M. TECH. DEGREE IN

MATERIAL SCIENCE AND ENGINEERING

(Twinning Program in association with VNIT Nagpur)

SYLLABUS

FOR

CREDIT BASEDCURRICULUM

DEPARTMENT OF MECHANICALENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

AGARTALA – 799046, INDIA

M.Tech. Material Science and Engineering (Syllabus Structure)
(Twinning Program in association with VNIT Nagpur)

I SEMESTER					
Sr. No.	Course Code	Course Name	Type DC/DE	Structure	Credits
1.		Thermodynamics of Materials	DC	3-1-0	4
2.		Structure & Characterization of Materials	DC	3-1-0	4
3.		Polymer Engineering	DC	3-1-0	4
4.		Ceramic Engineering	DC	3-1-0	4
5.		Numerical methods and Applied Statistics	DC	3-1-0	4
6.		Physical Metallurgy	DC	3-1-0	4
7.		Structure & Characterization of Materials Lab	DC	0-0-3	2
8.		Physical Metallurgy Lab	DC	0-0-3	2
				Total credits	**28**
II SEMESTER					
Sr. No.	Course Code	Course Name	Type DC/DE	Structure	Credits
1.		Design & Selection of Materials	DC	3-0-0	3
2.		Phase Transformation of Materials	DC	3-0-0	3
3.		Comprehensive Viva		0-0-0	1
Elective: (13 Credits): Choose any FOUR Courses **Any ONE from the following (01 Theory + Practical): 4 Credit**					
4.		Non Destructive Evaluation	DE	3-0-0	3
		Non Destructive Evaluation Lab	DE	0-0-2	1
5.		Process Modeling and Simulation	DE	3-0-0	3
		Process Modeling and Simulation Lab	DE	0-0-2	1
Any THREE courses from the following: 9 Credit					
6.		Advance Composite Materials	DE	3-0-0	3
7.		Powder Metallurgy	DE	3-0-0	3
8.		Deformation Behavior of Materials	DE	3-0-0	3
9.		Alloy & Special Steels	DE	3-0-0	3
10.		Biomaterials	DE	3-0-0	3
11.		Corrosion Process and Control	DE	3-0-0	3

12.		Advanced Ceramics	DE	3-0-0	3
13.		Failure Analysis of Engineering Materials	DE	3-0-0	3
14.		Welding & Joining	DE	3-0-0	3
15.		Defect in Crystalline Materials	DE	3-0-0	3
				Total credits	**20**
III SEMESTER					
Sr. No.	Course Code	Course Name	Type DC/DE	Structure	Credits
1		Project and Thesis – I	DC	-	12
				Total credits	**12**
IV SEMESTER					
Sr. No.	Course Code	Course Name	Type DC/DE	Structure	Credits
1		Project and Thesis – II	DC	-	20
				Total credits	**20**

*DC= Departmental core *DE=Departmental Elective

TOTAL CREDIT: 80

Note:

1) M.Tech Material Science and Engineering is twinning program offered by NIT Agartala in association with VNIT Nagpur.
2) Under this program, students will undergo first semester courses in NIT Agartala and second semester courses in VNIT Nagpur Campus.
3) Students are permitted to carry out their M.Tech Project either in NIT Agartala or in VNIT Nagpur.

Program Outcomes for M.Tech Material Science and Engineering Program

Material Science and Engineering post graduate students will have an

PO1: Ability to independently carry out research /investigation and development work to solve practical problems

PO2: Ability to write and present a substantial technical report/document

PO3: Ability 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: Ability to analyze and characterize the advanced engineering materials.

PO5: Ability to select / develop / process advance engineering materials considering economic, environmental, and societal context with ethical considerations leading to sustainable development.

PO6: Ability and competency to work in research and industrial sectors with multifaceted teams.

Program Specific Outcomes

PSO1: Ability to identify / analyze / interpret the attainment of properties in processing stages of materials.

PSO2: Ability to develop new materials based on societal needs.

FIRST SEMESTER

THERMODYNAMICS OF MATERIALS

Semester: 1st	Credit: **4**					
Course Name: Thermodynamics of Materials	**L**	**T**	**P**	3	1	0

Course Objectives:

To provide knowledge on:

1. Fundamentals of Materials Thermodynamics.
2. Applications of metallurgical Thermodynamics concept.
3. Thermodynamics of phase transformation and crystal defect formation.

Syllabus Content

Module 1:

Introduction to Thermodynamics- different approaches, emphasis on metallurgical Thermodynamics.

Module 2:

Laws and related applications, concept of energy and entropy, criteria for spontaneity. Maxwell's Relations and Clausius Clayperon Relations.

Module 3:

Introduction to solutions, solution model, regular and quasi chemical models, sub regular, cluster variation model, multi parameter models.

Module 4:

Statistical thermodynamics and multicomponent system, partial molar quantities, Gibbs-Duhem relations, thermodynamic aspects of metallic solutions and salt melts, Raoult's and Henry's Law.

Module 5:

Thermodynamic aspect of phase transformation, similarity in thermodynamic approach towards different classes of materials, thermodynamic aspect of defect formation in metals and ceramics.

Text Books:

i)Gaskell, david, R., Introduction to metallurgical Thermodynamics, McGraw Hilll.

ii) Upadhayaya, G.S., and Dube, R. K..Problems in Metallurgical Thermodynamics and Kinetics, Pergamon.

Reference Books:

i) Darken, L.S., and Gurry, R. W., Physical chemistry of Metals, McGraw Hill
ii) Thermodynamics of Solids by R ASwalin**.**

Course Outcomes:

At the end of course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Identify the concept of metallurgical thermodynamics.	1
2	Apply the various postulates related to materials thermodynamics	2
3	Develop the several types of solution model of metallic solutions	2, 3
4	Understand the concept of statistical thermodynamics of metallic solutions.	4
5	Apply the thermodynamics aspect of phase transformation and defect formation in materials.	5

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	1	0	2	2	0	1	2	1
CO-2	0	0	2	0	0	0	1	2
CO-3	2	1	2	2	2	2	2	3
CO-4	1	1	2	2	1	1	1	2
CO-5	2	2	2	3	1	2	2	1

STRUCTURE AND CHARACTERIZATION OF MATERIALS

Semester: 1st	Credit: 4					
Course Name: Structure and Characterization of Materials	**L**	**T**	**P**	3	1	0

Course Objectives:

1. To impart a sound understanding of principles of different fusion welding processes.
2. To understand the effect of welding parameters on weld quality.
3. To study the importance of allied welding processes

Syllabus Content

Module 1:

Basic crystallography & lattice structure

Basic crystallography (Bravais lattices, importance of symmetry in crystallography, SC,BCC, FCC, HCP, CsCl, NaCl, DC and ZnS structure description, description of planes and directions and their representation),Ideal vs. real crystals, definition of microstructure. Defect structure-points defects and its equilibrium concentration, methods of producing point defects, dislocations – edge, screw and mixed. Volterra model of dislocation, Burgers vector, dislocation line, dislocations in BCC, FCC and HCP crystals, energy of dislocations, partial dislocations, slip systems in BCC, FCC and HCP, stress field of a screw dislocation. Random vs. structural dislocations. 2D defects, classification (surface, grain boundary, stacking faults, twin boundaries, anti-phase boundaries),interfaces (coherent and in-coherent), concept of terraces, ledges and kinks. Types of grains boundaries (low angle and high angle), types of twins.

Module 2:

Structure property correlations in materials.

Importance of structure-property correlation in materials, structure sensitive /insensitive properties, introduction to materials characterization and its importance in materials engineering, levels of characterization (macro, meso and micro), concept of resolution and depth of field/focus in imaging, types of aberrations (spherical, chromatic, diffraction and astigmatism), remedial measures for aberrations. Optical microscopy (OM)– reflected/transmitted light microscopy, theoretical and practical resolution of an optical microscope, numerical aperture, principles of image formation, microscope construction and working, effective/empty magnification, different light sources, importance of stage design, capturing of image, flat field correction in OM, bright field, dark field, polarized light and phase contrast microscopy and applications of each in metallurgical and materials engineering, sample preparation for optical microscopy and limitations.

Module 3:

Scanning electron microscopy

Advantages / disadvantages as compared to OM and other imaging techniques, mechanics of SEM, types of electron gun and comparison between them (interms of resolution, brightness,

efficiency, cost, stability and applications), line diagram of SEM, its working and construction, concept of magnification as applied to SEM, electron-matter interaction, imaging modes (secondary and backscattered), effect of spot size, effect of apertures, effect of accelerating voltage on SEM imaging, signal detection (by using Everhart- Thornley, Robinson and solid state segmented detectors), atomic number and topological contrast, critical probe current, chemical analysis of phases using SEM (EDS/WDS working principle, construction and analysis, data acquisition modes – spot, line and area scans), resolution of EDS/WDS detector attached to SEM, advantages/disadvantages, working and calibration, qualitative and quantitative analysis.

Module 4:

X-ray diffraction

Elastic and inelastic scattering, Bragg's law, basic powder diffraction, generation of X-rays, characteristic X-ray spectrum, Moseley's law, methods toremove Kb radiation, detectors, factors affecting the intensity of diffraction peaks (atomic scattering factor, structure factor, multiplicity, Lorentz factor, Polarization factor, absorption effects), derivation of diffraction conditions for SC, BCC and FCC Bravais lattice, phase identification using XRD.

Module 5:

Thermal analysis techniques

Importance of thermal characterization techniques. Differential thermal analysis (DTA), differential scanning calorimetry (DSC) and thermogravimetric analysis (TG) analysis – working principle, differences, accuracy, sensitivity, calibration and applications (Tg, Tc, Tm determination, factors affecting them, crystallinity determination, quantification of moisture and decomposition products etc.).

Module 6:

Infrared spectroscopy

Infrared spectroscopy (conventional and Fourier transform, working principles, differences, instrumentation and applications).

Text Books:

i. Richard Little, Welding and Welding Technology, McGraw Hill, (2001), 1st edition.
ii. H Cary, Welding Technology, Prentice Hall, 1988, 2nd edition.
iii. S V Nadkarni, Modern Arc Welding Technology, Ador Welding Limited, 2010, New Delhi.

Reference Books:

i. Welding handbook, American Welding Society, (1983), 7th edition, volume 1 & 2, USA
ii. http://eagar.mit.edu/EagarPapers/Eagar138.pdf http://www.techno4india.com/arc.pdf

Course Outcomes

CO-No.	Course Outcome(4 to6)	Module Covered
1	To describe and explain fundamental concepts of Basic crystallography and structure	1,2
2	To know the details about Microstructural characterization techniques.	3
3	Have an understanding of IR spectroscopic techniques	4
4	Be able to know about the Thermal characterization methods	5
5	To identify the process of application of each technique for selection of a characterization method for a particular application and its limitations.	3,4,5

CO-PO Mapping (Rate: scaleof1 to3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	1	3	2	1	2	2	3
CO-2	2	2	1	3	2	3	3	2
CO-3	3	2	2	3	2	3	3	2
CO-4	2	3	2	3	2	3	3	2
CO-5	3	2	3	3	3	3	2	2

POLYMER ENGINEERING

Semester: 1st	Credit: 4					
Course Name: Polymer Engineering	**L**	**T**	**P**	**3**	**1**	**0**

Course Objectives:

1) To learn polymer materials
2) To learn classification of engineering polymers, different chain or molecule structures.
3) To learn and study polymerizations mechanisms and kinetics, solid state properties of polymers, polymer viscoelasticity.
4) To learn about polymer processing and engineering and specialty polymers.

Syllabus Content

Module 1:

Introduction and classification of engineering polymers: Basic concept in polymers, thermoplastic, thermosetting and elastomers

Module 2:

Polymer chain structures: Linear, cross-linked, branched and network structures. Chemical aspect of polymerization: Addition, condensation and ionic polymerization.

Module 3:

Physical aspect of polymerization: Bulk, solution, suspension and emulsion polymerization. Morphology of polymers: amorphous and semi crystalline structure, polymer crystallinity, factors affecting on crystallization and glass transition temperature, methods used for determination of molecular weight, polymer viscosity ,mechanical and creep behavior of amorphous and semi crystalline polymer.

Module 4:

Polymer viscoelasticity: Simple rheological responses, Mechanical models for linear viscoelastic response-The Maxwell model, The Voigt model, the four-parameter model, material response time-Deborah number, Maxwell-Weichert model, Volgt-Kelvin model.

Module 5:

Polymer Processing: Extrusion, injection molding, blow molding, thermoforming, calendaring, spinning, compression molding and transfer molding. Engineering and specialty polymers: Structure, properties and application of polyamide, polyester, polycarbonate, polyurethane and conducting polymers.

Text Books:

i. Clegg D.W., Collyer A.A., Structure and properties of polymeric Materials, Mats, pubin.
ii. Fried J.R., Polymer Science and Technology, Prentice Hall of India, New Delhi 2000.
iii. William D., Callister J.R.,Material Science and Engineering, John Wiley and Sons,1997.
iv. Dyswan R.W., Speciality Polymers, Chapman and hall,1987.

Course Outcomes:

At the end of this course, students will be able to understand

CO-No.	Course Outcome	Module Covered
1	Polymers, Classification of engineering polymers.	**1**
2	Polymer chain structures.	**2**
3	Different polymerization process and its thermodynamic and kinetic aspect.	**3, 4**
4	Solid state properties of polymers.	**3**
5	Polymer viscoelasticity.	**4**
6	Processing of Polymers, Engineering and specialty polymers.	**5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	3	3	2	3	2	3
CO-2	3	3	2	2	3	3	3	2
CO-3	2	3	3	3	3	3	3	3
CO-4	3	2	3	3	3	3	3	3
CO-5	3	3	2	3	3	2	2	3

CERAMIC ENGINEERING

Semester: 1st	Credit: 4					
Course Name: Ceramic Engineering	**L**	**T**	**P**	**3**	**1**	**0**

Course Objectives:

1. To provide overview of ceramic materials and its fabrication techniques.
2. To provide overview on defects in ceramics, properties and its applications.

Syllabus Content

Module 1:

Materials classification with special reference to ceramics. Classification of ceramics

Module 2:

Structures of ceramics - AX/AmXp/AmBnXp types.

Module 3:

Imperfections- Kroger Vink notations, Defect reactions

Module 4:

Processing, Powder synthesis techniques, Ceramic fabrication techniques- pressing, slip casting, tape casting, Isostatic pressing.

Module 5:

Characterization of ceramics - particle size and distribution, shape, surface area, porosity, phase.

Module 6:

Sintering- basics, stages and mechanisms in ceramics.

Module 7:

Physical, Electrical, Dielectric, Magnetic, Optical and Thermal Properties

Module 8:

Applications of Advanced ceramics.

Text Books:

i) Michel W. Barsoum, Fundamentals of Ceramics: 2nd Edition, CRC Press, 2020

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

iii) David W. Richerson, William E. Lee, Modern Ceramic Engineering: Properties, Processing, and Use in Design: 4th Edition, CRC Press, 2018

iv) W. David Kingery, H,K, Bowen and Donald R. Uhlmann, Introduction to Ceramics: 2nd Edition, 1976

Course Outcomes

At the end of this course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Classify ceramics and analyze the structure and imperfections of ceramics	**1,2,3**
2	Fabricate/identify the fabrication techniques of ceramics	**4,6**
3	Characterize the ceramics / Outline the Properties and application	**5,7,8**
4	Write and present a technical report on advanced ceramic materials	**1-8**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2		2	2		2	2	
CO-2	3		3		3	2		3
CO-3			3	2		2	2	
CO-4		3	3	2	2	2	2	2

NUMERICAL METHODS AND APPLIED STATISTICS

Semester: 1st	Credit: 4					
Course Name: Numerical methods and Applied Statistics	**L**	**T**	**P**	3	1	0

Course Objectives:

1) Estimation of errors and roots of polynomials and transcendental equations
2) System of Linear algebraic equations, Curve fitting and solution of ODE and PDE
3) Random Variables
4) Special Distributions and Joint Distributions
5) Correlation and Regression
6) Sampling Theory, Estimation and Testing of Hypotheses

Syllabus Content

Module 1:

Approximation, rounding-off error, significant error, Truncation error and Taylor series. Determination of roots using Newton-Raphson method, Secant and airstow's method.

Module 2:

Gauss Elimination and Gauss seidel iteration method. Backward, Forward and central difference relations, Numerical differentiation and integration. Numerical solution of PDE using difference relation, solution ODE using Euler, modified Euler, Runge-Kutta and Predictor- Corrector method.

Module 3:

Basic idea about random variables, Expectation, mean, variance, moments, skewness and kurtosis, median, mode, quartiles, moment generating function, Characteristic function, covariance, Chebyshev's inequality, Convergence in probability, Bernoulli's limit theorem, Law of large numbers.

Module 4:

Uniform, Binomial, Geometric, Poisson, Exponential, Gamma, Normal distributions. Joint, marginal and conditional distributions, product moments, joint characteristic function.

Module 5:

Correlation coefficient, rank correlation, linear regression and curvilinear regression.

Module 6:

Random sample, concept of sampling and various types of sampling, sample and population. Sample characteristic and their computation, sampling distribution of statistic, Estimates of

population characteristic or parameter. The Central Limit Theorem, Sampling distributions of the sample mean and the sample variance for a normal population, Chi-Square, t and F distributions.

Point estimation and interval, estimation, criterion of a good point estimate, maximum likelihood estimate. Interval estimation of population proportion, interval estimation of a Normal population parameters, estimate of population parameters with large sample when distribution of the population is unknown, confidence intervals for the mean(s) and variance(s) of normal populations.

Null and alternative hypotheses, the critical and acceptance regions, two types of error, power of the test, testing of hypothesis for a population proportion and Normal population parameters and large sample test for population with unknown distribution, Chi-square test of goodness of fit. The most powerful test and Neyman-Pearson Fundamental Lemma.

Text Books:

i) An Introduction to Numerical Methods and Analysis- James F. Epperson.
ii) Fundamentals of Engineering Numerical Analysis- P. Moin.
iii) Mathematical Statistics-Gupta and Kapur-Sultan Chand.

Reference Books:

i) Numerical Methods: Fundamentals and Applications- Rajesh Kumar Gupta.
ii) An Introduction to Probability Theory and its Applications – W. Feller, Wiley; 3rd ed.
iii) Ground Work of Mathematical Probability and Statistics-Amritabha Gupta, Academic Pub.
iv) Introduction to Probability and Statistics for Engineers and Scientists- S. Ross, Academic Press.
v) Statistical Methods,Vill-I and II-N.G.Das.
vi) A First Course in Probability-S. Ross, Pearson Education India.
vii) Introduction to Probability- C. M. Grinstead and J. L. Snell, Universities Press India.

Course Outcomes

At the end of this course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Estimation of errors and roots of polynomials and transcendental equations	**1**
2	System of Linear algebraic equations, Curve fitting and solution of ODE and PDE	**2**
3	Random Variables	**3**
4	Special Distributions and Joint Distributions	**4**

5	Correlation and Regression	**5**
6	Sampling Theory, Estimation and Testing of Hypotheses	**6**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PSO-1**	**PSO-2**
CO-1	3	2	3	2		2	2	
CO-2	3	3	3	2		2		
CO-3	2	3	3					
CO-4	2	3	3					
CO-5	3	3	3	2		2		

PHYSICAL METALLURGY

Semester: 1st	Credit: 4					
Course Name: Physical Metallurgy	L	T	P	3	0	1

Course Objectives:

1. To Learn about Crystalline nature of Metals.
2. To learn and study phase diagrams.
3. To study the effect of alloying elements in steels.
4. To study Non-ferrous alloys and special Alloys

Syllabus Content

Module 1:

Crystalline nature of Metals, Crystal lattice, unit cell, Miller indices, Crystal structures-BCC, FCC, SCP, Packing density, defects in Crystal, diffusion.

Module 2:

Alloys:-Binary phase diagram, solid solution, Hume- rothary rules, phase rules, intermettalic compounds, lever rule, binary diagram involving eutectic, eutecoid, peritectic reaction. Iron-Iron carbide diagram, classification of steels and diagram, critical temperatures ,TTT diagram, critical cooling rate, hardenability, measurement techniques, heat treatment such as annealing,normalizing,hardening,tempering,austempering,martempering

Module 3:

Alloys steels:-Effects of Alloying elements in general and in particular, Introduction to tool steels(Low alloy tool steels ,HCHC, HSS, OHNS, ball bearing steel ,alloy cast iron) Stainless steels- alloying elements and their purpose, Properties and applications.

Module 4:

Non- Ferrous alloys;- Structure, properties and applications of Cu – Zn alloys, braces,Cu-Sn alloys –Bronzes ,Al-Si alloys, age hardenable aluminum alloys etc.

Module 5:

Introduction to special alloys- super alloys, titanium alloys, silicon steels.

Text Books:

i) Raghavan, V. Phase transformations, Prentice Hall
ii) Narula and Narula, Materials science and Technology

Reference

i) Dieter, G.E., Mechanical Metallurgy, McGraw Hill
ii) Avener, Introduction to Physical Metallurgy
iii) Physical Metallurgy principals, Reza Abbaschim, Lara Abbaschim

Course Outcomes

At the end of this course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Basic crystalline structure of the metals.	**1**
2	Phases in metals and alloys and phase diagram of binary alloys.	**2**
3	Phase diagram of Iron-Iron carbide system, its various phases, microstructure of iron alloys, their properties and applications.	**2**
4	Alloy steels and effect of alloying elements	**3**
5	Non-ferrous alloys, their phase diagrams, their properties and applications.	**4**
6	Special Alloys	**5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1		2	2			1	2	1
CO-2	1	2			2	2	2	1
CO-3	1	1	1		2	2	2	1
CO-4	2	1	2	3	3	3	2	3
CO-5		1	2	3	3	3	3	3

STRUCTURE AND CHARACTERIZATION OF MATERIALS LAB

Semester: 1st	Credit: 2					
Course Name: Structure and Characterization of Materials	L	T	P	0	0	3

Course Objectives:

1) To learn the principles of material testing and characterization and to apply them for various Engineering applications.

List of Experiments

1. Optical microscopy: Study of metallurgical microscope and sample preparation, Microscopic examination of ferrous and nonferrous alloys
2. Scanning Electron Microscopy (imaging): understanding the basic operational procedure of SEM. Specimen mounting, inspection and analysis. Fractography using SEM
3. Chemical analysis using scanning electron microscopy (EDS)
4. Phase identification using X-ray Diffraction
5. Determination of Crystallize / Grain Size and Lattice Strain using XRD
6. Determination of onset of glass transition, crystallization and melting temperature using DTA.
7. Identification and purity determination using DSC
8. Quantification of crystalline percentage of a polymer using DSC
9. Identification of polymer using FTIR.

Text Books:

1. L. Yang, Materials Characterization: Introduction to microscopic and spectroscopic method, Wiley.
2. Goodhew, Humphreys and Beanland, Electron Microscopy and Microanalysis, Taylor and Francis.

Course Outcomes

At the end of this course, students will be able to

CO-No.	Course Outcome
1	Understand about basic crystallography
2	Perform microstructural characterization based on hands on experience.
3	Perform thermal characterization based on hands on experience.

4	Analyze and understand the limitation of characterization techniques.
5	Understand the proper procedure for selection of a characterization method for a particular application and perform the analysis

CO-PO Mapping (Rate: scaleof1 to3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	1	3	2	1	2	2	3
CO-2	2	2	1	3	2	3	3	2
CO-3	3	2	2	3	2	3	3	2
CO-4	2	3	2	3	2	3	3	2
CO-5	3	2	3	3	3	3	2	2

PHYSICAL METALLURGY LAB

Semester: 1st	Credit: 4					
Course Name: Physical Metallurgy Lab	L	T	P	0	0	1

Course Objectives:

1. To Learn about Crystalline nature of Metals.
2. To learn and study phase diagrams.
3. To study the effect of alloying elements in steels.
4. To study Non-ferrous alloys and special Alloys

List of Experiments

1. Study of equipment's used in the lab.
2. Sample preparations for optical microscopy.
3. Observe microstructure of a few steels.
4. Observe microstructure of few cast irons.
5. Observe microstructure of a few non-ferrous alloys.
6. Demonstration of Jominy hardenability Test.
7. Observe microstructure of a few hardened and tempered low alloy steels.
8. Observe microstructure of a few hardened and tempered tool steels

Course Outcomes

CO-No.	Course Outcome	Experiment Covered
1	Basic crystalline structure of the metals.	**1,2**
2	Phases in metals and alloys and phase diagram of binary alloys.	**3**
3	Phase diagram of Iron-Iron carbide system, its various phases, microstructure of iron alloys, their properties and applications	**4,5**
4	Alloy steels and effect of alloying elements	**6,7**
5	Non-ferrous alloys, their phase diagrams, their properties and applications.	**8**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3				2		
CO-2	3	3				2		
CO-3	3	3		2	2	2	3	3
CO-4	3	3		3	2	3	3	3
CO-5	3	3		3	2	3	3	3

SECOND SEMESTER

DESIGN AND SELECTION OF MATERIALS

Semester: 2nd	**Credit: 3**					
Course Name: Design and Selection of Materials	**L**	**T**	**P**	3	0	0

Course Objectives:

1. To inculcate knowledge on selection of materials based on required properties for design

Syllabus Content

Module 1:

Introduction to Material Selection and design

Module 2:

Engineering properties of Materials. Factors and property parameters in material selection.

Module 3:

Material selection vis – a – vis design, Material selection for strength and stiffness, Material selection and design for toughness and fatigue

Module 4:

Material selection for creep and wear, Material selection criteria and case studies.

Text Books:

i. Charles J.A.; Crane FAA, Furness JAG; Selection & Use of Engineering Materials; Butterworth & Heinemann,
ii. Dieter G.E.; Mechanical Metallurgy; McGraw Hill, 1988.
iii. Ashby M.F., Jones D.R.; Engineering Materials; Pergamon Press, 1992.
iv. Askeland DR : Engineering Materials
v. ASM Handbook : Vol.20: Material Selection : ASM

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Select materials based on service conditions and based on strength and stiffness requirement	**1,2,3**
2	Select materials considering the creep, fatigue and fracture toughness requirement	**3,4**
3	Analyze and solve numerical related to design for fracture toughness, fatigue and creep life estimation.	**3,4**
4	Analyze wear and select materials for different wear conditions.	**4**
5	Write and present a technical report on design and selection of materials	**1-4**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3				2		2	
CO-2	3				2		2	
CO-3	3		3	2		2	2	
CO-4	3		2	2		2	2	
CO-5		3	3	2	2	2	2	2

PHASE TRANSFORMATION OF MATERIALS

Semester: 2nd	Credit: 3					
Course Name: Phase Transformation of Materials	**L**	**T**	**P**	3	0	0

Course Objectives:

1. Phase transformation studies on steels, nonferrous alloys and other materials systems.
2. Kinetics of phase transformationsand applications

Syllabus Content

Module 1:

Phase diagram, free energy, composition diagram, kinetics of phase transformation, diffusion process mechanism Fick's, law solutions, kirkendall effect, diffusion in alloys, and other materials problems,

Module 2:

Mechanism of phase transformation, nucleation and growth, homogenous and heterogeneous transformation.

Module 3:

Transformation behavior in steel- isothermal and diffusion less transformation, structure of interfaces, precipitation and strengthening mechanism problems

Module 4:

Studies on typical transformation in steels, non ferrous alloys and other materials systems

Module 5:

Studies on order-disorder transformation, spinodal decomposition, massive transformation, higher order transformation.

Text Books:

i. Introduction to Materials Thermodynamics - D. R. Gaskell
ii. Kinetics of metallurgical processes – H. S. Ray
iii. Phase transformation in metals and alloys - Porter and Easterling
iv. Solid state phase transformation – V. Raghavan
v. Diffusion in solids – P. G. Shewmon
vi. Physical metallurgy principles - R. Reed-Hill

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Analyze and Interpret the phase transformation in steels, nonferrous alloys and other materials.	**4,5**
2	Analysis the kinetics of Phase transformation	**1,2,3**
3	Prepare and present a technical report on Phase Transformation in ferrous / nonferrous metals or alloys.	**1-5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2		2	3		2	3	2
CO-2	2		2	2		2	2	2
CO-3		3	3	2		2	2	

COMPREHENSIVE VIVA

Semester: 2nd	**Credit: 2**					
Course Name: Comprehensive Viva	**L**	**T**	**P**	0	0	0

Course Objectives:

1. To assess the overall knowledge of the student in the field of Material Science and Engineering acquired over one year of study in post graduate program.

Course Outcomes

At the end of the course, students will be able to

CO-No.	**Course Outcome**
1	Comprehend any given problem / concept related to material science and engineering domain.
2	Recall, recognize, visualize, demonstrate, criticize and appraise the concepts related to material science and engineering domain.

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PSO-1**	**PSO-2**
CO-1	3		3				2	
CO-2	3		3					

ELECTIVES
NON DESTRUCTIVE EVALUATION

Semester: 2nd	**Credit: 3**					
Course Name: Non Destructive Evaluation	**L**	**T**	**P**	3	0	0

Course Objectives:

1. To impart knowledge to the students on non destructive evaluation methods.
2. To impart the principles and limitation of non destructive evaluation techniques.

Syllabus Content

Module 1:

Introduction and scope of non-destructive testing and evaluation (NDT/NDE) methods. Visual examination, principles and equipment's, optical aids. Liquid penetrant testing:, principle, procedure, penetrant materials and methods, applications. Principles of magnetic particle testing, procedures and equipment's for MPT, magnetic field testing; limitations of MP methods, electromagnetic testing for residual stress measurement. Eddy current testing, principle and instrumentation, techniques like high sensitivity, multifrequency, high area, pulsed ECT, inspection of ferro-magnetic material, application and limitation ECT.

Module 2:

Radiographic inspection, principle, radiation sources, radiation attenuation's; film effect. Radiographic imaging, Imaging techniques: single wall, double wall, penetration, single image etc., applications and case studies; limitations. Ultrasonic Testing, case studies, limitations.Special / advanced techniques of NDE /AET, thermography, replica microscopy (in situ). Leak testing, remote field ECT, microwave inspection, topography, holography.

Module 3:

Criteria for selection of NDT methods and instruments related to metallurgical processes / defect in cast ,forged and rolled, heat treated and fabricated items (one case study for each category), reliability in NDT. Statistical method & quality control in NDT codes and standard specifications.

Text Books:

i. Baldev Raj & T. Jayakumar ; Practical Non-destructive Testing; Nanda Publishers, 1997.
ii. RaviPraksh: Non Destructive Testing Technique
iii. Paul E. Mix : Introduction to nondestructive testing
iv. ASM Handbook Volume 17: Non destructive Evaluation and Quality control.
v. J. Blitz: Electrical and Magnetic methods of Nondestructive testing
vi. B.P.C. Rao: Practical Eddy Current Testing

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Identify and select the techniques suitable for detecting the flaws in the engineering components based on knowledge of the principles and limitations of non destructive evaluation techniques.	**3**
2	Perform non-destructive testing on engineering components	**2**
3	Evaluate and interpret the defects using various NDE techniques.	**2**
4	Prepare and present a technical/ evaluation report based on non destructive evaluation in components.	**1,2,3**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2		2		2		2	
CO-2	2		3	2			2	
CO-3	3		3	2		2	2	
CO-4	3	3				2		

NON DESTRUCTIVE EVALUATION LABORATORY

Semester: 2nd	**Credit: 1**					
Course Name: Non Destructive Evaluation Laboratory	**L**	**T**	**P**	0	0	2

Course Objectives:

1. To provide hands on experience on handling non destructive testing kits
2. To provide practical skills on non-destructive testing of materials.

Syllabus Content

Exp 1: Study of ultrasonic testing equipments used in lab
Exp 2: Calibration of UT equipments
Exp 3: Flow detection by UT equipments
Exp 4: Study of Eddy Current testing equipments
Exp 5: Sorting of material by eddy current testing
Exp 6: Determination of electrical conducting by NDT techniques
Exp 7: Flaw detection by magnetic particle inspection
Exp 8: Flaw detection by liquid (Dye) penetrate test.

Course Outcomes

At the end of the course, students will be able to

CO-No.	**Course Outcome**	**Exp Covered**
1	Inspect and calibrate Ultrasonic Testing equipments	**1,2**
2	Detect flaws using Ultra Testing equipments and interpret the features of defects	**3**
3	Sorting of materials using eddy current testing techniques.	**4,5**
4	Determine the electrical conductivity by NDT techniques	**6**
5	Detect flaws by magnetic particle inspection and dye peneterate test	**7,8**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PSO-1**	**PSO-2**
CO-1	2			2				
CO-2	3	2	3	2		2		
CO-3		2	3	2		2		
CO-4	3	2	3	2				
CO-5	3		3	2		2		

PROCESS MODELING AND SIMULATION

Semester: 2nd	**Credit: 3**					
Course Name: Process Modeling and Simulation	**L**	**T**	**P**	3	0	0

Course Objectives:

1. Provide knowledge to the students on physical and mathematical modeling and simulation of metallurgical processes.

Syllabus Content

Module 1:

Essence of Modeling of Metallurgical Processes. Introduction to Simulation and its Importance in Engineering

Module 2:

Analysis of Transport Processes and their Application in Modeling. System Analysis

Module 3:

Development of Mathematical Model and Algorithm for Simulation, Presentation of Simulation Results.

Module 4:

Physical Modeling and its Importance in Engineering Studies.

Module 5:

Case Studies on Modeling and Simulation of some Metallurgical Processes e.g. Melting of Scrap, Refining of Melt, Solidification, Re-heating, Heat Treatment, Fluid Flow in Laddle,Tundish etc.

Text Books:

i. DipakMazumdar, James W Evans, Modelling of Steelmaking Processes, CRC Press, 2010.
ii. S. Pal, A. Patra, Process Modeling for Steel Industry, I K International Publishing House Pvt. Ltd., 2018.
iii. Hangos K M and Cameroon IT: Process Modeling and Model Analysis, Academic Press, London, 2001.
iv. G. K. Lal, Modelling Techniques for Metal Forming Processes, Narosa Publishing House, 2011.
v. Blast Furnace Phenomena and Modelling, The Iron and Steel Institute of Japan, Springer, 1987.
vi. Peter Hartley, Ian Pillinger, Numerical Modelling of Material Deformation Processes: Research, Development and Applications, Springer, 2012.
vii. John G. Lenard, Modelling Hot Deformation of Steels: An Approach to Understanding and Behaviour, Springer, 1989.

viii. Patankar S. V., Numerical Heat Transfer and Fluid Flow, Hemisphere.Washington. DC, 1980.
ix. Nastac, L., Pericleous, K., SABAU, A., Zhang, L., Thomas, B., CFD Modeling and Simulation in Materials Processing, 2018.
x. SeshadriSeetharaman, Treatise on Process Metallurgy, Volume 3: Industrial Processes, Elsevier, 2013.
xi. Relevant journal articles from published literature.

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Perform analysis of transport processes and its application in modeling.	**1,2**
2	Perform system analysis.	**1,2**
3	Develop Mathematical model and simulate metallurgical process and present simulation results	**3**
4	Develop physical models for metallurgical processes.	**4**
5	Undergo case studies on modeling and simulation of metallurgical processes and submit it as a technical report	**5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3		3	2			2	
CO-2	3		3	2			2	
CO-3	3	3	3		3			
CO-4	3		3		3			
CO-5	3	3	3		2	2	2	

PROCESS MODELING AND SIMULATION LAB

Semester: 2nd	**Credit: 1**					
Course Name: Process Modeling and Simulation Lab	**L**	**T**	**P**	0	0	2

Course Objectives:

1. To provide hands on experience on handling non destructive testing kits
2. To provide practical skills on non destructive testing of materials.

Syllabus Content

Exp 1: Study the use of commercial fluid dynamics software like Ansys Fluent.

Exp 2: Introduction of programming in Matlab, C++ etc software.

Exp 3: Study 2D Simulation of Metallurgical Processes.

Exp 4: Study 3D Simulation of Metallurgical Processes.

Exp 5: Observation of several Physical Models and find out the change of parameters like flow rate, composition, temperature, particle size, concentration, pressure, gas/liquid/solid flow rate, stirring speed, current density, etc on the efficiency or effect to the process.

Exp 6: Student will develop new innovative process for iron and steelmaking as well as will able to develop small scale innovative non ferrous metallurgical treatments. They will study it by CFD software. In some cases they will use physical model also to study the innovations.

Exp 7: Study and Use of Thermo-Calc Software.

Exp 8: Industrial Visit.

Text Books

i. Dipak Mazumdar, James W Evans, Modelling of Steelmaking Processes, CRC Press, 2010.
ii. S. Pal, A. Patra, Process Modeling for Steel Industry, I K International Publishing House Pvt. Ltd., 2018.
iii. Hangos K M and Cameroon IT: Process Modeling and Model Analysis, Academic Press, London, 2001.
iv. 4.G. K. Lal, Modelling Techniques for Metal Forming Processes, Narosa Publishing House, 2011.
v. Blast Furnace Phenomena and Modelling, The Iron and Steel Institute of Japan, Springer, 1987.
vi. Peter Hartley, Ian Pillinger, Numerical Modelling of Material Deformation Processes: Research, Development and Applications, Springer, 2012.
vii. John G. Lenard, Modelling Hot Deformation of Steels: An Approach to Understanding and Behaviour, Springer, 1989.
viii. Patankar S. V., Numerical Heat Transfer and Fluid Flow, Hemisphere.Washington. DC, 1980.
ix. Nastic, L., Pericleous, K., SABAU, A., Zhang, L., Thomas, B., CFD Modeling and Simulation in Materials Processing, 2018.
x. SeshadriSeetharaman, Treatise on Process Metallurgy, Volume 3: Industrial Processes, Elsevier, 2013.

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome (4 to 6)	Exp Covered
1	Perform Modeling and simulation on metallurgical processesusing advanced computing tools	**1,2,7**
2	Perform 2D and 3D simulation of metallurgical processes	**3,4**
3	Evaluate the influence of process parameters with respect to physical models on efficiency/effect to the process	**5**
4	Develop new innovative process on iron and steel making/non ferrous metallurgical treatments. Develop physical models and perform CFD analysis	**6**
5	Apply neural network and genetic algorithm in iron and steel making.	**7**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	2	3	2		2	2	
CO-2	3		3	2		2	2	
CO-3	3	3	3	2		2	2	
CO-4	3		3		2		2	
CO-5	3		3			2	2	

ADVANCE COMPOSITE MATERIALS

Semester: 2nd	**Credit: 3**					
Course Name: Advance Composite Materials	**L**	**T**	**P**	3	0	0

Course Objectives:

1. Provide knowledge on advanced composite materials, its properties and application.
2. Provide knowledge on fabrication techniques of composite materials.

Syllabus Content

Module 1:

Introduction, concept and definition of composite materials, classification, advantages and limitations, scope and applications of composite materials

Module 2:

Study of parameters like composite matrix, reinforcing materials with respect to their structure, properties and manufacturing methods.

Module 3:

Manufacturing techniques of composites such as vacuum bagging, filament winding, resin transfer, pultrusion, CVD, PVD etc.

Module 4:

Study of structural, thermal, mechanical, physical, chemical and environmental characterization of composites and also their respective properties.

Module 5:

Application and degradation of composites

Module 6:

Study of natural composites and laminates

Text Books:

i. Matthews F.L ; Composite Materials Engg. & Science; Chapman & Hall, 1996.
ii. Composites-ASM Vol.I (10th Edition), ASM Internationals, 1995.
iii. Holliday L.; Composite Materials; Elseveis Publishing Co.; 1966.
iv. Chawala C.K., Composite Materials; Springer Publishing Co., 1987
v. Prasad R.C. & P. Ramakrishnan, Composite Science & Technology; New Age International, 2000.

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Analyze the influence of matrix, reinforcements on structure, properties and manufacturing methods of composites.	**1,2**
2	Identify the suitable composite fabrication techniques for manufacturing composites	**3**
3	Develop and characterize the physical, thermal and mechanical and environmental properties of composite materials.	**4**
4	Present a technical seminar on advance composite materials and its applications	**1-5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3		3	3			3	
CO-2	3				3			3
CO-3	3		3	2	3		3	3
CO-4		3	3					

POWDER METALLURGY

Semester: 2nd	Credit: 3					
Course Name: Powder Metallurgy	**L**	**T**	**P**	3	0	0

Course Objectives:

1. To provide knowledge of powder production techniques to students.
2. To provide knowledge on powder compaction and sintering techniques.

Syllabus Content

Module 1:

Status of PM industries in India, advantages / disadvantages of PM techniques.

Module 2:

Powder production involved by comminution of solid metals like machining, crushing, milling etc. Powder production by pulverising molten metals, Physical methods of powder production, Chemical process of producing powder

Module 3:

Powder Characterization &Treatments: Thermal and mechanical treatments given to powders. Testing and evaluation of following characteristics of powder - particle size, shape & size distributions, surface topography, surface area, shape factors, apparent and tap density; mass and volume flow rates, compressibility and compression ratio etc.

Module 4:

Compaction techniques -Pressures and pressure - less compaction methods, die compaction (single / double / multiple action); reflex action, rotary compaction; isostatic compaction; rolling / forging / extrusion as techniques of compaction; vibratory compaction, continuos compaction; high energy rate following techniques; slip casting, green compact density, laminations and their control, hot pressing, explosive compaction.

Module 5:

Sintering, Powder Metallurgy Applications

Text Books:

i. Khanna A.K.; Powder Metallurgy.

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Understand and identify powder production techniques based on need.	**1,2**
2	Characterize and treat powder	**3**
3	Compaction and consolidation based on principles learnt	**4**
4	Analyzing mechanism involved in sintering process	**5**
5	Prepare and present a technical seminar based on current trends in powder metallurgy	**1-5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1
CO-1	2		2		2		2
CO-2	2		3	2		2	
CO-3	2		3		2		2
CO-4	3		3	2		2	
CO-5		3					

DEFORMATION BEHAVIOR OF MATERIALS

Semester: 2nd	**Credit: 3**					
Course Name: Deformation Behavior of Materials	**L**	**T**	**P**	3	0	0

Course Objectives:

1. To impart knowledge on elastic and plastic of materials

Syllabus Content

Module 1:

Elastic and Plastic behaviour of Materials, Engineering Stress – strain curve.flow curve, Important relations of flow curve. Concept of stress and strain in two dimensions. Principal stresses, Mohr's circle, Yield Criteria.

Module 2:

Mechanistic models for elastic, plastic and time-dependant deformation, phenomenological description of plastic deformation in metals – slip, twinning, stacking faults etc. , strengthening mechanisms, deformation modes and mechanisms for polymeric and ceramic materials.

Module 3:

Fatigue of engineering materials, S-N Curve, Characteristics of fatigue fracture, Evaluation of fatigue behavior, mechanical and metallurgical aspects of fatigue life. High temperature deformation of materials, creep, analysis of creep curve, structural changes during creep, deformation mechanism maps.

Module 4:

Fracture of materials, types, effect of notch, structure and temperature, concept of toughness and fracture toughness, preliminary concept of LEFM and PYFM, strain energy release rate, stress intensity factors, Fracture toughness, and design.

Module 5:

Toughening mechanisms in various materials.

Text Books:

i. Mechanical Metallurgy, G. E. Dieter
ii. Mechanical Behavior of Materials, T.H. Courtney
iii. ASM Handbook Vol. 14.; Forming & Forging, ASTM

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Appreciate and understand the phenomenon of elastic deformation	**1**
2	Analyze stress and strain at any point	**1**
3	Understand the significance of empirical tools like yield criteria and their application	**1, 2**
4	Understandthe phenomena occurring during plastic deformation of metals/alloys	**3, 4**
5	Co-relate the structure-property-co relationship during deformation	**4, 5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2	-	-	3			3	
CO-2	3	-	3	3			3	
CO-3	2	-	2		2			
CO-4	2	-	2	3				
CO-5	3	-	3				3	

ALLOY AND SPECIAL STEELS

Semester: 2nd	**Credit: 3**					
Course Name: Alloy and Special Steels	**L**	**T**	**P**	3	0	0

Course Objectives:

1. To provide knowledge on phase diagram on alloy steels
2. To provide knowledge on physical metallurgical aspects of alloy steel.

Syllabus Content

Module 1:

Classification and Specification of Alloy Steels. Effect of Alloying Elements on the Constitution, Structure and Properties of Steels.

Module 2:

Study of Phase Diagrams of Fe with Commonly used Alloying Elements. Low Alloy Structural and Engineering Steels, High Strength Low Alloy Steels, Dual Phase Steels.

Module 3:

Alloy Tool Steels, Classification, Fundamental Properties, Role of Alloying Elements, Various Carbides. Detailed Study of High Speed Steels, High Carbon High Chromium Steels, Selection of Tool Steels.Stainless and Heat Resistant Steels – Classification and Specifications.

Module 4:

Constituents Phase Diagrams, Precipitation Hardenable Steels.Maraging Steels – Special Properties, Alloying Elements, Heat Treatment and Applications.

Module 5:

Magnetic Steel, Classification, Heat Treatment Properties and Applications. Spring Steels Processing and Heat Treatment.

Text Books:

i. Physical Metallurgy, S. Avner
ii. Physical Metallurgy Principles- R. Reed-Hill
iii. Physical Metallurgy of Stainless Steel- F.B Pickering

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Interpret the phase diagrams of alloy steels	**1,2**
2	Interpret the properties based on physical metallurgical aspects of alloy steel	**3**
3	Analyze and interpret the micro structural changes during heat treatment of different alloy steels	**4,5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1			3	3				
CO-2			3				3	
CO-3			3	3			3	

BIO MATERIALS

Semester: 2nd	**Credit: 3**					
Course Name: Bio Materials	**L**	**T**	**P**	3	0	0

Course Objectives:

1. To impart knowledge on various types of Biomaterials and its applications

Syllabus Content

Module 1:

Introduction- Classification-General Characteristics-Structure & Properties of Materials-Relevance – Crystal/Molecular Structure-Imperfections-Phase Diagrams.

Module 2:

Implant Materials-Metallic, Ceramic, Polymer, Composite

Module 3:

Characterization of Biomaterials-Mechanical, Chemical, Thermal, etc.Structural evolution of biocompatibility with reference to corrosion. Structural property correlation

Module 4:

Application of Biomaterials-Orthopaedic, Dentistry, Cardiac Devices, etc.Tissue Engineering- Soft Biomaterials

Module 5:

Case Studies, Proliferation of Biomaterials for development of Medical Technology & mankind.

Text Books:

i. Biomaterials- Sujata Bhat
ii. Handbook of Materials Behaviour Models, Vol.3- Multiphase Behaviour
iii. Biomaterials- Artificial organs & Tissue Engineering (Handbook)
iv. Science & Engineering of Materials- D.R. Askeland
v. Light Alloys- Polmear

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Understand broad outline on bio materials	**1,2**
2	Characterize biomaterials based on knowledge learnt	**3**
3	Understand the aspects of tissue engineering	**4**
4	Write/ present technical presentation based on case study / literature review	**5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2			2				
CO-2	2			3			3	
CO-3	2					3		
CO-4		3						

CORROSION PROCESS AND CONTROL

Semester: 2nd	**Credit: 3**					
Course Name: Corrosion Process and Control	**L**	**T**	**P**	3	0	0

Course Objectives:

1. To provide students importance of corrosion studies.
2. To provide students better understanding on different forms of corrosion and its protection methods.

Syllabus Content

Module 1:

Introduction to corrosion with historic and industrial cases, cost of corrosion, importance of corrosion studies, Thermodynamic aspect of corrosion reaction, Nerst equation, basic wet corrosion, electrode potential, potential Ph diagram, kinetics of corrosion reactions, Butler-Volmer equation, mixed potential theory, immunity, problems based on the theory.

Module 2:

Types of corrosion-recognition and mechanisms- uniform corrosion-galvanic-pitting, dealloying-crevice corrosion-intergranular corrosion-filiform corrosion- impingement attack-cavitation-fretting-corrosion cracking process.

Module 3:

Corrosion measurements-methods of measurement of corrosion based on study of various ASTM standards for corrosion-weight loss-electrochemical-electrical-thickness.

Module 4:

Corrosion protection-principles of different methods of corrosion protection, anodic protection, cathodic protection-protective coatings.

Text Books:

i. Rajnarayan, An introduction to metallic corrosion and its prevention, New Delhi, Oxford & India Bank House-1983.
ii. Banerjee S. N., An introduction to Science of Corrosion & its inhibition, 1983.
iii. Fontana M.G. Green N.D., Corrosion Engineering , New York, McGraw Hill Publication
iv. Uhlig H.H, Corrosion Handbook (ASM) Vol.3.01

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Analyze the corrosion process and identify the type of corrosion.	**1, 2**
2	Evaluate the corrosion based on ASTM standard	**3**
3	Analyze the kinetics of electrochemical corrosion	**3**
4	Suggest appropriate corrosion protection techniques based on principle understanding	**4**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2				2			2
CO-2	2		3		2			2
CO-3			3		2			2
CO-4	3							

ADVANCED CERAMICS

Semester: 2nd	**Credit: 3**					
Course Name: Advanced Ceramics	**L**	**T**	**P**	3	0	0

Course Objectives:

1. To provide overview of advanced ceramic materials and its fabrication techniques.
2. To provide overview on processing of functional ceramics.

Syllabus Content

Module 1:

Background, Classification – Traditional v/s advanced ceramics, Spectrum of applications.

Module 2:

Novel processing techniques – Powder synthesis routes, consolidation/shaping techniques, advanced sintering techniques (Spark plasma sintering, microwave sintering), thin films**.**

Module 3:

Processing and properties of advanced ceramics – Oxide Ceramics - alumina, zirconia, titania, ceria Non-Oxide Ceramics - silicon carbide, silicon nitride.

Module 4:

Materials, structure, processing of functional ceramics: Electro ceramics, Bioceramics, Ultra-high temperature ceramics, Magnetic ceramics.

Module 5:

Glass ceramics – Synthesis, Processing, applications.

Text Books:

i. Modern ceramic engineering, Taylor and Francis, D.W. Richerson
ii. Ceramic materials, B. Carter and G. Norton
iii. Sintering theory and practice, R.M. German
iv. Powder metallurgy and particulate materials processing, R.M. German.

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Fabricate/identify the novel techniques of processing powder, consolidation and sintering	**1,2**
2	Process oxide and non-oxide ceramics based on knowledge learnt	**3**
3	Process functional ceramics / glass ceramics	**4,5**
4	Prepare and present with respect to advanced cermics	**1-5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2		2		2			2
CO-2			3		2			2
CO-3			3		2			2
CO-4		3	3					

FAILURE ANALYSIS OF ENGINEERING MATERIALS

Semester: 2nd	**Credit: 3**					
Course Name: Failure Analysis of Engineering Materials	**L**	**T**	**P**	3	0	0

Course Objectives:

1. To provide knowledge on techniques of failure analysis
2. To provide knowledge on failure analysis associated with metallurgical parameters.

Syllabus Content

Module 1:

Techniques of failure analysis Stage of analysis, procedural sequence, collection of background data, classification of various failure needs, preparation of questionnaire, review of mechanical testing methods used in failure analysis, review of NDT method and their application in failure analysis

Module 2:

Classification of fatigue and fracture modes, fractography and preparation of samples for fractography. Distortion failure, residual stress in engineering components, ductile and brittle fractures, fatigue fractures, Fundamentals of fracture mechanics; Casting / Welding related failures, Metallurgical failure in cast products and weldments ,Corrosion related failures. Practical examples and case studies, Elevated temperature failures. Creep Mechanism, Elevated temperature fatigue, Thermal fatigue, Metallurgical Instabilities, Environmentally induced failures.

Module 3:

Wearrelated failure: Wear types, Contact stress fatigue prevention methods. Subsurface origin and surface origin fatigue; Sub-case origin, cavitation fatigue, Case Studies on : (Metallurgical aspects) Failure of Shaft, bearings etc ,Failure of Mechanical fasteners ,Failure in Pressure vessels, Failure in Welded structure, Failure of gears, Advanced experimental techniques in failure analysis.

Text Books:

i. Bob Ross; Investigating Mechanical Failures; Chapman & Hall (1st Edition), 1995.
ii. Wulpi D.J; Understanding How Components Fail; (2nd Edition), 1999.
iii. Collins J.S.; Failure of Materials in Mechanical Design; A Wiley Interscience Publications, (2nd Edition), 1993.
iv. ASM; Failure Analysis; the British Engine Technical Reports, 1981.

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome	Module Covered
1	Perform failure analysis based on procedure stated	**1**
2	Perform failure analysis associated with metallurgical parameters	**2**
3	Perform analysis on wear related failures	**3**
4	Perform failure analysis on pressure vessels, welded structure,etc. and submit report	**1-3**

CO-PO Mapping(Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2			2				
CO-2	3			2			2	
CO-3	3			2				
CO-4		3		2				

WELDING AND JOINING

Semester: 2nd	Credit: 3					
Course Name: Welding and Joining	**L**	**T**	**P**	3	0	0

Course Objectives:

1. To provide basic knowledge on materials joining to the students.
2. To provide knowledge on welding metallurgy, welding defects, etc.

Syllabus Content

Module 1:

Introduction to welding and joining, classification of welding processes on the basis of technological factors, welding and allied processes, power density and welding processes etc. Soldering and Brazing: Principle, advantages, limitations, tools, types of solder, soldering techniques. Adhesive bonding: Principle, surface preparation and curing, methods of application, types, failure etc.

Module 2:

Physics of welding arc: welding arc and electron emission mechanism, zones in welding arc, electrical fundamentals of welding arc, arc initiation, arc characteristics, temperature of the arc, arc forces and their significance on welding, effect of electrode polarity, cleaning action, arc efficiency, mode of metal transfer-globular, short circuit, spray and dip transfer.

Module 3:

Scope, working principle, process parameters, electrode/consumables, shielding mechanism, instrument details, advantages, limitations, applications and standards and specifications of (i) various conventional fusion welding processes like gas welding, shielded metal arc welding, gas metal arc welding, gas tungsten arc welding, plasma arc welding, submerged arc welding, electroslag welding, carbon arc welding etc. (ii) Advanced welding techniques like laser beam welding, electron beam welding (iii) Variant welding techniques like a) Activated TIG- effect of surface active elements, Marangoni convection mode b) Magnetic impelled arc butt welding, pulsed TIG and MIG welding c) cold metal transfer welding. Issues and challenges in welding processes.

Module 4:

Solid state welding: pressure welding, ultrasonic welding, diffusion welding, explosive welding, friction welding and friction stir welding: heat generation, parameters, zones, tools, defects etc.

Module 5:

Computational welding mechanics : Analysis of heat flow, cooling rates, models for welding heat source, heat transfer, fluid flow, influence of surface active elements, analysis of stress and strain in welding, thermal cycle etc. (Numerical)

Module 6:

Welding metallurgy: Chemical reactions, distortion, solidification, weld microstructure, phase transformation, solidification cracking, post weld heat treatment of weld joints etc.

Module 7:

Welding and Joining of non-metals : plastic welding, ultra short pulse laser welding, laser transmission welding, glass and ceramic welding, biocompatible plastic to metal welding, metal printing, joining of dissimilar material combinations, microjoining and nanojoining, additive manufacturing, 3d printing, transient liquid phase bonding.

Text Books:

i. Littile R; Welding & Welding Technology; McGraw Hill, 2002.
ii. Gibson SW; Advanced Welding, MacMillan Press.
iii. Parmar RS; Welding Engineering and Technology, Khanna Publishers, Delhi

Reference Books:

i. 1.Joining of Materials and Structures by Robert W. Messler, Jr. – Elsevier (Butterworth-Heinemann)
ii. Joining of Advanced Materials byMessler and Savage - Elsevier (Butterworth-Heinemann)
iii. Welding Metallurgy by Sindo Kou – A John Wiley and Sons Inc. Publication

Course Outcomes

At the end of the course, students will be able to understand

CO-No.	Course Outcome	Module Covered
1	The broad outline on different types of welding and joining process based on learning	**1,3**
2	Physics of welding arc	**2**
3	Welding metallurgy	**6**
4	Welding defects and remedies	**4**
5	Heat transfer during welding	**4**
6	Perform computational welding mechanics	**5**

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	2			2				
CO-2	2			3				
CO-3	3			2				
CO-4	2			3				
CO-5	3			2				
CO-6	3			3				

DEFECT IN CRYSTALLINE MATERIALS

Semester: 2nd	**Credit: 3**					
Course Name: Defect in Crystalline Materials	**L**	**T**	**P**	3	0	0

Course Objectives:

1. To provide knowledge on defect in crystalline materials.

Syllabus Content

Module 1:

Point Defects: Equilibrium Point Defect Concentrations, Intrinsic/Extrinsic Point Defects, Diffusion, Impurity Diffusion.

Module 2:

Line Defects: Introduction to Dislocations, Elements of Elastic Theory, Stress Field of a Dislocation, Strain Energy of a Dislocation, Line Tension, Forces on Dislocations, Forces Between Dislocations, Dislocation Reactions, Dislocations in FCC Crystals, Dislocations in Other Crystal Systems, Dislocation Multiplication, Strength of Crystalline Solids.

Module 3:

Planar Defects: Twin Boundaries, Stacking Faults, Grain Boundaries Interface Boundaries.

Text Books:

i. Hull D. and Bacon D.J., Introduction to Dislocation, 5th ed., Butterworth-Heinemann, 2011.
ii. Kelly A. and Groves G.W., Crystallography and Crystal defects, Addison – Wesley, 2000.
iii. Shewmon P., Diffusion in Solids, A Publication of the Minerals, Metals & Materials Society, 1989.
iv. Weertman J. and Weertman J. R., Elementary Dislocation Theory, Oxford, 1992.
v. Hirth J.P., Theory of Dislocations, 2nd edition, A Wiley-Interscience Publication, 1982.

Course Outcomes

At the end of the course, students will be able to understand

CO-No.	Course Outcome	Module Covered
1	Gain basic understanding on the types, structures, formation mechanisms and physical effects of various kinds of crystal defects	**1-3**
2	To interpret various physical, thermal and mechanical features being observed in actual crystalline solids in terms of defect effects in addition to idealized bulk behaviours,	**1-3**
3	Get fundamental knowledge on the microstructures and mechanical behaviours of engineering materials	**1-3**

CO-PO Mapping

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3			3			2	
CO-2			3	3			3	
CO-3	3			3			2	

THIRD SEMESTER
PROJECT AND THESIS – I

Semester: 3rd	**Credit: 12**					
Course Name: Project and Thesis – I	**L**	**T**	**P**	0	0	0

Course Objectives:

1. To provide the opportunities to the student to demonstrate and develop concept/project in the respective Engineering Domain
2. To enable a student to work in cutting edge research problems in harmony.
3. To inculcate the practice of carrying research with ethics and safety.

Course Outcomes

At the end of the course, students will be able to

CO-No.	**Course Outcome**
1	Intensive literature survey and identify the research problems related to Material Science and Engineering.
2	Communicate and discuss research ideas
3	Develop a systematic model/approach to analyze and solve the research problems.
4	Outline the past, present and expected outcome based on systematic survey.
5	Conduct preliminary experiments / theoretical evaluation to certain extent.
6	Summarize their survey, research problem identification, approach, ,expected outcome and attained results with interpretation by means of oral presentation and written reports

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PSO-1**	**PSO-2**
CO-1	3	-	3	3			3	
CO-2	3	2	3			3		
CO-3	3		3		3			
CO-4	3	3	3		3	3		
CO-5	3		3			3	3	3
CO-6	3	3	3			3	3	3

FOURTH SEMESTER
PROJECT AND THESIS – II

Semester: 4th	**Credit: 20**					
Course Name:Project and Thesis – II	**L**	**T**	**P**	0	0	0

Course Objectives:

1. To provide the opportunities to the student to demonstrate and develop concept/project in the respective Engineering Domain
2. To enable a student to work in cutting edge research problems in harmony.
3. To inculcate the practice of carrying research with ethics and safety.

Course Outcomes

At the end of the course, students will be able to

CO-No.	Course Outcome
1	Survey, approach, identify and demonstrate the research / industrial problems using various available modern tools and techniques
2	Develop and validate a systematic model/processtoanalyze and solve the research problems.
3	Outline the past, present and expected performance / outcome of a material / product / process / model / system(s) in Engineering domain in confirmation to the standard of safety and environmental, economicand ethical yardstick.
4	Conduct experiments and theoretical evaluation extensively
5	Analyze, summarize, inferbased on extensive research and communicate their chosen domain problems and result optimistically by means of oral presentation and written dissertation reports
6	Present and publish their findings as technical manuscript in technical conference/ indexed research journals ethically.

CO-PO Mapping (Rate: scale of 1 to 3)

Course Outcome	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	3	3	3			
CO-2	3	2	3		3	3	3	3
CO-3	3	3	3	3	3			
CO-4	3	2	3			3	3	
CO-5	3	3	3	3		3	3	3
CO-6	2	3	3		3			