measurement gauges, conductance and other system design considerations.	
Teaching-Learning Process	

Module-2	
Thin film deposition techniques: Physical and chemical vapour deposition techniques including molecular beam epitaxy, laser ablation and hot wire and microwave CVD techniques. Film contamination, cosine law of deposition, conformal coverge and line of sight deposition.	
Teaching-Learning Process	.

Module-3	
Growth of thin films: Thermodynamic and kinetic considerations of deposition of thin films by both CVD and PVD. In situ characterization of thin film deposition process.	
Teaching-Learning Process	

Module-4	
Characterization of thin films: Different methods of thickness measurements, electrical, optical, chemical and structural property determination	
Teaching-Learning Process	

Module-5	
Some important applications of thin films: Hard and decorative coatings, semiconductor thin films, organic thin films.	
Teaching-Learning Process	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

11. Three Unit Tests each of **20 Marks**
12. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

26. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
27. The question paper will have ten full questions carrying equal marks.
28. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
29. Each full question will have a sub-question covering all the topics under a module.
30. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

Web links and Video Lectures (e-Resources):

- .

Skill Development Activities Suggested

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Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Students will be in a position to understand the science of thin films.	
CO2	Understanding of vacuum technology	
CO3	Knowledge of deposition techniques.	
CO4	Understanding of characterization techniques of thin film deposition.	
CO5	Apply knowledge to practical applications.	

SAMPLE TEMPLATEfor PCC/PEC/OEC

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	1	1	2	1	2	1	2
CO2	3	3	3	3	2	2	1	2	1	2	0	2
CO3	3	3	3	3	2	2	1	2	1	2	0	2
CO4	3	3	3	3	2	1	1	2	1	2	0	2
CO5	3	3	3	2	1	1	1	2	1	2	1	2

SAMPLE TEMPLATEfor PCC/PEC/OEC

Bio Materials & Technology			
Course Code	**MMST214D**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40H	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

-

Module-1	
Introduction: Definition of Bio material, Classification of Bio materials, Comparison of properties of some common bio materials, effects of physiological fluid on properties of biomaterials, surface properties, physical and Mechanical properties of Bio materials. Metallic Implants Materials: Stainless Steel, Co-based alloys, Ti and Ti based alloys, Important of stress corrosion cracking, Host tissue reaction with Bio metal, corrosion behaviour, hard tissue replacement implant, orthopaedic implant, dental implants, Percutaneous and skin implants, Vascular implants, Heart valve implant.	
Teaching-Learning Process	

Module-2	
Polymeric Implant Materials: polyolefins, polyamides, acrylic polymers, fluorocarnon polymers, Silicon rubber acetals. Visco elastic behaviour, creep recovery, stress relaxation, strain rate sensitivity, importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives, aging and environmental stress cracking, physiochemical characteristics of bio polymers, bio degradable polymers for medical purpose and their biological applications. Ceramic Implant Materials: Definitions of Bio ceramics, common type of Bio ceramics, Aluminium oxides, Glass ceramics, Carbons. Bioresorbable and Bioactive ceramics, Importance of wear resistance and low fracture toughness. Host Tissue reactions, Importance of Interfacial tissue reaction.	
Teaching-Learning Process	.

Module-3	
Composite Implant Materials: Mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement, polymers filled with osteogenic fillers (e.g. hydrosyapatite). Host tissue reactions. Bio Compatibility And Toxicological Screening Of Bio Materials: Definition of bio compatibility, blood compatibility and tissue compatibility, toxicity tests, acute and chronic toxicity (in situ implantation, tissue culture, haemolysis, thrombogenic, potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenicity and special tests.	
Teaching-Learning Process	

Module-4
Testing Of Bio Materials Implants: In vitro testing (Mechanical testing): tensile, compression, wears, fatigue, corrosion studies and fracture toughness. In vivo testing (animals): biological performance of implants. Exo- vivo testing, standards of implant materials.

Teaching-Learning Process	

Module-5

Sterilisation Techniques: ETO, gamma radiation, autoclaving, Effects of Sterilisation on material properties.

Teaching-Learning Process	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

13. Three Unit Tests each of **20 Marks**
14. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**
CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

31. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
32. The question paper will have ten full questions carrying equal marks.
33. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
34. Each full question will have a sub-question covering all the topics under a module.

Suggested Learning Resources:

Books

1. Biological performance of materials, Jonathan Black, MarceDecker,1981.
2. Blood Compatible Materials and Devices, C.P. Sharma & M. Szyehen, Technonic Publishing Co Ltd.,1991.
3. Polymetric Biomaterials. Piskin and S.HofmannMantinusNijhoff publication bordrechnt 1986.
4. Biomaterials, Science and engineering, J.B. Park, Plenum Press 1984
5. Biomaterials, Sujata V. Bhat, Narosa Publishing House – 2002

Web links and Video Lectures (e-Resources):

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SAMPLE TEMPLATEfor PCC/PEC/OEC

Skill Development Activities Suggested

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Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Leve
CO1	Students will be able to know various biomaterials	
CO2	Knowledge of its testing methods	
CO3	will be able to understand the significance of its use in various industrial applications.	
CO4	Apply sterilization techniques in industry.	
CO5	Develop models to demonstrate his knowledge.	

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**
CO2	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO3	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO4	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**1**	**2**	**0**	**2**
CO5	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**

SAMPLE TEMPLATEfor PCC/PEC/OEC

Professional Elective 4

Electronic, Optical and Magnetic Properties of Materials			
Course Code	**MMST215A**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40H	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

-

Module-1	
Lattice Vibrations: Hamiltonian Mechanics, Vibrations in Crystals-Phonons, Elastic Bandgap. Review of free electron and band theories of solids, Electrical conduction in metals and semiconductors, Hall effect, Temperature dependence of electrical conductivity.	
Teaching-Learning Process	

Module-2	
Quantum Mechanics: Schrodinger‟s Equation, 1-Dimensional Problems, Measurements-The Ehrenfest Theorem, Three Dimensions-Hydrogen Atom.	
Teaching-Learning Process	.

Module-3	
Electronic Band Structures: Periodic Potential, Central Equation, Understanding Band Diagrams, Engineering conductivity in Semiconductors.	
Teaching-Learning Process	

Module-4	
Solid-State Devices: PN Junctions, Solar Cells, LEDs. Optical Properties: Wave Equation, E/M Waves at Interfaces, Photonic Crystals.	
Teaching-Learning Process	

Module-5	
Magnetic Properties: Introduction, Dia, Para and Ferromagnetism, Weiss Field and Magnetic Domains, Anti ferromagnetism and Ferri magnetism. Ferromagnetic anisotropy and magnetostriction. Magnetic energy and Domain structure, Hysteresis loop. Soft and Hard magnetic Materials.	
Teaching-Learning Process	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

15. Three Unit Tests each of **20 Marks**
16. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

36. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
37. The question paper will have ten full questions carrying equal marks.
38. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
39. Each full question will have a sub-question covering all the topics under a module.
40. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Electronic, Magnetic, and Optical Materials (Advanced Materials and Technologies)-Pradeep Fulay& Jung-Kun Lee, CRC Press, Taylor & Francis Group.
2. Hyperlink: https://www.edx.org/course/electronic-optical-magnetic-properties-mitx-3-024x
3. Electronic properties of Materials, Hummel, R.E., Springer
4. Magnetic Materials, Azaroff, L.I, McGrawhill.

Web links and Video Lectures (e-Resources):

- .

Skill Development Activities Suggested

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SAMPLE TEMPLATEfor PCC/PEC/OEC

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Understand the various properties of materials	
CO2	Knowledge of materials	
CO3	Ability to identify materials for practical purpose.	
CO4	Identify the potential of the materials.	
CO5	Real time application.	

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

SAMPLE TEMPLATEfor PCC/PEC/OEC

Advanced Foundry Technology			
Course Code	**MMST215B**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40H	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

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Module-1	
Solidification of Casting: Concept of solidification of metals. Homogenous and heterogeneous nucleation. Growth mechanism. Solidification of pure metals and alloys. Mechanism of columnar and dendritic growth. Coring or Segregation. Solidification time and Chvorinov's rule. Concept of progressive and directional solidifications. Principles of Gating and Risering: Purpose of the gating system. Components of the gating System and its functions. Design of the gating System. Different types of gates. Gating ratio and its functions. Definition and functions of the riser. Types of risers and their application. Design of the riser - its shape. Size and location. Use of insulating material and exothermic compounds in risers.	
Teaching-Learning Process	

Module-2	
Design of Casting and Quality Control: Factors to be considered in casting design. Design consideration in pattern making, moulding techniques and core making and assembly. Cooling stresses and hot spots in	
Teaching-Learning Process	.

Module-3	
Special casting processes: Investment casting, Die casting, centrifugal casting, full mould casting, vacuum shield casting etc. Industrial melting practices: Aim of melting and melting practices as adopted in case of Cast Irons, Steel, Cu, Al and its alloys.	
Teaching-Learning Process	

Module-4	
Aluminium Foundry Practice:. Copper Alloy Foundry Practice: General characteristics of common cast copper alloys. Melting and casting of copper alloys. Gating and risering of cu-alloy castings.	
Teaching-Learning Process	

Module-5	
Foundry Mechanization and Modernization: Introduction to modernization. Mechanization of foundry and its advantages. Mechanization of sand plant, moulding and core making mechanization in melting, pouring and shakeout units. Material handling equipment‟s and conveyor systems. Brief sketches and description of layouts of job. Captive and mechanized foundries.	
Teaching-Learning Process	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

17. Three Unit Tests each of **20 Marks**
18. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

41. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
42. The question paper will have ten full questions carrying equal marks.
43. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
44. Each full question will have a sub-question covering all the topics under a module.
45. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

Principle of Metal Casting - Heine, et. al - Tata-McGraw-HiII Publication - 2003.

2. Foundry Technology - Beelely, P.R. – Butterworth & Co.

3. Fundamentals of Foundry Technology, Webster, P.D.,

4. Fundamentals of Metal casting Technology, Mukherjee, P.C

5.A Test Book of Foundry Technology - Lal, M. Khanna, P.O – Dhanpat Rai & Sons Publication. 2011

6. Advanced Foundry Technology – Pranav Pandey Pdf - 2017

Web links and Video Lectures (e-Resources):

- .

Skill Development Activities Suggested

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SAMPLE TEMPLATEfor PCC/PEC/OEC

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Understand and apply the studies of different processes used in Foundry Industries and their applications.	
CO2	Acquire the skill and knowledge of terms, facts, concepts, processes, techniques and principles of foundry industries	
CO3	Apply the skill and knowledge of contents of principles of furnace technology.	
CO4	Inquire of new skill and knowledge of foundry practises and developments therein.	
CO5	Expose and to develop interest in the fields of design of casting	

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

SAMPLE TEMPLATEfor PCC/PEC/OEC

SurfaceTreatmentandFinishing			
Course Code	**MMST215C**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40H	Total Marks	100
Credits	3	Exam Hours	3

CourseLearningobjectives:

Module-1	
FundamentalsofElectroplating,galvanizing,Hotdipmetalcoating,thincoating,thincoating,chromiumplating,Nickelplating.Vacuumcoating,FVD&CVDmetalspraying-Methods,surfacepreparation,mechanical.	
Teaching-LearningProcess	ChalkandTalk/PowerPointPresentation
Module-2	
Propertiesofsprayedmetals,Varioustypesandplasmacoating.Plasticcoatingofmetal-PVCcoatingSpherodisingprocessdetails,phosphatecoating-mechanismofformation.	
Teaching-LearningProcess	ChalkandTalk/PowerPointPresentation
Module-3	
Testingofsurfacecoating-Variousmethodsused.Heattreatmentmethods,Annealing,Normalizing,Tempering,Casehardeningmethods,flamehardening sub-zerotreatment.	
Teaching-LearningProcess	ChalkandTalk/PowerPointPresentation
Module-4	
Heattreatmentmethodsforgears,spindles,cuttingtools.	
Teaching-Learning Process	ChalkandTalk/PowerPointPresentation
Module-5	
Advancedcoatingtechnologies:Hardfacing,electrodepositiontechnique,nanocoating's,coatingcharacterization.	
Teaching-LearningProcess	ChalkandTalk/PowerPointPresentation

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

19. Three Unit Tests each of **20 Marks**
20. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

46. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
47. The question paper will have ten full questions carrying equal marks.
48. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
49. Each full question will have a sub-question covering all the topics under a module.
50. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

Web links and Video Lectures (e-Resources):

- .

Skill Development Activities Suggested

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Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Know about various techniques of simulation and modeling used to analyse manufacturing system.	
CO2	Undergo various case studies using real time simulation.	
CO3	understand variables involved and analyse output.	
CO4	Awareness of statistical techniques	
CO5	knowledge of simulation in real time applications	

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	1	1	2	1	2	1	2
CO2	3	3	3	3	2	2	1	2	1	2	0	2
CO3	3	3	3	3	2	2	1	2	1	2	0	2
CO4	3	3	3	3	2	1	1	2	1	2	0	2
CO5	3	3	3	2	1	1	1	2	1	2	1	2

SAMPLE TEMPLATEfor PCC/PEC/OEC

Modelling, Simulation & Analysis of Manufacturing System Title of the subject			
Course Code	**MMST215D**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40H	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

-

Module-1	
Principles of Modelling & Simulation: Basic Simulation Modeling, Limitation of Simulation, Monte – Carlo Simulation, Areas of Applications, Discrete and Continuous Systems.	
Teaching-Learning Process	

Module-2	
Modeling Approaches: Modeling Complex Systems, Simulation Software, Basics Probability and Statistics, Building Valid and Credible Simulation Models.	
Teaching-Learning Process	.

Module-3	
Random Number and Variable Generation: Selecting Input Probability Distributions, Random Number Generators, Generating Random Variants, and Output Data Analysis for a Single System.	
Teaching-Learning Process	

Module-4	
Statistical Techniques: Comparison of Alternative Systems, Variance Reduction Techniques.	
Teaching-Learning Process	

Module-5	
Simulation Studies: Discrete Event Simulation, Simulation of Inventory Problems, Experimental Design and Optimization, Simulation of Manufacturing Systems, Case Studies	
Teaching-Learning Process	

SAMPLE TEMPLATEfor PCC/PEC/OEC

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

21. Three Unit Tests each of **20 Marks**
22. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

51. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
52. The question paper will have ten full questions carrying equal marks.
53. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
54. Each full question will have a sub-question covering all the topics under a module.
55. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. **Simulation, Modeling and Analysis –Averill Law & David M.Kelt on, TMH 3rd Edition.**
2. **Discrete event and Simulation Systems – Banks & Carson, Prentice Hall Inc.**
3. **System Simulation" - Gordon, PHI.**
4. **System Simulation with Digital computer" – Deo, PHI**
5. **Computer Simulation and Modeling" – Francis Neelamkovil, John Wiley & Sons.**

Web links and Video Lectures (e-Resources):

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Skill Development Activities Suggested

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SAMPLE TEMPLATEfor PCC/PEC/OEC

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Know about various techniques of simulation and modeling used to analyse manufacturing system.	
CO2	Undergo various case studies using real time simulation.	
CO3	understand variables involved and analyse output.	
CO4	Awareness of statistical techniques	
CO5	knowledge of simulation in real time applications	

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**
CO2	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO3	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO4	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**1**	**2**	**0**	**2**
CO5	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**

SAMPLE TEMPLATEfor PCC/PEC/OEC

Materials Processing Technology			
Course Code	MMST206	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3;0;0;0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To acquaint students with the concept of polymer, ceramic materials and its processes and Additive Manufacturing (AM), various AM technologies, selectionof materials for AM, and their applications in various fields

Module-1	
Introduction of Materials, Types, distinctions, properties and applications of Metals, Ceramics and Polymers. Different types of polymer processing operations and engineering aspects: Mixing and compounding (twin screw extruders, banbury and other mixing equipments in polymer processing), extrusion process, injection moulding, blow moulding, thermoforming, rotational moulding, compression moulding, transfer moulding, reaction injection moulding, calendering, roller and blade coating, film blowing, textile/fiber spinning technology	
Teaching-Learning Process	

Module-2	
Technology for ceramic powder preparations, solid state reactions, Sintering operations, Types of sintering, sintering mechanisms, Colloidal processing of ceramics, DLVO theory, Porous ceramics and ceramic fibres, Co-precipitation method, Sol-Gel process, products for engineering applications.	
Teaching-Learning Process	.

Module-3	
Additive Manufacturing: Introduction: Traditional Manufacturing v/s Additive Manufacturing (AM); Computer Aided Design (CAD)and AM; AM Process Chain; Application Level: Direct Processes, Rapid Prototyping, Rapid Tooling, RapidManufacturing; Indirect Prototyping and Tooling, Indirect Manufacturing, Simultaneous Engineering and Additive Manufacturing Technologies (AMT),	
Teaching-Learning Process	

Module-4	
Support Structure in AM, Generation of Physical LayerModelling: Virtual Prototyping. Tessellation (STL Format) and Tessellation Algorithms. Defects in STL Filesand Repairing Algorithms. Various Slicing Procedures. Accuracy and Surface Quality in AM, Effect of PartOrientation on Accuracy, Surface Finish, Build Time and Cost; Various Rapid Tooling Techniques. Introductionto Reverse Engineering	
Teaching-Learning Process	

Module-5	
Materials for AM: Different Materials used for AM. Use of Multiple Materials, Multi-Functional and Graded Materials in AM. Role of Solidification Rate. Evolution of Non-Equilibrium Structure, Structure Property Relationship. Grain Structure and Micro-Structure.	
Teaching-Learning Process	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

23. Three Unit Tests each of **20 Marks**
24. Two assignments each of **20 Marks**or**one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

23. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
24. The question paper will have ten full questions carrying equal marks.
25. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
26. Each full question will have a sub-question covering all the topics under a module.
27. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Principles of Polymer Processing, Tadmor; 2nd (ed.), Wiley, 2006.
2. Polymer processing fundamentals, Tim A. Osswald, Hanser (eds.); 1998
3. Polymer Processing, David H. Morton-Jones, Routledge (eds.); Chapman & Hall, 1989
4. Ceramic Materials: Science and Engineering, C. Barry Carter, M. Grant Norton; 2nd (ed.), Springer, 2013.
5. Ceramic Processing and Sintering, Mohamed N. Rahaman; 2nd (ed.), Marcel Dekker Inc., 2003.
6. Chemical Processing of Ceramics, Burtrand Lee, Sridhar Komarneni; 2nd (ed.), CRC Press, 2010.
7. Solidification and Crystallization Processing in Metals and Alloys, HasseFredriksson; Wiley, 2012
8. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, by I.Gibson, D. Rosen and B. Stucker, Springer.
9. Rapid Prototyping: Principles and Applications in Manufacturing by Chua C. K. and L. K. Fai, World ScientificPublishing Co., Inc.
10. Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid manufacturing by AndreasGebhardt, Hanser Publishers.
11. Laser Induced Materials and Processes for Rapid Prototyping by Lu, Fuh and Wong, Springer.

Web links and Video Lectures (e-Resources):

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SAMPLE TEMPLATEfor PCC/PEC/OEC

Skill Development Activities Suggested

-

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Gain knowledge on Polymers and its processing for different application	
CO2	Identify the potential application of powders and its processing	
CO3	Identify areas where the knowledge of additive manufacturing can be applied through the theoretical studies.	
CO4	Describe portrayal of additive manufacturing and prototyping, their concepts, techniques, recent trends and challenges for the future.	
CO5	Assess the areas where additive manufacturing can make a greater contribution to industrial capabilities	

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**
CO2	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO3	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**2**
CO4	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**1**	**2**	**0**	**2**
CO5	**3**	**3**	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**2**

SAMPLE TEMPLATEfor PCC/PEC/OEC

Material Characterization Laboratory			
Course Code	**MMSTL207**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	01-00-02-0	SEE Marks	50
Credits	2	Exam Hours	3

Course objectives:

- .

Sl.NO	Experiments
1	Laboratory to tests based on the mechanical properties of materials, e.g., hardness, elastic modulus, tensile strength etc.
2	Laboratory to tests based on the mechanical properties of materials, e.g., hardness, elastic modulus, tensile strength etc. after various heat treatment processes
3	Applications of metallography and optical microscopy, phase analysis using microscopic information,
4	Laboratory tests on microstructures of metal, ceramic and polymer materials using optical microscopy and SEM.
5	Hands on experience on Phase identification using X-ray Diffraction
6	Study the effect of quenching media on microstructure and hardness of high-speed steels.
7	Establish relationship between hardness and microstructure of forged/rolled/extruded popular aerospace / light alloys.
8	**Analysis of metals deformed surface by using image processing technique**
Demonstration	
1	Hands on experience on Powder characterization using XRD, SEM and BET, gas pycnometer
2	Hands on experience on Thermal properties of materials, identification of materials based on their TG, DSC, DMA characteristic responses
3	Sintering and heat treatment furnaces, Thermocouple calibration, Fabrication and testing of composites, Nano-composites, Wear analysis, Welding of stainless steel, studies and experiments on Micro Machining Center, Unconventional machining , Porosity studies, Study of solidification software such as Pro-Cast, computational design of gating system, Commercial CAD/CAM softwares.

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

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SAMPLE TEMPLATEfor PCC/PEC/OEC

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marksis scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure

and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners) Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero. The duration of SEE is 03 hours
Suggested Learning Resources: •

SAMPLE TEMPLATEfor PCC/PEC/OEC

Ability Enhancement Course

IOT IN MANUFACTURING			
Course Code	MMST258A	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	00:02/01:00	SEE Marks	50
Total Hours of Pedagogy	30/15	Total Marks	100
Credits	01	Exam Hours	02
Examination Type (SEE)	Theory		

Course Learning objectives:
The course is designed to offer fundamentals of IoT in manufacturing and their applications in the business world. Learners will gain deep insights into how smartness is being harnessed and what needs to be done to overcome some of the challenges in the field of Mechanical Engineering

Module-1

Introduction to Industrial IoT: IoT background, History and definition, IoT enabling factors, IoT use cases, IoT key technologies, I-IoT – Fourth industrial revolution, use cases of the I-IoT, Similarities and differences of IoT and I-IoT, IoTanalytics and AI, Industry environment scenarios covered by I-IoT.

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-2

Understanding the Industrial process and devices: Industrial process, automation in the industrial process, control and measurement systems, types of industrial process, The CIM pyramid, CIM pyramid architecture – devices and networks, CIM network, The I-IoT data flow, The Industrial IoT data flow in a factory, The edge device, The Industrial IoT data flow in the cloud. Industrial data flow and devices, The I-IoT data flow in the factory, Measurement and the actuator chain.

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-3

Understanding of Node MCU: Open Source Microcontroller Platform, Node GPIO Pins, and Basics of Electronics. Introduction toEsp8266, Wifi Network, Web serve. Cloud Servers. IoT Sensors- Temperature, Humidity Sensor, Light, Gyro, Inclination, Magneto, Pressure, Flow, Aqua, Position, vibration and acoustic sensors. Protocol -MQTT Protocol, HTTP vs MQTT, Creating Adafruit account, Using Adafruit to read sensors value and send data to Node MCU

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-4

Implementing the I-IoT data flow: Discovering OPC, OPC classic, The data model and retrieving, data in OPC classic, OPC UA, The OPC UA information model, OPC UA sessions, OPC UA security model, The OPC UA data exchange, OPC UA notifications, Understanding the I-IoT edge, Features of the edge – edge gateway, edge tools, edge computing, The I-IoT edge architecture, Edge implementations – Azure IoT edge, Green grass, Android IoT, Node red, Docker edge, Intel IoT gateway, Edge Internet protocols.

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

SAMPLE TEMPLATEfor PCC/PEC/OEC

Module-5	
Understanding of I-IoT data loggers: Internal architecture of I-IoT data logger, communication protocols, I/O modules (Digital and Analog).Configuring I-IoT data logger through a web based application, Establishing communication between PLC and I-IoT data logger. Interfacing of industrial sensor with I-IoT data logger. Development of cloud based applications for the Mechatronics systems using the I-IoT data logger thorough web portal.	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks (25 marks out of 50) and for the SEE minimum passing mark is 40% of the maximum marks (20 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

- The**question paper shall consist of ten questions,** with**each question carrying 10 marks.**
- There shall be**two questions from each module.** Each question may or may not include **sub-questions**(with a**maximum of two sub-questions**).The**mark distribution**for sub-questions may follow any of the following formats**: 5+5, 4+6, or 3+7.**
- Students are required to**answer any five full questions, selecting one full question from each module.**
- In order to pass the SEE, students must obtain a**minimum of 40% of the maximum marks**allotted for the examination**.**
- The maximum duration of the examination is 02 hours

Textbooks

1. Oliver Hersent, David Boswarthick, Omar Elloumi, "The Internet of Things – Key, Applications and Protocols", Wiley Publications, 2011. ISBN: 1119966701.
2. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", A press, 1st Edition, 2017. ISBN: 1484220463.
3. RMD SundaramShriram K Vasudevan, Abhishek S Nagarajan, "Internet of Things", Wiley Publications, 2019. ISBN: 8126578378.

SAMPLE TEMPLATEfor PCC/PEC/OEC

Web links and Video Lectures (e-Resources):

- https://youtu.be/hv-aBonZMRQ?list=PLWbMIWDTOauBvP0ZxvoIshg55WPMF37UI
- https://youtu.be/De8MQWbhu3k

Skill Development Activities Suggested

- Individual projects on topics covered in class. Students will choose a real life problems related to the discussedtopics and implement the solution by using techniques and strategies discussed in the class. For each project,students have to submit a report and present a seminar.
- Assignments, Quiz and Industrial Visit on relevant topic of the course.

Program Outcome of this course

At the end of the course the student will be able to :

Sl. No.	Description Blooms Level	Blooms Level
CO1	Use IoT Sensors for data logging and communicate the data to cloud	L1
CO2	Use IoT Sensors data in AI & ML	**L1**
CO3	Automate different process using sensors and control components	**L2**
CO4	Understand IOT alliances/hardware and standards	**L1**

Mapping of COS and Pos (Note : High – 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	2	2	2	2
CO2	3	2	2	2	1	1	2
CO3	3	2	1	2	2	1	2
CO4	3	2	1	2	1	2	1
CO5	3	2	1	3	1	2	1

SAMPLE TEMPLATEfor PCC/PEC/OEC

MICRO MACHINING PROCESSES			
Course Code	MMST258B	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	00:02/01:00	SEE Marks	50
Total Hours of Pedagogy	30/15	Total Marks	100
Credits	01	Exam Hours	02
Examination Type (SEE)	Theory		

Course Learning objectives:

- Understand the Micro System design, Material properties, micro fabrication technologies etc.
- Study the Microstructure of materials, phase transformations in crystalline solids and smart materials.
- Learn about the various processes and special machining's.
- Understand the micro-and ultra precision machining.
- Awareness on semiconductors manufacturing using micro fabrication technologies.

Module-1

INTRODUCTION: Introduction to Micro System design, Material properties, micro fabrication technologies. Structural behavior, sensing methods, micro scale transport – feedback systems.

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-2

MICROMECHANICS: Microstructure of materials, its connection to molecular structure and its consequences on macroscopic properties – Phase transformations in crystalline solids including martensite, ferroelectric, and diffusional phase transformations, twinning and domain patterns, smart materials.

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-3

BASIC MICRO – FABRICATION: Bulk Processes – Surface Processes – Sacrificial Processes and Bonding Processes– Special machining: Laser beam micro machining – Electrical Discharge Machining – Ultrasonic Machining – Electro chemical Machining, Electron beam machining.

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-4

MECHANICAL MICROMACHINING: Theory of micromachining – Chip formation – Size effect in micromachining – micro turning, micro milling, micro drilling – Micromachining tool design – Precision Grinding – Partial ductile mode grinding – Ultra precision grinding – Binder less wheel – Free form optics.

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-5

SEMICONDUCTORSMANUFACTURING: Basic requirements–clean room–yield model–Wafer IC manufacturing–feature micro fabrication technologies–PSM–IC industry–New Materials–Bonding and layer transfer–devices–micro fabrication industries.

SAMPLE TEMPLATEfor PCC/PEC/OEC

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks (25 marks out of 50) and for the SEE minimum passing mark is 40% of the maximum marks (20 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

- The**question paper shall consist of ten questions,** with**each question carrying 10 marks.**
- There shall be**two questions from each module.** Each question may or may not include **sub-questions**(with a**maximum of two sub-questions**).The**mark distribution**for sub-questions may follow any of the following formats**: 5+5, 4+6, or 3+7.**
- Students are required to**answer any five full questions, selecting one full question from each module.**
- In order to pass the SEE, students must obtain a**minimum of 40% of the maximum marks**allotted for the examination**.**
- The maximum duration of the examination is 02 hours

1.

Textbooks

1 SamiFranssila,"IntroductiontoMicroFabrication",JohnWileyandsonsLtd.,UK,2004,ISBN:978-0-470- 85106-7.
2 MadoreJ,"FundamentalofMicroFabrication",CRCPress,2002
3 MarkJ.Jackson,"MicrofabricationandNanomanufacturing",CRCPress,2006.
4 PeterVanZant,"Microchipfabrication",McGrawHill,2004.

SAMPLE TEMPLATEfor PCC/PEC/OEC

Program Outcome of this course

Sl. No.	Description	Pos
1	An ability to independently carry out research/investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document.	PO2
3	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	

Mapping of COS and Pos (Note : High – 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**2**	**2**	**2**	**3**	**3**	**3**	**2**
CO2	**1**	**1**	**2**	**2**	**3**	**-**	**2**
CO3	**2**	**2**	**2**	**3**	**3**	**-**	**2**

SAMPLE TEMPLATEfor PCC/PEC/OEC

ARTIFICIAL INTELLIGENCE IN MANUFACTURING			
Course Code	MMST258C	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	00:02/01:00	SEE Marks	50
Total Hours of Pedagogy	30/15	Total Marks	100
Credits	01	Exam Hours	02
Examination Type (SEE)	Theory		

Course Learning objectives:

- To understand the modern manufacturing concepts.
- To learn the concept of AI based methods for process controls.
- To analyse the automated material handling systems.

Module-1	
Introduction to Modern Manufacturing and AI Based Applications: Introduction to Modern Manufacturing Process, Industry 4.0, Introduction to AI and its applications in manufacturing, Design in Manufacturing and AI Requirements.	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-2	
AI based Methods for Process Control & Monitoring: Machine Learning methods, AI based Monitoring and control of discrete manufacturing process, Online process monitoring in additive manufacturing, Industrial Machine Vision, Development of Digital Twins.	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-3	
AI based Design Space Exploration: Multi objective heuristic search for DSE, Algorithms for Customizable Manufacturing, Allocation and Layout, Scheduling for flexible manufacturing systems**.**	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-4	
AI & Robotics: AI based Robot Architecture & Applications in Automated Manufacturing, Robot Vision & Motion, Multi agent and swarm robotics, Robot to Robot and Robot to human coordination (Cobots - collaborative robotics) Reliable & Trusted AI in Robotics.	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.
Module-5	

SAMPLE TEMPLATEfor PCC/PEC/OEC

Automated material Handling Storage: Material functions, types of material handling equipment, analysis of material handling systems, design of system, conveyor system, automated guided vehicle systems, automated storage/retrieval systems, caroused storage systems work in process storage, interfacing handling & storage with manufacturing.

Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks (25 marks out of 50) and for the SEE minimum passing mark is 40% of the maximum marks (20 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

- The**question paper shall consist of ten questions,** with**each question carrying 10 marks.**
- There shall be**two questions from each module.** Each question may or may not include **sub-questions**(with a**maximum of two sub-questions**).The**mark distribution**for sub-questions may follow any of the following formats**: 5+5, 4+6, or 3+7.**
- Students are required to**answer any five full questions, selecting one full question from each module.**
- In order to pass the SEE, students must obtain a**minimum of 40% of the maximum marks**allotted for the examination**.**
- The maximum duration of the examination is 02 hours

Textbooks

1. Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig, 3rd Edition, Prentice Hall, 2009.
2. Deep Learning - Ian Goodfellow, YoshuaBengio, Aaron Courville, MIT Press, 2018
3. Additive manufacturing of Metals: The Technology, Materials , Design and Production; Ed. Li Yang, et al.; Springer International Publishing AG 2017
4. Laser Materials Processing, by W M Steen, J. Mazumder, 4th Ed. Springer
5. Handbook of Industrial Robotics by Shimon Y. Nof (Editor), ISBN 9788126540303.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=lTsvhSYstAE
- https://www.forbes.com/sites/bernardmarr/2018/09/02/what-is-industry-4-0-heres-a-super-easy-explanation-for-anyone/?sh=162dc3409788
- https://professional.mit.edu/news/articles/4-ways-ai-will-change-design-and-manufacturing
- https://theconversation.com/five-ways- -intelligence-can-help-space-exploration-153664
- https://www.systema.com/automated-material-handling-systems#:~:text=Automated%20material%20handling%20systems%20ensure,even%20in%20two%20separate%20buildings.

SAMPLE TEMPLATEfor PCC/PEC/OEC

Course outcome

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Learn how AI methods can be used in a manufacturing workflow for process optimization and control	L1, L2, L3, L4
CO2	Discover AI/machine learning methods that enable design automation and customization	L1, L2, L3, L4,L5
CO3	Explore AI/machine learning methods for performance-driven design that automatically translate functional specifications of objects to manufacturable designs	L1, L2, L3, L4,L5
CO4	Learn AI based Robot Architecture & Applications in Automated Manufacturing, Robot Vision & Motion, Multi agent and swarm robotics.	L1, L2, L3, L4,L5
CO5	Explore Material functions, types of material handling equipment, analysis of material handling systems, design of system, conveyor system.	L1, L2, L3, L4

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems	PO1
2	An ability to write and present a substantial technical report/document.	PO2
3	To be able to demonstrate a degree of mastery over the area as per the specialization of the program.	PO3
4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	PO4
5	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated use and misuse	PO5
6	Employ advanced prototyping methods to shorten design cycles and narrow alternatives without restricting innovation.	PO6
7	Understand and debate the roles and responsibilities of a product designer/manufacturer on society.	PO7

Mapping of COS and Pos (Note : High – 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**1**	**1**	**2**	**2**	**3**	**3**	**2**
CO2	**1**	**2**	**2**	**2**	**3**	**3**	**2**
CO3	**1**	**2**	**2**	**2**	**3**	**3**	**2**
CO4	**1**	**2**	**2**	**2**	**3**	**3**	**2**
CO5	**1**	**2**	**2**	**2**	**3**	**3**	**2**

SAMPLE TEMPLATEfor PCC/PEC/OEC

MACHINE LEARNING			
Course Code	MMST258D	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	00:02/01:00	SEE Marks	50
Total Hours of Pedagogy	30/15	Total Marks	100
Credits	01	Exam Hours	02
Examination Type (SEE)	Theory		

Course Learning objectives:
To discover patterns in the user data and then make predictions based on these and intricate patterns for Answering business questions and solving business problems.

Module-1	
Introduction, Concept Learning and Decision Trees Learning Problems – Designing Learning systems, Perspectives and Issues – Concept Learning – Version Spaces and Candidate Elimination Algorithm – Inductive bias – Decision Tree learning – Representation – Algorithm – Heuristic Space Search	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-2	
Neural Networks and Genetic Algorithms: Neural Network Representation – Problems – Perceptron‟s – Multilayer Networks and Back Propagation Algorithms – Advanced Topics – Genetic Algorithms – Hypothesis Space Search – Genetic Programming – Models of Evolution and Learning.	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-3	
Bayesian and Computational Learning Bayes Theorem – Concept Learning – Maximum Likelihood – Minimum Description Length Principle – Bayes Optimal Classifier – Gibbs Algorithm – Naïve Bayes Classifier– Bayesian Belief Network – EM Algorithm – Probably Learning – Sample Complexity for Finite and Infinite Hypothesis Spaces – Mistake Bound Model	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-4	
Instant Based Learning and Learning Set of Rules: K- Nearest Neighbor Learning – Locally Weighted Regression – Radial Basis Functions – Case-Based Reasoning – Sequential Covering Algorithms – Learning Rule Sets – Learning First Order Rules – Learning Sets of First Order Rules – Induction.	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Module-5	
Analytical Learning and Reinforced Learning: Perfect Domain Theories – Explanation Based Learning – Inductive Analytical Approaches - FOCL Algorithm – Reinforcement Learning – Task – Q-Learning – Temporal Difference Learning	
Teaching-Learning Process	Chalk and talk method and Power Point presentation and YouTube videos, Animation videos, creating right time in classroom discussions. Giving activities &assignments.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks (25 marks out of 50) and for the SEE minimum passing mark is 40% of the maximum marks (20 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

- The**question paper shall consist of ten questions,** with**each question carrying 10 marks.**
- There shall be**two questions from each module.** Each question may or may not include **sub-questions**(with a**maximum of two sub-questions**).The**mark distribution**for sub-questions may follow any of the following formats**: 5+5, 4+6, or 3+7.**
- Students are required to**answer any five full questions, selecting one full question from each module.**
- In order to pass the SEE, students must obtain a**minimum of 40% of the maximum marks**allotted for the examination**.**
- The maximum duration of the examination is 02 hours

1.

Textbooks

(1) Tom M. Mitchell, “Machine Learning”, McGraw-Hill Education (INDIAN EDITION), 2013.
(2)EthemAlpaydin, “Introduction to Machine Learning”, 2nd Ed., PHI Learning Pvt. Ltd., 2013.

Reference Books

(1) Stephen Marsland, Machine Learning: An Algorithmic Perspective
(2) T. Hastie, R. Tibshirani, J. H. Friedman, “The Elements of Statistical Learning”, Springer; 1st Edition, 2001
(3) Tom Mitchell, Machine Learning,

Web links and Video Lectures (e-Resources):

- VTU e-Shikshana Program
- VTU EDUSAT Program

SAMPLE TEMPLATEfor PCC/PEC/OEC

Course Outcomes

At the end of the course the student will be able to :

Sl. No.	Description Blooms Level	Blooms Level
CO1	Design the learning system for learning problem with this basic knowledge	L2
CO2	Apply effectively neural networks and genetic algorithms for appropriate applications.	L3
CO3	Apply bayesian techniques for classification problems	L2
CO4	Derive effectively learning rules for appropriate learning systems	L2
CO5	Choose and differentiate reinforcement and analytical learning techniques	L3

Program Outcome of this course

Sl. No.	Description POs	POs
1.	To prepare students to meet the industrial requirements at global level competitiveness.	PO1
2.	To develop the students analytical skills to enable them to understand real world problems and formulate solutions.	PO2
3.	To impart basic education to students in the areas of Design Engineering, Manufacturing Engineering and Thermal Sciences that will enable them to take up higher studies in these areas.	PO3
4.	To allow students to work in teams through group project works and thus help them achieve interpersonal and communication skills.	PO4
5.	To inculcate the habit of lifelong learning, adherence to ethics in profession, concern for environmental and regard for good professional practices.	PO5
6.	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO6
7.	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO7

Mapping of COS and Pos (Note : High – 3, Medium – 2, and Low – 1)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	3	3	2	2	2
CO2	3	3	3	3	3	3	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	2	2	3	3
CO5	3	3	3	3	3	3	1