VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI.

Scheme of Teaching and Examinations and Syllabus
M.Tech., Material Science and Technology (MST)
(Effective from the Academic year 2022-23)

Registrar,
Visvesvaraya Technological University
JnanaSangam, Machhe, Belagavi-590018
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Programme Outcome:

PO1 - An ability to independently carry out research/investigation and development work to solve practical problems.
PO2 -An abilityto write and present a substantial technical report/document.
PO3 - Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO4 -Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2022
M.Tech., Material Science and Technology (MST) (Font 09 Capital, Calibri)
Choice Based Credit System (CBCS) and Outcome-Based Education(OBE)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours per Week			Examination				Credits
				Theory	Practical/Seminar	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
						T/S					
	BSC	22MST/MTE/MPD /MEM/MPM/MPY/MSE11	Mathematical methods in Engineering	3	0	00	3	0	0	00	
	IPCC	22MST12	Advanced Materials Characterisation Techniques	3	2	00	3	0	0	00	
	PCC	22MST13	Computational Techniques	3	0	02	3	0	0	00	
	PCC	22MST14	Data Science	2	0	02	3	0	0	00	
	PCC	22MST15	Materials Processing Technology	2	0	02	3	0	0	00	
	MCC	22RMI16	Research Methodology and IPR	3	0	00	3	0	0	00	
	PCCL	22MSTL17	Material Characterization Lab - 1	1	2	00	3	0	0	00	
	AUD/ AEC	22AUD18/ 22AEC18	BOS recommended ONLINE courses	Classes and evaluation procedures are as per the policy of the online course providers.							P
			TOTAL	**7**	**4**	**06**	**1**	**50**	**50**	**00**	**2**

Note: BSC-Basic Science Courses, PCC: Professional core. IPCC-Integrated Professional Core Courses, MCC- MandatoryCredit Course, AUD/AEC –Audit Course / Ability Enhancement Course (A pass in AUD/AEC is mandatory for the award of the degree), PCCL-Professional Core Course lab, L-**Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities**(Hours are for Interaction between faculty and students)

Integrated Professional Core Course (IPCC): **Integrated Professional Core Course (IPCC)**: Refers to Professional Theory Core Course Integrated with practical of the same course. The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be included in the SEE question paper.

Audit Courses /Ability Enhancement Courses Suggested by BOS (ONLINE courses): Audit Courses: These are prerequisite courses suggested by the concerned Board of Studies. Ability Enhancement Courses will be suggested by the BoS if prerequisite courses are not required for the programs. **Ability Enhancement Courses**:

- These courses are prescribed to help students to enhance their skills in in fields connected to the field of specialisation as well allied fields that leads toemployable skills. Involving in learning such courses are impetus to lifelong learning.
- The courses under this category are online courses published in advance and approved by the concerned Board of

Studies.

- Registration to Audit /Ability Enhancement Course shall be done in consultation with the mentor and is compulsory during the concerned semester.
- In case a candidate fails to appear for the proctored examination or fails to pass the selected online course, he/she can register and appear for the same course if offered during the next session or register for a new course offered during that session, in consultation with the mentor.
- The Audit Ability Enhancement Course carries no credit and is not counted for vertical progression. However, a pass in such a course is mandatory for the award of the degree.

Skill development activities:Under Skill development activities in a concerning course, the students should

1. Interact with industry (small, medium, and large).
2. Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3. Involve in case studies and field visits/ fieldwork.
4. Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5. Handle advanced instruments to enhance technical talent.
6. Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7. Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc.

Students and the course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills of the study they have undertaken. The students with the help of the course teacher can take up relevant technical –activities which will enhance their skill. The prepared report shall be evaluated for CIE marks.

Program Outcome of the Course

POs	Description
PO1:	Acquire, demonstrate, and apply basic knowledge in the field of Materials.
PO2:	Identify problems in the field of Technology in manufacturing by advanced materials, formulate them and solve by using advanced techniques.
PO3:	Independently carry out research/investigation and developmental work to solve practical problems in Materials Science Technology.
PO4:	Write and present a substantial technical report/document.
PO5:	Demonstrate a degree of mastery over Materials Science Technology.
PO6:	Employ Advanced Material for diffrent tool to cater into Material needs in both discrete and process plants.
PO7:	Provide solutions to varied engineering problems through the interpretation of data using modern computational tools.

Semester- I

Mathematical Methods in Engineering Common To MST/MTE/MPD/MEM/MPM/MPY/MS			
Course Code	**22MST11**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03-00-00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To have an insight into solving linear Algebraic Equations.
- Learn to use the roots of equations.
- To develop proficiency in solving ordinary and partial differential equations arising in engineering applications, using numerical methods.
- To enable learning concepts of Sampling theory, RBD and their implication in Mechanical Engineering.
- To understand the technique of simple mathematical models in estimating high accuracy and their applications.

Module-1	
Errors and simple mathematical modelling: Error definition, round off errors and truncation errors. Mathematical modelling and Engineering problem solving: Simple mathematical model, Conservation Laws of Engineering. Engineering Applications) Deflection of Beams ii) Terminal velocity of a freely falling body (RBT Levels: L1 & L2)(Text Book:1)	
Teaching-Learning Process	Chalk and talk method/Power point Presentation
Module-2	
System of Linear Algebraic Equations and Eigen Value problems: Gauss-Jordan Method, Cholesky Method, Partition method, Givens method for symmetric matrices, (RBT Levels: L1 & L2) (Text Book:3)	
Teaching-Learning Process	Chalk and talk method/Power point Presentation
Module-3	
Roots of Equations: Muller's method, Graeffe's roots squaring method. Numerical solutions of second order ordinary differential equations: RungeKutta method & Milne's Predictor-corrector method..(RBT Levels: L2 & L3) (Text Book:3) 8hrs	
Teaching-Learning Process	Chalk and talk method/Power point Presentation
Module-4	
Partial Differential Equations: Numerical solution of one dimensional wave equation, Heat equation, (Schmidt's explicit formula)& Laplace equation(Gauss-Seidel process) by finite difference schemes. (RBT Levels: L2 & L3) (Text Book:6) 8hrs	
Teaching-Learning Process	Chalk and talk method/Power point Presentation
Module-5	
Sampling theory: Testing of hypothesis (Single mean & single proportion only), Chi square test and F-test. Analysis of Variance (ANOVA): one-way classification, Design of experiments, RBD. (RBT Levels: L2 & L3) (Text Book:6) 8hrs	
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. Steven C Chapra and Raymond P Canale," Numerical Methods for Engineers",7th Ed., cGraw-Hill Edition,2015
2. Theory of ordinary differential equations, Coddington E., Levinson N., McGraw-Hill publishing Company, TMH Edition, 9yh Reprint, 1987.
3. M K Jain, S.R.K Iyengar, R K Jain, Numerical methods for Scientific and Engg. computation, New Age International, 2003.
4. R. E, Walpole, R.H.Myres, S.L.Myres and Keying Ye, "Probability and Statistics for Engineers and Scientists", 9th Edition, Pearson, 2012
5. Dr.B.S.Grewal, "Numerical Methods in Engineering and Science", Khanna Publishers,1999.
6. K Shankar Rao,"Introduction to Partial Differential Equations" Prentice – Hall of India Pvt. Ltd., 1995 Edition.
7. C. Ray Wylie and Louis C Barrett," Advanced Engineering Mathematics". 6th edition, McGraw-Hill, 1995.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses.php?disciplineID=111
- http://www.class-central.com/subject/math(MOOCs)
- https://academicearth.org/
- http://www.bookstreet.in
- VTU e-Shikshana Program
- VTU EDUSAT Program

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms
CO1	Acquire the idea of significant figures, types of errors during numerical computation.	L1
CO2	Learn various numerical methods to solve system of linear equations	L2
CO3	Analyse and solve PDE's related to wave equation arising in vibration analysis.	L3
CO4	Understand sampling theory.	L1
C05	Acquire knowledge of algebraic equations and analyse.	L2

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Advanced Materials Characterisation Techniques			
Course Code	22MST12	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03-02-00	SEE Marks	50
Total Hours of Pedagogy	40Hrs+10-12 Lab Slots	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.

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

Practical Components of IPCC

1.	Study of X-Ray diffraction technique: Powder synthesis: XRD characterisation, particle size, surface area analysis
2.	Study the images obtained by Scanning electron microscopy for surface deformation, microstructure and so on.,
3.	Polishing Etching and microstructure analysis of Mild steel, Aluminium and Copper by using metallurgical microscope and by Scanning electron microscopy
4.	Study of Atomic Force Microscopy

5.	Study the fracture surface of the metals and non-metals
6.	Conduct and experiments for different materials when they are rubbing against each other and study the surface deformation.

Assessment Details (both CIE and SEE)

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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):

- https://youtu.be/bXyxwcvM3_E
- https://youtu.be/49RET0N-ITY?list=PLFW6lRTa1g808_CfYhZKdv2eXplAQiAwS

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.	L1
CO2	To familiarize the analysis of particles by using different techniques	L3
CO3	To familiarize optical microscopy, diffraction pattern, FESEM.	L1
CO4	Analysis of surface deformities using different techniques	L3
CO5	To familiarize rheological and visco elastic properties measurement and analysis	L2

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Computational Techniques			
Course Code	22MST13	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03-00-02	SEE Marks	50
Total Hours of Pedagogy	40Hrs+10-12Activities	Total Marks	100
Credits	04	Exam Hours	03

Course Learning objectives:

- This course provides students with the fundamentals of computational techniques for solving numerical problems with the application of different techniques.

Module-1	
Design of Experiments: Factorial Design, Taguchi Techniques, ANOVA	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2	
Artificial Intelligence: ANN, fuzzy Logic, Genetic Algorithm, Applications in Materials Engg.,8Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3	
Optimization Methods: Classical optimization methods, unconstrained minimization. Univariate, conjugate direction, gradient and variable metric methods, constrained minimization, feasible direction and projections. Integer and geometric programming.8Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4	
Numerical Fluid Flow and Heat Transfer: Classification of PDE, Finite differences, Steady and unsteady conduction, explicit and implicit method.**8Hrs**	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5	
Finite element Methods: Introduction to I-D FEM; Problems in structural Mechanics using 2D elements, Plane stress, plain strain, axisymmetric analysis; three-dimensional analysis.8Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Tutorial/Skill Development activities	
01	Students are identify and design the experimental conditions for any experiment to have at least 3 process parameters and 2 outcomes and complete statistical analysis and ANOVA.
02	Use any of the same experimental data shown in 1 and analyse using any of the techniques and in module 2.
03	Assume any practical data or collect the data by conducting the experiments and do the analysis by using any of the techniques shown in module 3
04	Analyze the fluid flow and analysis and FEM structural analysis by using appropriate sofware

Assessment Details (both CIE and SEE)

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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

12. Design and analysis of experiments - Douglas C. Montgomery, 5th ed., John Wiley and Sons, 2001.
13. A Text book of finite elements Analysis – P Seshu PHI Learning Private Limited, New Delh, 2003
14. Artificial Neural Networks - B. Yegnanarayana, Prentice-Hall of India, 1999
15. Taguchi techniques for quality engineering - Phillip J. Ross, McGraw-Hill Book company, 1996
16. Numerical heat transfer and fluid flow- Suhas V. Patankar, Hemisphere Publishing Corporation, 1980

Web links and Video Lectures (e-Resources):

- . https://youtu.be/fV2k2ivttL0?list=PLCD819D1E1C4F91C3
- https://youtu.be/XCPZBD9lbVo?list=PLbMVogVj5nJQu5qwm-HmJgjmeGhsErvXD

Skill Development Activities Suggested

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

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 & Identify Techniques of Optimisation for real industry problems	L1
CO2	Apply techniques to real time problems	L2
CO3	Apply AI techniques in Material Engineering	L3
CO4	Develop skill to solve simple beam problems using the steps of FEM	L4
CO5	Formulate element properties of 1D & 2D elements	L3

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Data Science			
Course Code	22MST14	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02-00-02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-12Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To provide exposure to principles of nanotechnology; characterization of nanostructured materials; and its applications

Module-1	
Introduction: What is Data Science? Big Data and Data Science hype – and getting past the hype, Why now? – Datafication, Current landscape of perspectives, Skill sets. Needed Statistical Inference: Populations and samples, Statistical modelling, probability distributions, fitting a model. 5 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-2	
Exploratory Data Analysis and the Data Science Process: Basic tools (plots, graphs and summary statistics) of EDA, Philosophy of EDA, The Data Science Process, Case Study: Real Direct (online real estate firm). 5 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-3	
Feature Generation and Feature Selection (Extracting Meaning from Data): Motivating application: user (customer) retention. Feature Generation (brainstorming, role of domain expertise, and place for imagination), Feature Selection algorithms. Filters; Wrappers; Decision Trees; Random Forests. 5 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-4	
Recommendation Systems: Building a User-Facing Data Product, Algorithmic ingredients of a Recommendation Engine, Dimensionality Reduction, Singular Value Decomposition, Principal Component Analysis, Exercise: build your own recommendation system.5 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-5	
Data Visualization: Basic principles, ideas and tools for data visualization. Data Science and Ethical Issues, Discussions on privacy, security, ethics, Next-generation data scientists.5 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

ssessment Details (both CIE and SEE)

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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. Nanophysics and Nanotechnology" – An Introduction to ModernConcepts in Nanoscience, Edward L. Wolf Second Edition, John Wile y & Sons, 2006.
2. Nano: The essentials, Pradeep, T, McGraw Hill.
3. Introduction to Nano Technology, Poole, C.P and Owens, J.F, Wiley
4. Surface Science Foundation of Catalysis and Nanoscience ", K.W. Kolasinski –Wiley, 2002
5. Nano particles: From theory to applications, Schmid, G., Wiley VCH VerlagGmBH and Co.
6. Nanoparticulate as Drug Carriers, Valdimir P, Torchilin (2006) imperial college press.
7. Nanomaterials and Nano systems for Bio-Medical Applications, M Reza Mozafari (2007) springer.

Web links and Video Lectures (e-Resources):

- https://youtu.be/t7yv4gSnNkE?list=PLwdnzlV3ogoWI8QEu4hsT-n_r8UbWbquy
- https://youtu.be/Bwog2XYCmN8

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate the working knowledge of nanotechnology principles and industry applications	L1
CO2	Design the nanoscale paradigm in terms of properties at the nanoscale dimension	L2
CO3	Apply key concepts in materials science, chemistry, physics, biology and engineering to the field of nanotechnology	L3
CO4	Identify current nanotechnology solutions in design, engineering and manufacturing	L2

Mapping of COS and POs

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

1:Slight (low) 2:Moderate (medium) 3: Substantial (High) "-": no correlation

Materials Processing Technology			
Course Code	22MST15	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02-00-02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-12Activities	Total Marks	100
Credits	03	Exam Hours	03

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, rotational moulding, compression moulding, transfer moulding, reaction injection moulding, textile/fiber spinning technology 5 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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.5 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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 Manufacturing; Indirect Prototyping and Tooling, Indirect Manufacturing, Simultaneous Engineering and Additive Manufacturing Technologies (AMT),5 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4	
Support Structure in AM, Generation of Physical Layer Modelling: Virtual Prototyping. Tessellation (STL Format) and Tessellation Algorithms. Defects in STL Files and Repairing Algorithms. Various Slicing Procedures. Accuracy and Surface Quality in AM, Various Rapid Tooling Techniques. Introduction to Reverse Engineering.5 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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.5 hrs	
Teaching-Learning Process	Chalk and Talk/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. 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):

- https://youtu.be/sCTgZv33tuA
- https://youtu.be/hv-aBonZMRQ

Skill Development Activities Suggested

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

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	L1
CO2	Identify the potential application of powders and its processing	L2
CO3	Identify areas where the knowledge of additive manufacturing can be applied through the theoretical studies.	L3
CO4	Describe portrayal of additive manufacturing and prototyping, their concepts, techniques, recent trends and challenges for the future.	L2
CO5	Assess the areas where additive manufacturing can make a greater contribution to industrial capabilities	L4

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Research Methodology and IPR			
Course Code	22RMI16	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To give an overview of the research methodology and explain the technique of defining a research problem
- To explain the functions of the literature review in research.
- To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review.
- To explain various research designs and their characteristics.
- To explain the details of sampling designs, and also different methods of data collections.
- To explain the art of interpretation and the art of writing research reports.
- To explain various forms of the intellectual property, its relevance and business impact in the changing global business environment.
- To discuss leading International Instruments concerning Intellectual Property Rights

Module-1

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India. Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration. 8 Hrs

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-2

Reviewing the literature: Place of the literature review in research, bringing clarity and focus to your research problem, improving research methodology, Broadening knowledge base in research area,Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed. Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs. 8Hrs

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-3

Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs.

Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Techniques, Multidimensional Scaling, Deciding the Scale.

Data Collection: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method. 8Hrs

Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-4

Testing of Hypotheses: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis. Chi-square Test: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests.

8Hrs	
Teaching-Learning Process	Chalk and talk method / PowerPoint Presentation

Module-5

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers‟ Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation(WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules,Patents,Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the RightHolder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.8Hrs

Teaching-Learning Process	Chalk and talk method / PowerPoint 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

- Research Methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg,New Age International,4th Edition, 2018.
- Research Methodology a step-by-step guide for beginners. (For the topic Reviewing the literature under module 2), RanjitKumar,SAGE Publications,3rd Edition, 2011.
- Study Material (For the topic Intellectual Property under module 5), Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September2013.

- Research Methods: the concise knowledge base, Trochim, Atomic Dog Publishing, 2005.
- Conducting Research Literature Reviews: From the Internet to Paper, Fink A, Sage Publications, 2009.

Web links and Video Lectures (e-Resources):

- VTU e-Shikshana Program
- VTU EDUSAT Program

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Discuss research methodology and the technique of defining a research problem	L1
CO2	Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review	L1
CO3	Explain various research designs, sampling designs, measurement and scaling techniques and also different methods of data collections.	L2
CO4	Explain several parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports	L1
CO5	Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leadingInternational Instruments concerning IPR	L2

Mapping of COS and Pos (indicative only)

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Material Characterization Lab 1			
Course Code	**22MST17**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	01-02-00	SEE Marks	50
Credits	02	Exam Hours	03

Course objectives:

- To learn basic principles of finite elements analysis procedure
- To learn the theory and characteristics of finite elements that represent engineering structures.
- To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite elements analyses.

Sl.NO	Experiments
1	Polishing Etching and microstructure analysis of Mild steel, Aluminium and Copper
2	Study of variation in Microstructure of dual phase stainless steels after heat treatment
3	Hardness analysis of Aluminium, brass, mild steel etc., (Before and after heat treatment)
4	Temperature Data Aquisition System for some of the experiments when the rubbing action between two surfaces
5	Study and analysis of Ultrasonic Flaw detector
6	Study of Atomic Force Microscopy
7	Study of Scanning electron microscopy
8	Casting of Aluminium or copper alloy
9	Impact testing on metals(at least two)
10	Analysis of metals deformed surface by using image processing technique

Course outcomes (Course Skill Set):

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

1. The students will be able to analyze the microstructure different metal and its alloys
2. Students will be able to analyze the suitability of different materials for different Applicatios

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 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 downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each 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 average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests 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:

- **Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Second Edition,** Author(s): **Prof. Yang Leng** First published: **2 August 2013** Print ISBN: **9783527334636 |**Online ISBN:**9783527670772 |**DOI:**10.1002/9783527670772 Copyright © 2013 Wiley-VCH Verlag GmbH & Co. KGaA**

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI.

Scheme of Teaching and Examinations and Syllabus
M.Tech., Material Science and Technology (MST)
(Effective from the Academic year 2022-23)

Registrar,
Visvesvaraya Technological University
JnanaSangam, Machhe, Belagavi-590018
eMail: registrar@vtu.ac.in
contact: 0831-2498112

Programme Outcome:

PO1 - An ability to independently carry out research/investigation and development work to solve practical problems.

PO2 -An abilityto write and present a substantial technical report/document.

PO3 - Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4 -Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2022
M.Tech., Material Science and Technology(MST) (Font 09 Capital, Calibri)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Seminar	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	T/SD					
	PCC	22MST21	Machine Learning Techniques	02	00	02	3	50	50	100	
	IPCC	22MST22	Mechanical Behaviour of metals	03	02	00	3	50	50	100	
	PE	22MST23x	Professional elective 1								
	PE	22MST24x	Professional elective 2								
	MP	22MST25	Mini Project with Seminar								
	PCCL	22MST26	Material Characterization Lab – 2	01	02	00	3	50	50	100	02
	AUD/A	22AUD27	Suggested ONLINE courses	Classes and evaluation procedures are as per the policy of the online course providers.							P
TOTAL				**10**	**08**	**08**	**5**	**350**	**250**	**600**	**18**

Note: PCC: Professional core courses,PEC: Professional Elective Courses, IPCC-Integrated Professional Core Courses. MPS-Mini Project With Seminar; AUD/AEC; Audit Courses / Ability Enhancement Courses(Mandatory), PCCL-Professional Core Course lab,
L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities(Hours are for Interaction between faculty and students)

Professional Elective 1		**Professional Elective 2**	
Course Code under	**Course title**	**Course Code under 22MST25X**	**Course title**
22MST/MDE/MEA/MMD231	Optimization Technique	22MST241	Electronic, Optical and Magnetic Properties of Materials
22MST232	Thermodynamics and Phase diagrams	22MST242	Nano science and Nano materials
22MST/MTR233	Smart Materials and Structures	22MST243	Advanced Foundry Technology
22MST234	Bio Materials & Technology	22MST244	Surface Treatment & finishing
22MST235	Mechanical Behaviour of thin films	22MST245	Modelling, Simulation & Analysis of Manufacturing Systems

Note:

1 Mini Project with Seminar: This may be hands-on practice**,** survey report, data collection and analysis, coding, mobile app development, field visit and report preparation, modelling of system, simulation, analysing and authenticating, case studies, etc.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Students can present the seminar based on the completed mini-project. Participation in the seminar by all postgraduate students of the program shall be mandatory.

The CIE marks awarded for Mini-Project work and Seminar, shall be based on the evaluation of Mini Project work and Report, Presentation skill and performance in Question and Answer session in the ratio 50:25:25. Mini-Project with Seminar shall be considered as a head of passing and shall be considered for vertical progression as well as for the award of degree. Those, who do not take-up/complete the Mini Project and Seminar shall be declared as fail in that course and have to complete the same during the subsequent semester. There is no SEE for this course.

2. Internship: All the students shall have to undergo a mandatory internship of **06 weeks** during the vacation of II and III semesters. A University examination shall be conducted during III semester and the prescribed internship credit shall be counted in the same semester. The internship shall be considered as a head of passing and shall be consideredfor vertical progression as well

asfor the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in the internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

Program Outcome of the Course

POs	Description
PO1:	Acquire, demonstrate, and apply basic knowledge in the field of Materials.
PO2:	Identify problems in the field of Technology in manufacturing by advanced materials, formulate them and solve by using advanced techniques.
PO3:	Independently carry out research/investigation and developmental work to solve practical problems in Materials Science Technology.
PO4:	Write and present a substantial technical report/document.
PO5:	Demonstrate a degree of mastery over Materials Science Technology.
PO6:	Employ Advanced Material for diffrent tool to cater into Material needs in both discrete and process plants.
PO7:	Provide solutions to varied engineering problems through the interpretation of data using modern computational tools.

Semester- II

Semester-II

Machine Learning Techniques			
Course Code	**22MST21**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-12Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.
- Have an understanding of the strengths and weaknesses of many popular machine learning approaches.
- Appreciate the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning.
- Be able to design and implement various machine learning algorithms in a range of real-world applications.

Module-1	
Introduction to Machine Learning, Applications of Machine Learning, Types of Machine Learning: Supervised, Unsupervised and Reinforcement learning, Dataset formats, Features and observations. 8hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2	
Supervised Learning: Linear Regression, Logistic Regression: Single and Multiple variables, Sum of squares error function, The Gradient descent algorithm: Application, The cost function, Classification using logistic regression, one-vs-all classification using logistic regression, Regularization. 8 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3	
Introduction to Neural Networks, Model representation, Gradient checking, Back propagation algorithm, Multi-class classification, Support vector machines, Applications & Use-cases.8 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4	
Unsupervised Learning: Clustering and Dimensionality Reduction Introduction to Clustering, K means Clustering Algorithm, Cost function, Application, Dimensionality reduction, PCA- Principal Component Analysis Applications, Clustering data and PCA.8 hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5	
Introduction to Deep Learning & CNN, What is deep learning? Difference between Machine Learning and Deep Learning, When to use Deep Learning? Deep Feedforward Networks, Example: Learning XOR, Convolution Neural Networks (CNN) – Convolutional Layer: Filters, Stacking Multiple Feature Maps, Tens or Flow Implementation, Pooling Layer, CNN Architectures 10	
Teaching-Learning Process	Chalk and Talk/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):

- https://youtu.be/v-3TmN4HhLc?list=PLwdnzlV3ogoW31clPN6Dn6c8Ia-n36vXk
- https://youtu.be/-NINgz6KQTA?list=PLOSWwFV98rfLAVnU2DJq8xO1LuFw6SXEa

Skill Development Activities Suggested

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

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	L1
CO2	Design simple models for smart structures & materials	L2
CO3	Perform simulations of smart structures & materials application	L3
CO4	Conduct experiments to verify the predictions	L3
CO5	Knowledge of sensors, actuators.	L4

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Mechanical Behaviour of Metals			
Course Code	22MST22	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03-02-00	SEE Marks	50
Total Hours of Pedagogy	40Hrs+10-12Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:
The main objectives are to provide students with basic understanding of phase transformation by heat treating and stress-induced hardening, linear and nonlinear elastic behavior, deformation under multiaxial loading, plastic deformation and yield criteria, dislocation plasticity and strengthening mechanisms, creep, stress concentration effects, brittle versus ductile fracture, fracture mechanisms at different scales, fatigue, contact deformation, and wear.

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. 5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2

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.

5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3

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. 5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4

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. 5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5

Introduction to creep: - creep mechanisms, creep curve, variables affecting creep, accelerated creep testing, development of creep resistant alloys, Larsen Miller parameter – Manson Hafred parameter. 5 hrs	
Teaching-Learning Process	Chalk and Talk/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. 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):

- https://youtu.be/dxAsr14DW6Y?list=PLbMVogVj5nJTKwm1WjlutrAEZrLE995Ja
- https://youtu.be/akZjDHD6JC4

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 develop skill sets to analyse behaviour of materials	L1
CO2	Analyse its characteristics to find its adoptability for an industrial application.	L3
CO3	Identify various stages of failure	L2
CO4	Thorough knowledge of wear	L2
C05	Understand the stages of failure	L1

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Professional Elective I

Optimization Technique			
Course Code	22MST/MDE/MEA/MMD231	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

-

Module-1	
Introduction: Engineering application of optimization, multivariable optimization Statement of a optimization problem. Design Vector, Design constraints, objective function, classification of optimization problems. Classical Optimization Technique: Single variable optimization, with equality Constraints solution by direct substitution, solution by the method of constrained Variation. Solution by the method of Lagrange multipliers	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2	
Non-linear Programming: (One Dimensional minimization method) Numerical method, Unimodal function, Unrestricted search, Exhaustive search. Dichotomous search, Fibonacci and Golden section method.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3	
Interpolation Method: Quadratic and Cubic Nonlinear programming (Unrestricted Optimization Technique) Random search methods, Univariate method, powels method, Simplex method.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4	
Descent Methods: Steepest descent, conjugate gradient, variable metricmethod. Non Linear Programming: (Constrained Optimization problem) Characteristic of a constrained problem.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5	
Direct Methods: The complex method, cutting plane method, methods of Feasible directions. Indirect Methods: Transformation technique, change variables and elimination of variables, penalty function methods- interior and exterior penalty function.	
Teaching-Learning Process	Chalk and Talk/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. Artificial Intelligence: Saroj Kaushik, Cengage Learning, 2014 Edition.
2. Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE)", McGraw Hill- 2008.)
3. Dan W. Patterson, "Introduction to AI and ES", Pearson Education, 2007
4. Peter Jackson, "Introduction to Expert Systems", 3rd Edition, Pearson Education, 2007.
5. Stuart Russel and Peter Norvig "AI – A Modern Approach", 2nd Edition, Pearson Education 2007

Web links and Video Lectures (e-Resources):

- https://youtu.be/MtqugJcsHZs?list=PLbRMhDVUMngdzwQyMgoUgdaGBqi_p4nVM
- https://youtu.be/KMcsjCXfLQw?list=PLyAZSyX8Qy5Am_2StOOQ5vCUE3VIcAenE

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 and apply the various processing and manufacturing techniques	L1
CO2	Understand and apply the techniques and their characteristics/limitations of synthesis of polymers	L1
CO3	Understand the structure-processing-property relationship of metals and polymers.	L2
CO4	Understand the basic issues involved in polymer blends, metal matrix composites and ceramic matrix composites	L3
CO5	Understand the significance of alloying element and phase diagrams.	L2

Mapping of COS and POs

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

1:Slight (low) 2:Moderate (medium) 3: Substantial (High) "-": no correlation

thermodynamics and Phase diagrams			
Course Code	22MST232	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02-00-02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-12Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- This course aims to provide a good platform to mechanical engineering students to understand, model and appreciate concept of dynamics involved in thermal energy transformation.
- To prepare them to carry out experimental investigation and analysis at later stages of graduation.

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. 5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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) numeral examples 5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. 5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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 5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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.
5hrs

Teaching-Learning Process	Chalk and Talk/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. 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, WillianF smith 5THEdn

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

Sl. No.	Description	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

	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

1:Slight (low) 2:Moderate (medium) 3: Substantial (High) "-": no correlation

Smart Materials and Structures			
Course Code	22MST/MTR233	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:02	SEE Marks	50
Total Hours of Pedagogy	40Hrs+10-12Activities	Total Marks	100
Credits	04	Exam Hours	03

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. 8hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. 8hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. 8hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4

MEMS – Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration. 8hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. 8hrs

Teaching-Learning Process	Chalk and Talk/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:

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

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):

- https://youtu.be/_n28vUPJzxM
- https://youtu.be/HQEkn-mJnas

Skill Development Activities Suggested

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

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	L1
CO2	Design simple models for smart structures & materials	L2
CO3	Perform simulations of smart structures & materials application	L2
CO4	Conduct experiments to verify the predictions	L2
CO5	Knowledge of sensors, actuators.	L1

Mapping of COS and Pos

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Bio Materials & Technology			
Course Code	22MST234	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02-00-02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-12Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Understand common use biomaterials as metals, ceramics and polymers and its chemical structure, properties and morphology.
- Describe general structure and function of cells, extracellular matrix and tissue.
- Understand and account for methods for categorisation of biomaterials.
- Explain methods to modify surfaces of biomaterials and choose material for desired biological response.
- Describe interactions between biomaterials, proteins and cells.
- Understand the interaction between biomaterial and tissue for short term and long term implantations, distinguish between reactions in blood and in tissue.
- Apply and account for methods to characterise interactions between materials and tissue.
- Explain methods to repair and regenerate injured or lost functional tissue with materials, autologious cells or stem cells.

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. 5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2

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.

Ceramic Implant Materials: Definitions of Bio ceramics, common type of Bio ceramics, Aluminium oxides, Glass ceramics, Carbons. Bioresorbable and Bioactive ceramics. 5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3

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.
5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4

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.

5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5

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

5hrs

Teaching-Learning Process	Chalk and Talk/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. 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):

- https://youtu.be/bbm79-UcNN0?list=PLbMVogVj5nJTNkhtkCEKQHhPOr2bpS3za
- https://youtu.be/8OVD2BHA5Hg?list=PLLy_2iUCG87CVglDEadTd_PRjA-g1KqVo

Skill Development Activities Suggested

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

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 able to know various biomaterials	L1
CO2	Knowledge of its testing methods	L2
CO3	Will be able to understand the significance of its use in various industrial applications.	L2
CO4	Apply sterilization techniques in industry.	L3
CO5	Develop models to demonstrate his knowledge.	L3

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Mechanical Behaviour of Thin Films			
Course Code	22MST235	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02-00-02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-12Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- The aim of thin film technology is the fabrication of thin layers that influence the physical properties and surfaces of selected materials, specifically adapted to the desired applications.

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. 5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. 5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. 5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4

Characterization of thin films: Different methods of thickness measurements, electrical, optical, chemical and structural property determination 5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5

Some important applications of thin films: Hard and decorative coatings, semiconductor thin films, organic thin films. 5hrs

Teaching-Learning Process	Chalk and Talk/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.Crystals and Crystal structures, R.J.D. Tilley, John Wiley and Sons, 2006

2. Materials Science and Engineering – W.D. Callister, Jr.Wiley India(P) Ltd., 2007

3. Materials Science and Engineering, G.S. Upadhyaya and Anish Upadhyaya, Viva books, 2010

4. Fundamentals of Materials Science-the microstructure-property relationship using metals as model systems, E.J. Mittemeijer, Springer, 2010

5. Microstructural Characterization of Materials – D. Brandon and W.D. Kaplan, John Wiley and Sons, 2008

6. Science of Microscopy, P.W. Hawkes and J.C.H. Spence, Springer, 2007

7. Scanning Electron Microscopy & X-Ray Microanalysis, J.Goldstein et.al, Springer, 2003

Web links and Video Lectures (e-Resources):

- https://youtu.be/a6_fgnuuYfE?list=PLyqSpQzTE6M_XM9cvjLLO_Azt1FkgPhpH
- https://youtu.be/rYWJdZ5qg6M?list=PLbRMhDVUMngcdUbBySzyzcPiFTYWr4rV_

Skill Development Activities Suggested

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

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.	L1
CO2	Understanding of vacuum technology	L1
CO3	Knowledge of deposition techniques.	L3
CO4	Understanding of characterization techniques of thin film deposition.	L3
CO5	Apply knowledge to practical applications.	L4

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Electronic, Optical and Magnetic Properties of Materials			
Course Code	22MST241	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-15Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- The primary aim of this course is to introduce students to the fundamentals underpinning electronic properties of materials. This spans everything from the basics of electron behavior in solids to the design of magnet and optoelectronic devices.

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. 5hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-2	
Quantum Mechanics: Schrodinger‟s Equation, 1-Dimensional Problems, Measurements-The Ehrenfest Theorem, Three Dimensions-Hydrogen Atom. 5hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-3	
Electronic Band Structures: Periodic Potential, Central Equation, Understanding Band Diagrams, Engineering conductivity in Semiconductors. 5hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-4	
Solid-State Devices: PN Junctions, Solar Cells, LEDs. Optical Properties: Wave Equation, E/M Waves at Interfaces, Photonic Crystals. 5hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
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. 5hrs	
Teaching-Learning Process	Chalk and Talk/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. 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):

- https://youtu.be/p7kYStiASLo?list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR
- https://youtu.be/hv-aBonZMRQ?list=PLWbMIWDTOauBvP0ZxvoIshg55WPMF37UI

Skill Development Activities Suggested

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

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	L1
CO2	Knowledge of materials	L2
CO3	Ability to identify materials for practical purpose.	L3
CO4	Identify the potential of the materials.	L3
CO5	Real time application.	L3

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Nano Science and Nano Materials			
Course Code	22MST242	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-12Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To develop a foundational knowledge of the extreme diversity in animal form, function, adaptation and natural history.
- Understand the importance of the plant classification and have a basic information of the different plant taxa with example
- To impart the knowledge on the essential of chemistry related to environment and resources.
- To help the students understand the essential components of the earth system.

Module-1

Introduction To Nanoscience And Nanotechnology: History, background scope and interdisciplinary nature of nanoscience and nanotechnology, scientific revolutions, nano sized effects surface to volume ratio, atomic structure, molecules and phases, energy at the nanoscale molecular and atomic size, quantum effects, types of nanotechnology and nanomachines. 5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2

Classification Of Nanostructures: Zero dimensional, one-dimensional and two dimensional nanostructure materials-clusters of metals, semiconductors, ceramics and nano composites, size dependent phenomena, quantum dots nano wires, tubes, nano sheets, nano and mespores, top down and bottom ups approach, misnomers and misconception of nano technology, importance of nanoscale materials and their devices.
5 Hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3

Properties Of Nanomaterials: Mechanical properties-Thermo physical properties -Electrical properties Electric properties – Electro chemical properties Magnetic properties -optical properties-Catalytic property – properties of gas permeation and separation membranes.5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4

Nanostructure Design: Functionality of nanostructures and their characteristics evaluation, size effect in semiconductor nanoparticles– particle size, shape density – Melting point, surface tension, wettability – specific surface area and pore – Assembly of nanoparticles and fictionalization – nanoparticles arranged structures as nanopores and nanocomposites –Structure control of nanoparticle collectives by sintering and bounding – Self – assembly.Nanoparticle dispersion and aggression behaviour – Single nanoparticle motion in fluid –Brownian diffusion – Adsorption properties – interactions between particles – Aggregation and dispersion, characterization and control – Rheology of slurry – Simulation of colloidal dispersion system. 5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5

Melting Point And Phase Transition Processes: quantum-size-effect (QSE) Size-induced metal-insulator-transition (SIMIT) nano-scale magnets, transparent magnetic materials and ultrahigh-density magnetic recording materials – chemical physical of atomic and molecular clusters. Surface energy – chemical potential as a function of surface curvature – Electrostatic stabilization – surface charge density-electric potential at the proximity of solid surface-Vander Waals attraction potential. Photochemistry, Photoconductivity, Electrochemistry of nanomaterials . 5hrs

Teaching-Learning Process	Chalk and Talk/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. Nanophysics and Nanotechnology – An Introduction to ModernConcepts in Nanoscience, Edward L. Wolf Second Edition, John Wile y & Sons, 2006.
2. Nano: The essentials, Pradeep, T, McGraw Hill.
3. Introduction to Nano Technology, Poole, C.P and Owens, J.F, Wiley
4. Surface Science Foundation of Catalysis and Nanoscience ", K.W. Kolasinski –Wiley, 2002
5.Nano particles: From theory to applications, Schmid, G., Wiley VCH VerlagGmBH and Co
6.Nanoparticulate as Drug Carriers, Valdimir P, Torchilin (2006) imperial college press.
7.Nanomaterials and Nano systems for Bio-Medical Applications, M Reza Mozafari (2007) springer
8. Nanotechnology – Basic science and emerging technologies Chapman and Hall/CRC (2002).

Web links and Video Lectures (e-Resources):

- https://youtu.be/oxMdDsud5vg?list=PLE8F9BF5CB1201D23
- https://youtu.be/1AT1yuQ9awM?list=PLFW6lRTa1g83sIfVY1p1xGqPGYUmXyahx

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Leve
CO1	Demonstrate the working knowledge of nanotechnology principles and industry applications. (PO-2)	L1
CO2	Design the nanoscale paradigm in terms of properties at the nanoscale dimension. (PO-2)	L3
CO3	Apply key concepts in materials science, chemistry, physics, biology and engineering to the field of nanotechnology. (PO-2)	L2
CO4	Identify current nanotechnology solutions in design, engineering and manufacturing. (PO-3)	L3
CO5	Understand and interpret the melting point and phase transition of nano materials. (PO-1,4)	L3

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Advanced Foundry Technology			
Course Code	22MST243	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-12Activities	Total Marks	100
Credits	04	Exam Hours	03

Course Learning objectives:

- Discuss the materials to prepare patterns and molds
- Explain various core making processes and special casting processes
- Describe various melting furnaces and fettling operations.
- Analyze gating systems and discuss mechanization procedures in foundries
- Discuss various foundry practices

Module-1

Solidification of Casting: Concept of solidification of metals. 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. 5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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 casting and modification in casting geometry to overcome them. Casting defects and factors responsible for them. Different inspection and testing methods to evaluate the casting. 5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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 and Steel. 5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. 5hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. 5hrs

Teaching-Learning Process	Chalk and Talk/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

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Suggested Learning Resources:

Books

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

1. Foundry Technology - Beelely, P.R. – Butterworth & Co.
2. Fundamentals of Foundry Technology, Webster, P.D.,
3. Fundamentals of Metal casting Technology, Mukherjee, P.C
4. A Test Book of Foundry Technology - Lal, M. Khanna, P.O – Dhanpat Rai & Sons Publication. 2011
5. Advanced Foundry Technology – Pranav Pandey Pdf - 2017

Web links and Video Lectures (e-Resources):

- https://youtu.be/o6W0opScrKY?list=PLuv3GM6-gsE01L9yDO0e5UhQapkCPGnY3
- https://youtu.be/liRPtvj7bFU?list=PL0E131A78ABFBFDD0

Skill Development Activities Suggested

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

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.	L1
CO2	Acquire the skill and knowledge of terms, facts, concepts, processes, techniques and principles of foundry industries	L2
CO3	Apply the skill and knowledge of contents of principles of furnace technology.	L2
CO4	Inquire of new skill and knowledge of foundry practises and developments therein.	L3
CO5	Expose and to develop interest in the fields of design of casting	L3

Expose and to develop interest in the fields of design of casting

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Surface Treatment and Finishing			
Course Code	22MST244	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

Module-1	
Fundamentals of Electro plating, galvanizing, Hot dip metal coating, thin coating, thin coating, chromium plating, Nickel plating. Vacuum coating, FVD & CVD metal spraying - Methods, surface preparation, mechanical.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-2	
Properties of sprayed metals, Various types and plasma coating. Plastic coating of metal - PVC coating Spherodising process details, phosphate coating - mechanism of formation.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-3	
Testing of surface coating- Various methods used. Heat treatment methods, Annealing, Normalizing, Tempering, Case hardening methods, flame hardening sub-zero treatment.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-4	
Heat treatment methods for gears, spindles, cutting tools.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-5	
Advanced coating technologies: Hard facing, electro deposition technique, nanocoating's, coating characterization.	
Teaching-Learning Process	Chalk and Talk/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. Surface preparations & finishes for Metals - James A Murphy - McGraw Hill.
2. Hand book, Friction, Lubrication and Wear Technology, Vol. 18, ASM .
3. Surface treatments for protection, Series3, No. 10, , The institute of metallurgist series.
4. Principles of metal surface treatment and protection - Pergamon Press Gabe, David Russell - Description, Oxford; New York - 2d ed., 1978.
5. Handbook of metal treatment and testing - John wiley& sons.
6. Heat Treatment of Metals – Zakrov - MlR Publications. 4. Metals Hand Book – ASM.

Web links and Video Lectures (e-Resources):

- https://youtu.be/De8MQWbhu3k
- https://youtu.be/-2Cd38P6YO0

Skill Development Activities Suggested

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

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 able gain knowledge in surface treatment, electroplating, and surface coating and heat treatment techniques.	L1
CO2	Understand the properties of coatings	L2
CO3	Apply knowledge of testing in surface coating	L2
CO4	Gain knowledge of various heat treatment methods used in industry	L4
CO5	Apply knowledge of advanced technologies in coating industry.	L3

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Modelling, Simulation & Analysis of Manufacturing System			
Course Code	22MST245	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-15Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- The students should develop and/or improve capabilities to develop or utilize models and employ simulators to analyze well construction and production systems.
- The students should understand the physical principles and the mathematical approach used in modeling and simulation of well construction and production systems. They should developed generic understanding of categories of models and simulators and, more specifically, models and simulators used in the analysis of well construction and hydrocarbon production systems.
- The students will develop skills to utilize commercial production simulators, acquire and prepare the input data, and organize the output data.
- The students will develop advanced skills in modeling relevant physical phenomena that occurs in wells and production systems. The students will develop advanced skills in the mathematical and numerical procedures employed in well and production simulators.
- The students will develop skills to create reduced parameters simulators or "proxy models" to be employed in production optimization and in design-optimization.

Module-1	
Principles of Modelling & Simulation: Basic Simulation Modeling, Limitation of Simulation, Monte – Carlo Simulation, Areas of Applications, Discrete and Continuous Systems. 5hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-2	
Modeling Approaches: Modeling Complex Systems, Simulation Software, Basics Probability and Statistics, Building Valid and Credible Simulation Models. 5hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
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. 5hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-4	
Statistical Techniques: Comparison of Alternative Systems, Variance Reduction Techniques. 5hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-5	
Simulation Studies: Discrete Event Simulation, Simulation of Inventory Problems, Experimental Design and Optimization, Simulation of Manufacturing Systems, Case Studies. 5hrs	
Teaching-Learning Process	Chalk and Talk/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. 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):

- https://youtu.be/MS3qJq2jvu0
- https://youtu.be/MS3qJq2jvu0

Skill Development Activities Suggested

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

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.	L1
CO2	Undergo various case studies using real time simulation.	L2
CO3	Understand variables involved and analyse output.	L2
CO4	Awareness of statistical techniques	L2
CO5	Knowledge of simulation in real time applications	L3

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

MINI PROJECT WITH SEMINAR			
Course Code	**22MPT25**	CIE Marks	100
Number of contact Hours/Week	**0-4-2**	SEE Marks	--
Credits	**03**	Exam Hours/Batch	--

Course objectives:

- To support independent learning and innovative attitude.
- To guide to select and utilize adequate information from varied resources upholding ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Mini-Project with seminar: This may be hands-on practice**,** survey report, data collection and analysis, coding, mobile app development, field visit and report preparation, modelling of system, simulation, analysing and authenticating, case studies, etc.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Students can present the seminar based on the completed mini-project. Participation in the seminar by all postgraduate students of the program shall be mandatory.

The CIE marks awarded for Mini-Project work and Seminar, shall be based on the evaluation of Mini Project work and Report, Presentation skill and performance in Question-and-Answer session in the ratio 50:25:25. Mini-Project with Seminar shall be considered as a head of passing and shall be considered for vertical progression as well as for the award of degree. Those, who do not take-up/complete the Mini Project and Seminar shall be declared as fail in that course and have to complete the same during the subsequent semester.

There is **no SEE** for this course.

Course outcomes:

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

- Present the mini-project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills.
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.

Material Characterization Lab 2			
Course Code	**22MST26**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	01-02-00	SEE Marks	50
Credits	02	Exam Hours	100

Course objectives:

- To learn basic principles of finite elements analysis procedure
- To learn the theory and characteristics of finite elements that represent engineering structures.
- To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite elements analyses.

Sl.NO	Experiments
1	Study and analyze Powder characterization using XRD, SEM and BET, gas pycnometer
2	Study and analyze Thermal properties of materials, identification of materials based on their TG, DSC, DMA characteristic responses
3	Laboratory testing practice related to tests based on the mechanical properties of materials, e.g., hardness, elastic modulus, tensile strength etc.
4	hands-on experience on the applications of metallography and optical microscopy, phase analysis using microscopic information,
5	hands-on experience in the area of microstructures of metal, ceramic and polymer materials using optical microscopy and SEM.
6	Phase identification using X-ray Diffraction
7	Study the effect of quenching media on microstructure and hardness of high-speed steels.
8	Establish relationship between hardness and microstructure of forged/rolled/extruded popular aerospace / light alloys.
9	Observation of specimens in TEM.
10	

Course outcomes (Course Skill Set):

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

- Materials Characterization has gained enormous importance in diverse fields in which the chemical, microstructure and physical properties of different materials are probed, measured and determined using a variety of analytical methods, techniques and tools. The course aims to provide the student with an overview of the current techniques used for the physicochemical characterisation of materials with special reference to the principles, practice and applications of X-ray diffraction, spectroscopic, microscopic, thermal and electro-analytical techniques..

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 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 downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each 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 average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests 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:

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VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI.

Scheme of Teaching and Examinations and Syllabus
M.Tech., Material Science and Technology (MST)
(Effective from the Academic year 2022-23)

Registrar,
Visvesvaraya Technological University
JnanaSangam, Machhe, Belagavi-590018
eMail: registrar@vtu.ac.in
contact: 0831-2498112

Programme Outcome:

PO1 - An ability to independently carry out research/investigation and development work to solve practical problems.

PO2 -An abilityto write and present a substantial technical report/document.

PO3 - Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4 -Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M.Tech., Material Science and Technology(MST) (Font 09 Capital, Calibri)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Mini–Project/ Internship	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	SDA					
	PCC	22MST31	Composite science and technology	03	00	02	3	50	50	100	
	PEC	22MST32X	Professional elective 3	03	00	00	3	50	50	100	
	OEC	22MST33X	**Professional Elective 4**	03	00	00	3	50	50	100	
	PROJ	22MST34	Project Work phase -1	00	06	00	-	100	- -	100	
	SP	22MST35	Societal Project	00	06	00	-	100	- -	100	
	INT	22MSTI36	Internship	(06 weeks Internship Completed during the intervening vacation of II and III semesters.)			3	50	50	100	
TOTAL				**09**	**12**	**03**	**2**	**400**	**200**	**600**	**2**

Note: PCC: Professional core courses, PEC: Professional Elective Courses, IPCC-Integrated Professional Core Courses. MPS-Mini Project With Seminar; AUD/AEC; Audit Courses / Ability Enhancement Courses (Mandatory), PCCL-Professional Core Course lab, **L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities**(Hours are for Interaction between faculty and students)

Professional elective 3		**Professional Elective 4**	
Course Code under 22MST31X	**Course title**	**Course Code under 22MST32X**	**Course title**
22MST/MMD/MPD/MDE/MEA321	Sustainability Engineering	22MST/MSE/MAU/MPE/MPD/MTE/MPT/MPY331	Non Destructive Testing
22MST322	Corrosion Science And Technology	22MST/MAU/MPD/MPE/MTE/MPE332	Hydraulics & Pneumatics
22MST/MPD/MDE/MEA/MMD/MPT/323	Design of experiments	22MST333	Renewable Energy for power plants
22MST324	Surface coating Technologies	22MST/MPT/MIA/MAR/MPM334	Total Quality Management
22MST325	Artificial Intelligence	22MST335	Materials for Cryogenic & High Temperature applications

Note:
1. Project Work Phase-1: The project work shall be carried out individually. However, in case a disciplinary or interdisciplinary project requires more participants, then a group consisting of not more than three shall be permitted.

Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall pursue a literature survey and complete the preliminary requirements of the selected Project work. Each student shall prepare a relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

2. Societal Project: Students in consultation with the internal guide as well as with external guide (much preferable) shall involve in applying technology toworkout/proposing viable solutions for societal problems.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

Those, who have not pursued /completed the Societal Project, shall be declared as fail in the course and have to complete the same during subsequent semester/s after satisfying the Societal Project requirements. There is no SEE (University examination) for this course.

3. Internship: Those, who have not pursued /completed the internship, shall be declared as fail in the internship course and have to complete the same during subsequent University examinations after satisfying the internship requirements. Internship SEE (University examination) shall be as per the University norms.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M.Tech., Material Science and Technology (MST) (Font 09Capital, Calibri)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
				L	P					
1	Project	22MST41	Project work phase -2	--	08	03	100	100	200	18
			TOTAL	--	**08**	**03**	**100**	**100**	**200**	**18**

Note:

1. Project Work Phase-2:

Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall continue to work of Project Work phase -1to complete the Project work. Each student / batch of students shall prepare project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

Total Credits 22+18+22+18 =**80**

Program Outcome of the Course

POs	Description
PO1:	Acquire, demonstrate, and apply basic knowledge in the field of Materials.
PO2:	Identify problems in the field of Technology in manufacturing by advanced materials, formulate them and solve by using advanced techniques.
PO3:	Independently carry out research/investigation and developmental work to solve practical problems in Materials Science Technology.
PO4:	Write and present a substantial technical report/document.
PO5:	Demonstrate a degree of mastery over Materials Science Technology.
PO6:	Employ Advanced Material for diffrent tool to cater into Material needs in both discrete and process plants.
PO7:	Provide solutions to varied engineering problems through the interpretation of data using modern computational tools.

Semester- III

Semester-III

Composite Science and Technology			
Course Code	22MST31	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02-00-02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-12Activities	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 composite material.
- 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. 5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. 5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. 5 hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. **5 hrs**

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

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. 5 hrs

Teaching-Learning Process	Chalk and Talk/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. 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):

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

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Le
CO1	Describe and explain model and analyze typical queuing scenarios	L1
CO2	Develop and apply appropriate random number, random variable generation techniques &appropriate simulation statistical output techniques	L3
CO3	Analyze appropriate input distributions and to explain simulation time advance mechanisms	L2
CO4	Use the Arena simulation language to model and analyze problems found in industrial engineering practice and to design and analyze a simulation experiment.	L2
CO5	Comparisons of systems and optimization techniques.	L3

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Sustainability Engineering			
Course Code	22MST/MMD/MPD/MDE/MEA321	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-12Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To have an increased awareness among students on issues in areas of sustainability
- To understand the role of engineering and technology with sustainable development.
- To know the methods, tools and incentives for sustainable products service system development
- To establish clear understanding of the role and impact t of various aspects of engineering decisions on environmental, societal and economic problems

Module-1	
Sustainability: Introduction, concept, evolution of the concept; Social, environmental and economic sustainability concepts; Sustainable development, Nexus between Technology and Sustainable development; 05Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2	
Environmental Pollution: Air Pollution and its effects, Water pollution and its sources, Zero waste concept and 3 R concepts in solid waste management; Greenhouse effect, Global warming, Climate change, Ozone layer depletion, legal provisions for environmental protection. 05Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3	
Environmental management standards: ISO 14001:2015 frame work and benefits, Scope and goal of Life Cycle Analysis (LCA), 05Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4	
Resources and its utilisation: Basic concepts of Conventional and non-conventional energy, General idea about solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, 05 Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5	
Sustainability practices: Basic concept of sustainable habitat, Methods for increasing energy efficiency in buildings, Green Engineering, Sustainable Urbanisation, Sustainable cities, Sustainable transport 05 Hrs	
Teaching-Learning Process	Chalk and Talk/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**
3. 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. Allen, D .T. and Shonnard, D .R., Sustainability Engineering: Concepts, Design and case studies, Prentice Hall
2. Bradley, A.S; Adebayo, A.O; Maria, P, Engineering applications in sustainable design and development, Cengage learning.
3. Environmental Impact assessment guidelines, Notification of Govt of India, 2006.
4. Mackenthun, K M; Basic concepts in Environmental management, Lewis publication, London 1998
5. Ni bin Chang, Systems analysis for sustainable engg Theory and applications, Mcgraw Hill professional.

Web links and Video Lectures (e-Resources):

- .VTU e-Shikshana Program
- VTU EDUSAT Program

Skill Development Activities Suggested

- Case study
- Quizzes
- Assignments
- Seminars

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Define data science and its fundamentals	L2
CO2	Demonstrate the processing data science	L3
CO3	Explain machine learning algorithms necessary for data sciences	L2
CO4	Illustrate the process of feature selection and analysis of data analysis algorithms	L2

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Corrosion Science and Technology			
Course Code	22MIA322	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

-

Module-1	
Definition of corrosion, corrosion damage, classification of corrosion, electrochemical aspects, electrochemical reactions, mixed potential theory, Electrode potential, Nernst equation. oxy-reduction potentials. 8Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-2	
Corrosion thermodynamics – Pourbaix diagrams; Polarization of the corrosion cell; Activation controlled kinetics and concentration polarization, Evans diagrams, partial corrosion reactions- anodic dissolution of metals; Cathodic reactions – oxygen reduction and hydrogen evolution.8Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-3	
Corrosion of materials in natural environments; Atmospheric corrosion, general characteristics, mechanism and prevention; soil corrosion – general characteristics, mechanism and prevention. Localized corrosion damages and materials failure- passivity and transpassivity of metals, breakdown of passivity and pitting corrosion. Stress – corrosion cracking of materials. Inter-granular corrosion failure. Corrosion failure of ceramic materials; mechanisms of corrosion of ceramics, effect of chemical, phase composition and structure on corrosion resistance. Corrosion degradation of concrete.8Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-4	
.Tafel and linear polarisation, AC impedance, small-amplitude cyclic voltammetry. Paint tests, sea water tests. Interpretation of results, Corrosion prevention; materials selection, alteration of environment, design, cathodic and anodic protection coating. 8Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-5	
Environmental effects from the chemical processes industry (like Pulp mill operations, bleach plants, boilers, paper machine, water treatment plants in the pulp and paper industry and others), infrastructure, and transportation industry. Safety aspects. .8Hrs	
Teaching-Learning Process	Chalk and Talk/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

Mars G. Fontana, Corrosion Engineering, McGraw-Hill Book Company, 1986.

2. David Talbot and James Talbot, Corrosion Science and Technology, CRC Press, New York, 1998.

3. Denny A. Jones, Principles and Prevention of Corrosion, Maxwell Matemillar 1992.

4. D. A. Jones: Principles and Prevention of Corrosion, Macmillan Publ. Co. (1996).

5. C. Scully: The Fundamental of Corrosion, 2nd ed., Pergamon Press: E. Stansbury and R. A. Buchanan, Fundamentals of Electrochemical Corrosion, ASM International (2000).

6. M.G. Fontana: Corrosion Engineering, 3rd. Ed., McGraw Hill. (1986)

7. J. M. West: Electrodeposition and Corrosion Control, J. Wiley W. Revie (ed.):

8. Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons (2000).

9. W. Revie (ed.): Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons, 2000: Metals Handbook, Vol. 13: Corrosion, ASM International

Web links and Video Lectures (e-Resources):

- https://youtu.be/9V_y41MF-co?list=PLSGws_74K018uDGyEGytB6-q31SpmAKug
- https://youtu.be/2YTyyFzJvEw?list=PLsROtkZ0LLB-SeADjhsjYb8wSkINKNQmD

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	Good knowledge of Corrosion Science.	L2
CO2	Assessment of its impact on its environment.	L1
CO3	Suggest the right technique	L3
CO4	Understand the safety aspects	L1
CO5	Prevent Environment degradation.	L2

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

Design of Experiments			
Course Code	22MST/MPD/MDE/MEA/MMD/MPT/323	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

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Module-1
Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments. Concepts of random variable, probability, density function cumulative distribution function. Sample and population, Measure of Central tendency; Mean median and mode, Measures of Variability, Concept of confidence level. Statistical Distributions: Normal, Log Normal &Weibull distributions. Hypothesis testing, Probability plots, choice of sample size. Illustration through Numerical examples. .

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2
Classical Experiments: Factorial Experiments: Terminology: factors, levels, interactions, treatment combination, randomization, Two-level experimental designs for two factors and three factors. Three-level experimental designs for two factors and three factors, Factor effects, Factor interactions, Fractional factorial design, Saturated Designs, Central composite designs. Illustration through Numerical examples.

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3
Measures of variability, Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE‟s algorithm for ANOVA, Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples. Quality, Western and Taguchi's quality philosophy, elements of cost, Noise factors causes of variation. Quadratic loss function & variations of quadratic loss function. Robust Design: Steps in Robust Design: Parameter design and Tolerance Design. Reliability Improvement through experiments, Illustration through Numerical examples.

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4
Types of Orthogonal Arrays, selection of standard orthogonal arrays, Linear graphs and Interaction assignment, Dummy level Technique, Compound factor method, Modification of linear graphs. Illustration through Numerical examples

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5
Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-better type, Nominal-the –better-type, Larger the-better type. Signal to Noise ratios for Dynamic problems. Illustration through Numerical examples. Parameter and tolerance design concepts, Taguchi‟s inner and outer arrays, parameter design strategy, tolerance design strategy. Illustration through Numerical examples.

Teaching-Learning Process	Chalk and Talk/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. 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):

- https://youtu.be/06QxjEAMrKc?list=PLwFw6Nkm8oWqFJUxiUuu5c0uHK076lz2K
- https://youtu.be/Sfj8_9oRCNk

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	To demonstrate the need for development of newer processes	L1
CO2	Able to identify different energy sources like fluid motion, electric current, high speed electrons, high energy radiation, etc	L2
CO3	To analyze the concept, mechanism, parameters associated with the processes.	L4
CO4	To demonstrate the operational principles, advantages applications, limitations of the various non-traditional machining processes.	L1

Mapping of COS and POs

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

1:Slight (low) 2:Moderate (medium) 3: Substantial (High) "-": no correlation

Surface Coating Technologies			
Course Code	22MIA324	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

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Module-1	
Introduction to coatings for different temperature applications, Properties of surfaces-wear, corrosion, optical, roughness, electrical and thermal properties, wetability	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2	
Concepts of coating, Thin film coating, Physical Vapour Deposition: Thermal Evaporation, E-Beam Deposition, Sputtering. Chemical Vapour Deposition: Thermal Assisted CVD, Plasma Enhanced CVD, Photo Assisted CVD, Metal Organic CVD, Sol-gel deposition,	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3	
Thick Coating: Thermal spray, Types of thermals spary and their advantages and disadvantages. Flame Spray, HVOF, Plasma spray- conventional vs. nanostructured coatings, Process parameters, thermal and kinetic history of inflight particle, microstructural features of plasma sprayed coatings, single splat studies, process-structure property relationship-challenges in prepartion, plasma spraying of nanopowders - its microsturcutre – properties –Liquid precurser plasma spray- Thermal barrier coatings and materials including yittria stabilized zirconia	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4	
. Characterization of film and thick coatings, Coatings –thickness-porosity-hardness, fracture toughness, elastic modulus – adhesion-bending strength-fracture strength- tensile strength, coating tribology, corrosion measurement, phase analysis and microstructure, Surface characterization techniques.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5	
Applications of coatings: wear resistance, corrosion, thermal barrier, Anti scratch, Biomedical, near net shape, embedded sensors, Energy applications like Solid oxide fuel cell, Dye sensitized solar cell	
Teaching-Learning Process	Chalk and Talk/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

Introduction to Surface Engineering and Functionally Engineered Materials, Peter Martin; Wiley, 2011.

2. Materials and Surface Engineering: Research and Development, J. Paulo Davim; Woodhead Publishing Ltd.,2012.

3. The Science and Engineering of Thermal Spray Coatings, Lech Pawlowski; Wiley, 2008.

4. The Cold Spray Materials Deposition Process: Fundamentals and Applications, Victor K. Champagne; Woodhead Publishing Ltd, Maney publishing Ltd., 2007

5.Quo Vadis Thermal Spraying? P. Fauchais, A. Vardelle, B. Dussoubs; Journal of Thermal Spray Technology, Vol. 10, 2001.

6. Thermal Spray Coatings, Kurt H Sien (ed); Chapman and Hall, 1996

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/108106165
- https://www.me.iitb.ac.in/~gandhi/me645/05L1_coursecontents_mtvn.pdf
- https://youtu.be/j9y0gfN9WMg?list=PL5873EDBDFB69BAD8

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	Understand the operation of micro devices, micro systems and their applications (L2)	L1
CO2	Apply scaling laws that are used extensively in the conceptual design of micro devices and systems (L3)	L2
CO3	Choose a micromachining technique, such as bulk micromachining and surface micromachining for a specific MEMS fabrication process (L3)	L3
CO4	Simplify the design of micro devices, micro systems using the MEMS fabrication process (L4)	L2

Mapping of COS and POs

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

1:Slight (low) 2:Moderate (medium) 3: Substantial (High) "-": no correlation

Artificial Intelligence			
Course Code	22MST325	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

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Module-1	
Introduction to AI-Problem formulation, Problem Definition, Production systems, Control strategies, Search strategies. Problem solving: state space search and control strategies.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2	
Problem characteristics, Problem reduction and Game playing, Logic concepts and logic programming, Production system characteristics, Specialized production system, Problem solving methods	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3	
Problem graphs, Matching, Indexing and Heuristic functions, Hill Climbing, Depth first and Breath first, Constraints satisfaction, Measure of performance and analysis of search algorithms	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4	
. Game playing, Knowledge representation, Knowledge representation using Predicate logic, Introduction to predicate calculus, Resolution, Use of predicate calculus, Knowledge representation using other logic-Structured representation of knowledge.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5	
Basic plan generation systems, Strips - Advanced plan generation systems, K strips: Strategic explanations -Why, Why not and how explanations.	
Teaching-Learning Process	Chalk and Talk/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. **Artificial Intelligence: Saroj Kaushik, Cengage Learning, 2014 Edition.**
2. **Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE)", McGraw Hill- 2008.) Dan W. Patterson, "Introduction to AI and ES", Pearson Education, 2007**
3. **Peter Jackson, "Introduction to Expert Systems", 3rd Edition, Pearson Education, 2007.**
4. **Stuart Russel and Peter Norvig "AI – A Modern Approach", 2nd Edition, Pearson Education 2007**

Web links and Video Lectures (e-Resources):

- https://youtu.be/UgtjRob5qMg?list=PLyqSpQzTE6M9spod-UH7Q69wQ3uRm5thr
- https://youtu.be/V004WUdpHeA?list=PLlYm0-AHZdZRLYSylFinxkspWmcgNvbtl
- https://youtu.be/omauHunp3EM?list=PLxApjaSnQGi5EN-fTsIxTKaXLQaVPKdor

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	Analyse the properties of material at low temperature. Pressure, temperature, flow,fluid quality and liquid level measurement at low temperature.	L1
CO2	Have Knowledge of Cryogenic systems.	L2
CO3	Acquire knowledge of low temperature measurements.	L3

Mapping of COS and POs

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

1:Slight (low) 2:Moderate (medium) 3: Substantial (High) "-": no correlation

Non-Destructive Testing			
Course Code	22MST/MSE/MAU/MPE/MPD/MTE/ MPT/MPY331	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

-

Module-1	
Introduction to ND Testing: selection of ND methods, visual inspection, leak testing, Liquid penetration inspection, its advantages and limitation. Magnetic Particle Inspection: Methods of generating magnetic field, types of magnetic particles and suspension liquids steps in inspection – application and limitations.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2	
Eddy Current Inspection: principles, operation variables, procedure, inspection coils, and detectable discounts by the method. Microwave Inspection: Microwave, holography, applications and limitations. Ultrasonic Inspection: Basic equipment characteristics of ultrasonic waves, variables inspection, inspection methods pulse echo A, B, C scans transmission, resonance techniques, transducer elements couplets, search units, contact types and immersiontypes inspection standards-standard reference blocks.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3	
Radiography Inspection: principles, radiation source X-rays and gamma rays, X-ray tube, radio graphic films, neutron radiography, Thermal inspection principles, equipment inspection methods applications.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4	
. Optical Holography: Basics of Holography, recording and reconstruction – Acoustical Holography: systems and techniques applications. Indian standards for NDT.	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5	
Visual Inspection and Thermographic methods: Acoustic emission, Total acoustic emission, felicity ratio, Generation of Acoustic Emission**.**	
Teaching-Learning Process	Chalk and Talk/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. Non-Destructive Testing Techniques Hardcover – 1 Jan 2010 by Ravi Prakash .
2. The Testing Instruction of Engineering Materials - Davis H.E Troxel G.E wiskovil C.T- McGraw hill.
3. Non-Destructive Testing - Mc Gonnagle JJ – Garden and reach New York.
4. Non-Destructive Evolution and Quality Control - volume 17 of metals hand book 9 edition Asia internal 1989.

Web links and Video Lectures (e-Resources):

- https://youtu.be/v-3TmN4HhLc?list=PLwdnzlV3ogoW31clPN6Dn6c8Ia-n36vXk
- https://youtu.be/-NINgz6KQTA?list=PLOSWwFV98rfLAVnU2DJq8xO1LuFw6SXEa

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 and analyze the significance and suitability of various non-destructive testing for different industrial applications	L1
CO2	Analyze different metals and alloys by visual inspection method and Thermo graphic method.	L3
CO3	Perform non-destructive tests like: Liquid penetrant test, Magnetic particle test, Eddy current test and Ultrasonic test, X-ray and Gamma ray radiography	L1
CO4	Identify defects by using relevant NDT methods	L3
CO5	Apply the knowledge of optical holography and industrial applications according to Indian standards for NDT.	L3

Mapping of COS and POs

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

1:Slight (low) 2:Moderate (medium) 3: Substantial (High) "-": no correlation

Hydraulics and Pneumatics			
Course Code	22MST/MAU/MPD/MPE/MTE/MPE32	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Course Learning objectives:
- To Study the fundamentals of Hydraulic Power Pumps, Actuators and Motors.
- To develop a sound knowledge of control components in Hydraulic Systems.
- To have basic skills to design Hydraulic Circuits and analyze them.
- To acquire the fundamental knowledge on pneumatic control.
- To develop skill sets to handle Pneumatic Actuators , Valves, Pneumatic circuits and logic circuits

Module-1

Introduction to Hydraulic Power and Pumps: review of fluid mechanics, Pascal's Law, structure of hydraulic control system. pumps: pumping theory, pump classification, gear pumps- external and internal type, vane pumps- simple, balanced, pressure compensated types, piston pumps- radial and axial (both swash plate and bent axis type), pump performance.

Hydraulic Actuators and Motors: Linear hydraulic actuators - single acting, double acting, tandem cylinder, telescopic rod cylinder, mechanics of hydraulic cylinder loading, cylinder cushioning, hydraulic rotary actuators, hydrostatic transmission – open and close circuit, performance of hydraulic motor.

08Hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2

Control Components in Hydraulic Systems: directional control valves (DCV), constructional features, 2/2,3/2,4/2,4/3 DCV, center configuration in 4/3 DCVopen, closed, tandem, regenerative, floating centre configuration, actuation of DCVs- manual, mechanical, solenoid, and indirect actuation, relays for the solenoid operation, check valve, pilot check valve, pressure control valves – direct and pilot operated types, pressure reducing valve, flow control valvesfixed throttle, and variable throttle, throttle check valve, pressure compensated flow control valve- relief and reducing type. 08Hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3

Hydraulic Circuit Design and Analysis: control of single and double acting hydraulic cylinder, regenerative circuit, counter balance valve application, cylinder sequencing circuits, cylinder synchronizing circuits, speed control of hydraulic cylinder – meter in and meter out, speed control of hydraulic motors, relay circuit design for the operation of solenoid directional control valve- single and double solenoid relay circuit 08Hrs

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4

Introduction To Pneumatic Control: choice of working medium, characteristics of compressed air, structure of pneumatic control system , supply, signal generators, signal processor, final control elements , actuators, production of compressed air – compressors - reciprocating and rotary type, preparation of compressed air – driers, filters, regulators, lubricators, distribution of compressed air – piping layout. 08 Hrs

Teaching-	

Learning Process	Chalk and Talk/Power Point Presentation

Module-5

Pneumatic Actuators , Valves: linear cylinder – types, conventional type of cylinder – working, directional control valve, shuttle valve, quick exhaust value, twin pressure valve, direct and indirect actuation of pneumatic cylinder, memory valve, time delay valve. Pneumatic circuits and logic circuits: supply air and exhaust air throttling, will dependent circuits, travel dependent controls – types – construction – practical applications, cylinder sequencing circuits, travel step diagrams, practical examples involving two or three cylinders, use of logic functions – OR, AND, NOR, NAND,YES, NOT functions in pneumatic applications, practical examples involving the use of logic functions.

08Hrs

Teaching-Learning Process	Chalk and Talk/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. S.R.Majumdar-Pnematic System, TMH, 1995
2. Antony Esposito, Fluid Power Systems and Control, Prentice Hall,1998
3. R.Srinivasan, Hydraulic and Pneumatics control published by Vijay Nicole Imprints Private Ltd.
4. Andrew Parr, Hydraulic and Pneumatics, Butterworth-Heinemann
5. Herbert R Merritt, Hydraulic control systems, John Wiely& Sons, Newyork,1967.
6. Dudbey A Peace, Basic fluid power, Prentice hall Inc,1967.
7. Peter Rohner, Fluid power logic circuit design, Macmillan press Ltd, London,1979.
8. Peter Rohner, Fluid Power logic circuit design, Mcmelan prem,1994.
9. Servo Pneumatics D SchilzA Zimmermann

Web links and Video Lectures (e-Resources):

- VTU e-Shikshana Program
- VTU EDUSAT Program

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	An ability to independently carry out research /investigation and development work to solve practical problems.	L2
CO2	An ability to write and present a substantial technical report/document.	L4
CO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	L1
CO4	Understand contemporary issues in manufacturing engineering and develop relationship between product design and manufacturability to create safe, reliable, and cost-effective products.	L2
C05	Understand the process of converting customer needs into engineering specifications to create product designs that are sensitive to user needs and robust against unanticipated uses and misuse	L3

Mapping of COS and POs

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

1:Slight (low) 2:Moderate (medium) 3: Substantial (High) "-": no correlation

Renewable Energy for Power Plants			
Course Code	22MIA333	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	03

Course Learning objectives:

- To provide exposure to principles of nanotechnology; characterization of nanostructured materials; and its applications

Module-1	
Introduction to new energy technology: Hydrogen production - water splitting - electrolytic methods Chemical cycle - photo splitting - photo galvanic - photo chemical.- Application of Hydrogen – Fuel for Vehicle 08Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-2	
Tidal energy - operating mode - overfilling of the basins - Energy content. Ocean Thermal Energy Cycle (OTEC) - Baseline design - Heat design - Power cycle design - plant working. Energy - commercialization - problems and opportunities. Geo- system – classification - convective and conductive systems - binary cycle conversion – water fed heat pumps - electric generation - steam generation - steam field. 08Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-3	
Nuclear power systems - light water reactor - high temperature gas reactors - liquid metal fast breeder reactor - Thermal - Fuel elements - Types - operation - Reactivity coefficient – Positioning fuel requirements. 08Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-4	
Fuel cells - General systems - Reactions - Gibbs' rule - of formation - Internal cell voltage - Types of fuel - Design of fuel cell systems - applications - Conversion - problems 08 Hrs	
Teaching-Learning Process	Chalk and Talk/Power Point Presentation
Module-5	
Thermoelectric converter - Thermionic converter – Magneto Hydra Dynamic system (MHD) - Electro gas dynamics (EGD) principles - types. 08Hrs	
Teaching-Learning Process	Chalk and Talk/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. Sorenson Bent, Renewable Energy, Academic Press, New York
2. Johansson Thomas B, Renewable Energy: Sorbes for Fuels and Electricity, Earthscan Publishers, London
3. Ravindranath NH and DO Hall, Biomass, Energy and Environment: A developing Country Perspective fron India, Oxford University Press
4. Boyles David, Bio-energy Technology Thermodynamics and Costs, Ellis Hoknood, Chichester
5. Mazumdar B, A textbook of Energy Technology: Both conventional and Renewable Source of Energy

Web links and Video Lectures (e-Resources):

- https://youtu.be/tiarT1YS-lM
- https://youtu.be/YoslM2Sxihs

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	Classify and identify potential biomass feedstock	L1
CO2	Have an understanding of the existing and emerging biomass to energy technologies	L2
CO3	Evaluate benefit of various conversion processes	L2

Mapping of COS and POs

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

1:Slight (low) 2:Moderate (medium) 3: Substantial (High) "-": no correlation

Total Quality Management			
Course Code	22MST/MPT/MIA/MAR/MPM334	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:00:00	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To give an overview of quality and TQM and explaining the salient contributions of Quality Gurus like Deming, Juran and Crosby. General barriers in implementing TQM.
- To study the TQM concepts like customer Focus, Employee Focus and their involvement, continuous process improvement and Supplier Management.
- To learn the basic and new seven management tools, Quality concepts like Six sigma, Failure mode effect analysis
- To explore industrial applications of Quality function deployment, Taguchi quality concepts and TPM.
- Detailed exposure to students on various quality systems like ISO and its standards

Module-1

Introduction: Need for quality - Evolution of quality - Definitions of quality - Dimensions of product and service quality - Basic concepts of TQM - TQM Framework - Contributions of Deming, Juran and Crosby - Barriers to TQM - Quality statements – Customer focus - Customer orientation, Customer satisfaction, Customer complaints, and Customer retention - Cost of Quality

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2

TQM Principles: Leadership - Strategic quality planning, Quality Councils - Employee involvement - Motivation, Empowerment, Team and Teamwork, Quality circles Recognition and Reward, Performance appraisal - Continuous process improvement - PDCA cycle, 5S, Kaizen - Supplier partnership - Partnering, Supplier selection, Supplier Rating.

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3

TQM Tools & Techniques – I: The seven traditional tools of quality - New management tools - Six sigma: Concepts, Methodology, applications to manufacturing, service sector including IT - Benchmarking - Reason to bench mark, Bench marking process - FMEA - Stages, Types.

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4

TQM Tools & Techniques – II: Control Charts - Process Capability - Concepts of Six Sigma - Quality Function Development (QFD) - Taguchi quality loss function - TPM - Concepts, improvement needs - Performance measures.

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5

QUALITY SYSTEMS Need for ISO 9000 - ISO 9001-2008: Quality System - Elements, Documentation, Quality Auditing - QS 9000 - ISO 14000 - Concepts, Requirements and Benefits - TQM Implementation in manufacturing and service sectors.

Teaching-Learning Process	Chalk and Talk/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. 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):

- https://youtu.be/jFDWlKayrTc?list=PLbRMhDVUMngdXebaRB59KdKwstzuAovua
- https://youtu.be/v-eltsixu4I?list=PLRa9Tg6V1LmeFDszsCBdtCVOfge7dmnRK

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 able to know various biomaterials	L2
CO2	Knowledge of its testing methods	L4
CO3	Will be able to understand the significance of its use in various industrial applications.	L1
CO4	Apply sterilization techniques in industry.	L2
CO5	Develop models to demonstrate his knowledge.	L3

Mapping of COS and POs

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

1:Slight (low) 2:Moderate (medium) 3: Substantial (High) "-": no correlation

Materials for Cryogenic and High Temperature applications			
Course Code	22MST335	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02-00-02	SEE Marks	50
Total Hours of Pedagogy	25Hrs+10-12Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- This course covers the fundamentals of mechanics and microstructure of structural materials for different high-temperature applications. The main emphasis during this course will be ceramic based materials. In addition, other high temperature materials like superalloys, Carbon, and their composites will be also covered. During this course, fundamental topics like bonding, structure, defects, sintering and grain growth, oxidation, and phase equilibria will be covered in detail. In addition, students will also get exposure to the mechanisms of time-dependent deformation, failure mechanism at high temperature, and thermal properties. Finally, different materials used at high temperature (metals, ceramics and their composites) will be reviewed.

Module-1

Introduction: Historical Background – Introduction to Cryogenic propellants –Liquid hydrogen, Liquid helium, Liquid nitrogen and Liquid oxygen and their properties. Production of low Temperature: Theory behind the production of low temperature –Expansion engine heat exchangers – Cascade process Joule Thompson Effect –Magnetic effect – Ortho and Para H2 – Helium4 and Helium3.

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-2

Efficiency of Cryogenic Systems: Types of losses and efficiency cycles –Specific amount of cooling – The fraction liquefied – Cooling coefficient of performance Thermodynamic efficiency – The energy balance Methods. Cycles Of Cryogenic Plant: Classification of cryogenic cycles – The structure of cycle –Throttle expansion cycles – Expander cycles – Thermodynamic analysis – Numerical problems.

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-3

Cryogenic Fluid Storage And Transfer Systems: Basic storage vessels, insulations, un insulated and porous insulated lines, vacuum insulated lines, cryogenic valves, cool down process. Measurement Systems for Low Temperatures: Introduction, Temperature scales and fixed points, Metallic resistance thermometers, thermo couples, constant volume gas thermometers, magnetic thermometers, vapour pressure thermometers.

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-4

Vacuum Technology: Importance flow regimes in vacuum system, components of vacuum system, mechanical vacuum pumps, diffusion pumps, vacuum gauges and valves.

Teaching-Learning Process	Chalk and Talk/Power Point Presentation

Module-5

Cryogenic In Automotive and Aerospace Applications: Cryogenic liquids in missile launching and space simulation – storage of cryogen in liquids- Effect of cryogenic liquids on properties of Aerospace materials – Cryogenic loading problems – Zero gravity problems associated with cryogenic propellants – Phenomenon of tank collapse – Elimination of Geysering effect in missiles.

Teaching-Learning Process	Chalk and Talk/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

5. **Cryogenics, Theory, Processes & Applications by Allyson E Hayes, Nova Publications -2013**
6. **Cryogenic Systems, Barron, Oxford University, 1985.**
7. **Cryogenic Fundamentals, Haseldom.G. Academic Press, 1971.**
8. **Propellant Chemistry, Parner S.F. Reinhold publishing Corpn., New York 1985.**
9. **Mechanical Properties of Materials at Low Temperatures, Wigley D.A. (1971) Plenum Press, New**

Web links and Video Lectures (e-Resources):

- https://youtu.be/r5k-_RLIpuA?list=PLFW6lRTa1g813IyYHLRP_bWJEKQDeEcSP
- https://youtu.be/4SJ7bEILPJk?list=PLLy_2iUCG87CNafffzNZPVa9rW-QmOmEv

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Analyse the properties of material at low temperature. Pressure, temperature, flow,fluid quality and liquid level measurement at low temperature.	L2
CO2	Have Knowledge of Cryogenic systems.	L2
CO3	Acquire knowledge of low temperature measurements.	L2
CO4	Have knowledge of vacuum technology	L2
CO5	Apply knowledge of cryogenics in practical situations	L2

Mapping of COS and POs

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

1:Slight (Low) 2:Moderate (Medium) 3: Substantial (High) "-": no correlation

PROJECT WORK PHASE – 1			
Course Code	**22MST34**	CIE Marks	100
Number of contact Hours/Week	**0-6-0**	SEE Marks	--
Credits	**03**	Exam Hours	--

Course objectives:

- Support independent learning.
- Guide to select and utilize adequate information from varied resources maintaining ethics.
- Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- Develop interactive, communication, organisation,time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgement, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instil responsibilities to oneself and others.
- Train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Phase-1: The project work shall be carried out individually. However, in case a disciplinary or interdisciplinary project requires more participants, then a group consisting of not more than three shall be permitted.

Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall pursue a literature survey and complete the preliminary requirements of the selected Project work. Each student shall prepare a relevant introductory project document, and present a seminar.

Course Outcomes:

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

- Demonstrate a sound technical knowledge of their selected project topic.
- Undertake problem identification, formulation, and solution.
- Design engineering solutions to complex problems utilising a systems approach.
- Communicate with engineers and the community at large in written an oral forms.
- Demonstrate the knowledge, skills and attitudes of a professional engineer.

Continuous Internal Evaluation

- CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of **50:25:25**.
- There will be **no SEE**.

INTERNSHIP			
Course Code	**22MPTI36**	CIE Marks	50
Number of contact Hours/Week	**6 Weeks**	SEE Marks	50
Credits	**06**	Exam Hours	03

Course Objectives:

Internship/Professional practice provide students the opportunity of hands-on experience that include personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc.

The objectives are further,

- To put theory into practice.
- To expand thinking and broaden the knowledge and skills acquired through course work in the field.
- To relate to, interact with, and learn from current professionals in the field.
- To gain a greater understanding of the duties and responsibilities of a professional.
- To understand and adhere to professional standards in the field.
- To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.
- To identify personal strengths and weaknesses.
- To develop the initiative and motivation to be a self-starter and work independently.

Internship: Students under the guidance of internal guide/s and external guide shall take part in all the activities regularly to acquire as much knowledge as possible without causing any inconvenience at the place of internship.

Each student, is required to

- Present the seminar on the internship orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit the report duly certified by the external guide.
- The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

Course outcomes:

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

- Gain practical experience within industry in which the internship is done.
- Acquire knowledge of the industry in which the internship is done.
- Apply knowledge and skills learned to classroom work.
- Develop a greater understanding about career options while more clearly defining personal career goals.
- Experience the activities and functions of professionals.
- Develop and refine oral and written communication skills.
- Identify areas for future knowledge and skill development.
- Expand intellectual capacity, credibility, judgment, intuition.
- Acquire the knowledge of administration, marketing, finance and economics.

Continuous Internal Evaluation

CIE marks for the Internship report, presentation and question and answer session shall be awarded in the ratio of 50:25:25 for the **total CIE of 50 marks** by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments.

Semester End Examination

SEE marks for the internship report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded in the ratio of 50:25:25 for the **total SEE of 50 marks** (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University.

IV SEMESTER

IV SEMESTER

PROJECT WORK PHASE -2

Course Code	**22MST41**	CIE Marks	100
Number of contact Hours/Week	**8 Hours/Week**	SEE Marks	100
Credits	**18**	Exam Hours	03

Course Objectives:

- To support independent learning.
- To guide to select and utilize adequate information from varied resources maintaining ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instill responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Work Phase - II: Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall continue to work of Project Work phase -1to complete the Project work. Each student / batch of students shall prepare project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

Course Outcomes:

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

- Present the project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.