B. Tech. DEGREE

METALLURGICAL AND MATERIALS ENGINEERING

SYLLABUS
FOR
CREDIT BASED CURRICULUM
2011 - 15 Batch

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

July 2011

III SEMESTER (REGULAR STREAM)

CODE	COURSE OF STUDY	L	T	P	C
MA 205	Transforms and Partial Differential Equations	3	0	0	3
EC 219	Applied Electronics	2	0	2	3
CE 281	Strength of Materials	3	0	0	3
PH 211	Electrical, Electronic and Magnetic Materials	3	0	0	3
MT 207	Metallurgical Thermodynamics	3	1	0	4
MT 209	Mineral Processing and Metallurgical Analysis	3	0	0	3
MT 213	Physical Metallurgy	3	1	0	4
	Total	**20**	**2**	**2**	**23**

IV SEMESTER

CODE	COURSE OF STUDY	L	T	P	C
MA 202	Numerical Techniques	3	0	0	3
EE 220	Electrical Technology	2	0	2	3
IC 216	Instrumentation and Control	3	0	0	3
MT 208	Transport Phenomena	3	0	0	3
MT 210	Phase Transformation and Heat treatment	3	0	0	4
ME 292	Mechanical Technology	3	0	0	3
IC 220	Instrumentation and Control Laboratory	0	0	3	2
MT 216	Ferrous Metallography Laboratory	0	0	3	2
MT 222	Process Metallurgy Laboratory	0	0	3	1
	Total	**17**	**0**	**11**	**24**

V SEMESTER

CODE	COURSE OF STUDY	L	T	P	C
MT 301	Metal Casting Technology	3	0	0	3
MT 303	Iron and Steel Making	3	1	0	4
MT 305	Polymers and Composites	3	0	0	3
MT 307	Materials Joining Technology	3	0	0	3
MT 309	Mechanical Behaviour of Materials	3	0	0	3
CA 351	C++ and UNIX	3	0	0	3
PR 331	Foundry & Welding Laboratory	0	0	3	2
MT 315	Mechanical Testing Laboratory	0	0	3	2
	Total	**18**	**1**	**6**	**23**

VI SEMESTER

CODE	COURSE OF STUDY	L	T	P	C
MT 304	Non ferrous Extraction	3	0	0	3
MT 306	Particulate Processing	3	0	3	4
MT 308	Non-Ferrous Physical Metallurgy	3	0	0	3
MT 310	Metal Forming Technology	3	0	0	3
MT 312	Fatigue, Creep and Fracture Mechanics	3	1	0	4
	Elective – I	3	0	0	3
MT 314	Heat Treatment Laboratory	0	0	3	2
MT 316	Non-Ferrous Metallography Laboratory	0	0	3	2
	Total	**18**	**1**	**9**	**24**

VII SEMESTER

CODE	COURSE OF STUDY	L	T	P	C
MT 401	Ceramic Materials	3	0	0	3
MT 403	Corrosion Engineering	3	0	0	3
MT 405	Materials characterization	3	0	0	3
MB 491	Management Principles and Concepts	3	0	0	3
	Elective-II	3	0	0	3
	Elective-III	3	0	0	3
MT 409	Corrosion Engineering Laboratory	0	0	3	2
MT 447	Comprehensive Evaluation	0	3	0	3
	Total	**18**	**3**	**3**	**23**

VIII SEMESTER

CODE	COURSE OF STUDY	L	T	P	C
HM 402	Industrial Economics	3	0	0	3
MT 402	Non Destructive Testing and Failure Analysis	3	0	0	3
	Elective-IV	3	0	0	3
	Elective-V	3	0	0	3
MT 498	Project work	0	0	15	6
	Total	**12**	**0**	**15**	**18**

Total Credits for the Course: 180 (Including 45 for First Year)

LIST OF ELECTIVES

VI Semester

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

VII Semester

MT 451	Surface Engineering
MT 453	Process Modeling and Applications
MT 455	Special topics in metal forming
MT 457	Nano materials and Applications
ME 451	Industrial Safety
PR 451	New Trends in Manufacturing

Any one elective from other departments

VIII Semester

MT 456	Ceramic Processing
ME 352	Finite Element Methods
PR 460	Project Management

Any one elective from other departments

Reserve Electives

MT 452	High Temperature Materials
MT 458	Introduction to Quality Management (Global)
MT 460	Emerging Materials
MT 462	Ladle Metallurgy & Continuous Casting of Steels
MT 466	Welding Metallurgy
MT 468	Computational techniques
HM 402	Corporate Communication

MA 205 TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS

L	T	P	C
3	0	0	3

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

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

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

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

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

Text Books

1. Grewal, B.S., Higher Engineering Mathematics, Khanna Publishers, Edn. 38, 2004.
2. Kandasamy, P. Thilagavathy, K. And Gunavathy, K., Engineering Mathematics, Vol. III, Chand and Company, 1996.
3. Venkataraman, M.K., Engineering Mathematics Vol.IV, National Publishing Company, 2004

EC 219 APPLIED ELECTRONICS

L	T	P	C
2	0	2	3

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

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

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

TEXT BOOK

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

List of Experiments

1. Characteristics of PN Junction diode
2. Characteristics of Zener diode

3. Inverting and Non Inverting operational amplifiers
4. Study of logic gates
5. Multiplexers and De-Multiplexers

CE 281 STRENGTH OF MATERIALS

L	T	P	C
3	0	0	3

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, ELECTRONICS AND MAGNETIC MATERIALS

L	T	P	C
3	0	0	3

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.

MT 207 METALLURGICAL THERMODYNAMICS

L	T	P	C
3	1	0	4

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*

MT 209 MINERAL PROCESSING AND METALLURGICAL ANALYSIS

L	T	P	C
3	0	0	3

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

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

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

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

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

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

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

Basics of open loop and closed loop system, classification of variables,
ON/OFF, P, PI, PID controllers and their applications.

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

TEXT BOOKS

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

REFERENCES

1. Patranabis, "Sensors and Transducers", Wheeler Publishing, 1999.
2. Doebelin E.O, " Measurement system-applications and design", 4th edition McGraw Hill New York 2003

MT 208 TRANSPORT PHENOMENA

L	T	P	C
3	0	0	3

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
4	0	0	4

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

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

List of Experiments

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

MT 216 FERROUS METALLOGRAPHY LABORATORY

L	T	P	C
0	0	3	2

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

MT 222 PROCESS METALLURGY LAB

L	T	P	C
0	0	3	1

List of experiments:

1. Sieve analysis
2. Sedimentation and decantation
3. Determination of size distribution in sample by Anderson pipette method
4. Jaw crusher
5. Rolls crusher
6. Rod mill
7. Heavy medium separations
8. Froth floatation
9. Tabling

MT 301 METAL CASTING TECHNOLOGY

L	T	P	C
3	0	0	3

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

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

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

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

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

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

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

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

TEXT BOOKS

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

MT309 MECHANICAL BEHAVIOUR OF MATERIALS

L	T	P	C
3	0	0	3

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

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++", 4th Edition, SAMS, 2002*
2. *Cameron Newham and Bill Rosenblatt, "Learning the bash shell: Unix Shell Programming" 3rd Edn. O' Reilly, 2005*

REFERENCES

1. *Paul Deitel and Harvey M, Deitel, "C++ How to Program",7th Edn., Prentice Hall,2009,*
2. *Sumitabha Das " Yoour UNIX: the Ultimate Guide", Tata McGraw-Hill, 2001*
3. *Yashavant P Kanetkar, Unix Shell Programming", Third Edn. BpB Publication 2004.*

PR 331 FOUNDRY & WELDING LABORATORY

L	T	P	C
0	0	3	2

List of Experiments

Foundry

1. Determination of permeability, shear strength and compression strength of the given foundry sand
2. Determination of clay content for the given moulding sand sample and also to study the variation of compression strength for various moisture contents
3. Determination of the grain fineness of the given foundry sand

4. Prepare the mould for the given pattern with core using two boxes and three - box moulding process
5. Determination of flowability for the given foundry sand
6. 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

MT 315 MECHANICAL TESTING LABORATORY

L	T	P	C
0	0	3	2

List of Experiments

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

MT 304 NON FERROUS EXTRACTION

L	T	P	C
3	0	0	3

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*

MT 306 PARTICULATE PROCESSING

L	T	P	C
3	0	3	4

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]

MT 308 NON-FERROUS PHYSICAL METALLURGY

L	T	P	C
3	0	0	3

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

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

MT 312 FATIGUE, CREEP AND FRACTURE MECHANICS

L	T	P	C
3	1	0	4

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

MT 314 HEAT TREATMENT LABORATORY

L	T	P	C
0	0	3	2

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

MT 316 NON-FERROUS METALLOGRAPHY LABORATORY

L	T	P	C
0	0	3	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

MT 401 CERAMIC MATERIALS

L	T	P	C
3	0	0	3

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

MT 403 CORROSION ENGINEERING

L	T	P	C
3	0	0	3

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.

MT 405 MATERIALS CHARACTERISATION

L	T	P	C
3	0	0	3

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

MB 491 MANAGEMENT CONCEPTS AND PRACTICES

L	T	P	C
3	0	0	3

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

Foundations of Planning: Meaning, purpose of planning. The role of goals and plans in planning: Types of goals, Types of plans, Establishing goals: approaches, characteristics and

steps in goal setting, Developing Plans: approaches and contingency factors. Contemporary issues in Planning:

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

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

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

TEXT BOOKS

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

MT 409 CORROSION ENGINEERING LABORATORY

L	T	P	C
0	0	3	2

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

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

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
MT 352 STEELS AND CAST IRONS

L	T	P	C
3	0	0	3

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

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*

MT 451 SURFACE ENGINEERING

L	T	P	C
3	0	0	3

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*

MT 453 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.

MT 457 NANO MATERIALS AND APPLICATIONS

L	T	P	C
3	0	0	3

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.*

ME 453 INDUSTRIAL SAFETY

L	T	P	C
3	0	0	3

Accident Prevention; Safety aspects in the use of machines and equipment

Safety in Material Handling; training for Safety – Safe Practices in Industry

Provisions for Safe Working – Create a Safe Environment

Personal Protection and Welfare

Some View Points on Safety

TEXT BOOK

1. William Handlin, "Industrial Hand Book", McGraw-Hill, 2000

PR 451 NEW TRENDS IN MANUFACTURING

L	T	P	C
3	0	0	3

Agile manufacturing – Lean manufacturing – Virtual Reality

Precision Engineering – its concept and significance – Micro machining – High speed machining – manufacturing of integrated circuits

Nano enginering – its conceopts, significance and applications – molecular and atomic level machining and its applications – rapid prototyping – stereolithography – 3D Printing

TEXT BOOK:

1. Serope Kalpakjian, "manufacturing process for engineering materials" – Addison Wesley publishing Co, 1997

2. Massood Tabid – azar, " Micro actuators – electrical, magnetic, thermal, optical , mechanical, chemical and smart structures", Kluwer academc publishers, 1997.

REFERENCES

1. Proceedings of the seminar on "Significance of precision engineering in the Indian context" September, 1998

MT 456 CERAMIC PROCESSING

L	T	P	C
3	0	0	3

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 452 FINITE ELEMENT METHODS

L	T	P	C
3	0	0	3

Introduction, different approaches in FEM, direct stiffness approach; simple examples; variational approach, elements of variational calculus, Euler-Lagranage equation; Rayleigh-Ritz method, weighted residual methods; point collocation method; sub-domain collocation method

Types of elements used - interpolation polynomials - linear elements - shape function-analysis of simply supported beam - element and global matrices - two dimensional elements; triangular and rectangular elements

Finite element formulation of field problems - classification of partial differential equations; quasi-harmonic equation - steady state problems - Eigen value problems - propagation problems - examples; torsional problem

Finite element formulation of solid mechanics problems - axial force member - element matrices for axial force members - truss element - analysis of pinned truss - two dimensional elasticity problems

Numerical methods in FEM and computer implementation - evaluation of shape functions; one dimensional and triangular elements; quadrilateral elements; iso parametric elements - numerical integration; guass-legendre

TEXT BOOKS

1. *Segerlind, L.J., "Applied Finite Element Analysis", John Wiley, 1984*

PR 460 PROJECT MANAGEMENT

L	T	P	C
3	0	0	3

Project Development Cycle – identification of investment opportunities – Market demand analysis

Technical analysis – materials and inputs – Production technology – product mix – plant capacity – location and site – machinery and equipment –structure and civil works – project charts and layouts

Cost of project and means of financing – terms loans – cost of production – estimation of tax burden

Financial and economic appraisal – mathematical programming approach – LP, ILP and goal programming model – Portfolio theory and network techniques

Portfolio theory and capital asset pricing model approaches to risk analysis – Network techniques for project management – PERT, CPM.

TEXT BOOKS

1. *Prasanna Chandra, Projects, Tata Mcgraw Hill, 1986.*
2. *Choudhury, S, Project Mgt, Tata Mcgraw Hill, 1988.*

MT 452 HIGH TEMPERATURE MATERIALS

L	T	P	C
3	0	0	3

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

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

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

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

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

TEXT BOOKS

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

REFERENCES

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

MT 458 INTRODUCTION TO QUALITY MANAGEMENT

L	T	P	C
3	0	0	3

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.*

MT 460 EMERGING MATERIALS

L	T	P	C
3	0	0	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*

MT 462 LADLE METALLURGY & CONTINUOUS CASTING OF STEELS

L	T	P	C
2	1	0	3

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.*

MT 466 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

HM 352 CORPORATE COMMUNICATION

L	T	P	C
3	0	0	3

OBJECTIVE:

The Course aims to:
1. Familiarize the students with the Corporate world and instil a sense of values.
2. Help them participate in seminars, group discussions and interviews successfully.
3. Make them present their ideas effectively to different levels of people.
4. Enable them to write reports, research papers and proposals.
5. Improve their ability to listen and comprehend different styles of English.

Adequate opportunities for individual practice will be provided.

1. **Importance of communication in the corporate world:**
   Corporate culture & communication - Process of communication – Networks & channels of communication – Barriers to communication – Strategies to overcome them - Use of technology in successful communication – Role of psychology in communication- Internal & External Communication.

2. **Fluent Oral Communication Techniques:**
   Speech mechanics – Mental process of speaking – Extempore speech practice – Body Language – Group discussion practice – Group dynamics – Seminar skills and interview strategies – Presentation skills – Use of Power point-- Techniques to make people listen.

3. **Developing Listening skills:**
   Importance of listening in the corporate world -Listening for information and content – Kinds of listening – Factors affecting this – Methods to overcome them – Retention of facts, data & figures.

4. **Writing for Technical Purposes:**
   Reader-writer relationship - Varieties of styles and registers- Mechanics of technical writing – Reports of different kinds – Oral and written reports – Executive summary and abstract –Memos & IOMs-- Use of charts, graphs etc.

5. **Writing for Business Purposes :**
   Circulars and notices – Proposals, Agenda and Minutes – Marketing language – Corporate Branding - 'You' tone - Captions & Eye catchers - Interoffice memos Communication in a crisis.

TEXT BOOKS:

1. A Guide to Scientific Writing – David Lindsay (1995) – Macmillan.
2. Business Listening Tasks - Patrick Hanks & Jim Corbett (1986) (CUP)

REFERENCES

1. New International Business English – Leo Jones & Richard Alexander (1996) Cambridge University Press. (CUP)
2. Business Communication Strategies -M. Monippally (2001) Tata McGraw Hill
3. Social Psychology – James A. Wiggins, Beverly B. Wiggins & James Vander Zanden (1987) McGraw Hill.