B.Tech. Degree

in

METALLURGICAL AND MATERIALS ENGINEERING

SYLLABUS

FOR

CREDIT BASED CURRICULUM

(For the students admitted in 2014-2015)

Department of Metallurgical and Materials Engineering

NATIONAL INSTITUTE OF TECHNOLOGY

Tiruchirappalli - 620 015
TAMIL NADU, INDIA

CURRICULUM for B. Tech. (MME)

The total minimum credits required for completing the B.Tech. Programme in Metallurgical and Materials Engineering is 185 (45 +140)

SEMESTER III

CODE	COURSE OF STUDY	L	T	P	C
MA 205	Transforms and Partial Differential Equations	3	0	0	3
EC 219	Applied Electronics	2	0	2	3
MT 291	Strength of Materials	3	0	0	3
MT 293	Electrical, Electronic and Magnetic Materials	3	0	0	3
MT 207	Metallurgical Thermodynamics	3	1	0	4
MT 209	Mineral Processing and Metallurgical Analysis	3	0	0	3
MT 213	Physical Metallurgy	3	1	0	4
TOTAL		**20**	**2**	**2**	**23**

SEMESTER IV

CODE	COURSE OF STUDY	L	T	P	C
MA 202	Numerical Techniques	3	0	0	3
EE 220	Electrical Technology	2	0	2	3
IC 218	Instrumentation and Control	3	0	0	3
MT 208	Transport Phenomena	2	1	0	3
MT 210	Phase Transformation and Heat treatment	3	1	0	4
ME 292	Mechanical Technology	3	0	0	3
IC 220	Instrumentation and Control Laboratory	0	0	3	2
MT 216	Ferrous Metallography Laboratory	0	0	3	2
MT 222	Process Metallurgy Laboratory	0	0	2	1
TOTAL		**16**	**2**	**10**	**24**

SEMESTER V

CODE	COURSE OF STUDY	L	T	P	C
MT 301	Metal Casting Technology	3	0	0	3
MT 303	Iron and Steel Making	3	1	0	4
MT 305	Polymers and Composites	3	0	0	3
MT 307	Materials Joining Technology	3	0	0	3
MT 309	Mechanical Behavior of Materials	3	0	0	3
	Elective I (MME elective)	3	0	0	3
MT 331	Foundry and Welding Laboratory	0	0	3	2
MT 315	Mechanical Testing Laboratory	0	0	3	2
TOTAL		**18**	**1**	**6**	**23**

SEMESTER VI

CODE	COURSE OF STUDY	L	T	P	C
MT 304	Non-ferrous Extraction	3	0	0	3
MT 306	Particulate Processing	3	0	3	4
MT 308	Non-Ferrous Physical Metallurgy	3	0	0	3
MT 310	Metal Forming Technology	3	1	0	4
	Elective 2 (MME elective)	3	0	0	3
	Elective 3 (MME elective)	3	0	0	3
MT 314	Heat Treatment Laboratory	0	0	3	2
MT 316	Non-Ferrous Metallography Laboratory	0	0	3	2
MT 392	Industrial Lectures	1	0	0	1
MT 394	Internship / Industrial Training / Academic Attachment[#] (2 to 3 months duration during summer vacation)	0	0	3	2
TOTAL		**19**	**1**	**12**	**27**

[#] To be evaluated at the beginning of semester VII by assessing the report and conducting seminar presentation

SEMESTER VII

CODE	COURSE OF STUDY	L	T	P	C
MT 401	Ceramic Materials	3	0	0	3
MT 403	Corrosion Engineering	3	0	0	3
MT 405	Materials characterization	3	0	0	3
MB 491	Management Practices and Concepts	3	0	0	3
	Elective IV	3	0	0	3
	Elective V *	3	0	0	0
MT 409	Corrosion Engineering Laboratory	0	0	3	2
MT 411	NDT and Ceramics Laboratory	0	0	3	2
MT 447	Comprehensive Evaluation	0	3	0	3
TOTAL		**18**	**3**	**6**	**25**

SEMESTER VIII

CODE	COURSE OF STUDY	L	T	P	C
HM 402	Industrial Economics	3	0	0	3
	Elective VI	3	0	0	3
	Elective VII *	3	0	0	3
	Elective VIII *	3	0	0	3
MT 498	Project work	0	0	15	6
TOTAL		**12**	**0**	**15**	**18**

* **Student free to take local MME elective / other department elective / global elective**

LIST ELECTIVES

Metallurgy stream

CODE	COURSE OF STUDY	L	T	P	C
MT001	Fatigue, Creep and Fracture Mechanics	3	0	0	3
MT002	Special Steels and Cast Irons	3	0	0	3
MT003	Special Casting Techniques	3	0	0	3
MT004	Special topics in metal forming	3	0	0	3
MT005	Ladle Metallurgy & Continuous Casting of steels	2	1	0	3
MT006	Welding Metallurgy	3	0	0	3
MT007	Processing of Aluminium alloys	3	0	0	3
MT008	Design of Castings and Weldments	3	0	0	3
MT009	Thermodynamics of Solidification	3	0	0	3
MT010	Alloy Development	3	0	0	3

Materials stream (All electives open to Mechanical, Production and Chemical engineering students)

CODE	COURSE OF STUDY	L	T	P	C
MT021	Ceramic Processing	3	0	0	3
MT022	High Temperature Materials	3	0	0	3
MT023	Emerging Materials	3	0	0	3
MT024	Automotive Materials	3	0	0	3
MT026	Nano materials and applications	3	0	0	3
MT031	Biomaterials	3	0	0	3
MT032	Advanced Characterization Techniques	3	0	0	3
MT033	Materials for extreme environments	3	0	0	3

GLOBAL ELECTIVES

CODE	COURSE OF STUDY	L	T	P	C
MT041	Non Destructive Testing and Failure Analysis	3	0	0	3

MT042	Process Modeling and Applications	1	1	2	3
MT043	Computational Techniques	3	0	0	3
MT044	Design and Selection of materials	3	0	0	3
MT045	New Product Development	3	0	0	3
MT046	Introduction to Quality Management	2	1	0	3
MT047	Surface Engineering	3	0	0	3

ADVANCED LEVEL COURSES FOR B.Tech. HONOURS

CODE	COURSE OF STUDY	L	T	P	C
MT091	Advanced thermodynamics of materials	3	0	0	3
MT092	Advanced Solidification Processing	3	0	0	3
MT093	Crystallography	3	0	0	3
MT094	Aerospace Materials	3	0	0	3
MT095	Recent Developments in welding processes	3	0	0	3
MT096	Recent Developments in Forming Processes	3	0	0	3
MT097	Recent Trends in Nano materials	3	0	0	3
MT098	Economics of metal production processes	3	0	0	3

SUBJECTS OFFERED TO OTHER DEPARTMENTS

CODE	COURSE OF STUDY	L	T	P	C
MT082	Metallurgy for non-metallurgists	3	0	0	3
MT083	Physical Metallurgy and Heat Treatment	3	0	0	3
MT084	Deformation Processing	3	0	0	3
MT085	Manufacturing Methods	3	0	0	3
MT086	Testing and Evaluation of materials	3	0	0	3
MT087	Physics of Materials	3	0	0	3
MT088	Non-Metallic Materials	3	0	0	3

MA 205 TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS

L	T	P	C
3	0	0	3

Course objective: To develop the skills of the students in the areas of Transforms and Partial Differential Equations. This will be necessary for their effective studies in a large number of engineering subjects like heat conduction, communication systems, electro-optics and electromagnetic theory. The course will also serve as a prerequisite for post graduate and specialized studies and research.

Laplace Transform of Standard functions, derivatives and integrals – Inverse Laplace transform – Convolution theorem-Periodic functions – Application to ordinary differential equations and simultaneous equations with constant coefficients and integral equations.

Fourier series – Dirichlet’s conditions – Euler’s formula- Convergence and of Fourier series- Half range Fourier cosine and sine series - Parseval's relation – Complex form of Fourier series- Harmonic analysis.

Fourier transforms - Fourier integral theorem- Fourier cosine and sine transforms- inverse transforms - Convolution theorem and Parseval's identity for Fourier transforms - Finite cosine and sine transforms.

Formation of partial differential equations by eliminating arbitrary constants and functions - solution of first order equations - four standard types - Lagrange’s equation - homogeneous and non-homogeneous type of second order linear differential equation with constant coefficients.

One-dimensional wave equation and one-dimensional heat flow equation – Variable separable solutions- Fourier series solution.

Text Books

1. Grewal, B.S., Higher Engineering Mathematics, Khanna Publishers, Edn. 38, 2004.

2. Kandasamy, P. Thilagavathy, K. And Gunavathy, K., Engineering Mathematics, Vol. III, Chand and Company, 1996.

3. Venkataraman, M.K., Engineering Mathematics Vol.IV, National Publishing Company, 2004

Course outcome: Upon completion of this class, the student will be able to:

1. Apply knowledge of Laplace transformation, Convolution theorem and periodic function to ordinary differential and integral equations. [1, 5]
2. Analysis the different types of Fourier series and parseval’s relation and also understanding of Harmonic analysis. [1, 5]
3. Differentiate Half range and Finite cosine and sine transforms and application of Parseval’s identity and convolution theorem for Fourier transforms. [1, 5]
4. Identify the difference between the partial and linear differential equations and analysis through their four different types. Formation of Lagrange’s equation. [1, 5]
5. Define the formation of one dimensional wave equation and heat flow equation and their solutions. [1, 5, 11]

EC 219 APPLIED ELECTRONICS

L	T	P	C
2	0	2	3

Course objective: To provide the students with an insight into the theoretical and application aspects of rectifiers, filters, feedback circuits, amplifiers, converters and construction of devices like UJT, SCR, DIAC and TRIAC etc., to enable them to pursue further academic work in this field.

Halfwave and fullwave rectifiers - capacitive and inductive filters; regulation in rectifiers - concept of positive and negative feedback - effect of feedback Barkhausen criterion for oscillation, RC and LC oscillators, crystal oscillators

Inverting and non-inverting amplifiers, integrator, differentiator, multiplier, divider, comparator, V-I and I-V converter, D/A and A/D converters, types, sample and hold circuit

Multiplexers, demultiplexers, decoders and encoders - UJT, SCR, DIAC, TRIAC - construction, characteristics and applications; stepper motors and their performance.

TEXT BOOK

1. *Jacob Millman, Halkias C.C., 'Integrated Electronics : Analog and Digital circuits and systems', TMH, 1996*

List of Experiments

1. Characteristics of PN Junction diode
2. Characteristics of Zener diode
3. Inverting and Non Inverting operational amplifiers
4. Study of logic gates
5. Multiplexers and De-Multiplexers

Course outcomes: Upon completion of this class, the student will be able to:

1. Design and studies of different kind of rectifies, filters, feedback circuits and oscillators, as well as analyze and interpret their input and outputs for the utilization in different devices. [1, 2]
2. Design and studies of different types of amplifiers, converters and their contributions in various circuits. [1, 2]
3. Construction and analysis of multiplexers, demultiplexers, decoders and encoders. [1, 2, 11]
4. Construction of UJT, SCR, DIAC, TRIAC and analysis of their characteristics. Also analysis of Stepper motor performance using combination of circuits. [1, 2, 11]

MT 291 STRENGTH OF MATERIALS

L	T	P	C
3	0	0	3

Course objective: The objective is to determine the stresses, strains on various structural object, displacements in various structures and their components under the specific external loads such as axial load, bending and shear load as well as torsion.

Elastic limit - Hooke's law - Poisson's ratio - Bar of uniform strength - Equivalent area of composites sections - temperature stresses - Hoop stress - Volumetric strain - stresses due to different types of axial loading - Gradually and Impact loads.

Stresses on an incline plane – principle stresses - thin cylinders - Circumferential and longitudinal stresses - Wire bound pipes - Thin spherical shells - Biaxial stresses doubly curved walls of pressure vessels

Beams – types - Shear forces and bending moment diagrams. Bending - Theory of simple bending - Practical application of bending equation - Section modulus - Shear stress distribution on a beam section

Center of gravity - centroid of a uniform lamina - centroids of lamina of various shapes - Moment of an Inertia of a lamina - definition - Parallel axes theorem - Perpendicular axes theorem - Moment of Inertia of lamina of different shapes

Pure torsion - Theory of pure torsion - Torsional moment of resistance - Power transmitted by a shaft - Torsional rigidity - Stepped shafts - Keys - couplings - Shear and Torsional resilience- Shafts of non-circular section - Close coiled helical springs

TEXT BOOKS

1. *Rajput R. K., 'Strength of Materials', S. Chand, 1996*
2. *Ramamrutham S., 'Strength of Materials', 8th Edition, Dhanapat Rai, 1992*

REFERENCES

1.Ramamrutham S and R. Narayanan, "Strength of Materials', 7th Edition, 1999

2.Strength of Materials, R.K. Bansal, Laxmi Publications.

Course outcomes:

1. Understand the different types of material behaviour such have elastic, plastic, ductile and brittle [1, 2]
2. Study the fundamental mechanics of solid deformable bodies. [1, 5, 11]
3. Use the concept of moment of inertia of lamina for different shapes [1, 5]
4. Able to solve the numerical and practical problems related to real world strength of materials [1, 5, 8]

MT 293 ELECTRICAL, ELECTRONIC AND MAGNETIC MATERIALS

L	T	P	C
3	0	0	3

Course objective: To understand the basic principles and physical origins of electronic, magnetic & optical properties of materials and to study the various materials which exhibit these functional properties*.*

Free electron theory - Band theory - discussion on specific materials used as conductors - Dielectric phenomena - concept of polarization- frequency and temperature dependence - dielectric loss - dielectric breakdown - ferro electricity - piezo electricity and pyro electricity – $BaTiO_3$ – structure and properties.

Origin of Magnetism - Introduction to dia, para, ferri and ferro magnetism – Curie temperature – Magnetic anisotropy - hard and soft magnetic materials- iron based alloys - ferrites and garnets – rare earth alloys - fine particle magnets.

Concept of superconductivity – BCS theory of super conductivity – Types of super conductors –YBCO- structure and properties – specific super conducting materials – Fabrication and engineering applications.

Semiconducting materials and types; simple, compound and oxide semiconductors – semiconducting materials in devices – Production of silicon starting materials – methods for crystal growth for bulk single crystals- zone melting – Czochralski method – Epitaxial films by VPE, MBE and MOCVD techniques – Lithography

Principles of photoconductivity, luminescence- - photo detectors – Optical disc and optoelectronic materials –LCD, LED and diode laser materials - electro optic modulators - Kerr and Pockel's effect – $LiNbO_3$.

TEXT BOOKS

1. *Kittel C., 'Introduction to Solid State Physics', 7th Edition, Wiley Eastern, New International Publishers, 2004*
2. *Dekker A. J., 'Electrical Engineering materialsPrentic Hall, 1995*
3. *Ed. Kasap and Capper, handbook of electronic and photonic materials, 2006, NY.*

REFERENCES

1. Dekker. A.J, Solid state Physics, Mac Millan India, 1995

2. Van Vlack L.H, Elements of Materials Science and Engineering, 6th edition,Addison Wiley, 1989

3. Raghavan V, Materials Science and Engineering – A First Course, Prentice Hall India, 2004.

Course outcomes:

1. To understand the band gap theory for conducting, semiconducting and insulating materials. To understand various electrical phenomenon such as ferro electricity, piezo electricity and pyro electricity along with dielectric behaviour of materials [a].
2. To study various kinds of magnetism principles, various types of materials exhibiting magnetism and their day to day applications in industrywith recent advancements [1, 2, 5].
3. To study the theory of superconductivity phenomenon and superconducting materials and their applications along with recent advancements [5, 8].
4. Understand the fundamentals of semiconducting materials and operational principles of solid state devices made of these semiconducting materials. To learn various methods of producing semiconductors and their processing methods used in the semiconducting materials industry [2, 11].
5. To learn about photoconduction phenomenon, optical materials and various optical devices and their performances [1].

MT 207 METALLURGICAL THERMODYNAMICS

L	T	P	C
3	1	0	4

Course objective: To learn the basic principles and concepts of thermodynamics, in the domain of metallurgy and materials; and to learn about equations and their applications; and to appreciate that metallurgical thermodynamics is a knowledge base with abundant applications.

Types of system, state of a system, state properties - First law of thermodynamics; heat of reaction, heat of formation, standard heats, heat of transition; Hess's law of heat summation.
Second law, entropy of irreversible processes,combined statements of 1^{st} and 2^{nd} laws - Maxwell's relations, Clausius - Clapeyron equation, Trouton's rule, Gibb's - Helmholtz relations.
Third law of thermodynamics, relation between C_P and C_V, Nernst heat theorem, equilibrium constant, Van't Hoff equation, concept of fugacity, activity, mole fraction.
Thermodynamics of solutions, Gibb's Duhem equation, partial molar properties of mixing, concept of chemical potential, ideal solution, Raoult's law,Henry's law; non ideal solution, excess functions, regular solutions.
Sievert's law - residual gases in steel –properties and functions of slags, slag compositions, structure of molten slags, molecular theory, concept of basicity index, ionic theory; thermodynamics of slag-metal reactions.
Numerical problems on the concepts mentioned in all the above units.

TEXT BOOKS

1. *Tupkary R.H., 'Introduction to Metallurgical Thermodynamics', 1st Edition, TU Publishers, Nagpur, 1995*
2. *Upadhyaya G.S., Dube R.K., 'Problems in Metallurgical Thermodynamics and Kinetics', 1st Edition, Pergamon Press, 1977*

Course outcomes: Upon completion of the course, the student will be able to:

1. Understand the basic laws of thermodynamics [1, 2]
2. Understand the multiple approaches to thermodynamics, from the bulk property point of view and from the atomistic point of view [1]
3. Understand concepts such as the theory of solutions, free energy, entropy, criteria for equilibrium and conditions for feasibility [1, 2]
4. Obtain the skill to use metallurgical thermodynamic concepts and equations for understanding phase diagrams, phase transformations, theory of solutions [11, 5]
5. Obtain problem solving skills in order to improve / modify industrial processes, esp. In extraction metallurgy, liquid metal treatment and in heat treatment [1, 2, 11, 8]

MT 209 MINERAL PROCESSING AND METALLURGICAL ANALYSIS

L	T	P	C
3	0	0	3

Course objective: Theoretical aspects of common mineral processing techniques and the associated equipment used in mining and pre-extraction practices.

Principles of combustion, testing of fuels, - Coal - Manufacture of metallurgical coke and its properties -typical energy consumption in metallurgical processes, overview of different raw materials (including fluxes) in metals processing

Physical properties of minerals, physical and chemical characteristics of industrial minerals such as magnetite, haematite, galena, chalcopyrite, azurite, sphalerite, monazite, cassiterite, chromite, bauxite and ilmenite ; economics of ore processing;

Chemical processing of ores - leaching ,ion-exchange and liquid- solvent extraction; crushing and grinding – types, washing, sorting and hand-picking; laboratory and industrial screening classifiers, mechanical and hydraulic; sedimentation principles

Concentration by jigs, tables, heavy media separation, froth floatation, magnetic and electrostatic separation, thickeners and filters; use of flow sheets (specific examples from metals processing), wet and dry sampling,

Principles of chemical analysis, - ores, metals, alloys, non-metallics, details of specific chemical analysis techniques, introduction to common analysis techniques used in metallurgical industries (spectrovac and spot testing)

TEXT BOOKS

1. *Gupta O. P., ' Elements of Fuels, Furnaces and Refractories', 2nd Edition, Khanna Publishers, 1990*
2. *Gaudin A.M., 'Principles of Mineral Dressing', 1st Edition, TMH, 1986*

REFERENCES

1. Gilchrist J.D., 'Extraction Metallurgy', 2nd Edition, Pergamon Press, 1980

2. Joseph Newton, 'Extractive Metallurgy', 1st Edition, Wiley Eastern, 1967

3. Vogel A.I.,'A TextBook of Quantitative Inorganic Analysis', 3rd Edition, ELBS, Longman, 1978

Course outcomes: Attending this course, students will be capable to:

1. Understand the mineral processing basic principles [1, 2]
2. Describe the physical and chemical properties of various minerals [1, 2]
3. To know and understand the various separation methods of mineral or gangue particles [2]
4. To know the common analysis techniques used in metallurgical industries [8, 11]
5. Explain the various types of process control in mineral processing [1]
6. To study about the different ores for different materials [1, 11]

MT 213 PHYSICAL METALLURGY

L	T	P	C
3	1	0	4

Course objective: To develop an understanding of the basic principles of physical metallurgy and apply those principles to engineering applications.

Crystallography - co-ordination number, effective number of atoms, packing factor, crystal system relevant to metals, indexing of crystal planes and directions in cubic and hexagonal system, linear and planar density, interplanar spacing

Crystal imperfections and its types; point defects, dislocations - unit dislocation, partial dislocation, motion of dislocations, slip and twin crystal orientation, concept of texture, grain and grain boundaries, methods of grain size determination,

Self-diffusion, diffusion in alloy, diffusion mechanisms, activation energy, laws of diffusion- Fick's I law, II law, inter-diffusion and Kirkendall effect, types of diffusion and examples of diffusion; problems based on diffusion

Solid solutions and its types and intermediate phases - Hume Rothery's rule - solidification of metals and alloys, cooling curves, concepts of phase diagrams, coring and segregation as applied to various binary systems, ternary systems.

Thermodynamic properties of binary metallurgical systems, free energy- composition curves and their relation to phase diagrams of different types; ternary phase diagram - Gibbs phase triangle.

TEXT BOOKS

1. *Reed Hill R.E., 'Physical Metallurgy Principles', 2nd Edition, Affiliated East West Press, 1973*
2. *Derek Hull, 'Introduction to Dislocations', Pergamon, 2nd Edition, 1981*

REFERENCES

1. Raghavan V., 'Physical Metallurgy - Principles and Practice', Prentice - Hall of India, 1993

2. Guy A.G., 'Elements of Physical Metallurgy', 3rd Edition, Addison Wesly, 1974.

Course outcomes: Upon completion of this class, students are expected to

1. Understand the geometry and crystallography of crystalline materials using Bravais lattices and Miller Indices [1, 2].
2. Define engineering materials technology and understand each stage of the materials cycle, material selection criteria [4, 6, 8, 9, 11]
3. Differentiate the four major families of materials and write the electron configuration for most elements. [1]
4. Select processing technologies for synthesizing and fabricating different materials [1, 5]
5. Describe the basic crystal structures (BCC, FCC, and HCP), recognize other crystal structures, and determine material microstructure using microscopes [1, 2]
6. Define various mechanical properties and the associated testing methods [1, 5, 11]
7. Analyse the microstructure of iron and steels using phase diagram and modify the microstructure and properties using different heat treatments [1, 5, 11]
8. Select different metallic materials for specific engineering applications [9, 11]

MA 202 NUMERICAL TECHNIQUES

L	T	P	C
3	0	0	3

Course objective: To develop the basic understanding of numerical algorithms and skills to implement algorithms to solve mathematical problems on the computer.

Solution of linear system - Gaussian elimination and Gauss-Jordan methods - LU - decomposition methods - Crout's method - Jacobi and Gauss-Seidel iterative methods - sufficient conditions for convergence - Power method to find the dominant eigenvalue and eigen vector.

Solution of nonlinear equation - Bisection method - Secant method - Regula falsi method - Newton- Raphson method for f(x) = 0 and for f(x,y) = 0, g(x,y) = 0 - Order of convergence - Horner's method - Graeffe's method - Bairstow's method.

Newton’s forward, backward and divided difference interpolation – Lagrange’s interpolation – Numerical Differentiation and Integration – Trapezoidal rule – Simpson’s 1/3 and 3/8 rules - Curve fitting - Method of least squares and group averages.

Numerical Solution of Ordinary Differential Equations- Euler's method - Euler's modified method - Taylor's method and Runge-Kutta method for simultaneous equations and 2nd order equations - Multistep methods - Milne's and Adams’ methods.

Numerical solution of Laplace equation and Poisson equation by Liebmann's method - solution of one dimensional heat flow equation - Bender - Schmidt recurrence relation - Crank - Nicolson method - Solution of one dimensional wave equation.

TEXT BOOKS

1. *GERALD, C.F., and WHEATLEY, P.O., Applied Numerical Analysis, Addison Wesley.*

2. *JAIN, M.K., IYENGAR, S.R. and JAIN, R.K., Numerical Methods for Scientific and Engineering Computation, Wiley Eastern.*

REFERENCES

1. KANDASAMY, P., THILAGAVATHY, K., and GUNAVATHY, S., Numerical Methods, Chand and Company.

Course outcomes: Upon completion of this class, the student will be able to:

- Analyze a mathematical problem and determine which numerical technique to use to solve it from Gaussian, Gauss-Jordan, LU, Crout's, Jacobi and Gauss-Seidel iterative method. Determine the dominant eigenvalue and eigenvector through Power method. [1, 5]
- Understanding to find the solution of nonlinear equation through Bisection method, Secant method, Regula falsi method, Newton- Raphson method and for Order of convergence using Horner's method, Graeffe's method and Bairstow's method. [1, 5]
- Solve the interpolation, numerical differentiation and integration and understanding of curve fitting and method of least squares and group averages. [1, 5]
- Finding the solutions of ordinary differential equations through Euler's methods, and Taylor's method.
- Use of Runge-Kutta, Milne's and Adam's method to solve the differential equations. [1, 5]
- Involve Liebmann's method to solve the Laplace and Poisson equation, use of Bender, Schmidt recurrence relation, Crank and Nicolson methods for one dimensional wave equations. [1, 5]

EE 220 ELECTRICAL TECHNOLOGY

L	T	P	C
2	0	2	3

Course objective: To provide the students with a close look into the mechanism and application aspects of DC machines, Synchronous machines, and electrical heating equipments to enable them to pursue wide industrial knowledge.

DC machines : generators-motors- Characteristics - Speed control and starting of DC motors - Transformers - types, constructional features and principles of operation – Efficiency.

Synchronous machines : Characteristics and Voltage regulation of Alternator. Synchronous motors - starting. Induction motors : Torque - speed characteristics - speed control and starters - single phase Induction motors.

Electric heating- design, power and efficiency calculations, applications - Welding- resistance welding, arc welding and ultrasonic welding, DC and AC welding sets, applications.

TEXT BOOKS

1. *Theraja B.L., ‘ Electrical Technology’, Volume II, S.Chand, 1997*
2. *Gupta J.B., ‘ A Course in Electrical Power’, S.K. Kataria, 1996*

Course outcomes: Upon completion of this class, the student will be able to:

- Define various DC machines and enables for the trouble shooting capability in different kind of machineries. [1, 2, 11]
- Differentiate the Synchronous motors with the induction motor and single phase induction motor and their control. [1, 2, 11]
- Define the various electrical heating methods and their power and efficiency calculations. [2, 5, 11]
- Understanding the need of different type of welding methods for different applications. [1, 2, 11]

IC 218 INSTRUMENTATION AND CONTROL

L	T	P	C
3	0	0	3

Course objective: To develop the basic understanding of measurements using different tools and skills to implement knowledge of techniques to control the systems.

General concepts of measurements, static and dynamic characteristics, Introduction to calibration, calibration standards.

Temperature measurements: Measurement using expansion thermometers, thermocouples, Resistance temperature detectors, thermistors and optical pyrometers.

Measurement using strain gauges, Capacitive transducers, inductive transducers and Piezoelectric transducers. Introduction to pressure , level and flow measurements.

Basics of open loop and closed loop system, classification of variables,

ON/OFF, P, PI, PID controllers and their applications.

Introduction to Micro Processor and its architecture. Instruction sets. Introduction Programmable logic controllers and instruction sets.

TEXT BOOKS

1. *John P. Bentley., "Principles of Measurement Systems" 3rd edition, Addison Wesley Longman Ltd., UK, 2000.*
2. *Neubert H.K.P., "Intrument Transducers: An Introduction to their performance and Desisn, 2nd Edition Oxford University Press, Cambridge, 1999.*
3. *Ramesh Goankar, "Microprocessor architecture, Programming and applications, with the 8085/8080A", 3rd edition, Penram International Publishing house, 2002.*

REFERENCES

1. Patranabis, "Sensors and Transducers", Wheeler Publishing, 1999.

2. Doebelin E.O, " Measurement system-applications and design", 4th edition McGraw Hill New York 2003

Course outcomes: Upon completion of this class, the student will be able to:

1. Differentiate static and dynamic characteristics and calibration standards for measurements. [1]
2. Select the suitable temperature measurement method for the suitable condition. [1, 2]
3. Application of various transducers for direct contact and non-contact measurements. [2, 11]
4. Design and measurements of PC based methods, construction of interface devices. [2, 11]
5. Differentiate loops and variables and their effective applications in various situations. [1, 2, 11]

MT 208 TRANSPORT PHENOMENA

L	T	P	C
2	1	0	3

Course objective: To understand basic concepts related to heat flow, fluid flow, mass transfer, in the context of metallurgical processes; to become familiar with the mathematical treatment and equations related to above transport phenomena; to comprehend the science behind process modelling.

Fluid Flow - Viscosity – differential mass and momentum balances –overall momentum balance – mechanical energy balance – applications
Heat Transfer – heat conduction equation – applications – convective heat transfer – concept of heat transfer coefficient – radiative heat transfer
Mass Transfer - Diffusion: Diffusivity in gases, liquids, solids – convective mass transfer –concept of mass transfer coefficient
Dimensionless analysis – Rayleigh's method, Buckingham method – use of differential equations – similarity criteria – applications in physical modeling
Reaction Kinetics - Basic definitions & concepts – reaction mechanisms – reaction rate theories – slag–metal reaction

TEXT BOOKS

1. A.K. Mohanty, "Rate Processes in Metallurgy", PH India Ltd., 2000
2. B.R.Bird., 'Transport Phenomena', John Wiley, New York, 1994

REFERENCES

1.. Szekely J., Themelis N. J., 'Rate Phenomena in Process Metallurgy', Wiley, 1971

Course outcomes: Upon completion of the course, the student will be able to:

1. Understand the scientific aspects related to heat flow, fluid flow and mass transfer [1, 2]
2. Learn about related equations, in the above context [1, 2, 8, 10]
3. Understand how transport concepts and equations are used in the modelling of metallurgical processes [1, 2, 11]
4. Obtain the ability to convert actual (descriptive) processes into appropriate equations and then attempt to solve the same [1, 5, 8, 9, 10, 11]
5. Obtain the basic skills essential for process modeling [1, 11]
6. Obtain the ability to carry out complex process calculations [5, 8]

MT 210 PHASE TRANSFORMATIONS AND HEAT TREATMENT

L	T	P	C
3	1	0	4

Course objective: To study the phase changes that occurs during both thermal and thermo mechanical treatments.

Introduction and classification of phase transformations. Diffusion in solids: phenomenological approach and atomistic approach. Nucleation and growth theories of vapour to liquid, liquid to solid, and solid to solid transformations; homogeneous and heterogeneous strain energy effect during nucleation; interface-controlled growth and diffusion controlled growth; overall transformation kinetics. Principles of solidification, evolution of microstructures in pure metals and alloys. Precipitation from solid solution: types of precipitation reactions, crystallographic description of precipitates, precipitation sequence and age hardening, spinoidal decomposition.

Iron-carbon alloy system: iron-carbon diagram, nucleation and growth of pearlite, cooling of hypo-eutectoid, eutectoid, and hyper-eutectoid steels, development of microstructures in cast irons. Heat treatment of steels: TTT and CCT diagrams, bainitic transformation, martensitic transformation, hardenability, role of alloying elements in steels

Conventional heat treatment of steels. Massive transformation. Order-disorder transformation. Phase transformations in and heat treatment of some common non-ferrous metals and alloys

Types of furnaces and furnace atmospheres; quenching media; types of quenching, mechanism of quenching, quenching characteristics, choice of quenchants; surface hardening of steels-carburizing, nitriding, carbonitriding and others.. Various thermo-mechanical treatments; Designing for heat treatment, defects in heat treated parts, causes for the defects in heat-treated parts and remedies

TEXT BOOKS

1. *Raghavan V., 'Physical Metallurgy- Principles and Practical', Prentice Hall, 1983*
2. *Rajan T. V. 'Heat Treatment - Principles and Practice', 2nd Edition, Prentice Hall of India, 1996*

REFERENCES

1. *Avner S.H., 'Introduction to Physical Metallurgy', 2nd edition, Tata McGraw Hill, 1984*
2. *Lakhtin Y., 'Engineering Physical Metallurgy', 2nd Edition, MIR Publishers, 1979*
3. *Prabhu Dev K. H., 'Handbook of Heat Treatment of Steel', TMH, 1988*

Course outcomes: Upon completion of the course, the student will be able to:

- Describe the mechanisms responsible for atomic and molecular movements in condensed phases [1, 2]
- Understand the heat treatment of steels using TTT and CCT [1, 2]
- Determine the heat treatment conditions required to obtain a given microstructure using TTT diagrams [1, 2, 8, 11]
- Relate solid state atomic mobility to transport phenomena in materials [5, 8, 11]
- Understand the different kinds surface hardening of steels [2, 11]

ME 292 MECHANICAL TECHNOLOGY

L	T	P	C
3	0	0	3

Course objective: To develop an understanding of the basic principles of machine design and machining technology and apply those principles to engineering applications.

Machine design concepts

Material and manufacturing in design; materials selection; reliability based design; Stresses in simple machine members - axial, bending, torsional, bearing stress, Hertz contact stress; combined stresses, principal stresses

Design of machine elements-I

Modes of failure, Theories of failure. Endurance limit. Stress concentration. Factor of safety. design of structural machine elements subjected to various types of loads e.g Static loading, Impact loading, Bending, Torsional loading, Fatigue loading; Fracture mechanics

Design of machine elements-II

Design of springs and Material selection, Design of Bearings Material selection, Fundamentals of measurement technology

Machining Technology

Basic machine tools, Shaper, planner and slotter machines, Milling. Hobbing. Broaching. Grinding machines, Work holding and tool holding devices; Selection of cutting tools, Materials for cutting tools; Fundamentals of NC & CNC machine tools

Non-traditional machining technology

Introductive to unconventional machining processes. Abrasive jet machining, ultrasonic machining, abrasive water jet machining, abrasive flow machining, water jet machining, electro chemical machining, electro discharge machining. Electron beam machining, laser beam machining and plasma arc machining.

TEXT BOOKS:

1. *Shigley's Mechanical Engineering Design, Budynas and Nisbett, 8th Ed., McGraw-Hill, 2006*
2. *William C.Orthwein., 'Machine component design', Volume 2, Jaico publishing house.*

REFERENCES

1. *Charles E.Wilson., 'Computer integrated machine design', Prentice-Hall.*
2. *Robert L.Norton., 'Machine design- an integrated approach', Prentice-Hall, 1998.*
3. *C.V.Collett, A.D.Hope., 'Engineering measurements', Pitman publishing*.

Course outcomes: Upon completion of this class, the student will be able to:

- Explain the concepts and methods of designing and materials selection and classification of stresses in simple machine members. [2, 3]
- Define various failure modes, their endurance limit and their association with stress concentration. [1, 3]
- Design of structural machine elements subjected to various types of loads e.g Static loading, Impact loading, Bending, Torsional loading, Fatigue loading; and analysis of Fracture mechanics.
  [2, 11]
- Design of Springs and Bearings with appropriate materials selection associate with the fundamental measurements. [2, 5, 11]
- Design of Basic machine tools, such as Shaper, planner and slotter machines, Milling, Hobbing, Broaching, Grinding machines, Work holding and tool holding devices. [2, 5, 11]
- Design of cutting tools, Materials for cutting tools, and select NC & CNC machine tools. [2, 5, 11]
- Define the Non-traditional unconventional machining technology and design of various machines in this category. [2, 11]

IC 220 INSTRUMENTATION AND CONTROL LABORATORY

L	T	P	C
0	0	3	2

Course objective: To measure the basic mechanical parameters like strain, torque, load, displacement, pressure and temperature through the electronic and PC based methods.

List of Experiments

1. Measurement of strain using strain gauges.
2. Measurement of displacement using LVDT.
3. Measurement of pressure.
4. Measurement of temperature using RTD.
5. Measurement of temperature using TC.
6. Measurement of temperature using Thermistor.
7. Simple exercise on 8085 Microprocessor.
8. Simulation ON/OFF,P, PI, PID controller design using MATLAB.
9. Simple exercise based on PLC instructions.

Course outcomes: Upon completion of this class, the student will be able to:

1. Construct strain gauge to measure the strain and torque and analysis. [1, 2]
2. Construct a circuit to measure load, displacement using load cells and LVDT, respectively. [1, 2]
3. Design of pressure measurement device and analysis. [2, 11]
4. Construction and analysis of temperature measurement devices and their selections. [2, 11]
5. Construction and analysis of design of PD, PID and PLC control devices. [1, 2, 11]

MT 216 FERROUS METALLOGRAPHY LABORATORY

L	T	P	C
0	0	3	2

Course objective:

- To learn and to gain experience in the preparation of metallographic specimens.
- To examine and analyse the microstructures of carbons steels, alloy steels, cast irons and other ferrous materials.
- To understand the basic principles of optical microscopy
- To measure the grain size of materials

List of Experiments

1. Specimen preparation for metallographic observation - working of metallurgical microscope
2. Grain size measurements
3. Macro etching - cast, forged and welded components
4. Sulphur printing and phosphor printing
5. Microstructure cast iron - gray, nodular and malleable iron - unetched
6. Microstructure of gray, nodular and white iron – etched
7. Microstructure of iron, steel (low carbon, medium carbon, high carbon, hypo and hypereutectoid steels)
8. Microstructure of stainless steels and high speed steels
9. Over heated structure and banded structure in steels

Course outcomes:

1. After the completion of this laboratory course, the student is able to prepare the specimens for metallographic examination with best practice, can operate the optical microscope and understand, interpret, analyze the microstructures of all ferrous materials. [1, 2, 5, 11]

MT 222 PROCESS METALLURGY LABORATORY

L	T	P	C
0	0	2	1

Course objectives: To learn about the properties of minerals; to become familiar with equipment used in mineral processing, by means of experiments / demonstration of laboratory scale equipment

List of experiments:

1. Sieve analysis
2. Sedimentation and decantation
3. Determination of size distribution in sample
4. Jaw crusher
5. Bomb Colorimeter
6. Viscosity Measurement
7. Heavy medium separations
8. Froth floatation
9. Observations of mineral samples
10. Observations of furnaces

Course outcomes:

1. Obtain the skills for physical observation of minerals / ores [1, 2]
2. Obtain the ability to perform sieve analysis [2]
3. Obtain the ability to observe comminution and to perform related calculations [1, 2, 5]
4. Become familiar with mineral beneficiation operations [2, 8, 10, 11]

MT 301 METAL CASTING TECHNOLOGY

L	T	P	C
3	0	0	3

Course Objectives: To know the basic concepts of metal casting technology and to apply them to produce of new materials

Introduction to casting and foundry industry; basic principles of casting processes; sequence in foundry operations; patterns; moulding practice; ingredients of moulding sand and core sand, sand testing; different moulding processes

Types of furnaces used in foundry; furnaces for melting; melting practice for steel, cast iron, aluminium alloys, copper alloys and magnesium alloys; safety considerations; fluxing, degassing and inoculation

Sand casting, permanent mould casting, die casting, centrifugal casting, plaster mould casting, investment casting, continuous casting, squeeze casting, full mould process, strip casting

Overview of pouring and solidification, concept of shrinkage, Chvorinov's rule, chilling; gating systems, functions of riser, types of riser, bottom pouring and top pouring , yield calculations, visualization of mould filling (modeling), methoding

Concepts of solidification; directional solidification, role of chilling; filtration of liquid metals; consumables; details of inoculation and modification – with respect to cast irons and Al-Si system; casting defects; soundness of casting and its assessment

TEXT BOOKS

1. *Heine R. W., Loper C. R., Rosenthal P. C., ' Principles of Metal Casting',2nd Edition, Tata McGraw Hill Publishers, 1985*
2. *Jain P. L., ' Principles of Foundry Technology', 3rd Edition, Tata McGraw Hill, 1995*

REFERENCES

1. *Srinivasan N. K., 'Foundry Technology', Khanna Publications, 1986*

Course Outcomes: At the end of this course, the students would be able to:

1. Select the appropriate design of the moulds, patterns etc. [1, 3, 11]
2. Design a new pattern or mould for required applications, if needed [1, 8]
3. Choose the appropriate furnace for the production of new materials [3, 8]
4. Distinguish the casting microstructures for different materials [1, 9]
5. Alter the microstructure for different applications [4, 5]

MT303 IRON AND STEEL MAKING

L	T	P	C
3	1	0	4

Course objective: To know the importance of the Iron and Steel making and to apply them for the advancement of the production feasibilities in steel Industries to compete with the modern day manufacturing routes.

Classification of furnaces; different kinds of furnaces; heat balance, energy conservation and energy audit; parts, construction and design aspects of blast furnace, ancillary equipment; blast furnace instrumentation.

Blast furnace reactions; Gruner's theorem, carbon deposition, the partitioning of solute elements between the Iron and the slag; reactions in blast furnace; blast furnace slags; mass balance and heat balance

Blast furnace (B/F) operations; B/F irregularities and remedial measures, B/F refractories and causes of failure, modern trends in (B/F) technology overview of direct reduction processes, electric smelting; production of DRI (HBI/Sponge iron)

Review of traditional steel making; physical chemistry and thermodynamics; air/O_2 impurity interaction, slag metal interaction, role of slags in refining ,continuous casting; foaming slag; removal of Sulphur and Phosphorous;de-oxidizers,alloying;

Open hearth F/C; Bessemer converters; bottom blown and top blown processes; slag practices and sequencing; LD,VD, AOD, and VOD; Ladle metallurgy; electric arc furnace and DRI usage; energy, environmental and quality considerations;

TEXT BOOKS

1. *Thupkary R.H, 'Introduction to Modern Iron Making', Khanna Publications, Delhi, 2004*
2. *Tupkary R.H., 'Introduction to Modern Steel Making', Khanna Publishers, 2004*

REFERENCES

1. *Gupta O. P., ' Elements of Fuels, Furnace and Refractories', 2nd Edition, Khanna Publishers, 1990*
2. *Bashforth G.R, 'Manufacture of Iron and Steel', Volume I - IV, Asia Publications, 1996*

Course outcomes: After the successful completion of this course, the student would be able to:

1. Classify different kinds of furnaces and their ancillary equipments used for Iron & Steel making [10, 11, 5]
2. Analyze various factors influencing quality of the product in blast furnace during Iron & Steel making[10, 11, 5]
3. Analyze the irregularities and cause of failures in blast furnace and apply the remedial measures for immediate rectification [2, 1]
4. Compare the traditional steelmaking to modern day manufacturing routes for the improvement of quality [11, 1, 2]

MT305 POLYMERS AND COMPOSITES

L	T	P	C
3	0	0	3

Course objective: To develop the basic knowledge of materials particularly polymers and composites other than conventional metals and alloys to apply them to advance engineering applications

Introduction - as a material, classification, types of polymerization, mechanisms, statistical approach, catalysts in polymerization, molecular weight determination, methods of molecular weight characterization

Plastic compounding of plastics mechanical, thermal, optical, electrical properties with reference to important engineering plastics - LDPE, HDPE, PVC, polyester, phenol formaldehyde, alkyds, cellulose, elastomers

Fabrication technology and polymer processing, moulding practices, extrusion; application of polymers and plastic fibers, elastomers, adhesives, bio-medical applications, fiber reinforced plastics, conducting polymers

Introduction, classification of composites, micro-mechanics, interphase bond, stress distribution and load transfer, prediction of strength of composites, anisotropy and failure criteria; reinforcement materials, whiskers, fibers and resins

Molten metal infiltration, powder metallurgy methods, hot pressing, hot rolling, co-extrusions; fiber-reinforced metals, eutectic alloys composites, their engineering properties and applications

TEXT BOOKS

1. *Schwartz. M. M., 'Composite Materials', Prentice Hall, 1977*
2. *Broutman K. J., Krock R.H., 'Modern Composite Materials', Addison Wesly Publishing, 1967*

REFERENCES

1. *Billmeyer F., 'Textbook of Polymer Science', Wiley Interscience, 1994*

Course outcomes: At the end of this course, the students would be able to:

1. Select different materials other than conventional metals and alloys for specific engineering applications [3, 4]
2. Solve the materials problems associated with the weight reduction through the appropriate choice of polymers and composites [1, 11]
3. Provide low cost alternative to expensive metals and alloys [8]
4. Describe the selection criterion for polymers and composites for various engineering applications [1, 10, 11]
5. Analyze different microstructure of polymers and composites and alter them according to application requirements [1, 11, 5]
6. Emphasis the need of modern materials over conventional metal and alloys [8]

MT307 MATERIALS JOINING TECHNOLOGY

L	T	P	C
3	0	0	3

Course objective: To know the concepts of different materials joining technology and emphasis on underlying science and engineering principle of every processes.

Classification of welding processes, energy sources used in welding, working principle, advantages, limitations of arc welding processes –MMAW, GTAW, GMAW, SAW, ESW & EGW

Working principle, advantages and limitations of solid state welding processes. - Friction, friction stir, explosive, diffusion and ultrasonic welding.

Working principle, advantages and limitations of power beam processes: Plasma arc welding, electron beam & laser beam welding.

Principles of operation, process characteristics, types and applications – Resistance welding, Gas welding, brazing, soldering and joining of non metallic materials.

Welding metallurgy: Introduction, thermal cycles, prediction of peak temperature, pre heat and cooling rate, PWHT. Weldability of carbon steel, stainless steel & aluminum. Hot & cold cracking phenomenon, weld defects, causes and their remedies.

TEXT BOOKS

1. *Parmer R. S., 'Welding processes", Khanna Publishers, 1997*
2. *Robert W Messler, Jr. " Principles of welding, Processes, physics, chemistry and metallurgy, Col 10, Wiley,2004.*
3. *Larry Jeffus, " Welding Principles and Applications" Fifth edition, Thomson, 2002*

Course Outcomes: At the end of this course, the students would be able to:

1. Understand the working principle, merits and demerits of different joining processes[1,3,7,10,11,12]
2. Understand the working principle and importance of welding allied processes[1,3,4,10,11,12]
3. Solve welding heat flow related problems[2,5,8,12]
4. Learn weldability and welding related problems of different materials[5,6,7,9]

MT309 MECHANICAL BEHAVIOUR OF MATERIALS

L	T	P	C
3	0	0	3

Course objective: To know the fundamental concepts of mechanical behavior of materials and to apply them to design the materials for various load-bearing structural engineering applications.

Elastic and plastic deformation, stress-strain relationship; plastic deformation of metallic materials, Mohr's circle, Yielding criterion- Von Mises, and maximum-shear-stress/Tresca yielding criterion, failure criteria under combined stresses

Elements of theory of plasticity, dislocation theory properties of dislocation, stress fields around dislocations, elementary dislocation interactions; application of dislocation theory to work hardening and strengthening mechanisms.

Engineering stress-strain curve, true stress-strain curve, instability in tension, stress distribution at the neck, ductility measurement, effect of strain rate and temperature on flow properties, testing machines, Tensile properties of important materials.

Introduction, Brinell, Vickers and Rock well hardness tests, Meyer hardness, analysis of indendation by an indenter, relationship between hardness and the flow curve, microhardness tests, hardness conversion; hardness at elevated temperatures.

Introduction, mechanical properties in torsion, torsional stresses for large plastic strains, types of torsion failures torsion test vs. tension test, hot torsion testing.

TEXT BOOKS

1. *Dieter G. E., 'Mechanical Metallurgy', 3rd Edition, McGraw Hill Publications, 2004*
2. *Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979*

REFERENCES

1. *Rose R. M., Shepard L. A., Wulff J., 'Structure and Properties of Materials', Volume III, 4th Edition, John Wiley, 1984*
2. *Honeycombe R. W. K., 'Plastic Deformation of Materials', Edward Arnold Publishers, 1984*

Course outcomes: At the end of this course, the students would be able to:

1. Define various mechanical properties of materials and their importance in materials selection criteria [1, 2, 5]
2. Classify different mechanical properties and how they can influence the materials behavior with respect to applied load [5]
3. Provide the microstructure-mechanical property correlation for the betterment of the materials performance [1, 2, 11]
4. Select the appropriate processing route and alter the microstructures of various engineering materials to meet the design and application demands [1]
5. Select the suitable processing route in order to achieve the superior strength of materials [1, 5]
6. Analyze the various metallurgical factors affecting mechanical properties of different metals and alloys [2, 1, 11]

MT 331 FOUNDRY AND WELDING LABORATORY

L	T	P	C
0	0	3	2

Course objectives: To know the concepts of materials joining technology and to apply them for the advanced manufacturing processing for various structural engineering applications.

List of Experiments

Foundry

1. Determination of permeability, shear strength and compression strength of the given foundry sand
1. Determination of clay content for the given moulding sand sample and also to study the variation of compression strength for various moisture contents
2. Determination of the grain fineness of the given foundry sand
3. Prepare the mould for the given pattern with core using two boxes and three - box moulding process
4. Determination of flowability for the given foundry sand
5. Foundry melting practice – demonstration

Welding

1. Arc striking practice
2. Bead-on-plate welding
3. Effect of welding parameters on weld bead
4. GTA welding (Demonstration)
5. Microstructural observation of weldments

- Carbon steel
- Stainless steel
- Aluminium alloy
- Titanium alloy
- Dissimilar joints

Course outcomes

1. Determination of properties of foundry sand [1,11,12]
2. Understand the foundry melting practice [1,11]
3. Develop basic welding skills in manual arc welding processes [1,2,11,12]
4. Analysis the weldment microstructure [2,7,9]

MT 315 MECHANICAL TESTING LABORATORY

L	T	P	C
0	0	3	2

Course objective: To know the concepts of mechanical testing and to apply them for the testing of various structural engineering applications.

List of Experiments

1. Tensile testing; theory of testing, standard specimens, calculation of various engineering and true properties – yield strength, tensile strength, fracture strength, % elongation, % area reduction, resilience, toughness
2. Hardness measurement: definition, various methods of measurements – Rockwell, Vickers, Brinell, Moh's – testing procedure, derivation of various expressions.
3. Tension testing of metallic materials using UTM
4. Tension testing of metallic materials of various standard specimens using Hounsfield tensometer
5. Compression testing of metallic material
6. Creep testing
7. Microhardness testing for case hardened specimens

Course outcomes: At the end of this course, the students would be able to:

1. Classify the different mechanical testing methods with their inherent merits and limitations [1, 10, 5]
2. Analyze the test sample for different testing methods [1, 2]
3. Solve the materials problems associated testing [1, 11]

MT 304 NON FERROUS EXTRACTION

L	T	P	C
3	0	0	3

Course objective: To evaluate the various microstructure of the non-ferrous metals and alloys using microscope and apply the concepts to make tailor made materials for given engineering design and applications.

Principles of pyrometallurgy, chemistry of roasting, drying and calcination; classification of pyrometallurgical processes, use of Ellingham diagram in pyrometallurgy

Metallic oxide reduction by C, CO, hydrogen and metals; principles of metallothermic reduction and halide metallurgy; physico chemical principles of fused salt electrolysis

Principles of hydrometallurgy; properties of good solvent, leaching and precipitation, solvent extraction, ion exchange and pressure leaching gaseous reduction of aqueous solutions, bacterial leaching

Extraction schemes for copper, nickel, titanium, aluminium, magnesium, indium, gold and silver

Extraction of metals from secondary sources, energetics of non-ferrous extraction, extraction schemes of zinc, lead, zirconium and tantalum; prospects of non-ferrous industries in India

TEXT BOOKS

1. *Ray H. S., Sridhar R., Abraham K. P, 'Extraction of Non- ferrous Metals', 1st Edition, Affiliated East West Press, 1987*
2. *Rosenquist T., 'Principles of Extractive Metallurgy', 2nd Edition McGraw Hill, 1983*

Course outcomes: At the end of this course, the students would be able to:

1. Differentiate variety of microstructure of non-ferrous materials (Al, Mg, Ti etc) using microscope [1, 2]
2. Provide the comprehensive metallography procedure for a given non-ferrous metal or alloy [2, 1, 5, 11]
3. Analyze the microstructure of the given non-ferrous metal or alloy using microscope [1, 2, 11]
4. Classify different heat treated microstructure of non-ferrous metals and alloys [1, 2]

MT 306 PARTICULATE PROCESSING

L	T	P	C
3	0	3	4

Course objective: To introduce the importance non-conventional processing routes for different materials and its importance for advanced materials manufacturing.

Introduction – Historical background, important steps in powder metallurgy (P/M) process – Advantage and Limitations of powder metallurgy process and Applications

Methods – Production of ceramic powders - powder production by newer methods such as electron beam rotating electrode, rotating electrode process, electron beam rotating disc and the rotating rod process, automation, rapid solidification technique. Characteristics: sampling – chemical composition, particle shape and size analysis, Surface area, packing and flow characteristics, Porosity and density, compressibility, Strength properties. Blending and mixing of metal powders;

Compaction of powders, pressureless and pressure compaction techniques - single action and double action compaction, Cold Isostatic compaction, powder rolling, continuous compaction, explosive compaction, Hot temperature compaction – Uni axial hot pressing, Hot extrusion, Spark sintering, Hot isostatic pressing, Injection moulding – Sintering – Types – Theory of sintering – process variables, Effects of sintering – Sintering atmospheres – metallographic technique for sintered products.

Post sintering operations – Sizing, coining, repressing and resintering, impregnation, infiltration, Heat treatment, steam treatment, machining, joining, plating and other coatings. Products: Porous parts, sintered carbides, cermets, dispersion strengthened materials, electrical applications, sintered friction materials

Atomisation, Mechanical alloying, Metal Injection moulding, Microwave sintering and self propagating high temperature synthesis.

TEXT BOOKS:

1. *Angelo.P.C. and R.Subramanian 'Powder metallurgy – science, Technology and applications', Prentice hall Publishers, 2008*
2. *Kuhn H. A., 'Powder Metallurgy Processing - New Techniques and Analysis', Oxford & IBH, New Delhi, 1978.*

REFERENCES

1. *Randel German, 'Powder Metallurgy Sciene', 2nd ed., MPIF, 1994*
2. *Fritz.V. Lenel 'Powder metallurgy – Principles and Applications" Metal powder Industries federation, New Jersy, 1980.*

List of Experiments

1. Determination of
   a) Metal powder size and shape
   b) Apparent density and tap density
   c) Flow rate
   d) Compressibility
   e) Green density and sinter density
2. Cold upset forming of aluminium
   Extrusion of aluminium [Demonstration]

Course outcomes: At the end of this course, the students would be able to:

1. Describe the basic mechanism of powder production for variety of materials to meet the demand of the research and industrial needs[1]
2. Characterize the various powders (materials) based on the engineering applications [1, 2]
3. Differentiate the processing routes for various powders (materials) and associated technology [1, 2, 5]
4. Define modern day processing routes and apply them successfully to materials processing [1]
5. Apply the powder metallurgy concepts to design new materials for advanced engineering materials [1, 3]
6. Apply the concepts of particulate processing to produce non-conventional materials which are difficult to produce other techniques. [1, 10]

MT 308 NON-FERROUS PHYSICAL METALLURGY

L	T	P	C
3	0	0	3

Course objective: To comprehend the basic principles of physical metallurgy of non-ferrous materials and apply those principles to demanding engineering applications.

Aluminium and its alloys; physical chemical and mechanical properties, classifications, heat treatable and non heat treatable types - structural features corrosion behaviour; cladding and other methods of corrosion protection.

Titanium and its alloys; physical, chemical and mechanical properties of titanium, effect of other elements on its properties, types of titanium alloys, microstructural features, properties and applications.

Magnesium and its alloys; structure, properties and applications of magnesium and some its alloys; metallurgy of magnesium castings; copper and its alloys, electrical conductivity as influenced by other elements, alloys for high conductivity

Lead, tin, zinc, antimony, silver, gold and platinum alloys, relevant phase diagrams and microstructural features, properties and applications

Creep resistant materials, structure-property relationship, high temperature applications, superalloys, application based on structure and properties, Tungsten and Molybdenum alloys.

TEXT BOOKS

1. *Avner S. H., 'Introduction to Physical Metallurgy', 2nd Edition, McGraw Hill, 1974*
2. *Brick R. M., Gorden R. B, Phillips A., 'Structure and Properties of Alloys', McGraw Hill, 1965*

REFERENCES

1. *Polmear I. J., 'Light Alloys -Metallurgy of the Light Metals', 3rd Edition, Arnold, 1995*
2. *N. S. Stoloff and Sikka V. K., 'Physical Metallurgy and Processing of Intermetallic Compound', Chapman and Hall, 1996*

Course outcome: After the completion of this course, the student will be able to:

1. Understand the structure and properties of nonferrous metals and alloys [1, 2, 5, 11]
2. Identify the phases present in different alloy systems by analyzing the phase diagrams [1, 2, 11]
3. Design the heat-treatment cycles for different alloy systems to obtain the desired phases [1, 11]
4. Understand the structure-property correlation in different nonferrous materials [1, 2, 11]
5. Apply the basic principles of non-ferrous physical metallurgy for selecting materials for specific applications [1, 10]
6. Apply the basic principles of non-ferrous physical metallurgy for developing new non-ferrous alloys and composites [1, 5, 10]

MT 310 METAL FORMING TECHNOLOGY

L	T	P	C
3	1	0	4

Course objective: To know the concepts of metal forming and associate technologies and apply them to the conventional and advanced materials manufacturing for various structural applications.

Classification of metal forming processes, hot, cold and warm working, flow curve for materials, effect of temperature, strain rate and microstructural variables; residual stresses, experimental techniques, yielding theories, processing maps

Classification of forging processes, forging equipment, forging defects, plane strain forging analysis, open die forging and close die forging operations, force calculations

Classification of rolling processes, rolling mills, cold rolling, hot rolling, rolling of bars, billets and shapes, defects in rolled products, gauge control systems, process variables in rolling

Types of extrusion, process variables, extrusion defects, force calculation, wire, rod, and tube drawing, lubrication processes

Shearing, blanking, bending, stretch forming, deep drawing, defects in formed products, explosive forming, electro-hydraulic and magnetic forming processes, formability diagrams

TEXT BOOKS

1. *Dieter G. E, 'Mechanical Metallurgy', 3rd Edition, McGraw Hill, 1988*
2. *Higgins R.A, 'Engineering Metallurgy', Volume II, ELBS, 1975*

REFERENCES

1. *Harris J.N, 'Mechanical Working of Metals-Theory and Practice', Pergamon Press, 1983*
2. *Narayanasamy R, 'Metal Forming Technology', Ahuja Book Company, 1997*

Course outcomes: At the end of this course, the students would be able to:

1. Apply the concept of plastic deformation for metals and alloys to convert them in to useful shapes for intended engineering applications [1, 8]
2. Differentiate the various metal forming technology and choose the appropriate one for required engineering applications [1, 5]
3. Provide the successful solution to the various materials design and selection criteria for demanding engineering applications. [2, 5]
4. Analyze various operational and materials parameters influencing the metal forming quality [1, 2, 3, 10, 11]
5. Classify various metal forming technology (forging, rolling, extrusion etc.) and associated forming equipments [1, 2, 5]
6. Define various secondary forming procedures like stretch forming, deep drawing blanking and associated equipments [1, 11]

MT 314 HEAT TREATMENT LABORATORY

L	T	P	C
0	0	3	2

Course objective: To develop the knowledge of heat treatment and associated procedure of various engineering materials and apply them to study how it influences the microstructure and results in different mechanical behavior.

List of Experiments

1. Determination of grain size of low carbon steels
2. Heat treatment of mild, medium carbon and alloy steels
3. Carburizing of steel
4. Heat treatment of tool steels
5. Heat treatment of stainless steels
6. Heat treatment of titanium alloys
7. Heat treatment of magnesium alloys
8. Heat treatment of aluminium alloys
9. Heat treatment of super alloys
10. Microstructural evaluation of nitrocarburised steels

Course outcomes: At the end of this course, the students would be able to:

1. Define various heat treatment procedures for variety of engineering materials and their importance in materials behavior [1, 2]
2. Classify different heat treated microstructure using microscope [1]
3. Provide the practical solution procedure for the betterment of the materials performance based heat treatment [1, 2, 10]
4. Develop comprehensive heat treatment procedure and process map for newly developed metals and alloys. [1, 5, 10]

MT 316 NON-FERROUS METALLOGRAPHY LABORATORY

L	T	P	C
0	0	3	2

Course objective: To evaluate the various microstructure of the non-ferrous metals and alloys using microscope and apply the concepts to make tailor made materials for given engineering design and applications.

List of Experiments

1. Selection of etchants for various non-ferrous alloys
2. Electrochemical polishing/etching for metallography
3. Microstructure of copper alloys
4. Microstructure of aluminium alloys
5. Microstructure of lead alloys
6. Microstructure of magnesium alloys
7. Microstructure of titanium alloys
8. Microstructure of superalloys

Course outcomes: At the end of this course, the students would be able to:

1. Differentiate variety of microstructure of non-ferrous materials (Al, Mg, Ti etc) using microscope [1, 2]
2. Provide the comprehensive metallography procedure for a given non-ferrous metal or alloy [2, 1, 5, 11]
3. Analyze the microstructure of the given non-ferrous metal or alloy using microscope [1, 2, 11]
4. Classify different heat treated microstructure of non-ferrous metals and alloys [1, 2]

MT 394 INTERNSHIP / INDUSTRIAL TRAINING / ACADEMIC ATTACHMENT

L	T	P	C
0	0	3	2

Course Learning Objectives

To become familiar with current practises and emerging trends in the engineering sector, with emphasis on processing of metals and materials

Course Content

[Flexible; series of lectures in topics of current interest, as visualized by the course co-ordinator and the Head of the department, considering relevant institute guidelines]

Course Outcomes

At the end of the course student will be able

1. Become familiar with current design, manufacturing and application activities in the domain of metallurgical and materials engineering [10]

2. Understand professional responsibility of the engineer and become capable of engineering problem solving [5,6]

3. Visualize emerging trends in the context of metals and materials [12]

MT 401 CERAMIC MATERIALS

L	T	P	C
3	0	0	3

Course objectives: To understand the fundamentals (structure, properties and processing) of ceramic materials to appreciate its advantages and limitations and to apply those fundamentals for selecting and developing ceramic materials for different engineering applications.

Ceramics as a class of engineering materials, overview of properties; classification of ceramics; ceramic raw materials and their characteristics, production of ceramic powders, ceramics processing, Introduction to glazes and enamels.

Ionic and covalent bonding, variations in properties as a function of bonding, crystalline and non crystalline ceramics, concept of co-ordination number, ratio of ionic radii and corresponding crystal structures, oxides and silicates, polymorphism.

Defects in crystalline ceramics. Non-stoichiometry, significance of defects with respect to applications; Glasses: types, structure, bridging and non-bridging oxygen, significance of oxygen to silicon ratio, commercial oxide glasses, devetrification.

Electrical, magnetic and optical properties of important ceramic systems, correlation of properties with structure; Mechanical properties and testing. Introduction to bio-ceramics and bio-glass.

Classification of refractories, characteristics of refractories. Production of refractories, properties and applications of various refractories.

TEXT BOOKS

1. *Kingery W. D., Bowen, H. K., Ulhmen D. R., 'Introduction to Ceramics', 2nd Edition, John Wiley, 1976*
2. *Van Vlack L. H., 'Physical Ceramics for Engineers', Addison Wesly, 1964*

REFERENCES

1. *Richerson D. W., 'Modern Ceramic Engineering - Properties Processing and Use in Design', Marcel Deckker, 1982*
2. *Norton F. H., ' Elements of Ceramics' 2nd Edition., Addison Wesley, 1974*

Course outcome: After the completion of this course, the student will be able to:

1. Know the structure and properties of different ceramic materials [1, 2, 5, 11]
2. Understand the phase diagrams and comprehend the phase transformations in ceramic materials [1, 3, 4, 11]
3. Understand the testing methods for evaluating the mechanical properties of ceramic materials [2, 11]
4. Understand the electrical, magnetic and optical properties of important ceramic systems [1, 3, 4, 11]
5. Appreciate the properties of ceramic materials for different engineering applications [1, 11]

MT 403 CORROSION ENGINEERING

L	T	P	C
3	0	0	3

Course objective: To provide a practical knowledge about corrosion and its application in engineering field.

Electrochemical and thermodynamic principles, Nernst equation and electrode potentials of metals, EMF and galvanic series, merits and demerits; origin of Pourbaix diagram and its importance to iron, aluminium and magnesium metals

Exchange current density, polarization - concentration, activation and resistance, Tafel equation; passivity, electrochemical behaviour of active/passive metals, Flade potential, theories of passivity

Atmospheric, pitting, dealloying, stress corrosion cracking, intergranular corrosion, corrosion fatigue, fretting corrosion and high temperature oxidation; causes and remedial measures

Purpose of testing, laboratory, semi-plant and field tests, susceptibility tests for IGC, stress corrosion cracking and pitting, sequential procedure for laboratory and on-site corrosion investigations, corrosion auditing and corrosion map of India

Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors

TEXT BOOKS

1. *Raj Narayan, 'An Introduction to Metallic Corrosion and its Prevention', 1st Edition, Oxford and IBH, 1983*
2. *Fontana M. G., Greene N. D., 'Corrosion Engineering', 2nd Edition, McGraw Hill, 1983*

REFERENCES

1. Denny Jones, "Principles and Prevention of Corrosion", Prentice Hall of India, 1996.

Course outcomes: At the end of this course, the student will be able to

1. Do electro and electroless plating of Cu, Al alloys [1, 2, 11]
2. Determine the corrosion rate by weight loss method, electrical resistance method, potentionstatic polarization experiment and atmospheric corrosion using color indicator method [1, 2, 4, 10, 11]
3. Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking [1, 2, 11]
4. Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness [1, 2, 10, 11]

MT 405 MATERIALS CHARACTERIZATION

L	T	P	C
3	0	0	3

Course objective: To provide an understanding of the basic principles of various characterization tools and use those tools to analyze metallurgical components.

The metallurgical microscope, phase contrast polarized light and interference microscopy; high-temperature microscopy, quantitative metallography, specimen preparation techniques
Continuous and characteristic X-radiation; Bragg's law and X-ray diffraction, determination of lattice parameter, phase identification/quantification, solvus line determination, and residual stress measurement
Construction of scanning electron microscope, modes of operation, study of surface topography and elemental composition analysis, electron probe analysis (EPMA/EDX), and Auger spectroscopy
Constructional feature of transmission electron microscope, imaging and diffraction modes, bright and dark field imaging, selected area diffraction, specimen preparation techniques
Thermal analysis, dilatometry, resistivity and magnetic measurements. methods of growing single crystals

TEXT BOOKS

1. *Small man R.E., 'Modern Physical Metallurgy', 4th Edition, Butterworths, 1985*
2. *Philips V.A., 'Modern Metallographic Techniques and Their Applications', Wiley Interscience, 1971*

REFERENCES

1. *Cullity B.D., 'Elements of X-ray Diffraction', 4th Edition, Addison Wiley, 1978*
2. *Weinberg F., 'Tools and Techniques in Physical Metallurgy, Volume I and II, Marcel and Decker, 1970*
3. *Giflin R.C., Optical Microscopy of Metals', Isaac Pitman, 1970*

Course outcomes: By successful completion of this course, the student will be able to

1. Know the principles of metallurgical microscope, X-ray Diffractrometer (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Thermal analysis and dilatometer [1, 11]
2. Describe the various sample/specimen preparation techniques for XRD, SEM, TEM and thermal analysis and quantitative metallography [2, 11]
3. Determine crystal structure, lattice parameter, phase identification, solvus line estimation and residual stress analysis using XRD [1, 2, 11]
4. Describe the modes of SEM operation, study the surface topography using different modes, elemental compositional analysis and spectroscopy studies [1, 11]
5. Select the appropriate tool to characterize the material by knowing its merits and demerits. Analyze the material in atomic level by using different modes of TEM like bright and dark field imaging, selected area diffraction [1, 2, 5, 11]
6. Evaluate the specimen by thermal analysis, dilatometry, resistivity and magnetic measurements [11]

MB 491 MANAGEMENT PRACTICES AND CONCEPTS

L	T	P	C
3	0	0	3

Course objective: The objective of this paper is to familiarize the student with basic management concepts and behavioral processes in the organization. The course will be an introduction to the way in which a firm can develop its managerial thinking, mission and strategy.

Introduction to organization and Management: Management function and process, Managerial roles, management skills, Organization, Evolution and Development of Management: Historical background, Scientific management, General administrative theorists, Quantitative approaches, Behaviourai, approaches, Current trends and Issues.

Foundations of Planning: Meaning, purpose of planning. The role of goals and plans in planning: Types of goals, Types of plans, Establishing goals: approaches, characteristics and steps in goal setting, Developing Plans: approaches and contingency factors. Contemporary issues in Planning:

Organizational: Defining organizational structure: Work specification, Departmentalization, Chain of command, Span of control Centralization and Decentralization, Organization Design decision. Mechanical and organic organization, contingency factors, common organizational design: Traditional and contemporary organizational design.

Human resources management: Human resources planning, Recruitment and Decruitment, selection, employee, training, Employee performance and measurement, Compensation and Benefits, career development, current issues in Human resources management. Understanding Groups and Teams: States of group development process, Group decision making, Developing and Managing effective teams. Motivating Employees: Early theorities and Contemporary theories of motivation. Current Issues in Motivation. Leadership: Early leadership theories: Trait and behavioural theory of leadership. Contingency theories of leadership, contemporary issues in leadership.

Foundation of Control: control process, Types of Control, Contemporary issues in control, Functional management: Operations and value chair management, Marketing management, Finance management, information and Systems management. Human resources and industrial relations management.

TEXT BOOKS

1. *Management, authored by Stephen P. Robbins and Mary Coulter, published by Prentice Hall, Latest Edn.*
2. *Principles of Management, authored by Harold Koontz and Heintz Weihrich, Published by Tata McGraw-Hill's Latest Edn.,*

Course outcomes: Upon completion of this class, the student will be able to:

1. Define the management, evolution of management, modern management and their principles and elements. [4, 6]
2. Select the methodology for the planning, organizing, staffing, directing, co-directing, reporting and budgeting. [6, 8]
3. Define the concepts of marketing, product value, price and promotion and their regulations. [4, 6]
4. Select product design, plant location and factors to be consider and plant layout. [4, 6]
5. Describe inventory management, project management, PERT, CPM and their applications. [4, 6, 8]

MT 409 CORROSION ENGINEERING LABORATORY

L	T	P	C
0	0	3	2

Course objective: To provide a practical knowledge about corrosion and its application in engineering field.

Copper electroplating, electroless plating, anodizing of aluminum, and corrosion rate determination by weight loss method (with and without inhibitor)
Corrosion rate by electrical resistance method, corrosion rate by potentiostatic polarization experiment (a) Tafel method and (b) LPR method, atmospheric/environmental corrosion (using colour indicator method)

Galvanic corrosion, pitting corrosion, stress corrosion cracking

IGC susceptibility tests for stainless steels, salt spray test, coating thickness measurements,
Cathodic protection, high temperature corrosion.

Course outcomes: At the end of this course, the student will be able to

1. Do electro and electroless plating of Cu, Al alloys [1, 2, 11]
2. Determine the corrosion rate by weight loss method, electrical resistance method, potentionstatic polarization experiment and atmospheric corrosion using color indicator method [1, 2, 4, 10, 11]
3. Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking [1, 2, 11]
4. Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness [1, 2, 10, 11]

MT 411 NDT AND CERAMICS LABORATORY

L	T	P	C
0	0	3	2

Course Learning Objectives

To provide knowledge and enrich ideas about the NDT techniques and to give an insight about synthesis, processing and characterization of ceramic materials.

Course Content

1. Synthesis of ceramic materials by wet precipitation method
2. Synthesis of nano-structured ceramic materials by mechano-chemical method
3. Study of densification behavior of ceramic materials by conventional/ new sintering methods
4. Determination of hardness/fracture toughness of the ceramic materials by Indentation method
5. Determination of young modulus of ceramic materials by non-destructive method
6. Determination of band gap of ceramic materials.
7. Determination of crystal size and precise lattice parameters of ceramic material by X-ray diffraction.
8. Identification of functional groups present in the ceramic materials by FTIR spectroscopy.
9. Fabrication of ceramic coatings on metals by plasma electrolytic oxidation method
10. Preparation of glasses/ glass-ceramics
11. Liquid penetrant Inspection
12. Magnetic Particle Inspection
13. Ultrasonic Inspection

Course Outcomes

After completing these experiments the students will be able to

1. Synthesize ceramic materials with desired particle sizes.[1,2,5]
2. Understand the various testing and characterization methods used for evaluating the ceramic materials [2, 5,11]
3. Process the materials to obtain desired micro-structures and coatings [1,5,10,11]
4. Perform NDT techniques and identify the defects [1,3]

HM 402 INDUSTRIAL ECONOMICS

L	T	P	C
3	0	0	3

Course Objective: The objective of this paper intends (i) to provide knowledge to the students on the basic issues such as productivity, efficiency, capacity utilization and debates involved in industrial development; and (ii) to give thorough knowledge about the economics of industry in a cogent and analytical manner.

Micro Economics; demand analysis - Law of Demand Demand forecasting - Supply Analysis - Determinants of supply - Supply Elascticities - Consumption laws - Indifference curve analysis – Cost, Revenue and Break even analysis - Competitions

Macro economics - Importance of macro economic analysis - Keynes' theory of Income and Employment - Multiplier and Accelerator - Functions of Central and Commercial bank - Credit creation by Commercial Banks

Contributions of Fayol, Taylor - Managerial functions - Preparation of Balance Sheet- Sources of Finance - Capital Budgeting

Differences between marketing and selling - 4 P's of Marketing and Marketing Myopia - Market Segmentation - Product Life Cycle

Recruitment and Selection - Job Evaluation and performance Appraisal Methods - Industrial Accidents and Fatigue - Communication - Motivation - Leadership

TEXT BOOKS

1. *Dewett KK Chand & Coy, "Modern Economic Theory", 1998 Ed.*
2. *Gupta C.B. Chand.S & Coy, "Business Organisation and Management", 1998*

REFERENCES

1. Maheswari SN., "An Introduction to Accountancy", 1999

2. Ramasamy VS, NamaKumari S., "Marketing Management",1996

3. Aswathappa K., "Organisational behavior", 1998

Course outcomes: Upon completion of this class, the student will be able to:

1. Define micro economics, demand analysis, supply analysis, consumption laws, indifference curve analysis and competitions. [4, 6]
2. Define macro economics, differentiate with micro economics, importance, Keynes theory, functions of central and commercial bank. [4, 8]
3. Contributions of Fayol, Taylor in managerial functions, balance sheet, and sources of finance. [4, 8]
4. Differentiate marketing and selling, marketing myopia, and product life cycle. [3, 4]
5. Describe recruitment and selection, job evaluation and performance appraisal methods, communication, motivation and leadership. [3, 4, 8]

MT 498 PROJECT WORK

L	T	P	C
0	0	15	6

Course Learning Objectives

To get hands-on experience in problem solving, design and experimental skill in the context of metals and materials

Course Content

The details/content of the project work will be worked out by the project student and project guide considering the generic instructions provided be the department and institute

Course Outcomes

[Project work is expected to deliver outcomes, as many of the 12 programme outcome as defined in the program].

1. Apply basic knowledge of mathematics, science and engineering towards development of new process, product, materials and comprehend industrial problems [1,11]

2. Comprehend engineering problems and to come up with solutions based on theoretical, conceptual, experimental and innovative approached [8,12]

3. Perform experimental investigations in the shop floor/research laboratory in a logical manner [9]

ELECTIVES

MT 001 FATIGUE, CREEP AND FRACTURE MECHANICS

L	T	P	C
3	0	0	3

Course objective: To develop the knowledge about the essential mechanical properties of engineering materials such as fracture, fatigue and creep and to apply them to design the materials for various load-bearing structural engineering applications.

Characteristics of fatigue failure, initiation and propagation of fatigue cracks,; methods of improving fatigue behaviour, fatigue testing; analysis of fatigue data, fracture mechanics of fatigue crack propagation, corrosion fatigue, case studies

Introduction to creep - creep mechanisms, creep curve, Presentation and practical application of creep data; accelerated creep testing, time-temperature parameters for conversion of creep data; creep resistant alloys, creep testing, stress rapture test,

Introduction, types of fracture in metals, theoretical cohesive strength of metals, Griffith theory of brittle fracture, fracture of single crystals, metallographic aspects of fracture, fractography, fracture under combined stresses.

Brittle fracture problems, notched bar impact tests, instrumented Charpy test, significance of transition temperature curve, metallurgical factors affecting transition temperature, drop-weight test and other large-scale tests, fracture analysis diagram, Introduction, strain energy release rate, stress intensity factor, fracture toughness and design, K_{IC} plane strain toughness testing, plasticity corrections, crack opening displacement, J integral, R curve, toughness of materials.

TEXT BOOKS

1. *Dieter G. E., 'Mechanical Metallurgy', 3rd Edition, McGraw Hill Publications, 1988*
2. *Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979*

REFERENCES

1. Rose R. M., Shepard L. A., Wulff J., 'Structure and Properties of Materials', Volume III, 4th Edition, John Wiley, 1984
2. Honeycombe R. W. K., 'Plastic Deformation of Materials', Edward Arnold Publishers, 1984

Course outcomes: At the end of this course, the students would be able to:

1. Define the life assessment of various engineering materials and associated testing methods [1]
2. Describe basic mechanisms of fatigue and creep behavior of various engineering materials and their importance in materials design [1, 2]
3. Analyze the various metallurgical factors influencing the fatigue and creep performance of materials for different structural engineering applications [1, 2, 5]
4. Select the appropriate processing route and alter the microstructure for the life enhancement of materials at room and elevated temperatures [1, 10, 11]
5. Provide suitable remedial measure to prevent premature failure and reduction in performance [1, 5
6. Describe the failure modes and root cause of the materials failure based on fracture mechanics and fractography approach [1, 11]

MT 041 NON DESTRUCTIVE TESTING AND FAILURE ANALYSIS

L	T	P	C
3	0	0	3

Course objective: To develop the fundamental knowledge about non-destructive and destructive analysis, in order to control the quality in manufacturing and production engineering components.

Visual examination, Basic principles of liquid penetrant testing and Magnetic particle testing.
Radiography - basic principle, electromagnetic radiation sources, radiographic imaging, inspection techniques, applications, limitations and safety.
Eddy current testing - principle, application, limitation; ultrasonic testing - basic properties of sound beam, transducers, inspection methods, flaw characterisation technique, immersion testing, advantage, limitations; acoustic emission testing.
Leak testing, Holography and Thermography - principles, procedures and applications, Comparison and selection of NDT methods; defects in casting, forging, rolling and others.
Failure analysis methodology, tools and techniques of failure analysis, failure data retrieval, procedural steps for investigation of a failure for failure analysis; types of failure and techniques for failure analysis.
Some case studies of failure analysis, Introduction to quality management, concept of ISO9000, ISO14000, QS9000; Inspection, inspection by sampling.

TEXT BOOKS

1. *Baldevraj, Jayakumar T., Thavasimuthu M., 'Practical Non-Destructive Testing', Narosa Publishing, 1997*
2. *Das A. K., 'Metallurgy of Failure Analysis', TMH, 1992*

REFERENCES

1. *Colangelo V. A., 'Analysis of Metallurgical Failures', John Wiley, 1985*
2. *Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979*

Course outcomes: At the completion of this course, the student will be able to

1. Differentiate various defect types and describe the main criteria to select the appropriate NDT methods for the product [1, 4, 5]
2. Define tools and techniques of failure analysis, procedural steps for investigation of failure and failure data retrieval [1, 4, 5, 11]
3. Describe various types of failure and select suitable techniques for failure analysis [1, 4, 5]
4. Know about various ISO standards, inspection, inspection by sampling and quality management [2, 3, 4, 7, 8, 9]

MT 002 SPECIAL STEELS AND CAST IRONS

L	T	P	C
3	0	0	3

Course objective: To know different types of steel and Cast-iron.

Definition of high strength steels, problems in developing high strength steels; discussion on fracture toughness; HSLA steels, principle of microalloying and thermomechanical processing; importance of fine grained steels

Phase diagrams, composition, properties and applications of ferritic, austenitic, martensitic, duplex and precipitation hardenable stainless steels

Dual phase steels, TRIP steels, maraging steels, metallurgical advantages, heat treatment, properties and applications

Tool steels; classification, composition, and application, constitution diagram of high speed steels, special problems in heat treatment of tool steels

Types of cast irons - grey, SG, white, malleable; austempered ductile iron; alloy cast irons, Ni hard, high silicon cast irons, heat resistant cast irons- high chrome cast iron- structure, property and engineering applications

TEXT BOOKS

1. *Leslie W. C., 'The Physical Metallurgy of Steels', McGraw Hill, 1982*
2. *Pickering P. B., 'Physical Metallurgy and the Design of Steels', Applied Science Publishers, 1983*

Course outcomes: Upon completion of the course, the student will be able to:

1. Understand major types of special steels such as HSLA, TRIP, Dualand Tool steels and cast-irons[1, 5]
2. Know the processing techniques of specials steels and cast-irons[1, 2, 5]
3. Selection of Special steels and cast-irons for specific engineering applications[1, 2, 5,11]

MT 042 PROCESS MODELING AND APPLICATIONS

L	T	P	C
1	1	2	3

Mathematical modeling, physical simulation, advantages and limitations; process control, instrumentation and data acquisition systems

Review of transport phenomena, review of differential equations, review of numerical methods; concept of physical domain and computational domain, assumptions and limitations in numerical solutions, introduction to FEM & FDM

Introduction to software packages – useful websites and generic information about different products - ANSYS, Thermocalc, CFD; introduction to expert systems and artificial intelligence; demonstration / practical training in some software packages

Physical modeling – cold and hot models; case studies of water models, use of computers for the construction of phase diagrams, alloy design, crystallography, phase transformations and thermo chemical calculations.

Case studies from literature – pertaining to modeling of solidification / heat transfer, fluid flow, casting, welding and liquid metal treatment

TEXT BOOKS

1. *Szekely J., Themelis N. J., 'Rate Phenomena in Process Metallurgy', Wiley, 1971*
2. *P.S. Ghosh Dastidar, "Computer Simulation of Flow and Heat Transfer", Tata McGraw Hill, New Delhi, 1998*

MT 043 COMPUTATIONAL TECHNIQUES

L	T	P	C
3	0	0	3

Design of Experiments and Analysis

Factorial design, Taguchi Techniques, ANOVA

Artificial Intelligence

Artificial Neural Networks, Fuzzy logic, Genetic Algorithm; Applications in Materials Engg.,

Numerical Fluid Flow and Heat Transfer

Classification of PDE, finite differences, Steady and unsteady conduction, explicit and implicit method

Finite Element Methods

Introduction to I-D FEM. Problems in structural mechanics using two dimensional elements; Plane stress, plane strain, axisymmetric analysis; Three dimensional stress analysis

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,

TEXT BOOKS:

1. Douglas C. Montgomery Design and analysis of experiments, 5th ed., John Wiley and Sons, 2005

2. Phillip J. Ross Taguchi techniques for quality engineering - McGraw-Hill Book company,2002

REFERENCES

1. Suhas V. Patankar Numerical heat transfer and fluid flow-, Hemisphere Publishing Corporation, 1998

2. Tirupathi R. Chandrupatla and Ashok D. Belegundu Introduction to Finite Elements in Engineering, 3rd Ed., Prentice-Hall, 2003

3. Simon Haykin , Neural Networks- A comprehensive foundation-, 2nd Ed., Pearson Education Asia, 2002

MT 003 SPECIAL CASTING TECHNIQUES

L	T	P	C
3	0	0	3

Shell moulding : Process details ,types , characteristics and process variables, types of sand used and additives, application

Investment casting: Pattern material and its production, techniques of Investment casting – Investment , Pattern removal and firing , pouring and casting , process variables and characteristics, application

Die casting: Process details, gravity and pressure die casting equipment and die details, casting techniques, characteristics of the process , application

Centrifugal casting : Process details, centrifugal force calculations , production techniques- True, semi centrifugal and centrifuging processes , process variables and characteristics, application

Squeeze casting , Low pressure die casting , thixo and rheo casting , full mold process , electro slag casting , Magnetic casting , No bake or pepset moulding, casting process for reactive metals

TEXT BOOKS:

1. Heine R., Loper C.R., Rosenthal P.C. , Principles of metal casting . 2 nd edition , Tata Mcgraw Hill publishers ,1985

2. Jain P.L., Principles of foundry technology, 3 rd edition, Tata Mcgraw Hill, 2004

REFERENCES

1. Beeley P.R. Foundry Technology , , Butterworth- Heimann publishers, London 2006

MT 004 SPECIAL TOPICS IN METAL FORMING

L	T	P	C
3	0	0	3

High velocity forming – comparison with conventional forming –
Explosive forming - explosives – detonation velocity of explosives – energy transfer media – safety circuit – process parameters – application of explosive forming

Petro forge system – rubber pad forming – electro magnetic forming coil requirements – effect of work piece dimensions and conductivity - applications – electro hydraulic forming – types of electrodes – applications

Superplastic forming – superplasticity – definition - components – mechanism of superplastic deformation – diffusion bonding – superplastic forming and diffusion bonding – methods of forming -

Severe plastic deformation – ECAP -types- microstructural variations with processing route – cryo rolling – process- types – stress strain distribution

Severe plastic deformation by mechanical alloying – types – equipment – compaction – sintering – mechanism of sintering

TEXT BOOKS

1.Hosford W.F and Caddell, ' Metal forming mechanics and metallurgy" Prentice Hall, 1983

2. Explosive forming process and techniques – A.A.Ezra, Prentice Hall, 1980

REFERENCES

1. ASM metals Handbook, Volume 5, 1984

2. Padmanabhan K A and G.J.Davis, Superplasticity, Springer Verlag, Berlin Heidberg, NY, 1980.

MT 021 CERAMIC PROCESSING

L	T	P	C
3	0	0	3

Course objective:

To know manufacture of different type of Ceramic materials and develop for specific engineering applications.

Surface and interfaces, grain boundaries, interfacial energy and wetting; phase equilibria in ceramic system - single component SiO_2 transformations in silica; two component systems

Overview of ceramic processing - emphasis on powder processing route - crushing, grinding, sizing, pre-consolidation by pressing, casting, plastic forming, tape forming and spraying - - sintering stages, mechanisms, solid state sintering, liquid phase

Hot pressing - reaction sintering - self sustaining high temperature synthesis - high pressure synthesis - fusion cast ceramics - slurry casting - overview of refractory processing - sol-gel processing - ceramic coatings - manufacture of glasses

Principles, properties, applications and processing for important systems such as : silicon carbide, silicon nitride, boron carbide, boron nitride, cermets, molybdenum di silicide and ceramic fibres

Principles, properties, applications and processing of important systems such as: zirconia, stabilized zirconia, sialons, magnetic ceramics, superconducting ceramics, semiconductors, glass ceramics, bio ceramics

TEXT BOOKS

1. *McColm J., 'Ceramic Science for Materials Technology', Leonard Hill, 1983*
2. *Richerson D. W., 'Modern Ceramic Engineering - Properties Processing and Use in Design', Marcel Deckker, 1982*

REFERENCES

1. Kingery W. D., Bowen H. K., Uhlman D. R., 'Introduction to Ceramics', 2nd Edition, John Wiley, 1976

Course outcomes: Upon completion of the course, the student will be able to:

- Define the Type of Component system present in the refractory materials.[1, 7, 10]
- Select the powder Processing route to prepare the ceramics[1, 3, 5]
- Differentiate Pressing and Casting techniques for the ceramic materials[3, 4, 11]
- Develop refractory materials for specific application[1, 2, 11]
- Apply the Principle and Evaluate the properties of materials[1, 2]

MT 005 LADLE METALLURGY & CONTINUOUS CASTING OF STEELS

L	T	P	C
2	1	0	3

Course Objectives: To develop an understanding of the basic principles of ladle metallurgy and continuous casting, impart modeling skills and to apply them for industrial problems to enable them to solve the problems encountered in the steel industries.

Terminology – scrap based operation Vs refining ; trends in quality of liquid steel; different approaches to refining; overview of various treatments including vacuum, inert gas, injection, electro-slag.

Terminology related to injection metallurgy; Ladle furnace; advantages and approaches; injectibles – type of materials; discussion of some specific treatments; impact on overall quality; foaming of slags

Ingot casting Vs continuous casting (CC) ; difficulties in CC of steels; increasing CC output in the steel industry; mould and machine details including different components and configurations; SEN, Ladle and Tundish

Role of mould powders (fluxes) in CC; physical and chemical interactions during CC; overview of defects in CC; production stoppages such as breakouts; indicative heat sizes and machine output; concept and implementation of sequence casting;

Overview of process modeling; applications in ladle metallurgy and CC; mathematical modeling of solidification; physical modeling of fluid flow in CC; case studies from current literature

TEXT BOOKS

1. *Tupkary R.H., 'Introduction to Modern Steel Making', Khanna Publishers, 2004*
2. *B.Deo, R. Boom, 'Fundamentals of steel making metallurgy', Prentice Hall International, New York, 1993*

REFERENCES

1. *Continuous casting – Vol.1, 'Chemical and Physical Interactions during transfer operations', Iron and Steel Society, Warrendale, PA, USA, 1983.*

Course Outcomes: After the completion of this course, the student would be able to:

1. Understand the terminologies used in the field of ladle metallurgy and continuous casting of steels [3]
2. Classify different kinds of treatments for the steel during manufacturing [5, 11]
3. Compare the capabilities of ingot casting and continuous casting [11]
4. Apply the basic modeling skills in the area of ladle metallurgy and continuous casting [1,4]

MT 022 HIGH TEMPERATURE MATERIALS

L	T	P	C
3	0	0	3

Factors influencing functional life of components at elevated temperature, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate

Design of transient creep, time hardening, strain hardening, expressions for rupture life for creep, ductile and brittle materials, Monkman - Grant relationship

Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage fracture, ductile fracture due to micro void coalescence - diffusion controlled void growth; fracture maps for different alloys and oxides

Oxidation, Pilling-Bedworth ratio, kinetic laws of oxidation - defect structure and control of oxidation by alloys additions, hot gas corrosion deposit, modified hot gas corrosion, fluxing mechanisms, effect of alloying elements on hot corrosion

Iron base, nickel base and cobalt base superalloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase - embrittlement, solidification of single crystals

TEXT BOOKS

1. *Raj R., 'Flow and Fracture and Elevated Temperatures', American Society for Metals, 1985*
2. *Hertzberg R. W., 'Deformation and Fracture Mechanics of Engineering Materials', 4th Edition, John Wiley, 1996*

REFERENCES

1. *Courtney T.H, 'Mechanical Behaviour of Materials', McGraw Hill, 1990*

MT 023 EMERGING MATERIALS

L	T	P	C
3	0	0	3

Course objective: To define new engineering materials and apply for multi-functional areas.

Techniques of rapid solidification. production of metallic glasses, atomic arrangement, comparison with crystalline alloys - mechanical, electrical, magnetic, superconducting and chemical properties and applications
Phase diagrams of ferritic, martensitic and austenitic stainless steels, duplex stainless steels, precipitation hardenable stainless steels, mechanical and metallurgical properties of stainless steels, HSLA steels, micro-alloyed steels
Aluminium alloys, magnesium alloys and titanium alloys; metallurgical aspects, mechanical properties and applications
Development of super alloys-iron base, nickel base and cobalt base - properties and their applications; materials for cryogenic service, materials in nuclear field, materials used in space
Carbonaceous materials - including nano tubes and fullerenes; shape memory alloys, functionally gradient materials, high temperature super conductors - bio materials

TEXT BOOKS

1. *Sukh Dev Sehgal, Lindberg R.A., 'Materials, their Nature, Properties and Fabrication', S Chand, 1973*
2. *Polmear I. J. 'Light alloys: Metallurgy of Light Metals', 3rd Edition, Arnold, 1995*

Course outcomes: Upon completion of the course, the student will be able to:
1. Describe various processing techniques of different engineering materials.[1, 3, 5]
2. Analye the Phase diagram and Microstructure using Microscope for different type of Stainless steel materials.[2, 4, 5, 11]
3. Select the material for Biological, Nuclear, Space and Cryogenic service applications.[1, 4, 10, 3]

MT 006 WELDING METALLURGY

L	T	P	C
3	0	0	3

Heat flow - temperature distribution-cooling rates - influence of heat input, joint geometry, plate thickness, preheat, significance of thermal severity number

Epitaxial growth - weld metal solidification - columnar structures and growth morphology- effect of welding parameters - absorption of gases - gas/metal and slag/metal reactions

Phase transformations- weld CCT diagrams - carbon equivalent-preheating and post heating- weldability of low alloy steels, welding of stainless steels use of Schaffler and Delong diagrams, welding of cast irons
Welding of Cu, Al, Ti and Ni alloys – processes, difficulties, microstructures, defects and remedial measures

Origin - types - process induced defects, - significance - remedial measures**,** Hot cracking - cold cracking -lamellar tearing - reheat cracking - weldability tests - effect of metallurgical parameters,

TEXT BOOKS

1. *Linnert G. E.,'Welding Metallurgy', Volume I and II, 4th Edition, AWS, 1994*
2. *Granjon H., 'Fundamentals of Welding Metallurgy', Jaico Publishing House, 1994*

REFERENCES

1. *Kenneth Easterling, 'Introduction to Physical Metallurgy of Welding', 2nd Edition, Butterworth Heinmann, 1992*
2. *Saferian D., 'The Metallurgy of Welding', Chapman and Hall, 1985*
3. *Jackson M. D., 'Welding Methods and Metallurgy', Grffin, London,* 1967

MT 007 PROCESSING OF ALUMINIUM ALLOYS

L	T	P	C
3	0	0	3

Course Learning Objectives

- To gain understanding the various processing methods to fabricate light alloys
- Gain knowledge of design and selection of suitable process for fabricating engineering light weight structures

Course Content

Introduction to light alloys: Aluminium alloys, Magnesium alloys, titanium alloys and non-structural light elements and their importance in various engineering applications. Limitations of light in harsh environments. Introduction to various processing methods : casting, metal forming, powder metallurgy, welding, etc.

Pre-requisite:

Knowledge in physical metallurgy of non ferrous alloys and various manufacturing methods

Casting: Casting processes used for processing light alloys. Special processes employed for fabrication Al, Ti and Mg alloys. Problems in castings and the remedial actions.

Forming: Forming methods used for fabrication light alloys. Difficulties in forming Al, Ti and Mg alloys. Special processes used for forming light alloys. Superplasticity and superplastic forming of Al, Ti and Mg.

Metal joining: Metal joining techniques used for light alloys. Difficulty in fusion welding processes. Solid state joining techniques employed for light alloys, Other joining techniques such as mechanical methods, adhesive bonding etc.,

Machining: Machinability of light alloys. Problems during machining of Al, Ti and Mg. Unconventional machining processes.

Powder methods : Composites and ODS aluminium alloys, Hot isostatic pressing, Spark plasma sintering.

Processing of other light alloys (beryllium and lithium) for structural and non-structural applications

Reference Books

1. *Light Alloys: Metallurgy of the Light Metals (Metallurgy & Materials Science) , Wiley Publishers, I. J. Polmear*

2. *Magnesium and Magnesium Alloys (ASM Specialty Handbook) M. M. Avedesian and Hugh Baker*

3. *Titanium: Physical Metallurgy, Processing, and Applications, ASM International, F.H. Froes*

4. *Titanium: A Technical Guide 2nd Edition,ASM International, Matthew J. Donachie*

Course Outcomes

Upon completion of the course, the student will be able to:

1. Understand the various processing methods to fabricate light alloys
2. Capable of designing process procedure in developing light alloy components
3. Design and selection of suitable process for fabricating engineering light weight structures
4. Difficulties involved in processing of light alloys

MT 008 DESIGN OF CASTINGS AND WELDMENTS

L	T	P	C
3	0	0	3

Course Learning Objectives

To select the proper design for various casting techniques and to minimize the defects. Knowledge of the various welding codes used in industry parlance.

Course Content

Designing for economical moulding – designing for sand moulding – investment castings. Design for economical coring – general rules for designing cored holes. Design problems involving thin sections, uniform sections unequal sections. Considering metal flow, riser location, feed path, mould-metal temperature effect.

Design problems involving junctions, distortion – possible design remedies. Dimensional variations and tolerances – influence of cores – influence of location of cores. Dimensions for inspection and machining. Surface finish ISI specification, effect of mould material, parting line, fillet influences. Design of gating and risering for ferrous and non-ferrous metals

Types of joints, joint efficiency, edge preparation, types of loads, design for static lading, design for cyclic loading, rigid structures, primary and secondary welds, treating a weld as a line, structural tubular connections, influence of specifications on design, symbols for welding and inspection, estimating and control of welding costs.Residual stresses, causes and effects, methods to measure residual stresses, weld distortion.

Boiler and pressure vessel codes, structural welding codes, pipelines codes.
Welding procedure specifications, welding procedure qualifications, welder performance qualifications, welding variables, filler metal qualifications, qualification of welding inspectors, welding supervisors and welding engineers, qualification of NDT personnel.

Reference Books

1. *"Casting.Design Hand Book" , American Society for Metals,1962*
2. *Matousek R., "Enginering Design".,Blackwell Scientific Publications.,1962*
3. *Heine, Loper and Rosenthal, "Principles of Metal Casting", Tata McGraw Hill Publishing Co,1995.*
4. *Harry Peck, "Designing for Manufacture", Pitman Publications, 1983.*

Course Outcomes

Upon completion of the course, the student will be able to:

1. Select the appropriate design for the particular casting. [1, 3, 11]
2. Minimize the defects by proper selection of casting systems [1, 8]
3. Choose the appropriate codes for the production of pipeline and structural materials [3, 8]
4. Categorize welding procedures for different applications [1, 9]

MT 009 THERMODYNAMICS OF SOLIDIFICATION

L	T	P	C
3	0	0	3

Course Learning Objectives

A study of important thermodynamic functions related to solidification of metal in molds involving the characteristics of liquid-solid phase transformations, laws of thermodynamics and other functions.
To analyze solidification processing of engineering materials in terms of the phase equilibrium, transport, and interface phenomena governing microstructure development in liquid-solid transformations.
To apply these principles to industrial solidification processes, with emphasis on microstructural capabilities and limitations.

Course Content

Introduction and important thermodynamic functions: Laws ofthermodynamics-enthalpy, heat capacity, applications of first law to open and closedsystems including chemical reactions; entropy, free energy and their interrelationships
Thermodynamics of solidification; Nucleation and growth; Pure metalsolidification, Alloy Solidification, Constitutional undercooling, Mullins-Sekerkainstability; Single phase solidification: Cellular and Dendritic growth; Multiphasesolidification: eutectic, peritectic and monotectic; Modelling of solidification
Heterogeneous systems –equilibrium constants, Ellingham-Richardson diagrams,predominant area diagrams, principles of free energy minimization; energy balance ofindustrial systems; solutions-chemical potential, Raoult/Henry’s law, Gibbs-Duhemequations, regular solutions, quasi chemical theory
Evolution of Phase diagrams -phase rule, free-energy-composition diagrams,solidus-liquidus lines, retrograde solidus; determination of activity and otherthermodynamic parameters from phase diagrams,; thermodynamic analysis of ternaryand multi component systems, interaction parameters
Principles of applications- principles of applications to molten slags and silicatemelts; electrochemical methods and applications, aqueous systems; Interfaces-energy,shape, segregation at external and internal interfaces; solid electrolytes; Effect of highpressure on phase transformations; Point imperfections in crystalline solids.

Reference Books:

1*. Solidification Processing; Fleming, M.C., McGraw-Hill, N.Y., 1974*
2. Fundamentals of Solidification by Kurz, W. and Fisher, D.J., Trans-Tech Publications,Switzerland, 1989

Course outcomes

The students will be able to analyze and understand the

1. Thermodynamics of solidification processes and alloys.[2]
2. Thermodynamic modelling of solid-liquid phase change and solutions[4]
3. Kinetics of solidification such as nucleation & growth [5, 11]
4. Multiphase solidification. [3,4]
5. Thermodynamic analysis of ternary and multicomponent system.[5, 11]

MT 010 ALLOY DEVELOPMENT

L	T	P	C
3	0	0	3

Course Learning Objectives
To study the fundamentals, classification, properties of applications of various ferrous and non-ferrous systems.
Course Content

Metals vs Alloys; superiority of alloys over pure elemental metals; strategies for alloying; concepts such as strengthening mechanisms. Thermodynamics aspects of alloying; relation between alloy composition, structure and properties. ICME approach to alloy design and development.

Ferrous systems – Effect of specific alloying elements; alloy grades of cast irons, carbon steels; role of heat treatment

Ferrous systems – Highly alloyed steels; specific examples; Effect of alloying elements on phase transformations; development of novel grades of steels such as maraging steels, IF steels, AHS steels, PH steels, DP steels and Duplex stainless steels, role of heat treatment

Non-Ferrous systems based on Aluminium, Titanium and Copper; Typical alloying elements and their effects; relevant phase diagrams; Input on heat treatment

Use of alloying elements for grain refinement; Inclusion engineering; concept of ODS alloys; special cases such as High Entropy Alloys and Bulk metallic glasses
Reference Books
1. *Alloying: Understanding the Basics Edited by Joseph R. Davis, ASM International*
2. *Phase Transformations in Metals and Alloys, Third Edition by David A. Porter, Kenneth E. Easterling, CRC Press*
3. *Bain, E.C. and Paxton, H.W. Alloying Elements in Steels, ASM,Metal Park, Ohio*
4. *Lakhtin, Yu, M., Engineering Physical Metallurgy and Heat Treatment, Mir Publishers, Moscow.*

Course Outcomes
Upon completion of the course the student will be able to,

1. Describe various alloy systems, their classification [1, 2, 4].

2. Define and differentiate engineering materials on the basis of structure and properties for engineering applications [1,4, 8].

3. Proper processing technologies for synthesizing and fabricating different materials [1, 3, 10, 11].

MT 024 AUTOMOTIVE MATERIALS

L	T	P	C
3	0	0	3

Course objective: To understand the working principles of automobiles, different systems in automobiles and materials used in automobile components fabrication

Reciprocating engines, Otto cycle, Diesel cycle, four stroke and two stroke engines, working principle and constructional details of two stroke and four stroke engine, engine components, automobile construction, recent trends in automobile technology.

Engine cylinder: Structure and functions, types, cylinder blocks materials and manufacturing processes, improving engine components with surface modifications, Piston: Structures and functions, types, piston materials, piston manufacturing processes

Structure, function and materials for piston rings, camshaft, valves and valve seats, valve springs, connecting rod, crankshafts, turbocharger and exhaust manifold; tailor welds.

Types of chassis layout and chassis materials, vehicle frames, materials used for car body, front axle and steering system, drive line, propeller shaft, universal joints, wheels and suspension system.

Types of tires, applications of polymers in automobiles, environmental impact of emissions from IC engines and its control.

Text Books

1. Ganesan.V, Internal Combustion Engines, Tata-McGraw Hill Publishing Co., New Delhi, 1994.
2. Hiroshi Yamagata, The Science and Technology of Materials in Automotive Engines, Woodhead Publishing in Materials, 2005.
3. Hajra Choudhury, Elements of Workshop Technology, Vol-I and Vol-II Asia Publishing House, 1996.

Course outcomes:

- To understand air standard cycles and to estimate efficiencies of air standard cycles [1].
- To understand the functions of engine block and materials for engine block [3].
- To study various components used in automobile and selection of materials [2,4]
- To understand the automobile emissions and methods of controlling them [4,3,8]

MT 044 DESIGN AND SELECTION OF MATERIALS

L	T	P	C
3	0	0	3

Course objective: To know different types of materials and properties and to select better materials for different applications.

Technologically important properties of materials - Physical, chemical, mechanical, thermal, optical, environmental and electrical properties of materials. Material property charts - Modulus – density, strength-density, fracture toughness-strength,

Types of design, Design tools and materials data – Materials and shape – microscopic and micro structural shape factors – limit to shape efficiency
Comparison of structural sections and material indices – case studies
Service, Fabrication and economic requirements for the components – Methodology for selection of materials – Collection of data on availability, requirements and non functional things- its importance to the situations – case studies
Classifying process- -systematic selection of process – Selection charts - Ranking of processes – case studies - Influence of manufacturing aspects and processing route on properties of materials and its influence on selection of materials.
Selection of materials for automobile, nuclear, power generation, aerospace, petrochemical, electronic and mining industries.

TEXT BOOKS

1. *M.F.Ashby, " Materials Selection in Mechanical Design' – Third edition, Elsevier publishers, Oxford, 2005.*
2. *Gladius Lewis,"Selection of Engineering Materials", Prentice Hall Inc, New Jersey, USA, 1995.*

REFERENCES

1. Charles.J.A. and Crane,F.A.A., "Selection and Use of Engineering Materials", Butterworths, London, UK, 1989.

Course outcomes: Upon completion of the course, the student will be able to:

1. Understand types of materials and properties [1, 5]
2. Know different methods for materials selection [1, 2, 5]
3. Selection of materials for Specific engineering applications [1, 2, 11, 5, 7]

MT 045 NEW PRODUCT DEVELOPMENT

L	T	P	C
3	0	0	3

Objective: Expose students to the structured New Product Development (NPD) Methodology and help them understand the methodology; and effectively apply it to a practical situation.

Fundamentals of Product Development - Global Trends Analysis and Product decision - Types of various trends affecting product decision - Social Trends (Demographic, Behavioral, Psychographic), Technical Trends (Technology, Applications, Tools, Methods), Economical Trends (Market, Economy, GDP, Income Levels, Spending Pattern, target cost, TCO), Environmental Trends (Environmental Regulations and Compliance), Political/Policy Trends (Regulations, Political Scenario, IP Trends and Company Policies) - PESTLE Analysis

Product Development Methodologies and Management - Overview of Products and Services (Consumer product, Industrial product, Specialty products etc.,) - Types of Product Development (NPD/ Re-Engineering (Enhancements, Cost Improvements) / Reverse Engineering/ Design Porting & Homologation) - Overview of Product Development methodologies - Product Life Cycle (S-Curve, Reverse Bathtub Curve) - Product Development Planning and Management

Requirement Engineering and Management - Types of Requirements (Functional, Performance, Physical, Regulatory, Economical, Behavioral, Technical, Stakeholder, Environmental, Industry specific, Internal-Company Specific) - Gathering (VOC), Analysis (QFD), Design Specification - Traceability Matrix and Analysis - Requirement Management - System Design & Modeling - Introduction to System Modeling - System Optimization - System Specification - Sub-System Design - Interface Design

Design and Testing – Conceptualization - Industrial Design and User Interface Design - Introduction to Concept generation Techniques - Concept Screening & Evaluation - Concept Design - S/W Architecture - Hardware Schematics and simulation - Detailed Design - Component Design and Verification - S/W Testing - Hardware Testing – Prototyping - Types of Prototypes (Mockups, Engineering Assessment Prototype, Alpha, Beta, Gama) - Introduction to Rapid Prototyping and Rapid Manufacturing

System Integration and Business Dynamics - Testing, Certification and Documentation - Manufacturing/Purchase and Assembly of Systems - Integration of Mechanical, Embedded and S/W systems - Product verification processes and stages – Industry specific (DFMEA, FEA, CFD) - Product validation processes and stages - Industry specific (Sub-system Testing/ Integration Testing/ Functional Testing/ Performance Testing / Compliance Testing) - Product Testing standards and Certification – Industry specific - Product Documentation - Sustenance Engineering and End-of-Life (EoL) Support – Maintenance and Support - Obsolescence Management - Configuration Management - EoL Disposal; Business Dynamics – Engineering Services Industry - Product development in Industry versus Academia - vertical specific product development processes - Intellectual Property Rights and Confidentiality

TEXTBOOKS:

1. *Kevin Otto, Kristin Wood, "**Product design techniques in reverse engineering and new product development**", Pearson, India, 2006*
2. *Ulrich, Karl T. and Eppinger, Steven D, "**Product Design and Development**", 3rd Edition, McGraw-Hill, New York, 2004*

REFERENCE BOOKS:

1. *Ullman, David G., "The Mechanical Design Process", Mc Graw-Hill, 4th edition, 2009*
2. *Kenneth B. Kahn, George Castellion, Abbie Griffin, The PDMA Handbook of New Product Development, 2005, John Wiley & Sons , Inc. Hoboken, New Jersey, USA.*
3. *Merle Crawford, Anthony Di Benedetto, New Products Management, ninth edition, 2008, Mc Graw Hill Companies Inc. New York, USA*
4. *A.K.Chitale, R.C.Gupta, 'Product Design and manufacturing'*
5. *Hand outs provided by industrial experts*
6. *Resource Materials / 'BoK' provided by NASSCOM, related to NPD*

Course Outcome:

1. Clear understanding of the NPD Methodology

   Clear understanding of the influence of STEEP Factors for the success of New Product

   Clear understanding of the importance of Customer study, requirement gathering and analysis, Patent Study and analysis and Concept Generation Techniques and Evaluation Methods

   Execution of Pilot NPD Project

   Enhance the ability of students to apply individual Creative skills, work as a team to achieve the results and present the project outcome to management review team

MT 046 INTRODUCTION TO QUALITY MANAGEMENT

L	T	P	C
2	1	0	3

Course objective:

- To learn important concepts in quality;
- To learn about quality philosophy; and
- To learn about statistical tools used in quality

Quality – introduction; philosophical approach; cost of quality; overview of the works of Juran, Deming, Crosby, Taguchi; PDCA cycle; quality control; quality assurance Quality organization; quality management; quality system; quality audit; vendor quality assurance; total quality management; quality awards; quality certification; typical procedure for ISO9000, ISO14000, QS9000.

Variations; analysis of variance, statistical tools, statistical quality control; control charts; process capability analysis; statistical process control.

Inspection; inspection by sampling; acceptance sampling; statistical approaches; single, double and multiple sampling plans.

Reliability – concept; difference between reliability and quality; different measures of reliability; time to failure distributions; MTBF.

TEXT BOOKS

1. *J.M.Juran and F.M.Gryna, 'Quality Planning and Analysis', McGraw Hill, New York, 2nd Edition, 1980*
2. *B.L. Hansen, P.M. Ghare, 'Quality Control and Application', Prentice Hall of India – Eastern Economy Edition, 1997.*

Course outcomes: Upon completion of the course, the student will be able to:

- Understand the significance of quality management[a]
- Actively participate in quality systems certification initiatives[3, 4, 5, 6, 7]
- Qualitatively use quality concepts to real applications[2, 5]
- Perform basic calculations in SQC / SPC[3, 5]
- Appreciate the benefits of advanced concepts such as Six Sigma[1, 10, 6]
- Perform simple calculations in reliability[2, 5, 11]

MT 047 SURFACE ENGINEERING

L	T	P	C
3	0	0	3

Course objective: To analyse the various concepts of surface engineering and comprehend the design difficulties.Asses the surface testing methods and comprehend the degradation properties [1, 2, 5, 11]

Introduction tribology, surface degradation, wear and corrosion, types of wear, adhesive, abrasive, oxidative, corrosive, erosive and fretting wear, roles of friction and lubrication- overview of different forms of corrosion

Chemical and electrochemical polishing, significance, specific examples, chemical conversion coatings, phosphating, chromating, chemical colouring, anodizing of aluminium alloys, thermochemical processes -industrial practices

Surface pre-treatment, deposition of copper, zinc, nickel and chromium - principles and practices, alloy plating, electrocomposite plating, properties of electro deposits, electroless, electroless composite plating; application areas, properties.

Definitions and concepts, physical vapour deposition (PVD), evaporation, sputtering, ion plating, plasma nitriding, process capabilities, chemical vapour deposition (CVD), metal organic CVD, plasma assisted CVD.

Thermal spraying, techniques, advanced spraying techniques - plasma surfacing, detonation gun and high velocity oxy-fuel processes, laser surface alloying, laser cladding, specific industrial applications, tests for assessment of wear and corrosion

TEXT BOOKS

1. *Sudarshan T S, 'Surface modification technologies - An Engineer's guide', Marcel Dekker, Newyork, 1989*
2. *Varghese C.D, 'Electroplating and Other Surface Treatments - A Practical Guide', TMH, 1993*

Course outcomes: Upon completion of the course, the student will be able to:

1. Define different forms of processing techniques of surface engineering materials[4, 6 ,1,5]
2. Know the types of Pre-treatment methods to be given to surface engineering[1, 4, 6, 8, 11]
3. Select the Type of Deposition & Spraying technique with respect to application [1]
4. Study of surface degradation of materials[1]

MT 026 NANO MATERIALS AND APPLICATIONS

L	T	P	C
3	0	0	3

Course Objectives: Students who complete this course will be able to describe methods for production of nano materials, characterization of nano materials and applications of nano materials

Introduction: Concept of nanomaterials – scale / dimensional aspects, nano and nature, effect of size reduction on various properties, advantages and limitations at the nano level.

Methods to produce nanomaterials: Plasma arching, chemical vapour deposition, sol-gel process, electro deposition, ball milling, severe plastic deposition, etc.

Characterization of nanomaterials and nanostructures: Salient features and working principles of SEM, TEM, STM, AFM, XRD, etc.

Applications: Fullerenes, carbon nano tubes, nano composites, molecular machines, nanosensors, nanomedicines, etc.

Health Issues: Understanding the toxicity of nanoparticls and fibers, exposure to quartz, asbestos, air pollution. Environmental issues: Effect on the environmental and other species. Societal implications: Implications of nanoscience and technology in society, government regulations, etc.

TEXT BOOKS:

1. *T. Pradeep, Nano: The Essentials, Tata McGraw Hill, 2007.*
2. *Mick Wilson et all, Nanotechnology: Basic Science and Emerging Technologies, Overseas Press, 2005.*

REFERENCES

1. *Charles P. Poole Jr, Frank J. Owens, Introduction to nanotechnology, Wiley-India (P) Ltd., 2006.*

Course outcomes: Upon completion of the course, the student will be able to:

- Understand the terminologies used in the field of nano materials [3]
- Classify different methods of manufacturing of nano materials [5, 11]
- To select nano materials for different industrial applications [4,9,11]
- To understand the health issues related to nano materials [10]

MT 031 BIOMATERIALS

L	T	P	C
3	0	0	3

Course Learning Objectives

The objective of this course is to provide students a fundamental understanding of different materials for biomedical-applications and their *in-vitro* and *in-vivo* characteristics.

Course Content

Need for biomaterials; Salient properties of important material classes for different bio-implant applications. Introduction biodegradable implant materials.

Processing and properties of different biomaterials; Nanomaterials and nanocomposites for medical applications; Nanostructured coatings for bio-implants.

Mechanical property evaluation and phyisco-chemical characterization of biomaterials; *In-vitro* and *In-vivo* evaluation of biomaterials.

The structure and composition of hard tissues, Bone biology: Introduction to tissue engineering; Applications of tissue engineering; Biomaterials for drug delivery applications.

Biomaterials worldwide market, technology transfer and ethical issues; Standards for biomaterials and devices.

Reference Books

1. *Hench L. Larry, and Jones J., (Editors), Biomaterials, Artificial organs and Tissue Engineering, Woodhead Publishing Limited, 2005.*
2. *Hench L. Larry, & Wilson J., (Editors), An Introduction to Bio ceramics, World Scientific, 1994.*

Course Outcomes

At the end of the course student will be able

1. Understand the properties of different biomaterials, know the advantages and disadvantages of different biomaterials and select materials for different applications. [1,2,11]
2. Understand the processing and testing of biomaterials [2,5]
3. Characterize the biomaterials for their physico-chemical properties and analyze the cell-material interactions [1,2]
4. Understand the basics of tissue engineering.[1]
5. Design and develop new biomaterials for different biomedical applications [2,3,4,5,11]

MT 032 ADVANCED CHARACTERIZATION TECHNIQUES

L	T	P	C
3	0	0	3

Course Learning Objectives
To make the students understand the concepts of various advanced characterization tools and their applications.

Course Content

Concepts, principles and applications of Electron diffraction, Synchrotron diffraction, Neutron diffraction and Electron back scattered diffraction.
Introduction, principles and applications of CBED, nano-diffraction, LEED, RHEED and HAADF
Introduction principles and applications of advanced spectroscopic techniques like XPS, SANS and SAXS, GISAXS, AES and SIMS
Basics and applications of *in-situ* metallographic techniques, *in-situ* SEM and *in-situ* TEM
Introduction, basic principles and applications of nano-mechanical characterization like AFM, STM and Nanoindentation studies

Reference Books

1. Transmission Electron Microscopy; D.B. Williams and C.B. Carter, Plenum Press (2004)
2. Modern ESCAThe Principles and Practice of X-Ray Photoelectron Spectroscopy, Terry L.Barr, CRC press, (1994)
3. Scanning Electron Microscopy and X-ray Microanalysis by Joseph Goldstein, Dale E. Newbury, David C. Joy, and Charles E.; Springer Science (2003)
4. Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series) A. K. Tyagi, Mainak Roy, S. K. Kulshreshtha and S. Banerjee;, Volumes 49 – 51 (2009)
5. Encyclopedia of Materials Characterisation Editors: C.R. Brundle, C.A. Evens, Jr, S. Wilson, Butterworth-Heinmann, Boston (1992)

Course Outcomes

At the end of the course student will be able to

1. Understanding diffraction phenomenon and its application in identifying phases
2. Understanding specialized diffraction tools in TEM
3. Understanding the specialized spectroscopic techniques
4. Understanding the concepts of in-situ microscopic techniques
5. Understanding the various nano-mechanical characterization techniques

MT 033 MATERIALS FOR EXTREME ENVIRONMENTS

L	T	P	C
3	0	0	3

Course Learning Objectives

Student should be capable of understand various extreme environment conditions and choose suitable materials for various conditions.

Course Content

Fundamentals of high temperature deformation, creep - Mechanism - Deformation Mechanism Maps - Superplasticity - Engineering materials applied in extreme environments: structural materials at high temperatures such as gas turbine applications

Introduction radiation resistance materials; radiation damage - half life period - irradiation damage resistance - BCC structures and ferritic grade steels for radiation damage resistance applications - Liquid sodium storage materials in nuclear industry - nuclear waste disposal.

Space environment - anomalous behavior of materials in space - Engineering materials applied in extreme environments: spacecraft materials - reusable space vehicles - carbon-carbon composites (CCC).

Understanding high strain rate deformation - Elastic wave propagation - Materials under thermo-mechanical extremes (static vs dynamic; high-pressure phases; shock; detonation; cavitation; super-cooled liquids and glasses) - Shock resistant materials - armor grade materials.

Materials for cryogenic applications - DBTT - FCC structures - Deformation behavior in cryogenic temperatures - cryorolling.

Reference Books

1. G.E. Dieter, “Mechanical Metallurgy”, Mc Graw Hill Publishers, NY,2002
2. Materials Under Extreme Conditions, Vincenzo Schettino and Roberto Bini, Imperial College Press, winter 2012.

Course Outcomes

At the end of the course student will be able

1. Can understand the behavior of high temperature materials
2. Capable of assessing behavior of various irradiation damage resistance materials
3. Can understand the space environment and choosing materials for space applications
4. Analyze the high strain rate deformation behavior and capable of choosing or fabricating materials
5. Capable of understanding deformation at cryogenic temperatures

MT 083 PHYSICAL METALLURGY AND HEAT TREATMENT

L	T	P	C
3	0	0	3

Course Learning Objectives

To develop an understanding of the basis of physical metallurgy and correlate structure of materials with their properties for engineering applications.

Course Content

Introduction to engineering materials. Atomic structure and inter atomic bondings, theoretical concept of crystalline materials – types of packing, voids and packing factors for each of the packings, concept of alloy design using lattice positions and intristitial voids. Planes and directions and imperfections in solids. Polymorphism and allotropy.
Diffusion, energetic of solidification Nucleation and growth-dealing homogeneous and heterogeneous nucleations and growth of solids, dendritic growth in pure metals, constitutional super cooling and dendritic growth in alloys.
Phase diagrams – solid solution –types, Hume –Rothery rule. Phase diagrams – Binary-types – Lever rule. Solidification of different types of solid solutions – Iron-Carbon diagram – Effect of alloying element on Iron-carbon diagram. Ternary phase diagrams- Understanding of isotherms and isopleths.
Het treatment of ferrous alloys; Annealing, Normalising, TTT and CCT diagrams, Hardening – hardenability measurements, tempering. Thermo mechanical treatments. Heat treatment furnaces – atmospheres – quenching media – case hardening techniques.
Basic concept of dislocations their types and its interactions.Dislocations and strengthening mechanisms strengthening by grain-size reduction, solid solution strengthening, strain hardening, dispersion hardening and other recent modes of hardening.

Reference Books

1. *Avner, S. H., "Introduction to Physical Metallurgy", second edition, McGraw Hill, 1985.*
2. *William F. Hosford, Physical Metallurgy, Taylor & Francis Group, 2008*
3. *Raghavan, V., "Physical Metallurgy", Prentice Hall of India, 1985*
4. *Donald R Askland and Pradeep P Phule "Essentials of Materials Science and Engineering, Baba Barkha NathPrinters, Delhi.*
5. *Willam D. Callister, Jr. Materials Science and Engineering, Wiley India Pvt. Ltd.*
6. *Vijendra Singh, Physical Metallurgy, Standard Publishers.*

Course Outcomes

Upon completion of the course, the student will be able to:

1. Describe the basic crystal structures (BCC, FCC, and HCP), recognize other crystal structures, and their relationship with the properties.

2. Define and differentiate engineering materials on the basis of structure and properties for engineering applications.

3. Proper processing technologies for synthesizing and fabricating different materials.

4. Analyse the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments

MT 084 DEFORMATION PROCESSING

L	T	P	C
3	0	0	3

Course Learning Objectives

To know the concepts of metal forming and associate technologies and apply them to the conventional and advanced materials manufacturing for various structural applications.

Course Content

Yielding criteria of von Mises and Tresca. Levy-Von Mises equations and Prantl Reuses equations for ideal plastic and elastic plastic solids respectively. Yield Locus. Methods of load calculation including slab method, slip line field theory, FEM, upper and lower bound methods.
Texture effects. Metallurgical factors affecting recrystallization temperature and grain size. Effect of temperature, strain rate, hydrostatic pressure, Microstructure. Residual stresses, Friction and lubrication mechanisms. Lubricants in rolling, forging, extrusion, wire drawing, sheet metal forming. Tool design
Types of rolling mills, Geometrical factors and forces, Factors affecting rolling load and minimum thickness, Roll pass design, wheel and tyre production. Rolling defects,Processes and equipment, Forgeability, effect of various factors, definitions. Selection of equipment, die design, parting line, flash, draft, tolerance. Defects, causes and remedies.
High velocity forming methods, superplastic forming, hydroforming, isothermal forging. Principles and processes. FLD and LDR, CAD, CAM in forming use of softwares like OPTRIS, DEFORM, etc. Workability.
Sol-gel and other processes for powders. Slip casting, extrusion injection moulding, HIP and CIP (Isostatic pressing), sintering. Blow moulding,Blow and Injection Moulding. Compression and transfer Moulding, Pultrusion. Filament Moulding. Resin Transfer Moulding

Reference Books

1. Dieter, G.E., “Mechanical Metallurgy”, McGraw Hill, 2001.
2. *ASM “Metals Handbook, Vol. 14, Forming & Forging”, ASM, Metals Park, Ohio, USA, 1998.*
3. *Kurt Lange, “Handbook of Metal Forming”, Society of Manufacturing Engineers, Michigan, USA, 1985.*
4. *Belzalel Avitzur, “Metal Forming- Processes and Analysis”, Tata McGraw Hill, 1977.*
5. *Pat.L.Manganon, “Principles of Materials Selection for Engineering Design”, Prentice Hall Int. Inc,1999*
6. *Knigery,W.D., Ceramic Fabrication Processes, John Urley, 1950.*
7. *ASM, “Metals Handbook, Vol. I”, Properties and selection, McGraw Hill, 2001.*

Course Outcomes

At the end of this course, the students would be able to:

1. Apply the concept of plastic deformation for metals and alloys to convert them in to useful shapes for intended engineering applications
2. Differentiate the various metal forming technology and choose the appropriate one for required engineering applications
3. Provide the successful solution to the various materials design and selection criteria for demanding engineering applications.
4. Analyze various operational and materials parameters influencing the metal forming quality.
5. Classify various metal forming technology (forging, rolling, extrusion etc.) and associated forming equipments
6. Define various secondary forming procedures like stretch forming, deep drawing blanking and associated equipments

MT 085 MANUFACTURING METHODS

L	T	P	C
3	0	0	3

Course Learning Objectives

To understand the fundamentals of manufacturing methods in the view of metallurgical perspective with reference to engineering applications.

Course Content

Types of production and production processes, product configuration and manufacturing requirements.

Pattern making, allowances and core making. Casting processes of ferrous and non-ferrous metals including die casting, investment casting, centrifugal casting, loam moulding, transfer moulding. Solidification principles, design of moulds, riser, sprues and gating system, casting defects.

Metal joining processes: soldering, brazing, fusion and non-fusion welding processes, various modern welding processes like TIG, MIG, Submerged Arc Welding, Friction Welding. Welding defects.

Fundamentals of hot and cold working processes – forging, extrusion and rolling.

Introduction. Production of metal powders. Compaction and sintering processes. Secondary and finishing operations. Economics, advantages, and applications of powder metallurgy.

Reference Books

1. *Manufacturing Technology: Foundry, Forming and Welding by P.N.Rao, TMH.*
2. *Principles of Manufacturing Materials and Processes, James S.Campbell, TMH.*
3. *Welding Metallurgy by G.E.Linnert, AWS.*
4. *Production Engineering Sciences by P.C.Pandey and C.K.Singh, Standard Publishers Ltd.*
5. *Manufacturing Science by A.Ghosh and A.K.Mallick, Wiley Eastern.*

Course Outcomes

At the end of this course, the students would be able to:

1. Understand the basic principles of different manufacturing processes in terms of metallurgical perspective
2. Understand the solidification mechanism of casting and welding
3. Learn causes of defects due to various manufacturing processes and remedies

MT 086 TESTING AND EVALUATION OF MATERIALS

L	T	P	C
3	0	0	3

Course Learning Objectives

To develop the fundamental knowledge on testing and evaluation of materials, in order to control the quality in manufacturing and production engineering components.

Course Content

Visual examination, Basic principles of liquid penetrant testing and Magnetic particle testing. Radiography - basic principle, electromagnetic radiation sources, radiographic imaging, inspection techniques, applications, limitations and safety.

Eddy current testing - principle, application, limitation; ultrasonic testing - basic properties of sound beam, transducers, inspection methods, flaw characterisation technique, immersion testing, advantage, limitations; acoustic emission testing. Leak testing, Holography and Thermography - principles, procedures and applications, Comparison and selection of NDT methods; defects in casting, forging, rolling and others.

Mechanical Testing: Indentation hardness tests - principle, practice, precautions and uses; Tensile test-sample types and dimensions, stress-strain diagrams for ductile and brittle materials, interpretation and estimation of tensile properties; compression, shear, bend and torsion tests - principle, practice and uses; introduction to relevant standards.

Charpy and Izod impact tests - techniques and applications; low and high cycle fatigue testing methods, S-N diagram, applications; creep and creep rupture tests, time compensated parameters; relevant standards

Reference Books

1. *Baldevraj, Jayakumar T., Thavasimuthu M., 'Practical Non-Destructive Testing', Narosa Publishing, 1997*
2. *Das A. K., 'Metallurgy of Failure Analysis', TMH, 1992*
3. *Colangelo V. A., 'Analysis of Metallurgical Failures', John Wiley, 1985*
4. *Suryanarayana A. V. K., Testing of metallic materials, (2nd Edition), BS publications, 2007*
5. *Dieter G.E., Mechanical Metallurgy, (3rd Edition), ISBN: 0070168938, McGraw Hill, 1988.*

Course Outcomes

At the completion of this course, the student will be able to

1. Differentiate various defect types and describe the main criteria to select the appropriate NDT methods [1, 4, 5]
2. Select suitable NDT method for specific industrial application [1, 2, 8, 10]
3. Understand the criteria to select the appropriate destructive testing methods and corresponding standards for a specific application [1, 4, 5]
4. Carry out destructive to evaluate the mechanical properties for industrial purposes [2, 5, 10, 11]

MT 088 NON-METALLIC MATERIALS

L	T	P	C
3	0	0	3

Course Learning Objectives

To provide an understanding of the various non-metallic materials, their properties and applications

Course Content

Clasisification of Engineering materials – Metals, Ceramics, Polymers (and Composites): Ceramics- Definition, classification; Ionic and Covalent ceramics; Oxide and Non-oxide ceramics; Crystalline and Non-Crystalline ceramics

Oxide ceramics – Examples, Structures, Properties and Applications; Indicative domains as in refractories, glasses, abrasives and Biomaterials

Non-oxide ceramics - Examples, Structures, Properties and Applications; Indicative information on synthesis/production, indicative application domains

Polymers – Basic unit, degree of polymerisation, Structure, Properties and Applications; Thermoplastic and Thermoset polymers, speciality polymers

Composite Materials – Concept, Definition, Structure, Classification and Manufacturing. Specific discussion on any two types of particulate composites and fibrous composites; Novel applications of special composites especially in strategic areas.

Reference Books

1. *Van Vlack L.H, Elements of Materials Science and Engineering, 6th edition,Addison Wiley, 1989*
2. *Billmeyer F., 'Textbook of Polymer Science', Wiley Interscience, 1994*
3. Richerson D. W., 'Modern Ceramic Engineering - Properties Processing and Use in Design', 3rd edition, CRC press, 2006
4. Carter, C. Barry, Norton, M. Grant, Ceramic Materials: Science and Engineering, 2nd Edition, Springer,2013
5. Donald R. Askeland and Pradeep phule, The science and Engineering Materials.Thmson,2003

Course Outcomes

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

1. Understand the concept of metallic and non-metallic materials [1,2]
2. Understand the basics of ceramics, its types and synthesis methods [1,2]
3. Understand the basics of polymers, its structure properties and applications [1,2]
4. Understand the composite materials, its applications and its recent developments [1,9,10]

MT 091 ADVANCED THERMODYNAMICS OF MATERIALS

L	T	P	C
3	0	0	3

Course objectives

To become familiar with recent developments in thermodynamics and applications; and get exposed to thermodynamic modelling activity

Review of thermodynamics – metallurgical, mechanical and statistical perspectives

Experimental procedures related to Thermodynamics – calorimetry, activity measurements, interaction co-efficient, and electrochemical cells

Thermodynamics of Defects – Theoretical calculations and practical significance

Application of thermodynamics to surfaces, interfaces, bulk metallic glasses, high-entropy systems and novel materials

Modeling techniques used in thermodynamics of materials - In the context of phase diagrams, free energy calculations, electrochemical cells, corrosion, solution thermodynamics, slags and alloy development; exposure to techniques in computational materials science; introduction to thermodynamics of nano systems

Text books

1. D. R. Gaskell, Introduction to the Thermodynamics of Materials, 4th Edition, Taylor and Francis, New York, 2003.
2. R.T. Dehoff, Thermodynamics in Materials Science, 1st and 2nd Edition, McGraw-Hill, 1993 and 2006.

References

1. D. V. Ragone, Thermodynamics of Materials, Vol. 1 & 2, John Wiley & Sons, 1994.
2. Richard A Swalin, Thermodynamics of Solids, John Wiley & Sons, 1994.
3. S. A. Porter and K. E. Easterling, Phase Transformation in Metals and Alloys, 2nd Edition, Chapman and Hall, 1992.
4. J.J. Moore, Chemical Metallurgy, 2nd Edition, Butterworths, 1990.
5. Current literature, open web resources and materials for case study

Course outcome

Upon completion of this class, the students will be able to:

1. Use thermodynamics as a tool for developing metals and materials [1, 2, 5, 8]
2. Develop next generation materials with superior properties [3, 5, 8, 10, 12]

MT 092 ADVANCED SOLIDIFICATION PROCESSING

L	T	P	C
3	0	0	3

Course objective: A study of important thermodynamic functions related to

- solidification of metal in molds involving the characteristics of liquid-solid phase transformations, laws of thermodynamics and other functions.
- To analyze solidification processing of engineering materials in terms of the phase equilibrium, transport, and interface phenomena governing microstructure development in liquid-solid transformations.
- To apply these principles to industrial solidification processes, with emphasis on microstructural capabilities and limitations.
- Asses the surface testing methods and comprehend the degradation properties [1, 2, 5, 11]

Introduction and important thermodynamic functions: Laws of thermodynamics-enthalpy, heat capacity, applications of first law to open and closed systems including chemical reactions; entropy, free energy and their interrelationships

Thermodynamics of solidification; Nucleation and growth; Pure metal solidification, Alloy Solidification, Constitutional undercooling, Mullins-Sekerka instability; Single phase solidification: Cellular and Dendritic growth; Multiphase solidification: eutectic, peritectic and monotectic; Modelling of solidification

Heterogeneous systems –equilibrium constants, Ellingham-Richardson diagrams,predominant area diagrams, principles of free energy minimization; energy balance of industrial systems; solutions-chemical potential, Raoult/Henry's law, Gibbs-Duhem equations, regular solutions, quasi chemical theory

Evolution of Phase diagrams -phase rule, free-energy-composition diagrams, solidus-liquidus lines, retrograde solidus; determination of activity and other thermodynamic parameters from phase diagrams,; thermodynamic analysis of ternary and multi component systems, interaction parameters

Principles of applications- principles of applications to molten slags and silicate melts; electrochemical methods and applications, aqueous systems; Interfaces-energy,shape, segregation at external and internal interfaces; solid electrolytes; Effect of high pressure on phase transformations; Point imperfections in crystalline solids.

REFERENCE:

1. *Solidification Processing; Fleming, M.C., McGraw-Hill, N.Y., 1974*
2. *Fundamentals of Solidification by Kurz, W. and Fisher, D.J., Trans-Tech Publications, Switzerland, 1989*

Course outcome:

The students will be able to analyse and understand the

1. Thermodynamics of solidification processes and alloys.
2. Thermodynamic modelling of solid-liquid phase change and solutions
3. Kinetics of solidification such as nucleation, growth, and constitutional super cooling
4. Multiphase solidification.
5. Thermodynamic analysis of ternary and multicomponent system.

MT 093 CYSTALLOGRPHY

L	T	P	C
3	0	0	3

Motif, lattices, lattice points, lattice parameter, Crystal systems,14 bravice lattices, Coordination number, number of atoms per unit cell, packing factor, Miller indices of planes directions, repeat distance, linear density packing factor along a direction, planar density, planar packing fraction

Radius ration for coordination number 2,4,6,8. Interestial solid solution, interestial compounds. AX,AX2,AB03 A 2B04 crystal structures

Frenkel schkotty ionic defects. Ionic defect concentration, solu;t;e incorporation,

Electronic defect Electronic defect concentration.

Band Gap, density of states,defects. Defects and chemical reaction.

Symmetry and crystallography. Symmetry in crystals. Rotational symmetry, sterograhic projection. Cystallograhic point goups, micro translations, symmetry of reciprocal lattice, systematic absences, space groups special position

Reference books:

1.Donald R. Askeland and Pradeep phule, The science and Egineering Materials.

Thmson,2003

2. Cullity, Elements of X-ray diffraction, Addison-Wesley Publishing company 1956

MT 094 AEROSPACE MATERIALS

L	T	P	C
3	0	0	3

Course objective: To analyse the various concepts of surface engineering and comprehend the design difficulties.

Asses the surface testing methods and comprehend the degradation properties

Classification and different components in Aircraft, Helicopter and Rocket – Properties of Materials-Airworthiness-Aerospace material design drivers-Quality Standardsfor aerospace industry-Materials requirements for aerospace structures,Engines and Rockets

Mechanical and durability testing of aerospace materials – Aerospace materials certification- Structural health monitoring and non-destructive testing of aircraft components-Corrosion and corrosion testing of aerospace materials – Materials selection for aerospace,space environments and its effect on materials – stealth technology

Yield strength anamoly(Kerf-Wilsdorf Mechanism)-Materials for Gas turbine-Ni-based super alloys-Intermetallics-Ti-Al alloy – Bond coat-Thermal barrier coating(plasma spraying)-Materials for Rocket combustion chambers and Nozzles-Copper alloys-Cobalt base alloy-Stellite-Columbium alloy
Al-Li alloys-Magnesium alloys-Titanium alloys-Super alloys-Stainless steels-Maraging steel
Composites-Polymer matrix composites-Carbon-Carbon composites-Ablative composites

MT 095 RECENT DEVELOPMENTS IN WELDING PROCESSES

L	T	P	C
3	0	0	3

Course objective:

- Understand the various advancements in welding processes.
- Gain knowledge of the concepts, operating procedures, applications, advantages and limitations of various recent welding processes.

GMAW, types of metal transfer, CO_2 welding, pulsed and synergic MIG welding and surface tension transfer, CMT-Concepts, processes and applications.

key hole TIG, Narrow gap TIG, cold and hot wire TIG, dual shielding TIG, multi cathode TIG, buried arc TIG, A-TIG, AA-TIG, micro- plasma arc welding and AC/DC submerged arc welding process, twin wire SAW, tandem SAW, metal power addition SAW. cold and hot wire -SAW.

MIAB, Micro wave welding Concepts, processes and applications, types of metal transfer and applications, advances in diffusion welding, advances in electron beam welding, laser welding, resistance welding, flash butt welding and under water welding-concepts, types and applications.

Metal flow phenomena in friction stir welding, tool design, retreating tool, friction stir spot welding, friction stir processing, linear friction welding, orbital friction welding processes and applications. Advances in adhesive bonding, Brazing and soldering

Cladding, CVD, PVD, Laser and electron beam surface modification, ion implantation, and Cutting

TEXT BOOKS

1. *Parmer R. S., 'Welding Engineering and Technology', Khanna Publishers, 1997*
2. *Cary, Howard, "Modern Welding Technology', prentice Hall, 1998*
3. *Schwartz M.,' Materials and Applications - Metal Joining Manual', McGraw-Hill, 1979*
4. *Nadkarni S.V., 'Modern Arc Welding Technology', Oxford IBH Publishers, 1996*
5. *Christopher Davis, 'Laser Welding - A Practical Guide', Jaico Publishing House, 1994*
6. *Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM,2007*

Course outcomes: Upon completion of this class, students are expected to

- Explain the various advancements in GMW and their applications [3, 4, 6]
- Explain the various advancements in TIG welding and their applications [3, 4, 6]
- Explain the various advancements in MEAB, microwave welding, EBW, Laser and resistance welding and their applications [3, 4, 6]
- Describe the various advancements in under water welding and their applications [3, 4, 6]
- Explain the various advancements in FSW and their applications [3, 4, 6]
- Explain the various advancements in surfacing methods and their applications [3, 4, 6]

MT 096 RECENT DEVELOPMENTS IN FORMING PROCESSES

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To understand the concepts of advanced forming processes and their applications.

Ring rolling: types and classification. Ring rolling of steels and non ferrous alloys- defects, remedial actions. Ring rolling mills.

Incremental bulk forming: Orbital riveting - types, orbital forging processes - types, Advantages and limitations. Presses and modifications needed for the incremental bulk forming.

Superplastic forming: Superplasticity – definition, types, structural Superplasticity – Superplastic materials – metals/alloys, composites and ceramics. Superplastic forming methods. Advantages and Limitations.

Pressing and sintering: Production of simple and complicated shapes – sequence of operation – sintering – mechanisms- near net shape production- Advantages and limitations

Isostatic pressing: Definition – stress tensor in Isostatic conditions – types – near net shape production- Advantages and limitations

References:

1. Numerical Analysis- Theory and Application – Edited by john Awreicewicz, In Tech publisher, 2011.
2. J.M. Allwood, A.E. Tekkaya, T.F. Stanistreet, The development of ring rolling technology, Steel Res Int, 76 (2005), pp. 111–120
3. J.M. Allwood, A.E. Tekkaya, T.F. Stanistreet, The development of ring rolling technology-part 2: investigation of process behavior and production equipment, Steel Res Int, 76 (2005), pp. 491–507.
4. Edwards, L. and Endean, M., Manufacturing with materials,1990, Butterworth Heinemann
5. Groche P., Fritsche D., Tekkaya E.A., Allwood J.M., Hirt G., Neugebauer R., Incremental bulk metal forming, Annals of the CIRP, 56, 2007, 635-656.
6. Cubberly, W. H.; Ramon, Bakerjian; Society of Manufacturing Engineers (1989), Desk edition: Tool and manufacturing engineers handbook, SME, p. 42-17, ISBN 978-0-87263-351-3.
7. K.A. Padmanabhan and G.J. Davies “Superplasticity", Springer Verlag, Berlin-Heidelberg-New York, August 1980,
8. Angelo P C and Subramanian R, “Powder Metallurgy: Science Technology and Applications”, PHI, New Delhi, 2011.

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Understand the Concepts of the advanced forming processes
2. Understand the applications of the advanced forming processes
3. Can choose suitable process for the given material.

MT 097 RECENT TRENDS IN NANOMATERIALS

L	T	P	C
3	0	0	3

Course objective: To provide an understanding of the various concepts involved in fabrication of nanomaterial and the focus is on technological applications in various fields of science and engineering.

Synthesis of Nanomaterials Recent advances in Physical Vapor Deposition (PVD), pulsed laser deposition, Magnetron sputtering, Multi Beam Epitaxy, Chemical Vapor Deposition (CVD), Atomic Layer Deposition (ALD) - Micro lithography, Vapor (or solution) – liquid – solid (VLS or SLS) growth - pulsed electrochemical deposition – Super Plastic Deformation, High energy ball milling, Chemical-Mechanical milling, Electro explosion, Laser ablation.

Nanotechnology in Electronics and Energy Nano electronic devices and circuits – Semiconductor Memories - Dynamic Radom Access Memory- Nonvolatile Semiconductor Memories- Quantum Dot based Memory Cell- Sensors; physical and chemical- Electronic noses- Actuators- Micro and Nano-Electromechanical systems– Lighting and Displays – Quantum optical devices- Lasers – Batteries – Super capacitors- Fuel cells–Role of nanomaterials in fuel cell applications- Photovoltaic cells –Application of nanotechnology in solar cells- Application of power in transportation including space

Nanotechnology in Biomedical Industry Nanoparticles and Micro–organism- Biosensors-Bioreceptors and their properties - Biochips- Integrated nanosensor networks for detection and response- Natural nanocomposite systems; spider silk, bones, shells - Nanomaterials in bone substitutes and dentistry –Tissue Engineering – Neuroscience - Neuro-electronic Interfaces -Nanorobotics–– Protein Engineering – Nanosensors in Diagnosis–Drug delivery – Cancer therapy and other therapeutic applications.

Nanotechnology in Agriculture and Food Sector Nanotechnology in Agriculture -Precision farming, Smart delivery systems – Insecticides using nanotechnology – Potential of nano-fertilizers – Potential benefits in Nanotechnology in Food industry – Global Challenges- Product innovation and Process improvement- Consumer benefits- Food processing - Packaging- - Packing materials; physical properties- Improvements of mechanical and barrier properties- Antimicrobial functionality- Active packaging materials- -Information and communication technology- Sensors- RF identification- Food safety- Nanomaterial based

Food diagnostics – Contaminant detection – Intelligent packaging- Nanoengineered Food ingredients- Potential risks to Nanofood to consumers

Nanotechnology in Defence and Aerospace Pathways to Physical protection- Detection and diagnostics of chemical and biological agents, methods- Chemical and Biological counter measures- Decontamination- Post exposure and pre exposure protection and decontamination- Nanotechnology enabled bio chemical weapons- Influence operations- Evasion of medical countermeasures- Nanotechnology based satellite communication system- Guidance, Navigation and control- Spacecraft thermal control- mini, micro, nanosatellite concepts- Fiber optic and Chemical microsensors for space craft and launch support- Micro/Nano pressure and temperature sensors for space missions.

Text Books:

1. *Charles P. Poole, Jr., Frank J. Owens, "Introduction to nano technology", Wiley, 2003*
2. *Gunter Schmid, "Nanoparticles: From Theory to Applications", Wiley-VCH Verlag GmbH & Co., 2004.*
3. *Bharat Bhushan, "Springer Handbook of Nanotechnology", Barnes &Noble, 2004*.

Reference Books:

1. *Neelina H. Malsch (Ed.), "Biomedical Nanotechnology", CRC Press 2005.*
2. *W.N. Chang, "Nanofibres fabrication, performance and applications", Nova Science Publishers Inc, 2009.*
3. *Margaret E, Kosal, "Nanotechnology for Chemical and Biological defence", Springer 2009.*

Course Outcome

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

1. To choose a tailor made synthesis route according to the requirements of the end product. [1,2,3]
2. To provide instances of contemporary industrial applications of Nanotechnology. [1,2,5,8,10,11]
3. To provide an overview of future technological advancements and increasing role of nanotechnology in industries. [3,5,8,9,11,12]

MT098 ECONOMICS OF METAL PRODUCTION PROCESSES

L	T	P	C
3	0	0	3

Course objectives

To understand the role of metallurgical industries in the economy; to understand how metallurgical companies come up with innovative practices with respect to raw materials, processes, cost, yield and market conditions.

Tonnage production, range of products and annual turnover of companies in the metals and materials sector; Input on macroeconomics and government policies

Typical approaches to cost estimation with respect to capital expenses and operating expenses; quantum of investment associated with different sectors in the metallurgical domain; approaches to estimation of savings and profits, such as ROI and EBITDA

Natural resources required for major metallurgical industries; trends in mining and public policy; Time frame required for moving from idea to actual production, in green field sites

Need for developing new grades or new varieties of products, related investment requirements, related technological initiatives and impact on profitability

Sustainability in the production of metals and materials; discussion on energy, environment, waste generation, losses and disposal; targets with respect to emissions and related penalties; Concept of green manufacturing

Text books

1. Bruce R. Beattie and C. Robert Taylor, The Economics of Production, reprinted by Krieger Publishing Company, 1993.

References

1. Philips Maxwell, Mineral Economics - An Introduction, in Mineral Economics: Australian and Global Perspectives, Australian Institute of Mining and Materials, Carlton, Victoria; 2nd Edition, 2013.
2. David Humphreys, China Changes Everything, The Remaking of the Mining Industry, Palgrave MacMillan, 2015.
3. Case studies on initiatives and experiences of various metallurgical companies
4. Supplementary reading materials on cost reduction, quality improvement and innovative manufacturing

Course outcome

Upon completion of this class, the students will be able to:

1. Understand the practices in operation in industries [1, 2, 4, 7]
2. Explore new grades of metals and materials compatible with green manufacturing [3, 5, 6, 8, 12]

MINOR ELECTIVES

MT087 PHYSICS OF MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

To provide an understanding of the various approaches used to understand important properties of materials and the relationships between these properties.

Introduction and Approach, Properties of materials and some important relationships, Free electron theory of metals, Drude model Electronic Conductivity, Drude model Thermal Conductivity - Ratio the Wiedemann Franz Law.

Maxwell Boltzmann Statistics, Limitations of the Drude model, Elementary quantum mechanics: History and Significant concepts, The Drude Sommerfeld model, Fermi Dirac statistics, Density of states, Fermi Energy and Fermi Surface, Improvements over Drude model, remaining limitations.

Specific heat, phonons, Real space Vs Recirpocal space, Diffraction condition and its significance for electron energy, Wigner Seitz cells, Brillouin zones, Band Theory, Density of occupied states, the origin of anisotropy.

Electrons and Holes, Classification of semiconductors, Direct Band gap, indirect Band gap, opto electronic materials, Magnetic properties, superconductivity, Meissner effect, Bose-Einstein Statistics, BCS theory, High temperature superconductors, physics of nano scale materials

Principles of photoconductivity, luminescence- - photo detectors – Optical disc and optoelectronic materials –LCD, LED and diode laser materials - electro optic modulators - Kerr and Pockel's effect – LiNbO3.

Text Books:

1. *David Jiles, "Introduction to electronic properties of materials", Chapman and Hall, 1994.*
2. *S.O. Kasap, "Principles of Electrical Engineering Materials" McGraw Hill, 1977.*
3. *Alan Cottrell, "Introduction to the Modern Theory of Metals", Ashgate Publishing Company, 1988.*
4. *Ed. Kasap and Capper, "Handbook of electronic and photonic materials", Springer, 2006.*

Reference Books:

1. *Ashcroft and Mermin, "Solid State Physics", Saunders College Publishing, 1976.*
2. *William D. Callister, Jr., "An introduction to Materials Science and Engineering", John Wiley & Sons, 2003.*
3. *David R. Gaskell , "Introduction to Metallurgical Thermodynamics", Hemisphere Publishing Corp., 1981.*

Course Outcomes

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

1. To understand the electrical and thermal conductivity of the materials based on the modular, statistical approach. [1, 2]
2. To understand the conduction mechanism exhibited by materials based on band gap theory for conducting, semiconducting and insulating materials. [1, 2]
3. To study the theory of superconductivity phenomenon and superconducting materials and their applications along with recent advancement [1, 9, 10]
4. To learn about photoconduction phenomenon, optical materials and various optical devices and their performances. [1, 2]+

MT082 Metallurgy for Non-metallurgists

L	T	P	C
3	0	0	3

Course Objective:

To give basic ideas about alloys classification, material characterization and protection of materials

Type of steels; Plain carbon steel, alloy steels, tool steels, Stainless steel

Types of cast iron; Grey, White, SG, Malleable and alloy cast iron

Industrially important Cu, Al, Ti, Mg and Ni based non-ferrous alloys

Introduction to materials characterization - Optical and Electron microscopy, and X-ray diffraction

Degradation of Materials; Corrosion and protective methods

Text Book:

1. Sidney H Avner, Introduction to Physical Metallurgy, 2nd Edition, Tata McGraw Hill, 1997

Reference Books:

1. William D. Callister, Materials Science and Engineering, 2nd Edition, Wiley, 2014
2. V. Raghavan, Physical Metallurgy: Principles and practice, 2nd Edition, PHI, 2006

Course Outcome:

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

1) Understand the basic classification of steels and cast iron [1, 2]
2) Characterize the materials by microscopy and X-ray diffraction [1, 2, 11]
3) Identify the form of corrosion and suggest protection methods [1, 3, 9, 10]