



- 1 . GENERAL PRINCIPLES AND OPEN HEARTH STEEL MAKING 10**  
An outline of various methods of steel making - Physical chemistry of steel making process - Raw materials for steel making Acid open hearth and basic open hearth processes. Oxygen Enrichment of fuel Operation, control of composition and different slag practices.
- 2 . PNEUMATIC AND ELECTRIC STEEL MAKING 10**  
Acid Bessemer. Basic Bessemer. Side blown convertor. L.D.convertor. Kaldo Rotor and O.I.P- Bottom blown and combined blown processes of steel making Principles of operation under different slag practices for steel making by Electric Arc furnace and Induction furnace. Rapid steel making.
- 3 . DUPLEXING AND INGOT MAKING 10**  
Introduction to secondary steel making. Some modern developments in steel making like ESR VOD and AOD process Pre-treatment of steels. Ingot solidification. killed, semi killed. Rimmed and capped steels. Ingot defects, their identification and remedial actions - continuous casting of steel.
- 4 . DEOXIDATION OF STEELS 7**  
Deoxidation by Si. Al- Mn etc., Comparison of deoxidising effects of various deoxidisers. Deoxidation by complex deoxidisers. Vacuum degassing of steels. Ladle Metallurgy. Concept of clean steel.
- 5 . CARBON AND ALLOY STEELS 8**  
Low, medium and high carbon steels. Manganese steels. Free cutting steels. Tool steels and stainless steels.

**Total No of periods: 45**

*Text Books:*

1. Tupkary .R.H . " *Modern Steel Making*". 3rd edn. Khanna Publications. New Delhi. 2000.

*References:*

1. Bashforth.G.R ."*Manufacture of Iron and Steel*".Vol 2. 3rd edition. Chapman & Hall. London. 1964.

2. "*Making. Shaping and Treating of Steel*". US Steel Corporation. 1994.

- 1 . STRESS TENSOR AND YIELD CRITERIA 10**  
 State of stress. Components of stress, symmetry of stress tensor. principal stresses, stress deviator - Von Mises. Tresca yield criteria. Comparison of yield criteria. Octahedral shear stress and shear strain- Forming load calculations.
- 2 . FUNDAMENTALS OF METAL FORMING 7**  
 Flow stress determination. Temperature in metal forming. Hot. Cold and Warm working. Strain rate effects. Metallurgical structures, friction and lubrication. Deformation zone geometry. Hydrostatic pressure. Workability. Residual stresses.
- 3 . FORGING AND ROLLING 10**  
 Forging-types of presses and hammers, defects and remedies. Classification. Open die forging - Forging of disks - Closed die forging - Die design. Calculation of forging loads - Defects, causes and remedies - Rolling of Blooms, billets, slabs and sheet, types of rolling mills, rolling defects. Forces and geometrical relationship in rolling-Analysis of rolling load. Torque and power. Forward slip and position of neutral point. Maximum possible reduction. Gauge control. Factors which determine rolling load. minimum thickness and spread. Defects causes and remedies.
- 4 . EXTRUSION AND DRAWING 8**  
 Direct and Indirect extrusion, equipments, port hole extrusion die. hydrostatic extrusion, defects and remedies simple Analysis of extrusion, tube extrusion and production of seamless pipe and tube. Hydrostatic extrusion. Defects causes and remedies - drawing of rods. wires and tubes: Simple Analysis of wire and tube drawing. Residual stress in rod. wire and tubes.
- 5 . SHEET METAL FORMING AND OTHER PROCESSES 10**  
 Bending, wrap forming, spinning, stretch forming. deep drawing. Forming methods - Rubber forming. Shearing, blanking, bending, stretch forming, deep drawing. Forming limit criteria. Defects - high velocity forming: Comparison with conventional forming. Types - Explosive forming. Electro hydraulic, Magnetic pulse forming and pneumatic method. Dyna pak. superplasticity: Definition. Conditions. Merits and demerits of superplasticity.

**Total No of periods: 45**

*Text Books :*

1. Dieter.G.E ."*Mechanical Metallurgy*", Mc Graw Hill Co. SI Edition. 1995.
2. Nagpal .G.R., "*Metal Forming processes*", Khanna Pub., New Delhi,2000.
3. Narayanasamy R., "*Metal Forming Technology*", Ahuja Book Co., New Delhi, 1997.

*References:*

1. Kurt Lange "*Handbook of Metal Forming*". Society of Manufacturing Engineers. Michigan. USA. 1988
2. Avitzur "*Metal Forming - Processes and Analysis*". Tata Mc Graw Hill Co. 1977.
3. *Metals Handbook*. Vol.14, "*Forming and Forging*". Metals Park. Ohio. USA. 1990.
4. Taylan Altan. Soo IK Oh. Harold.L.Gegel. "*Metal Forming Fundamentals and Applications*".ASM. Metals Park. Ohio. USA. 1983.

<b>1 .</b>	<b>PATTERN AND FOUNDRY SAND</b>	<b>8</b>
	Foundry as a manufacturing process - Types of patterns - Pattern materials - Pattern allowances - Pattern layout, pattern making - various sands - testing of foundry sand: Strength permeability, moisture content. Shatter Index, mouldability., compactability. loss on ignition, clay content and AFS grain fineness number.	
<b>2 .</b>	<b>MOULDING METHODS</b>	<b>10</b>
	Materials: Ingredients, properties. Moulding processes. Moulding methods:- Green sand moulding. dry sand moulding. CO: moulding, no bake moulding, shell moulding. Investment casting, permanent moulding, die casting and centrifugal casting. Modern moulding methods like rheocasting. Thixo casting. Squeeze casting, magnetic moulding. Impulse moulding and high pressure moulding Sand reclamation, moulding machines. Core and core making and types of cores.	
<b>3 .</b>	<b>GATING AND RISERING</b>	<b>10</b>
	Solidification, Cooling rate on freezing pattern-Gates and risers -their functions - Types - Riser efficiency. Feed metal calculation. Design principles, design of gating system and riser for steels and cast irons with examples. computer aided design of gate and riser.	
<b>4 .</b>	<b>MELTING FURNACES</b>	<b>10</b>
	Constructional details - Operation of crucible furnaces. Reverberatory furnaces - Cupola, rotary furnace - Core type and coreless type Induction furnaces - Arc furnace (direct and indirect arc furnaces). Resistance furnaces. Composition control and temperature control. Simple problems in composition control for steels and cast irons.	
<b>5 .</b>	<b>FETTLING, INSPECTION AND AUTOMATION</b>	<b>7</b>
	Removal of gates and risers. Grinding, shot blasting and finishing - Inspection - Casting defects , remedies - principles of mechanisation, automation and foundry layout - Sand plant - pollution control - safety considerations. - Functional design - simplification of foundry practices - metallurgical design.	
	<b>Total No of periods:</b>	<b>45</b>

*Text Books:*

1. Heine.R.W. Loper. C.R.Rosenthal, P.C ."*Principles of Metal Casting*", Tata-Mc Graw Hill Publishing Co ltd. New Delhi. 1995.
2. Jain.P.L. "*Principles of Foundry Technology*", Tata Mc Graw Hill Publishing Co Ltd. New Delhi. 1995.

*References:*

1. Ramana Rao.T.V ."*Metal Casting Principles and Practice*". New Age Pub.Co., NewDelhi. 1996.
2. Beeley.P.R.,"*Foundry Technology*". Butterworths, London, 1982.
3. Srinivasan.N.K,"*Foundry Engineering*",Khanna Tech Publications. New Delhi. 1994.
4. ASM Metals hand Book. Vol 15. "*Casting*" ASM International. 10th edition. 1991.

<b>1 . PHYSICAL AND CHEMICAL PROPERTIES MEASUREMENTS</b>	<b>10</b>
Resistometry - Dilatometry- Thermal analysis - differential scanning calorimetry - spectroscopy and their applications in metallurgy.	
<b>2 . OPTICAL MICROSCOPY</b>	<b>7</b>
Bright field and dark field microscopy, resolving power, phase contrast, polarised light and interference microscopy. Polaroid and Digital cameras- image processing.	
<b>3 . X-RAY DIFFRACTION</b>	<b>8</b>
Generation of X- rays.- White and mono chromatic radiation- characteristic X-rays- Filters - Bragg's Law. Powder methods. Camera- diffractometer. Basic applications. determination crystal structure and crystal parameters.	
<b>4 . ELECTRON MICROSCOPY</b>	<b>10</b>
electron beam interaction with material - Scanning electron microscopy - secondary electron and back scattered image -. Electron Probe Micro Analysis - Transmission electron microscopy - electron diffraction- bright field and dark field imaging.	
<b>5 . OTHER MEASUREMENTS AND TECHNIQUES</b>	<b>10</b>
damping capacity- Torsion pendulam - Electromechanical and piezoelectric methods -Anelastic measurements for diffusion studies crystal growth Purification methods-Zone refining Bridgeman. Stockbarger, Czochralski,vernuel and other methods -vaccum techniques:pumps, gauges,systems.	
<b>Total No of periods:</b>	<b>45</b>

*Text Books:*

1. *Cherepin and Malik, "Experimental Techniques in Physical Metallurgy", Asia Publishing Co. Bombay, 1968.*
2. *Smallman R.E and Bishop R.J, "Metals and Materials", Butterworth-Heinemann Ltd, New Delhi, 1995*
3. *Bunshah R.F, ed, Techniques of metals research, Interscience Pub. 1968.*

*References:*

1. *Laudise R.I , " Preparation of single Crystals", Prentice Hall Inc. New York, 1970.*
2. *Brise J.C, "Growth of crystals from Liquids", North Hollond Publishing Co. London, 1973.*
3. *Brandon D.G, " Modern Techniques in Metalography", VonNostrand Inc. NJ, USA, 1986.*
4. *Cullity, B.D., "Elements of X-Ray Diffraction ", Addison Wesley Publishing Co., Massachusetts, 1968.*
5. *Thomas G., "Transmission electron microscopy of metals" , John Wiley, 1996.*

**1 . TRANSFORMATIONS IN STEELS 10**

Iron - carbon equilibrium diagram: Transformations on heating and cooling - Influence of alloying elements - General principles of heat treatment of steels - Isothermal and Continuous cooling transformations in steels. Continuous cooling curves TTT and CCT diagrams. Mechanism of Pearlitic, Bainitic and martensitic transformations.

**2 . HEAT TREATMENT PROCESSES 10**

Annealing - Normalising - Hardening - retained austenite - measurement and methods of its elimination, hardenability studies. Jominy end quench test. Grossman's experiments - tempering. Hollomon & Jaffe. tempering correlations. Austempering and Martempering Precipitation hardening. Thermomechanical treatment, intercritical heat treatment. Other heat treatment processes: Splat cooling.

**3 . CASE HARDENING 8**

Different methods of carburising and nitriding. Induction hardening and flame hardening, case depth. Steels used for these processes . Laser and electron beam hardening - Special diffusion processes , siliconising, chromising and boronising- Duplex treatments, aluminising and nitro carburising

**4 . HEAT TREATMENT EQUIPMENTS 7**

Various heating media used for heat treatment. Temperature and atmosphere control Quenching media and their characteristics. heat treatment furnaces- fluidised bed furnaces- cryo chamber- cryo treatment of steels

**5 . HEAT TREATMENT OF SPECIFIC ALLOYS 10**

Heat treatment of carbon steels, high speed steels, maraging steels, tool steels and die steels. Heat treatment of gray irons, white irons (malleabilising) and S.G.irons. Austempering of S.G.Iron. Heat treatment of aluminium alloys. copper alloys and nickel alloys.

Defects in heat treated parts. causes and remedy Design for heat treatment.

**Total No of periods: 45**

*Text Books:*

1. Rajan and Sharma, " *Industrial Heat Treatment*" - Oxford IBH. New Delhi. 1995.

*References:*

1. American Society for Metals. "*Metals Handbook Vol.4*". ASM Metals Parks. Ohio. USA. 1991.
2. Prabhudev. K H.. "*Handbook of Heat Treatment of Steels*". Tata - McGraw Hill Publishing Co . New Delhi. 1988.
3. Novikov .I. "*Theory of Heat Treatment of Metals*", MIR Publishers. Moscow. 1978.
4. Vijendra Singh. "*Heat Treatment of Metals*", Standard Publishers Distributors. Delhi. First ed. 1998.
5. Thelning K.E., "*Steel and its heat treatment*", Bofors handbook, 1975.

**1 . SPECIAL STEELS 10**

Detailed discussion on compositional factors, microstructural considerations - mechanical and physical properties -Corrosion and oxidation resistance of the following class of steels: a)Stainless steels b) Tool and die steels c) Heat resistant steels d) Wear resistant steels e) Steels for magnetic and electrical applications f) Spring steels g) Low alloy constructional steels h) HSLA i) Ultra high strength steels

**2 . COPPER 10**

Properties and applications of metallic copper: Major alloys of Copper: Brasses-Cu-Zn alloys - Phase diagram of industrially relevant portion - different compositions, characteristics and uses. Bronzes - Tin bronze - compositions, properties and uses - Other bronzes like Cu-Al. Cu-Si. Cu-Mn and Cu-Be alloy systems - Their special properties and applications - Cu-Ni alloys. Cu-Cr alloys.

**3 . LIGHT METALS 10**

Aluminium - Properties and uses of metallic aluminium. Alloys of aluminium - Classification - Wrought and Cast alloys - Heat treatable and Non-heat treatable - Age hardening: overaging - Al-Cu, Al-Mg-Si, Al-Zn-Mg, Al-Li Alloys - Magnesium - properties and uses of Magnesium alloys. Titanium -Unique characteristics of the metal - Titanium alloys - major types- Titanium aluminides their properties and uses.

**4 . NICKEL AND ZINC ALLOYS 8**

Properties of nickel and uses of nickel - alloys of nickel - nickel in special alloys and magnetic materials- Nickel aluminides - Use of zinc in corrosion protection of ferrous materials - Zinc alloys-properties and uses- Die-casting qualities.

**5 . LEAD, TIN, ANTIMONY & PRECIOUS METALS 7**

Major characteristics and applications - low melting nature and solder alloys.: Gold. Silver and Platinum - Nobility of these metals - Engineering properties and applications of these metals and their alloys.

**Total No of periods: 45**

*Text Books:*

1. *Balram Gupta. "Aerospace Materials". Vol,1.2 and 3. S.Chand & Co.. New Delhi. 1996.*
2. *Brick R.M. Gordon R.A. and Phillips A., "Structure and Properties of Engg Materials". McGraw Hill Book Co., New York. 1992*

*References :*

1. *Clark and Varney. "Physical Metallurgy for Engineers". Affiliated east West press- New York. 1987.*
2. *Willam F. Smith , "Structure and properties of Engineering alloys", Mc Graw- Hill,1993.*

**1 . CLASSIFICATION OF POLYMERS 10**

Types of polymers: addition, condensation and copolymers - Crystalline and amorphous polymers - Number Average Molecular weight and weight average molecular weight and their uses (Experimental determination of molecular weight not included)-Glass transition temperature and its significance - Plastics - thermoplastics and thermosets - examples, structure, properties and applications of engineering plastics (Polyethylene, polypropylene, poly styrene, poly vinyl chloride- poly tetrafluoroethylene. poly oxymethylene. poly phenylencoxide. poly ether ketone. poly urethane and poly methyl methacrylate). Elastomers:Engineering rubbers: natural rubber. styrene-butadiene rubber, nitrite rubbers - Structure properties and applications.

**2 . BEHAVIOUR OF POLYMERS 7**

Viscoelasticity: Concept of creep and stress relaxation in polymers Introduction to yielding and fracture of polymers - Crazing of polymers. Brief idea of fracture mechanics. Simple problems.

**3 . PROCESSING OF POLYMERS 10**

Brief description of equipments and process details of :Extrusion- injection moulding (Reaction and Reinforced Reaction Injection Moulding), thermoforming. blow moulding, compression moulding and calendering . Concept of Polymer Design Selection criteria - examples.

**4 . ENGINEERING CERAMICS 10**

Ceramic crystal structures: Sodium chloride, caesium chloride, alumina, spinel and fluorite structures - examples.Co-ordination number and ionic radius ratio - Pauling's Rules. Simple problems involving Packing Fraction - Ceramics for mechanical functions:Abrasives - properties and applications SiC. Cubic Boron Nitride (CBN) - properties and applications. Ceramics for Electrical and Insulating Functions-Barium Titanate and its modifications-insulating porcelains - properties and applications. Ceramics for magnetic functions - Normal and inverse spinel structure - Zinc. Nickel. Manganese and Iron ferrites - structure properties and applications Ceramics for thermal functions : Refractories - Desirable characteristic - applications - Ceramics for nuclear applications.

**5 . FORMING OF CERAMICS AND GLASSES 8**

Brief description of slip and slurry casting - applications. Powder processing equipment and process details of hot pressing. Hot Isostatic Pressing and Cold Isostatic Pressing - Liquid Phase sintering -Types of glasses - structure, properties and applications Blowing. pressing, drawing, rolling and casting - Pilkington process for float glass.

**Total No of periods: 45**

*Text Books:*

1. Brent A Strong. "Plastics: Materials and Processing". Prentice Hall inc . USA. 1997.
2. Michel Barsoum. "Fundamentals of Ceramics". Mc Graw Hill Publishing Co., Singapore. 1997.
3. Nobuka Ichinose. ed. "Introduction to Fine Ceramics". John Wiley & Sons. USA. 1987.

*References:*

1. Raymond Seymour. "An Introduction to Polymer Chemistry". McGraw Hill Book Co. New York. 1971.
2. Charles A Harper. Ed.. "Handbook of Plastics. Elastomers and Composites". McGraw Hill Publishing Co. USA. 1997
3. McCrum N.G.. Buckley C P. and Bucknall.C.B "Principles of Polymer Engineering" , Oxford University Press. 1992.
4. Kingery W.D. "Introduction to Ceramics". John Wiley. USA. 1960.
5. Van Vlack.K.H . "Physical Ceramics for Engineers". Addison Wesley. 1964.
6. Brydson ,J.A., "Handbook for Plastics Processors", PRI Pub., Portland, 1990.

**1 . FIBER COMPOSITES 10**

Types of composite materials - Constituents, functions of fiber and matrix- Properties of fibres- Critical fiber length - Aligned and random fiber composites, Property prediction - Rule of Mixtures - Simple problems. Production of fibers : Glass fibers, boron, carbon, alumina, mettalic fibers and ceramic fibers Matrix materials: metallic, polymer and ceramic matrix materials - Concept of interfaces and interfacial reactions in fiber composites. Tensile strength of continuous and discontinuous composites. Fracture modes in fiber composites (concepts only ).

**2 . PARTICULATE COMPOSITES 10**

Types - True particulate and Dispersion strengthened composites - Function and examples of dispersoids - Particle size - imparticle spacing - Examples of particulate composites - Brief idea of creep in dispersion strengthened composites.

**3 . MISCELLANEOUS TYPES 8**

Laminar composites Types - Layered and honeycomb structures - examples and applications Hybrid composites, filled and flake composites - applications. Directionally Solidified Eutectics (DSE's)- Production, properties and applications.

**4 . PRODUCTION TECHNIQES 10**

Metal Matrix Composites (MMCs), Polymer Matrix Composites (PMCs) and Ceramic Matrix Composites (CMCs) - Applications in aerospace, automobile, sports and biomedical fields.

**5 . PROPERTIES AND TESTING 7**

Elastic and plastic behavior - rule of mixture - optimising the size, shape and amount of reinforcement - dynamic behavior - fatigue and creep fracture - tensile ,compressive , flexural ,impact and wear behavior of selective composites.

**Total No of periods: 45**

*Text Books:*

1. *Mathews F.L and Rawlings.R.D., "Composite Materials: Engineering & Science", Chapman & Hall , London, 1994.*
2. *Ramarao.P., " Advances in Materials and their applications", Wiley Eatern Ltd, 1993.*

*References:*

1. *Chawla K.K , "Ceramic Matrix Composites", Chapman and Hall, UK, 1993.*
2. *Savage.G, "Carbon-Carbon Composites", Chapman and Hall, UK, 1993.*
3. *Brouman .L.J and Krock, "Modern Composite Materials", Addison Wesley Publishing Company, Massachusettes, 1967.*

<b>1 . CHARACTERISTICS AND TESTING OF METAL POWDERS</b>	<b>10</b>
Sampling, chemical composition (purity, surface contamination etc.) Particle size. and its measurement : Principle and procedure of sieve analysis, microscopic analysis: sedimentation, elutriation. permeability. adsorption methods and resistivity methods: particle shape, classifications, microstructure. specific surface area. apparent and tap density. green density.. green strength, sintered compact density, porosity, shrinkage .	
<b>2 . POWDER MANUFACTURE AND CONDITIONING</b>	<b>10</b>
Mechanical methods (Machine milling, ball milling, atomisation. shotting) Chemical methods (Condensation, thermal decomposition, carbonyl. reduction by gas- hydride - dehydride process, electrodeposition. precipitation from aqueous solution and fused salts, hydrometallurgical method). Physical methods : Electrolysis and atomisation processes -types of equipment - factors affecting these processes - examples of powders produced by these methods - applications. Powder Conditioning Heat treatment, blending and mixing - Types of equipment - types of mixing and blending.	
<b>3 . POWDER COMPACTION</b>	<b>7</b>
Pressureless Compaction : slip casting and slurry casting. Pressure compaction- lubrication, single ended and double ended compaction - Isostatic pressing, powder rolling, forging and extrusion, explosive compaction.	
<b>4 . SINTERING</b>	<b>8</b>
Stage of sintering. property changes, mechanisms of sintering - liquid phase sintering and infiltration - activated sintering - Hot pressing and Hot Isostatic Pressing (HIP) - vacuum sintering. Sintering furnaces and sintering atmosphere, finishing operations - sizing, coining, repressing - heat treatment.	
<b>5 . APPLICATIONS</b>	<b>10</b>
Major applications in aerospace. nuclear and automobile industries. Bearing Materials : Types (self lubrication and other types) - methods of production, properties. applications. Sintered Friction Materials (clutches- brake linings) Tool Materials: Cemented Carbides - oxide ceramics (Cermets): Dispersin strengthened materials - Mechanical alloying - Principles and applications-Advantages & disadvantages of powder metallurgy.	

**Total No of periods: 45**

*Text Books:*

1. *Sinha.A.K "Powder Metallurgy". Dhanpat Rai & Sons. New Delhi. 1982.*
2. *Sands. R L.. and Shakespeare. C.R.- "Powder Metallurgy", George Newes Ltd. London ,1966.*

*References:*

1. *Metals Handbook. Vol 7,"Powder Metallurgy ",Metals Park. Ohio. USA. 1990.*
2. *Animesh Bose., " Advances in Particulate Materials", Butterworth - Heinemann. New Delhi ,1995.*
3. *Kempton. H Roll., "Powder Metallurgy", Metallurgical Society of AMIE,1988.*
4. *Ramakrishnan.P., " Powder Metallurgy Opportunities for Engineering Industries", Oxford and IBH Publishing Co Pvl Ltd, New Delhi,1987.*
5. *Erhard Klar., "Powder Metallurgy Applications, Advantages and Limitations", American Society for Metals, Ohio,1983.*



*Text Books:*

1. *G.M.Masters, " Introduction to Environmental Engineering & Science ", Prentice Hall, New Delhi, 1997*
2. *J.G. Henry and G. W. Heike, " Environmental Science & Engineering ", Prentice Hall International Inc., New Jersey, 1996.*

*References:*

1. *S. K. Dhameja, Environmental Engineering and Management, S. K. Kataria and Sons, New Delhi, 1999.*
2. *State of India's Environment - A Citizen's Report, Centre for Science and Environment and Others, 1999.*
3. *Shyam Divan and Armin Rosencranz, Environmental Law and Policy in India, Cases, Materials and Statutes, Oxford University Press, 2001.*

**1 . ENGINEERING ETHICS 9**

Senses of 'Engineering Ethics' - variety of moral issues - types of inquiry - moral dilemmas - moral autonomy - Kohlberg's theory - Gilligan's theory - consensus and controversy - professions and professionalism - professional ideals and virtues - theories about right action - self-interest-customs and religion - uses of ethical theories

**2 . ENGINEERING AS SOCIAL EXPERIMENTATION 9**

Engineering as experimentation - engineers as responsible experimenters - codes of ethics-a balanced outlook on law-the challenger case study

**3 . ENGINEER'S RESPONSIBILITY FOR SAFETY 9**

Safety and risk - assessment of safety and risk - risk benefit analysis-reducing risk-the three mile island and Chernobyl case studies.

**4 . RESPONSIBILITIES AND RIGHTS 9**

Collegiality and loyalty - respect for authority - collective bargaining - confidentiality - conflicts of interest - occupational crime - professional rights - employee rights - intellectual property rights (IPR)-discrimination.

**5 . GLOBAL ISSUES 9**

Multinational corporations - environmental ethics-computer ethics-weapons development-engineers as managers-consulting engineers-engineers as expert witnesses and advisors-moral leadership-sample code of conduct.

**Total No of periods: 45**

*Text Book:*

1. Mike Martin and Roland Schinzinger, *"Ethics in Engineering"*, McGraw Hill, New York 1996.

*References :*

1. Charles D. Fleddermann, *"Engineering Ethics"*, Prentice Hall, New Mexico, 1999.
2. Laura Schlesinger, *"How Could You Do That: The Abdication of Character, Courage, and Conscience"*, Harper Collins, New York, 1996.
3. Stephen Carter, *"Integrity"*, Basic Books, New York, 1996.
4. Tom Rusk, *"The Power of Ethical Persuasion: From Conflict to Partnership at Work and in Private Life"*, Viking, New York, 1993.

**1 . BASIC CONCEPTS AND VISUAL INSPECTION 10**

Concepts of Non-Destructive testing - relative merits and limitations - NDT vs Mechanical testing - Various physical characteristics of materials and their applications in NDT - liquid penetrant inspection - Principle ,applications ,advantages and limitations. Dyes developers and cleaners fluorescent penetrant test.

**2 . RADIOGRAPHY 10**

X-rays and Gamma rays, properties of X-rays relevant to NDE, Absorption of rays, scattering, types and use of filters, screens, geometric factors, inverse square, law, film type and processing, characteristics of films- graininess, density, speed , contrast, Characteristic curves, penetrameters, Exposure charts, radiographic equivalence gamma ray sources, Characteristics of Gamma rays, fluoroscopy - Xero - Radiography - safety with X-rays and Gamma rays, Industrial computed tomography(CT).

**3 . ULTRASONICS 10**

Types of ultrasonic waves, principles of wave propagation, characteristics of ultrasonic waves, attenuation, Production of ultrasonic waves, couplants - inspection methods-pulse echo, transmission and resonance techniques. Thickness measurement. Types of scanning. Test block. IIW - reference blocks.

**4 . MAGNETIC PARTICLE AND EDDY CURRENT INSPECTION 8**

Principles , applications, Magnetisation methods, magnetic particles. Dry technique and wet technique, demagnetization - Eddy current testing.

**5 . OTHER TECHNIQUES 7**

Principle , application and instrumentation of thermal inspection.. Holography and acoustic emission. - Pressure and leak testing. Chemical spot testing. Spark testing.

**Total No of periods: 45**

*Text Books:*

1. *Barry hull and vernon John, " Non-Destructive testing",ELBS/Macmillan, 1988.*
2. *Baldev Raj. Jayakumar. T. Thavasimuthu. M, "Practical Non-Destructive testing", Narosa Publishing House, NewDelhi,1997.*

*References:*

1. *Louis Cartz , "Non-Destructive testing", ASM International , Metals Park ohio, US, 1995.*
2. *ASM Metals Hand Book, " Non-Destructive Evaluation and Quality control ", American society of Metals, Metals Park ohio, USA, 1989.*
3. *McGonnagle.W.T," Non-Destructive testing",McGraw Hill Book Co, 1988.*

<b>1 . SOURCES OF FAILURES</b>	<b>8</b>
Deficiencies in design, material, processing, service and maintenance. - Stages of failure analysis Classification and identification of various types of fracture - overview of fracture mechanics concepts: Ductile and brittle fracture - Fracture origin, initiators, characteristics of ductile and brittle fracture.	
<b>2 . FATIGUE AND CREEP FAILURE</b>	<b>10</b>
General concepts, Fracture characteristics revealed by microscopy, Factors affecting fatigue life Some case studies of fatigue failures. Creep, stress rupture, Elevated temperature fatigue, Metallurgical instabilities, Environmental induced failure, Elevated temperature effects on certain Gas turbine components and Petroleum refinery components.	
<b>3 . WEAR AND CORROSION FAILURES</b>	<b>10</b>
Types of wear, role of friction in wear, lubricated and non-lubricated wear, Analysing wear failure - corrosion failures: Factors influencing corrosion failures, analysis of corrosion failures, Overview of various types of corrosion Stress corrosion cracking - Sources, Characteristics of stress corrosion cracking. Procedure for analysing stress corrosion cracking, Various types of hydrogen damage failures.	
<b>4 . FAILURE OF FORGING AND WELDMENTS</b>	<b>10</b>
Causes of failure in forging like material characteristics, deficiencies in design, improper processing/ fabrication or deterioration resulting from service conditions, Failure of iron and steel castings - Effect of surface discontinuities, internal discontinuities, microstructure improper composition, improper heat treatment, stress concentration and service conditions. - failure of weldments: Reasons for failure. Procedure for weld failure analysis. Failure origins in arc welds, failures in arc welded low carbon steel, hardenable carbon steel, alloy steel, stainless steel. Failures in Resistance welds.	
<b>5 . RELIABILITY</b>	<b>7</b>
Reliability concept and hazard function, Life prediction, Condition monitoring, application of Poisson. exponential and Weibull distribution for reliability - bath rub curve - Parallel and series system - mean time between failures and life testing.	

**Total No of periods: 45**

*Text Books:*

1. *ASM Metals Handbook "Failure Analysis and Prevention", ASM Metals Park. Ohio- USA. Vol 10, 10th edition, 1995*

*References:*

1. *Charlie R Brooks and Ashok Choudhury ",Metallurgical Failure Analysis", McGraw Hill Publishing Co. USA, 1993.*
2. *Das.A K "Metallurgy of Failure Analysis", Tata McGraw Hill Publishing Co . New Delhi, 1996.*
3. *ColangeloV.J. and Heiser.F.A., "Analysis of Metallurgical Failures", John Wile and Sons Inc. NewYork USA 1974.*

<b>1 . ARC WELDING PROCESSES</b>	<b>10</b>
Classification of welding processes - heat sources and shielding methods - Welding terms - Arc welding power sources - Drooping. Flat and Rising arc voltage characteristics - Shielded metal arc welding - Specifications of coated electrodes. Gas Tungsten Arc Welding. Gas Metal Arc Welding. Flux Cored Arc Welding. Plasma Arc Welding. Submerged Arc Welding. Stud Arc Welding.	
<b>2 . OTHER PROCESSES</b>	<b>10</b>
Oxy Acetylene Welding. Electro Slag Welding, solid state welding processes. Electron Beam Welding. Laser Beam Welding and Resistance Welding, Brazing and soldering processes.	
<b>3 . THERMAL CYCLE ,WELDING DEFECTS AND WELDABILITY</b>	<b>10</b>
Weld thermal cycles and their effects, structural changes in different materials during welding - Defects, appearances, their causes and remedies. Definition of weldability. Factors affecting weldability - weldability tests - Mechanical tests, cold cracking tests and hot cracking tests.	
<b>4 . WELDING OF STEELS AND LOW ALLOY STEELS</b>	<b>7</b>
Problems encountered in welding of carbon steels and low alloy steels - Hydrogen induced cracking. hot cracking Lamellar tearing and Reheat cracking.	
<b>5 . WELDING OF STAINLESS STEELS AND OTHER METALS</b>	<b>8</b>
Metallurgical difficulties in welding of austenitic. ferritic and martensitic stainless steels Detailed study on austenitic stainless steel welding, constitution diagrams: welding of dissimilar metals - Brief description about metallurgical difficulties in welding of cast irons, aluminium alloys- nickel alloys and titanium alloys.	
<b>Total No of periods:</b>	<b>45</b>

*Text Books:*

1. Parmar, R.S., "Welding Processes And Technology", 2nd edn. Khanna Pub.,New Delhi, 2001
2. Srinivasan.N.K.. "Welding Technology". Khanna Publications. Delhi, 1995.
3. Nadkarni.S V. . "Modern Arc Welding Technology". ,Oxford & IBH,New Delhi,1988.

*References:*

1. ASM Metals Handbook. Vol 6. "Welding Brazing & Soldering". ASM International. Metals park.Ohio. USA, 1993.
2. AWS Welding Handbooks, AWS, New York, 1995
3. Davies-A C . "Welding",10th edition, Cambridge University Press, UK, 1996.
4. Howard B Cary., "Modern Welding Technology", 4th edn., Prentice Hall, New Jersey USA,1997.
5. Lancaster..J.F., "Metallurgy of Weldings", George Alien Co- Boston, 1980.

**1. INTRODUCTION****9**

Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs - Analysis Techniques for Quality Costs, Basic concepts of Total Quality Management, Historical Review, Principles of TQM, Leadership – Concepts, Role of Senior Management, Quality Council, Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation.

**2. TQM PRINCIPLES****9**

Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits, Continuous Process Improvement – Juran Trilogy, PDCA Cycle, 5S, Kaizen, Supplier Partnership – Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures – Basic Concepts, Strategy, Performance Measure.

**3. STATISTICAL PROCESS CONTROL (SPC)****9**

The seven tools of quality, Statistical Fundamentals – Measures of central Tendency and Dispersion, Population and Sample, Normal Curve, Control Charts for variables and attributes, Process capability, Concept of six sigma, New seven Management tools.

**4. TQM TOOLS****9**

Benchmarking – Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) – House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) – Concept, Improvement Needs, FMEA – Stages of FMEA.

**5. QUALITY SYSTEMS****9**

Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 – Concept, Requirements and Benefits.

**TEXT BOOK:**

1. Dale H.Besterfield, et al., Total Quality Management, Pearson Education Asia, 1999. (Indian reprint 2002).

**REFERENCES:**

1. James R.Evans & William M.Lindsay, The Management and Control of Quality, (5<sup>th</sup> Edition), South-Western (Thomson Learning), 2002 (ISBN 0-324-06680-5).
2. Feigenbaum.A.V. “Total Quality Management, McGraw-Hill, 1991.
3. Oakland.J.S. “Total Quality Management Butterworth – Heinemann Ltd., Oxford. 1989.
4. Narayana V. and Sreenivasan, N.S. Quality Management – Concepts and Tasks, New Age International 1996.
5. Zeiri. “Total Quality Management for Engineers Wood Head Publishers, 1991.

**1 . ENGINEERING ECONOMICS 10**

Introduction - Demand and Revenue Analysis - Demand Forecasting - Production Analysis - Cost and Supply Analysis, Price and output Determination - Investment Analysis - Plant Location - Economic Optimization.

**2 . MANAGEMENT OF WORK 8**

Types of Business Organisation, Forms, Planning - Organising - Designing effective organisations - Coordination.

**3 . THE MANAGEMENT OF ENGINEERS 10**

Human Resource Development - Motivating individuals and workgroups - Leadership for Managerial Effectiveness - Team working and Creativity - Managerial Communication - Personal Management - Time Management - Stores Management - Career Planning.

**4 . THE MANAGEMENT OF ENGINEERING 10**

Financial Management - Product development - Management techniques in product development - Nature of controlling - Operations Management - Just-in-Time.

**5 . CONTEMPORARY MANAGEMENT ISSUES 7**

Managing World Economic Change - The global environment - Multinational Strategies - Economic Cycles and Director Investment - Change and Organisation Development - Managerial Ethics and Social responsibilities.

**Total No of periods: 45**

*Text Books:*

1. *Gail Freeman - Bell and Janes Balkwill, " Management in Engineering - Principles and Practive ", Prentice Hall of India Pvt.Ltd., 1998.*
2. *Gene Burton and Manab Thaker, " Management Today Principles and Practice ", Tata McGraw Hill, 1995.*

*References:*

1. *M. Joesph, Putti Management - " A Functional Approach ", McGraw Hill, 1999.*
2. *R.R. Barathwal, " Engineering Economics ", McGraw Hill, 1997.*

**1 . PROPERTIES 8**

Technologically important properties of materials Physical, Chemical, Mechanical and Electrical properties of metals. Criteria of selection of materials like properties , cost, manufacturing process, availability, legal and safety factors.

**2 . MATERIALS FOR CORROSION AND WEAR RESISTANCE 10**

Materials for atmospheric, soil, water, acid and alkaline resistance - Corrosion prevention coatings - Material for Chemical and Petroleum industries - Materials and coatings for wear resistance.

**3 . MATERIALS FOR HIGH AND LOW TEMPERATURES 7**

High temperature strength and stability - Hot hardness requirements - High temperature steels and super alloys - ductile -brittle transition- HSLA steel - low temperature materials.

**4 . MATERIALS FOR AUTO AND AERO INDUSTRY 10**

Materials for engine components - cylinder block, head. liner, piston , ring, pin, connecting rod, crank shaft, exhaust, cam shaft, rocker arm and tappet etc. Materials for chasis- Materials for aero structure - wings - landing gears - Turbine blades, shafts - compressor blades etc.

**5 . MATERIALS FOR NUCLEAR AND MINING INDUSTRY 10**

Nuclear fuels, control rods, coolants , clad materials etc. - Wear resistant materials - Impact resistant materials - Friction materials - Anti-friction materials - Bearing materials. electrical &. magnetic materials: Power plant requirement - Materials with special thermal properties - Thermal expansion.

**Total No of periods: 45**

*Text Books:*

1. *Gladius Lewis, "Selection of Engineering Materials", Prentice Hall Inc. New Jersey USA, 1995.*
2. *Charles J A and Crane. F A.A., "Selection and Use of Engineering Materials", 3rd edn., Butterworths. London UK, 1996.*

*References:*

1. *James A. Jacobs, Thomas F. Kilduff., "Engineering Materials Technology: Structure, Processing, Properties & Selection", Prentice Hall, 1996.*
2. *ASM Handbook, "Selection of Materials Vol 1 and 2", ASM Metals Park, Ohio. USA, 1991.*
3. *Daniel P. Henkel , Alan Pense., "Structure and Properties of Engineering Materials", 5th edn., McGraw Hill Book Co, New York. USA. 2001.*
4. *ASM Handbook. "Materials Selection and Design". Vol.20- ASM Metals Park Ohio. USA, 1997.*