B. Tech. DEGREE

METALLURGICAL AND MATERIALS ENGINEERING

SYLLABUS
FOR
CREDIT BASED CURRICULUM
Batch: 2009 – 2013 & 2010-2014
(OBE Format: 2013)

Department of Metallurgical and Materials Engineering
National Institute of Technology
Tiruchirappalli 620 015

May 2009
(Reprinted on 12th April 2014)

III SEMESTER (REGULAR STREAM)

CODE	COURSE OF STUDY	L	T	P	C
MA205	Transforms and Partial Differential Equations	3	0	0	3
EC219	Applied Electronics	2	0	2	3
CE281	Strength of Materials	3	0	0	3
PH211	Electrical, Electronic and Magnetic Materials	3	0	0	3
MT207	Metallurgical Thermodynamics	3	1	0	4
MT209	Mineral Processing and Metallurgical Analysis	3	0	0	3
MT213	Physical Metallurgy	3	1	0	4
	Total	**20**	**2**	**2**	**23**

IV SEMESTER

CODE	COURSE OF STUDY	L	T	P	C
MA202	Numerical Techniques	3	0	0	3
EE220	Electrical Technology	2	0	2	3
IC216	Instrumentation and Control	3	0	0	3
MT208	Transport Phenomena	3	0	0	3
MT210	Phase Transformation and Heat treatment	3	0	0	3
ME292	Mechanical Technology	3	0	0	3
IC220	Instrumentation and Control Laboratory	0	0	3	2
MT216	Ferrous Metallography Laboratory	0	0	3	2
	Total	**17**	**0**	**8**	**22**

V SEMESTER

CODE	COURSE OF STUDY	L	T	P	C
MT301	Metal Casting Technology	3	0	0	3
MT303	Iron and Steel Making	3	1	0	4
MT305	Polymers and Composites	3	0	0	3
MT307	Materials Joining Technology	3	0	0	3
MT309	Mechanical Behaviour of Materials	3	0	0	3
CA351	C++ and UNIX	3	0	0	3
PR331	Foundry & Welding Laboratory	0	0	3	2
MT315	Mechanical Testing Laboratory	0	0	3	2
	Total	**18**	**1**	**6**	**23**

VI SEMESTER

CODE	COURSE OF STUDY	L	T	P	C
MT304	Non ferrous Extraction	3	0	0	3
MT306	Particulate Processing	3	0	3	4
MT308	Non-Ferrous Physical Metallurgy	3	0	0	3
MT 310	Metal Forming Technology	3	0	0	3
MT312	Fatigue, Creep and Fracture Mechanics	3	1	0	4
	Elective – I	3	0	0	3
MT314	Heat Treatment Laboratory	0	0	3	2
MT316	Non-Ferrous Metallography Laboratory	0	0	3	2
	Total	**18**	**1**	**9**	**24**

VII SEMESTER

CODE	COURSE OF STUDY	L	T	P	C
MT401	Ceramic Materials	3	0	0	3
MT403	Corrosion Engineering	3	0	0	3
MT405	Materials characterisation	3	0	0	3
MB491	Management Concepts and Practices	3	0	0	3
	Elective-II	3	0	0	3
	Elective-III	3	0	0	3
MT409	Corrosion Engineering Laboratory	0	0	3	2
MT447	Comprehensive Evaluation	0	3	0	3
	Total	**18**	**3**	**3**	**23**

VIII SEMESTER

CODE	COURSE OF STUDY	L	T	P	C
HM402	Industrial Economics	3	0	0	3
MT402	Non Destructive Testing and Failure Analysis	3	0	0	3
	Elective-IV	3	0	0	3
	Elective-V	3	0	0	3
MT498	Project work	0	0	15	6
	Total	**12**	**0**	**15**	**18**

Total Credits for the Course: 178 (Including 45 for First Year)

LIST OF ELECTIVES

VI Semester

MT 352	Special Steels & Cast Irons
MT 354	Design and Selection of Materials (Global)
MT 356	Special Casting Techniques

VII Semester

MT451	Surface Engineering
MT453	Process Modeling and Applications
MT 455	Special topics in metal forming
MT 457	Nano materials and Applications
ME451	Industrial Safety
PR451	New Trends in Manufacturing
	Any one elective from other departments

VIII Semester

MT456	Ceramic Processing
ME352	Finite Element Methods
PR460	Project Management
MT452	High Temperature Materials
MT458	Introduction to Quality Management (Global)
MT460	Emerging Materials
MT462	Ladle Metallurgy & Continuous Casting of Steels (Open to B.Tech Chemical Engg)
MT466	Welding Metallurgy
MT 468	Computational techniques
HM 402	Corporate Communication
MT 472	New Product Development
	Any one elective from other departments

MA205 TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS

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.

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

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

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 - Half range Fourier cosine and sine series - Parseval's relation - Fourier series in complex form - Harmonic analysis.
Fourier transforms - 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 - method of separation of variables - Fourier series solution.

Text Books

1. Grewal, B.S., Higher Engineering Mathematics, Khanna Publishers.

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

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

EC 219 APPLIED ELECTRONICS

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.

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

- 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]
- Design and studies of different types of amplifiers, converters and their contributions in various circuits. [1, 2]
- Construction and analysis of multiplexers, demultiplexers, decoders and encoders. [1, 2, 11]
- Construction of UJT, SCR, DIAC, TRIAC and analysis of their characteristics. Also analysis of Stepper motor performance using combination of circuits. [1, 2, 11]

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*

CE 281 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.

Course outcomes:

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

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.

PH 211 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.

Course outcomes:

- 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].
- 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].
- To study the theory of superconductivity phenomenon and superconducting materials and their applications along with recent advancements [5, 8].
- 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].
- To learn about photoconduction phenomenon, optical materials and various optical devices and their performances [1].

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.*

MT207 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.

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

- Understand the basic laws of thermodynamics [1, 2]
- Understand the multiple approaches to thermodynamics, from the bulk property point of view and from the atomistic point of view [1]
- Understand concepts such as the theory of solutions, free energy, entropy, criteria for equilibrium and conditions for feasibility [1, 2]
- Obtain the skill to use metallurgical thermodynamic concepts and equations for understanding phase diagrams, phase transformations, theory of solutions [11, 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]

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 1st and 2nd 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*

MT209 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-extractionpractices.

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

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

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*

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.

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

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

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.*

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.

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]

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 eigenvector.

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.

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.

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]

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*

IC 216 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.
Course outcomes: Upon completion of this class, the student will be able to:

- Differentiate static and dynamic characteristics and calibration standards for measurements. [1]

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

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

Measurement using expansion thermometers, thermocouples, Resistance temperature detectors, thermistors and optical pyrometers

Classification, Measurement using strain gauges, capacitive transducers, inductive transducers, Piezoelectric transducers . Measurement of level : Basic methods, Non-contact measurement techniques

Introduction to PC- based measurement system, interface standards, Virtual instruments

Basics of open loop, closed loop system, classification of variables, basic control actions and its applications

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.*

REFERENCES

1. Patranabis, "Sensors and Transducers", Wheeler Publishing, 1999.
2. Stephanoponilos, "Chemical Process Control : An Introduction to Theory and practice, PHI, New Delhi, 1999.

MT208 TRANSPORT PHENOMENA

L	T	P	C
3	0	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.

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

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

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

MT 210 PHASE TRANSFORMATIONS AND HEAT TREATMENT

L	T	P	C
3	0	0	3

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

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]

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*

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.

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]

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.*

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.

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

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

List of Experiments

1. Measurement of strain using strain gauges.
2. Measurement of torque using strain gauges
3. Measurement of load using load cells.
4. Measurement of displacement using LVDT
5. Measurement of sound level.
6. Measurement of pressure.
7. Measurement of temperature using RTD.
8. Measurement of temperature using TC.

9. Measurement of temperature using Thermistor
10. Measurement using PC- based Instrumentation system
11. Design of P, I, PI, PD, PID control.
12. Design of control using PLC

MT216 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

Course outcomes:

- 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]

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

MT301 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

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

- Select the appropriate design of the moulds, patterns etc. [1, 3, 11]

- Design a new pattern or mould for required applications, if needed [1, 8]
- Choose the appropriate furnace for the production of new materials [3, 8]
- Distinguish the casting microstructures for different materials [1, 9]
- Alter the microstructure for different applications [4, 5]

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

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.

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

- Classify different kinds of furnaces and their ancillary equipments used for Iron & Steel making [10, 11, 5]

- Analyze various factors influencing quality of the product in blast furnace during Iron & Steel making[10, 11, 5]
- Analyze the irregularities and cause of failures in blast furnace and apply the remedial measures for immediate rectification [2, 1]
- Compare the traditional steel making to modern day manufacturing routes for the improvement of quality [11, 1, 2]

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 S and P; 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

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

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

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

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

MT307 MATERIALS JOINING TECHNOLOGY

L	T	P	C
3	0	0	3

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

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

- Classify the different welding processes with their inherent merits and limitations [1,5,10]
- Select appropriate process route and fillers based on the materials [1, 2, 11]
- Analyze the microstructure of the weldments for different materials for different applications [1, 2]
- Solve the materials problems associated joining technology [1, 11]
- Produce the engineering structure with the dissimilar materials [1, 8]
- Provide the low cast manufacturing possibilities by appropriate selection of the joining process. [8, 1, 11]

Welding versus other joining/processes

Classification of welding processes - heat sources and shielding methods - fusion welding processes, oxy - acetylene welding, arc welding processes electroslag and electrogas welding, resistance welding

Cold and hot pressure welding; friction, friction stir, ultrasonic, induction pressure, explosive and diffusion welding

Electron beam, plasma arc and laser beam welding . advantages, limitations and applications of the electron beam, plasma arc and laser beam welding processes

Brazing, soldering, cutting and surfacing processes, soldering materials, applications of soldering , brazing and surfacing

Weld thermal cycles and their effects, structural changes in different materials, effects of pre and post heat treatments, concept of weldability and its assessment. Welding of different materials, defects in welds, their causes and remedies

TEXT BOOKS

1. *Houldcroft P. T , 'Submerged Arc Welding', Abington Publishing, 1988*
2. *Linnert G. E., 'Welding Metallurgy', Volume 1 and 2, 4th Edition, American Welding Society, 1994*

REFERENCES

1. Jackson M. D., 'Welding Methods and Metallurgy', Griffin, London, 1967
2. Lancaster L.F, 'The Physics of Welding', Pergamon Press, 1984

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.

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

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

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

CA 351 C++ AND UNIX

L	T	P	C
3	0	0	3

Course objective: To develop an understanding of the basics of C++ and object oriented designing methods and successful development of programs using C++ compiler under UNIX environment.

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

- Define the concepts of object-oriented programming and various functions for the well structured programs. [1, 5]
- Define the Constructors and Inheritance and differentiate the classifications of Constructors and Inheritance for effective usages in application programs. [1, 5]
- Select process of polymorphism in operator, type conversion and functions. [1, 5]
- Define the files, streams, object-oriented database and their case studies experience. [1, 5]
- Define UNIX, their filing systems, commands and understanding of Java programming. [1, 5]

Concepts in object-oriented programming, Classes and Objects, C++ programming basics, Object-oriented analysis, Object-oriented Design methods, Functions: Friend functions, Arrays and Pointers.

Constructors and Inheritance: Derived classes, The protected access specifier, Derived class constructors, Overriding Member functions, Class Hierarchies, Public and Private inheritance, Multiple inheritance.

Polymorphism: Operator Overloading and Type conversion, function overloading, Virtual functions, Abstract base classes and Pure Virtual functions.

Files and Streams, Generic Programming, Introduction to object-oriented database- case studies.

History of UNIX – Kernel introduction, file system, UNIX commands, introduction to Java programming.

TEXT BOOKS

1. Robert Lafore, "Object Oriented Programming in Turbo C++", 1992, Galgotia Publications.

2. Bourne, SF, "Unix Operating System"., I Edition, 1983, Addison Wiley.

REFERENCES

1. Yashwant Kanetkar, "Unix shell Programming" I Edition, 1994, BPB Publication,

2. SUMITABHA DAS, "Unix Concepts and Applications", 3rd Edition, Tata McGraw-Hill, 2003

PR331 FOUNDRY & 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.

Course outcomes: At the end of this course, the students would be able to:
Classify the different welding and casting processes with their inherent merits and limitations [1, 10, 5]

- Select appropriate process route and fillers based on the materials [1, 2, 11]
- Analyze the microstructure of the weldments for different materials for different applications [1, 2]
- Produce the engineering structure with the dissimilar materials [1, 8]
- Provide the low cast manufacturing possibilities by appropriate selection of the joining / casting process. [8, 1, 11]

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

MT315 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.

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

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

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

   Hardness measurement: definition, various methods of measurements – Rockwell, Vickers, Brinell, Moh's – testing procedure, derivation of various expressions.

2. Tension testing of metallic materials using UTM

3. Tension testing of metallic materials of various standard specimens using Hounsfield tensometer

4. Compression testing of metallic material

5. Creep testing

6. Microhardness testing for case hardened specimens

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.

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

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

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*

MT306 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.
Course outcomes: At the end of this course, the students would be able to:

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

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]

MT308 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.
Course outcome: After the completion of this course, the student will be able to:

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

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

MT 310 METAL FORMING TECHNOLOGY

L	T	P	C
3	0	0	3

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.

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

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

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*

MT312 FATIGUE, CREEP AND FRACTURE MECHANICS

L	T	P	C
3	1	0	4

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.

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

- Define the life assessment of various engineering materials and associated testing methods [1]
- Describe basic mechanisms of fatigue and creep behavior of various engineering materials and their importance in materials design [1, 2]
- Analyze the various metallurgical factors influencing the fatigue and creep performance of materials for different structural engineering applications [1, 2, 5]

- Select the appropriate processing route and alter the microstructure for the life enhancement of materials at room and elevated temperatures [1, 10, 11]
- Provide suitable remedial measure to prevent premature failure and reduction in performance [1, 5
- Describe the failure modes and root cause of the materials failure based on fracture mechanics and fractography approach [1, 11]

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

MT314 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.
Course outcomes: At the end of this course, the students would be able to:

- Define various heat treatment procedures for variety of engineering materials and their importance in materials behavior [1, 2]

- Classify different heat treated microstructure using microscope [1]
- Provide the practical solution procedure for the betterment of the materials performance based heat treatment [1, 2, 10]
- Develop comprehensive heat treatment procedure and process map for newly developed metals and alloys. [1, 5, 10]

List of Experiments

1. Determination of grain size of low carbon steels
2. Heat treatment of mild, medium carbon and alloy steels
3. Carburising 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

MT316 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.

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

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

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

MT401 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.

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

C1: Know the structure and properties of different ceramic materials [1, 2, 5, 11]

C2: Understand the phase diagrams and comprehend the phase transformations in ceramic materials [1, 3, 4, 11]

C3. Understand the testing methods for evaluating the mechanical properties of ceramic materials [2, 11]

C4. Understand the electrical, magnetic and optical properties of important ceramic systems [1, 3, 4, 11]

C5. Appreciate the properties of ceramic materials for different engineering applications [1, 11]

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*

MT403 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.

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

- Do electro and electroless plating of Cu, Al alloys [1, 2, 11]
- 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]
- Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking [1, 2, 11]
- Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness [1, 2, 10, 11]

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.

MT405 MATERIALS CHARACTERISATION

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.

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

- Know the principles of metallurgical microscope, X-ray Diffractrometer (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Thermal analysis and dilatometer [1, 11]
- Describe the various sample/specimen preparation techniques for XRD, SEM, TEM and thermal analysis and quantitative metallography [2, 11]
- Determine crystal structure, lattice parameter, phase identification, solvus line estimation and residual stress analysis using XRD [1, 2, 11]
- Describe the modes of SEM operation, study the surface topography using different modes, elemental compositional analysis and spectroscopy studies [1, 11]
- 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]
- Evaluate the specimen by thermal analysis, dilatometry, resistivity and magnetic measurements [11]

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*

MT491 MANAGEMENT CONCEPTS AND PRACTICES

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.

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

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

Introduction to management, evolution of scientific management, modern management, principles – Elements of management –

Planning, Organizing, Staffing, Directing, Co-ordinating, Reporting, Budgeting,

Core concepts of marketing, Need, want, demand, product, value, satisfaction, marketing mix –product, price, place, promotion.

Product design, Types of production system. Plant location – Factors to be considered, Plant layout.

Types of layout, Inventory management, Project Management – PERT – CPM – Applications.

TEXT BOOKS

1. *Principles & Practice of Management by L.M. Prasad, Sultan Chand & Sons.*
2. *Philip Kotler, 'Marketing Management', 12th Edition, Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2005*

REFERENCES

1. *'Financial Management Theory and Practice', by Prasanna Chadra 3rd Edition, Tata McGraw Hill, 2004*

MT409 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.

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

- Do electro and electroless plating of Cu, Al alloys [1, 2, 11]
- 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]
- Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking [1, 2, 11]
- Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness [1, 2, 10, 11]

Copper electroplating, electroless plating, anodizing of aluminum, 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.

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.

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

- Define micro economics, demand analysis, supply analysis, consumption laws, indifference curve analysis and competitions. [4, 6]

- Define macro economics, differentiate with micro economics, importance, Keynes theory, functions of central and commercial bank. [4, 8]
- Contributions of Fayol, Taylor in managerial functions, balance sheet, and sources of finance.
  [4, 8]
- Differentiate marketing and selling, marketing myopia, and product life cycle. [3, 4]
- Describe recruitment and selection, job evaluation and performance appraisal methods, communication, motivation and leadership. [3, 4, 8]

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*

MT 402 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, inorder to control the quality in manufacturing and production engineering components.

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

- Differentiate various defect types and describe the main criteria to select the appropriate NDT methods for the product [1, 4, 5]

- Define tools and techniques of failure analysis, procedural steps for investigation of failure and failure data retrieval [1, 4, 5, 11]
- Describe various types of failure and select suitable techniques for failure analysis [1, 4, 5]
- Know about various ISO standards, inspection, inspection by sampling and quality management [2, 3, 4, 7, 8, 9]

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

ELECTIVES

MT352 SPECIAL STEELS AND CAST IRONS

L	T	P	C
3	0	0	3

Course objective: To know different types of steel and Cast-iron.
Course outcomes: Upon completion of the course, the student will be able to:

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

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*

MT 354 DESIGN AND SELECTION OF MATERIALS

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

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

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

PRE-REQUISITE: Candidate should have under gone courses in Physical metallurgy, Metallic materials, Ceramics, Polymers, Composites, Mechanical behaviour of materials and Manufacturing Processes in undergraduate or in post graduate level.

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.

MT 356 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

MT451 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.

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

- Define diffetent forms of processing techniques of surface engineering materials[4, 6 ,1,5]
- Know the types of Pre-treatment methods to be given to surface engineering[1, 4, 6, 8, 11]
- Select the Type of Deposition and Spraying technique with respect to the application [1, 3, 5]
- Study of surface degradation of materials[1]
- Asses the surface testing methods and Comrehend 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*

MT452 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*

MT453 PROCESS MODELING AND APPLICATIONS

L	T	P	C
2	1	0	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 455 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.

MT456 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.

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]

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*

MT 457 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

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]

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.*

MT458 INTRODUCTION TO QUALITY MANAGEMENT

L	T	P	C
3	0	0	3

Course objective:

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

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]

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.*

MT460 EMERGING MATERIALS

L	T	P	C
3	0	0	3

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

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

- Describe various processing techniques of different engineering materials.[1, 3, 5]
- Analye the Phase diagram and Microstructure using Microscope for different type of Stainless steel materials.[2, 4, 5, 11]
- Select the material for Biological, Nuclear, Space and Cryogenic service applications.[1, 4, 10, 3]

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*

MT462 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.

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

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

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.

MT466 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*
2. *Jackson M. D., 'Welding Methods and Metallurgy', Grffin, London, 1967*SPECIAL

MT 468 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 472 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.

Course Outcome:
- 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

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

Mode of Delivery / class / assessment:

This course will include conventional class room lectures by faculty of NITT, lectures by industrial experts and lectures by video conferencing, team projects; and mini – project presentations by students of this course. Internal assessment will be based on twenty marks from one cycle test and thirty marks from the mini-project.

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*