Course Structure and Syllabi for

M. Tech. (Materials Science &Engineering)

National Institute of Foundry & Forge Technology

Hatia, Ranchi - 834 003 (Jharkhand)

Course Structure, M. Tech (Materials Science& Engineering)

Semester- I

Sl no.	Course code	Subject	L T P	Credits
1.	MM101	Thermodynamics& Kinetics of Materials	3-1-0	4
2.	MM102	Advanced Physical Metallurgy	3-0-2	4
3.	MM103	Mechanical Behavior of Materials	3-1-0	4
4.	MM104	Engineering Mathematics	3-1-0	4
5.	MM105	Degradation of Materials	3-0-2	4
6.	MM106	Advanced Materials	3-1-0	4
				24

Semester- II

Sl no.	Course code	Subject	L T P	Credits
1.	MM201	Characterization of Materials	3-0-2	4
2.	MM202	Fracture Mechanics& Failure analysis	3-0-2	4
3.	MM203	Advanced Foundry Technology	3-0-2	4
4.	MM204	Mechanical Working of Materials	3-0-2	4
5.	MM205	Elective- I		4
6.	MM206	Elective- II		4
				24

Plant Visit during summer for Industrial project of FOUR weeks duration.

Semester-III

Sl.no.	Course code	Subject	L T P	Credits
1.	MM301	Powder Metallurgy	3-1-0	4
2.	MM302	Composite Materials Technology	3-1-0	4
1.	MM303	Seminar	2	
2.	MM304	Industrial Training (Seminar)		2
4.	MM304	Project- Part I (Presentation)	3	
				15

Semester- IV

Sl. no.	Course code	Subject	L T P	Credits
1.	MM401	Comprehensive viva		2
2.	MM402	Project- Part II (Presentation)		5

3.	MM403	Project Pre Submission Presentation	5
4.	MM404	Project Viva Voce	5
			17

Total- 80 Credits

Elective- I

1. Joining of Materials (3-0-2)
2. Nano Science& Its Applications (3-1-0)
3. High Temperature Materials (3-1-0)
4. Manufacturing Processes (3-0-2)
5. Advances in Steel Making (3-1-0)
6. Operations Management& Behavioral Science (3-1-0)

Electives- II

1. Materials Growth& Processing for Micro& Nano systems (3-0-2)
2. Electronic, Optical& Magnetic Properties of Materials (3-1-0)
3. Surface Engineering. (3-1-0)
4. Refractories for Metallurgical& Allied Processes (3-1-0)
5. Computer Modeling and Simulation (3-1-0)
6. Decision Science (3-1-0)

Annexure-A (a)

M. Tech (Materials Science and Engineering) Syllabus

SEMESTER-I

MM101 Thermodynamics and kinetics of Materials: L-T-P-C (3-1-0-4)

Introduction to thermodynamics and kinetics- different approaches, emphasis on metallurgical thermodynamics.

Law of thermodynamics and related applications, Concepts of free energy and entropy, criteria for spontaneity.

Introduction to solutions, Partial molar quantities, Gibbs- Duhem relations, thermodynamic aspects of metallic solutions and salt melts, Raoult's and Henry's Law, Regular and quasi chemical models.

Thermodynamic aspects of phase diagrams, Similarity in thermodynamic approach towards different classes of materials, thermodynamic aspect of defect formation in metals and ceramics.

Principles of metallurgical kinetics, reaction rates and reaction mechanism.

Reference Books:

1. Gaskell, David, R., Introduction to Metallurgical Thermodynamics, McGraw Hill.
2. Mohanty, A. K., Rate processes in metallurgy, Prentice Hall of India.
3. Upadhayaya, G.S., and Dube, R.K., Problems in metallurgical thermodynamics and kinetics, Pergamon
4. Darken, L.S., and Gurry, R.W., Physical chemistry of Metals, McGraw Hill

MM102 Advanced physical metallurgy: L-T-P-C (3-0-2-4)

Classification of Transformations: Phase transformation of first degree and second degree, Energy aspects of homogeneous and heterogeneous nucleation, nucleation ratio, fraction transformation at constant rate of nucleation and growth, Nucleation in solids.

Recovery, Recrystallisation and Grain growth: Property changes, Driving forces, N- G aspects, annealing twins, textures in cold worked and annealed alloys, Polygonisation.

Austenite – Pearlite Transformation, role of diffusion and temperature on lamellar spacing.

Bainite transformation: Nature of carbide in Bainite, Upper and lower Bainite, Isothermal transformation in Austempered ductile iron.

Martensitic transformation: Crystallographic aspects and mechanism of atom movements, Comparision between twinning and Martensitic transformations; Effect of grain size, Plastic deformation, arrested cooling on kinetics.

Order- disorder transformations: Common structures in ordered alloys, variation of order with temperature; determination of degree of ordering, effect of ordering on properties, applications. Spinodal decomposition.

Precipitation hardening: Structural changes, mechanism and integration of reactions, effect of retrogression, Double peaks, Spinodal decomposition.

Reference Books:

1. Raghavan, V.,, Phase transformations, Prentice Hall
2. Smallman, R.E., Modern physical metallurgy
3. Reed Hill, R.E., Principles of physical metallurgy, Affiliated East West Press.

MM103 Mechanical behavior of Materials: L-T-P-C (3-1-0-4)

Strength of Materials: Basic assumptions, elastic and plastic behavior, stress- strain relationship for elastic behavior, elements of plastic deformation of metallic materials, Mohr's circle, yielding theories.

Theory of plasticity: Dislocation theory, properties of dislocations, stress fields around dislocations, application of dislocation theory to work hardening, solid solution strengthening, grain boundary strengthening, dispersion hardening.

Ductile and brittle fracture: Charpy and Izod testing, Significance of DBTT, ECT, NDT and FATT; Elements of fractography; Griffith theory, LEFM- COD and J integral, determination of K_{IC}, COD and J integral.

Fatigue failure: Initiation and propagation of Fatigue cracks, factor affecting fatigue strength and methods of improving fatigue behavior, testing analysis of fatigue data, mechanism of fatigue crack propagation, Corrosion fatigue.

Creep failure: Creep mechanism, creep curve, variables affecting creep, accelerated creep testing, development of creep resisting alloys, Larsen- Miller parameter, Manson Hafred parameter.

Reference Books:

1. Dieter, G. E., Mechanical metallurgy, McGraw Hill.
2. Hertzberg, R.W., Deformation and fracture mechanics of engineering materials, John Wiley
3. Hull, D., Introductions to dislocations, Pergamon.
4. Garofalo, F., Fundamentals of creep and creep rupture in metals, McMillan.
5. Meyers, M. A., and Chawla, K.K., Mechanical behavior of materials, Prentice Hall.

MM104 Engineering Mathematics: L-T-P-C (3-1-0-4)

Partial differential equation: Basic concepts, one dimensional heat flow equation, Two dimensional heat flow equation in steady flow in cartesian and polar co- ordinates.

Calculus of variations: Euler's equation, Variational problems in parametric form; Natural boundary condition, Conditional extremum, Isoperimetric problems.

Numerical solution of ODE's: Euler's, Taylor's and Runge Kutta methods, Milne's and Adam's Predictor- Corrector methods.

Finite difference scheme for elliptic, parabolic and hyperbolic partial differential equations.

Introduction to finite element method, Rules for forming interpolation functions, shape functions, Application to fluid flow and heat transfer problems. Statistical methods. Tensor analysis.

Reference books:

1. Desai, C.S. and Abel, J.P., Introduction to Finite elements method, Van Nostrand Rheinhold.
2. Elsegolts, L., Differential equations and the calculus of variations, Mir publishers
3. Grewal, B.S., Higher engineering Mathematics, Khanna publishers
4. Reddy, J.N., Introduction to Finite elements method, Mcgraw Hill

MM105 Degradation of Materials: L-T-P-C (3-0-2-4)

Introduction, Importance of corrosion, Economics of corrosion.

Corrosion of Materials: Oxidation, Corrosion and wear. Basics of Thermodynamics and Kinetics of oxidation and corrosion. Pourbaix diagram, Polarization, Mixed potential theory. Passivity, Characteristics of passivation, degradation of composites.

Corrosion: Fundamental of corrosion studies, types of corrosion, atmospheric, galvanic, pitting, crevice corrosion, intergranular corrosion and dealloying. Stress corrosion cracking, Season cracking,

Hydrogen damage and radiation damage, hydrogen embrittlement. Corrosion rate measurement, Weld decay and knife line attack. Taffel's extrapolation, oxidation and hot corrosion of materials at high temperature. Kinetics of oxidation, Pilling- Bed Worth ratio.

Prevention of degradation: Alloying environment, environment conditioning, design modification, Cathodic and anodic protection, organic and inorganic coating, inhibitors and passivators, Wear resistant coating.

Reference Books:

1. Glasstone, S., An introduction to electrochemistry, Van Nostrand
2. Fontana, M.C., Corrosion Engineering, McGraw Hill
3. Scully, J.C., The fundamentals of Corrosion, Pergamon
4. Mantell, C.L., Electrochemical Engineering, McGraw Hill

MM106 Advanced Materials: L-T-P-C (3-1-0-4)

Introduction, Demand of advanced materials, design principles and processing.

Structural Materials: Porous matrix ceramics- composites, Metallic foam, Cellular Materials, Nano tubes, Nano wires.

Mechanically alloyed oxide dispersion strengthened superalloys, High strength and ductile bulk quasi crystalline alloys and their composites. Thermal barrier coating for aero engines and gas turbines. Processing of Ni- base superalloys for turbine engine discs, Gamma- Titanium aluminades.

Functional Materials: Low dielectric constant materials, optoelectronic materials.

Glassy and Nano crystalline materials for soft and hard magnetic properties and their applications.

Smart Materials: Shape memory alloys, hydrogen storage alloys, Functionally gradient material (FGM).

Reference Books:

1. Gandhi, M.V., Thompson, B.S., Smart Materials and Structures, Chapman and Hall
2. Ray, A.K. (ed), Advanced Materials, Allied publishers.

3. Rama Rao, P. (ed), Advances in Materials and their applications, Wiley Eastern Ltd.
4. Bhushan, B., Nano Technology (ed), Springer.

II SEMESTER

MM201 Characterization of Materials: L-T-P-C (3-0-2-4)

Scope of Characterization of materials; Materials beam interaction

Optical Microscopy**:**Techniques, Polarised and interferomery phase contrast. In-situ metallography, colour metallorgaphy, inclusion characterization.

Quantitative Microscopy**:** Techniques

Diffraction Techniques: X-ray diffraction technique for phase identification, strain & particle size, phase diagram and Texture determinations, synchrotron radiation, Neutron diffraction.

Scanning electron microscopy and Electron probe micro analysis: Principles of image formation in SEM and application. Energy dispersive X-ray analysis and wavelength dispersive X-ray analysis. Electron probe micro analysis and its application for chemical analysis. Scanning Transmission electron microscopy.

Transmission and analytical electron microscopy. Formation of image and selection area diffraction patterns. Theories of image contrast and their application to perfect and imperfect crystalline specimens. High resolution electron microscopy, analytical electron microscopy, convergent beam electron diffraction, micro diffraction, composition analysis by EELS.

Surface probe microscopy: Scanning Tunneling microscopy, Atomic Force microscopy.

X-ray fluorescence; EDXRF, WDXRF; optical absorption spectroscopy, emission spectroscopy, Auger spectroscopy.

Thermal analysis: DTA, DSC and TGA, working principle and applications.

Types and applications of strain gauges.

Reference Books:

1. Cullity, B.D., Elements of X- Ray diffraction, Addison Wesley
2. Sridhar, G., Ghosh Choudhary, S., and Goswami, N. G., Materials characterization techniques (ed) NML, Jamshedpur.
3. Williams, D.B., and Carter, C.B., Transmission electron microscopy: A Text Book of Materials Science.
4. Krishna, R., Anantraman, T.R., Pande, C.S., Arora, O.P., Advanced techniques for microstrutural characterization (ed), Trans Tech Publication.

MM202 Fracture Mechanics & Failure analysis: L-T-P-C (3-0-2-4)

Griffith's crack theory, stress intensity factor, stress analysis of cracks, strain energy release rate, Derivation of relationship between strain energy release rate and stress intensity factor, crack tip plastic zone, Dugdale's plastic strip model.

Fracture mode transition: Plane stress vs. plane strain, crack opening displacement, plane strain fracture toughness (K_{IC}) testing, Fracture toughness determination with elastic plastic analysis (J_{IC}), concept of R-curve and Fracture toughness measurement using it, Microstructural aspect of fracture toughness, optimizing microstructure and alloy cleanliness to enhance fracture toughness.

Fatigue stress life approach, Basquin's equation, Fatigue strain life approach, Low cycle fatigue, Cofin- Manson's equation, Fatigue total strain life relation, Fatigue life prediction, Neuber's analysis for notched specimens, Fatigue crack growth rate, Paris law, fatigue life calculation using this approach.

Mechanism of fatigue crack nucleation and propagation, factors affecting fatigue crack growth rate, influence of load interaction, short fatigue crack; stress corrosion cracking and $K_I$scc determination. Corrosion fatigue, temper embrittlement, hydrogen embrittlement, liquid metal embrittlement, neutron embrittlement.

Fractographic analysis of ductile, brittle, fatigue and high temperature fractured surfaces.

Failure analysis**:** Steps involved; case studies of some engineering failures.

Reference Books:

1. Hertzberg, R.W., Deformation and fracture mechanics of engineering materials, John Wiley.
2. Dieter, G.E., Mechanical Metallurgy, McGraw Hill
3. Metal Hand book, Failure analysis and prevention (Volume- XI), ASM Pub.
4. Metal Hand book, Fractography (Volume- XII), ASM Pub.

MM203 Advanced Foundry Technology: L-T-P-C (3-0-2-4)

Critical review of some foundry operations: Various casting processes, mould reinforcements, mould factors in metal Flow, moulding factors in casting design, limitations in controlling some moulding factors in casting design, Effect of process variables on property of core and mould making sand.

Properties of liquid metals: Thermal properties, viscosity, surface tension and density of liquid metals and their role in foundry technology;

Gases in liquid metals: Simple gases in metals, complex gases in metals, gas defects and their control;

Solidification of metals and alloys: Plane front solidification, interface stability, dendritic growth, cellular growth, independent nucleation. Structure of casting as influenced by alloy constituents, thermal conditions, inherent nucleation and growth condition in the liquid like temperature gradient, liquidus temperature profile and G/R ratio. Control of structure; principles of gating and risering,

Directionality in solidification, Characteristics of different alloys, Chworinov rule, Design of gating system, Wlodawer system of determining the feeder head requirements. Feeder head efficiency, concept of feeding range, use of supplementary techniques and introduction of design modifications.

Special casting processes: Investment casting, Die casting, centrifugal casting, full mould casting, vacuum shield casting etc.

Industrial melting practices: Aim of melting and melting practices as adopted in case of Cast Irons, Steel, Cu, Al and its alloys.

Casting defects & their remedies: Shaping faults arising in pouring, Inclusions and sand defects, gas defects, shrinkage defects during solidification in liquid phase. Contraction defects, Dimensional errors, compositional errors and segregation.

Reference Books:

1. Beeley, P.R., Foundry Technology, Butterworth and Co.
2. Webster, P.D., Fundamentals of Foundry Technology,
3. Mukherjee, P.C, Fundamentals of Metal casting Technology

MM204 Mechanical working of materials: L-T-P-C (3-0-2-4)

Mechanical working fundamentals: Hot, warm and cold working. Role of temperature, strain rate and friction in metal working. Effect of working on structure and properties of metals and alloys. Texture and fibering. Concept of workability, Processing maps.

Rolling: Classification of rolling mills, forces and geometrical relationships in rolling, theories of hot and cold rolling. Calculation of rolling load and power. Soaking pits and reheating furnaces. Rolling of blooms, billets, slabs and rails. Defects in rolled products.

Other mechanical working processes**:** Principles, equipment and manufacturing methods; Forging, Extrusion, wire drawing and tube making. Elementary theories and calculation of working load and power. Sheet metal working operations. Forming limit diagrams.

Special working processes: Super plastic forming, high energy forming and controlled rolling.

Reference Books:

1. Dieter, G.E., Mechanical Metallurgy, McGraw Hill
2. Harris, J.N., Mechanical working of Metals, Theory and practice; Pergamon
3. Metals Hand book, Vol 14, IX edition, Forming and Forging, ASM
4. 4. Kalpakjian, S. and Steven, R.S., Manufacturing processes for Engineering materials, Pearson, 4th edition.

MM301 Powder Metallurgy: L-T-P-C (3-1-0-4)

Scope, advantages and limitations of powder metallurgical techniques.

Powder Production:Chemical reaction and decomposition, atomization of liquid metals, electrolytic deposition and mechanical processing of solid materials.

Powder characteristics**:** Composition, structure, size, shape, surface topography, area, apparent and tap density, Flow rate, compressibility, pyrophorocity and toxicity.

Compaction Methods: Die, isostatic and continuous compaction. Effect of compaction variables. Pressure, speed, particle characteristics and lubrication, characteristics of compacts.

Sintering mechanism: Driving force, material transport mechanism, sintering variables, solid and liquid phase sintering, hot and warm pressing.

Production of Powder metallurgy products**:** Bearing, sintered carbides, magnetic materials, electrical contact materials, refractory materials and cermets and SAP.

Reference Books:

1. Randal,G., Powder Metallurgy, John Wiley
2. Metal Powder Handbook, ASM

MM302 Composite Materials Technology: L-T-P-C (3-1-0-4)

Introduction:Types and constituents, reinforcement and matrices, interface and mechanism of strengthening.

Metal Matrix Composites: Processing: Liquid state processes, solid state processes and in situ processes.

Interface: Role, reactions, bonding mechanisms and bond strength.

Properties and applications: Strength, stiffness, creep, fatigue and fracture; thermal, damping and tribological properties.

Polymer Matrix Composites Processing: Hand lay up and spray technique, filament winding, pultrusion, resin transfer moulding, bag and injection moulding, sheet moulding compound. Interfaces.

Properties: Mechanical, damping, environmental effect and fracture.

Ceramic Matrix Composites Processing: Cold pressing & sintering, hot pressing reaction bonding processes, infiltration, in-situ chemical reaction, Sol-Gel and polymer pyrolysis, self propagating high temperature synthesis. Carbon- carbon composites, Interfaces.

Properties and applications: Strength, toughness and thermal shock resistance.

Reference Books:

1. Chawla, Composite Materials Science and Engineering, Springer
2. Hull, An introduction to composite materials, Cambridge.
3. Mathews and Rawlings, Composite materials: Engineering and Science, Chapman and Hall.

MM205 Elective -I

Joining of materials: **L-T-P-C (3-0-2-4)**

Introduction: theory and classification of welding and other joining processes.

Manual metal arc welding: equipment, electrodes for structural steels, coating constituents and their functions. Types of coatings, current and voltage selection for electrodes, power sources, conventional transformers, rectifiers, current and voltage. Influence of power sources on welding. Metal transfer and Heat transfer.

Submerged arc welding: process details, consumables for welding mild steel, variations in the process.

Gas metal arc welding or MIG/MAG welding: process details, shielding gases, electrode wires, sizes and current ranges.

TIG welding: process details, power source, electrode sizes and materials, current carrying capacity of electrodes. Shielding gases, applications.

Resistance welding: principles, applications, process details and working principle of spot, seam and projection welding, electrode materials, shapes of electrode, electrode cooling, selection of currents, voltages; welding metallurgy of carbon and alloy steels, cast irons, stainless steels, Al-

and Cu- based alloys. Weldability and heat affected zones. Welding defects and detection techniques.

Soldering and brazing: difference between processes, consumables, methods of brazing, fluxes used, their purposes and flux residue treatment.

Reference Books:

1. Lancaster, Allen and Unwin, Metallurgy of Welding,
2. Little, R.L., Welding and Welding Technology, TMH
3. Norrish, J. and Woodhead, Advanced Welding processes.

Nano science and its applications: L-T-P-C (3-1-0-4)

Concept of nano materials, scale/dimensional aspects, top down and bottom up approaches for preparing nano materials. Advantages and limitations at the nano level, thermodynamic aspects at the nano level, health and environmental issues.

Long range and short range order forces, van der waal forces, solvation forces, electrostatic forces, hydrophobic forces, electric double layer forces, steric forces; Relevant theories, advantages and limitations, applications in colloidal stability.

Thermodynamics of surfaces; surface and interfacial energy, uses of Wulff plot, binding energy, surface roughness, adhesion and wetting.

Principles of photo and nano lithography, steps involved and applications.

Synthesis routes of nano particles: mechanical alloying, sol- gel process, dispersed phase and dispersion medium and their interactions; gaseous reduction, Chemical vapor deposition, hydrogen plasma arc method, laser ablation, radiolysis, photolysis; Applications.

Reference Books:

1. Pradeep, T., Nano: The essentials, McGraw Hill
2. Wilson, M et al, Nano Technology, Overseas Press
3. Poole, C.P and Owens, J.F, Introduction to Nano Technology, Wiley
4. Schmid, G., Nano particles: From theory to applications, Wiley VCH Verlag GmBH and Co

High temperature materials: L-T-P-C (3-1-0-4)

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

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

Various type of fracture, brittle to ductile from low to high temperature, cleavage, 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 alloy additions, sulphation, hot gas corrosion deposits, modified hot gas corrosion, effect of alloying elements on hot corrosion.

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

Reference Books:

1. Raj, R., Flow and Fracture at elevated temperatures, American society for metals.
2. Courtney, T.H, Mechanical behavior of materials, McGraw Hill
3. Hertzberg, T.H, Deformation and Fracture Mechanics of Engineering Materials, John Wiley

Manufacturing processes: L-T-P-C (3-0-2-4)

Introduction to manufacturing processes: different approaches, technical and economic considerations, significance of material properties with respect to selection of manufacturing processes.

Conventional casting processes: advantages and limitations, melting practices, design of castings, special casting processes.

Conventional material joining processes: concept of weldability, need for dissimilar joints, machining proceses, concept of machinability, material examples, developments in machining processes.

Rolling, forging, extrusion, drawing, sheet metal forming; classification, advantages and limitations.

Introduction to powder metallurgy, recent developments especially in forging and mechanical alloying, concept of near net shape praceesing, concept and applications of rapid proto typing, emerging technologies for nano processing.

Reference Books:

1. Rao, P.N, Manufacturing Technology, Tata McGraw Hill

2. Kalpakjian, S., Manufacturing Engineering and Technology, Addison Wesley

Advances in steel making: L-T-P-C (3-1-0-4)

A critical appraisal of hybrid blowing processes, ultra high power electric arc furnace and induction furnace with respect to raw materials, energy consumption, productivity and product quality; special grade steels.

Development of secondary steel making and their importance under Indian conditions, sources of inclusions, sulphur, phosphorus and gases in steel.

Secondary steel making technologies: inert gas purging, vacuum degassing-RH/DH, VOD,VAD etc, ladle furnace.

Powder injection system: powder dispenser, lance, phsico-chemical and fluid dynamic aspects of powder injection and stirring processes; role of slag and powders in inclusion control, desulphurization, wire feeding; production of ultra low sulphur, ultra low phosphorus and inclusion free steels, ultra low carbon steels such as extra deep drawing and IF steels; modification of inclusion morphologies;

Production of stainless steel through VOD, AOD, CLU processes.

Production of ultra clean steel through post solidification treatments (VAR,ESR). Refractory for secondary steel technology, slide gate, porous plug, ladle lining etc. properties and selection of refractories.

Process selection.

Reference Books:

1. Ghosh, A., Secondary steel making- Principle and applications, CRC press
2. Ghosh, A and Chatterjee, A., Iron making and steel making theory and practice, Prentice Hall
3. Ghosh, A., Principles of secondary processing and casting of liquid steel, Oxford and IBH

Operations management and behavioral science: L-T-P-C (3-1-0-4)

Introduction, Operations strategy, competitive advantages, time based competition, product decision and analysis, product development, process selection, process design, process analysis, facility location, facility layout, capacity planning, capacity decisions, waiting lines, aggregate pinning; Basics of MRP/ ERP, Basics of scheduling, Basics of project management, Basics of total quality management, Basics of quality control, statistical quality control, total quality management, Basics of environmental management. Value engineering and analysis.

Psychology, Sociology and anthropology; stages of infancy, childhood, adolescence, adulthood, and old age. Influence of the environment and heredity on human development, various theories of personality, personality disorders, the biological influences on behavior, various psychological theories, social norms and values set by society, culture and cultural values, the diversity of ethnic groups within a society, conformity and deviance; racism, prejudice, discrimination, and reverse discrimination; major social problems such as crime, AIDS, Poverty and homelessness.

Reference Books:

1. Chary, S.N., Production and operation management
2. Ditworth, J.B., Production and operations management
3. McMahon, J. and Romano, T, Psychology and You,West publishing Co.

MM206 Elective-II

Materials growth and processing for micro and nano systems: L-T-P-C (3-0-2-4)

Growth of metallic, alloy and semi conductive thin films. Recent advances in the synthesis, lithography and characterization of nano materials.

Theory and technology of micro/nano fabrication. Processing of bulk, thin film and nano scale materials for applications in electronic, magnetic, electro-mechanical and photonic devices and micro systems.

Growth of bulk, thin film and nano scale single crystals via vapor and liquid phase processes, epitaxy, formation and processing of thin films with a relationship among processing, structures and properties.

Examples from materials processing for applications in high performance integrated electronic circuits, integrated sensors and data storage systems.

Reference Books:

Pradeep, T., Nano: The essentials, McGraw Hill

1. Wilson, M et al, Nano Technology, Overseas Press
2. Poole, C.P and Owens, J.F, Introduction to Nano Technology, Wiley
3. Schmid, G., Nano particles: From theory to applications, Wiley VCH Verlag GmBH and Co

Electronic, optical and magnetic properties of materials: L-T-P-C (3-1-0-4)

Review of free electron and band theories of solids, Electrical conduction in metals and semiconductors, Hall effect, Temperature dependence of electrical conductivity.

Thermoelectric properties of metals and semicondutors, Semicondutors, Direct and indirect band gap semiconductors, Electron transport in amorphous solids, Principles of semiconductor devices.

Ionic conductivity, Super conductivity, Piezo- electricity and Ferro- electricity.

Optical Properties: Introduction, Refraction, Absorption, Absorption in Dielectrics, Photographic images, Luminescence, Lasers.

Magnetic Properties: Introduction, Dia, Para and Ferromagnetism, Weiss Field and Magnetic Domains, Anti ferromagnetism and Ferri magnetism. Ferromagnetic anisotropy and magnetostriction. Magnetic energy and Domain structure, Hysteresis loop. Soft and Hard magnetic Materials.

Reference Books:

1. Hummel, R.E., Electronic properties of Materials, Springer
2. Raghavan, V., Materials Science and Engineering, Prentice Hall
3. Azaroff, L.I, Magnetic Materials;
4. Lovell, M.C., Avery, A.J, and Vernon, M.W, Physical properties of materials.

Surface Engineering: L-T-P-C (3-1-0-4)

Introduction: Material surfaces and their importance in tribology.

Surface modification processes: Case hardening, Short peening, Chemical vapor deposition, Physical vapor deposition, Thermal barrier coatings, Plasma deposition, Sputter coating, Laser processing, Ion implantation, Electro and electroless plating processes, Surface cleaning and finishing processes, Testing and evaluation of surface coatings.

Friction: Fundamentals, Types and measurement of solid, liquid and gaseous friction. Friction heat and calculation.

Wear: Modes of adhesive, abrasive, erosive, fretting, Corrosive, erosive- corrosive, sliding, rolling, impact and lamination wear, Worn surface topography, debris analysis and wear mechanism maps.

Lubrication: Lubricants and additives, mechanism of solid, liquid and gaseous lubricants.

Mode of friction and wear: Al- Si, Ti- alloys, Cemented carbides and metal, polymer and ceramic matrix composites.

Friction and wear: Sliding bearings, Pistons, Cylinders, Brakes, Cutting Tools, Dies, Electrical contacts.

Reference Books:

1. Sarkar, A.D., Wear of Metals, Pergamon
2. Rabinowiez, E., Friction and Wear of Materials, Wiley
3. Hand book, Friction, Lubrication and Wear Technology, Vol. 18, ASM
4. Surface treatments for protection, Series3, No. 10, , The institute of metallurgist series.

Refractories for Metallurgical and Allied processes: L-T-P-C (3-1-0-4)

Review of metallurgical processes, Refractory linings for primary and secondary steel making operations;

Refractories used in coke oven, Blast Furnace, Properties and problems, Refractories for hot metal handling.

Continuous casting refractories- Materials, Production, properties and future trends, Hot repairing- Materials, repairing techniques; Ladle refractories, Direct bonded Mag- Chrome aggregates, New generation slide gate refractories with improved performance.

Types of furnace and refractories used in non ferrous industries. Factors affecting the performance of refractories.

Refractories used in glass production, Cement industries, Limestone calcinations, Regenerators. Standardization, Testing including NDT.

Plant trial performance of non shaped and advanced refractories developed using surface chemistry, thermo mechanical considerations for refractory linings. Use of non oxide ceramic materials in ferrous and non- ferrous industries. Future trends in utilization of refractories. Recent advances.

Reference Books:

1. Chesters, J.H., Refractories- production and properties, The Iron and Steel Institute, London
2. Amavis, R. (ed), Refractories for steel industry, Elsevier applied science

Computer modeling and simulation: L-T-P-C (3-1-0-4)

Review of computational methods: Solution of ordinary differential equations, Initial value and boundary value problems.

Modeling: Classification, Functions, Limitations and interrelationship of different types of models, Types and development of mathematical model. Development of rigorous and semi-rigorous physical models

Solution of partial differential equations, Initial value and boundary value problems, Hyperbolic, parabolic and elliptic equations, Explicit and Implicit methods, Finite difference methods. Finite element method.

.Simulation: Survey of simulation techniques, Molecular dynamics and Monte- Carlo simulations. Fuzzy Logic, neural networks and genetic algorithms.

Applications: Application of above to model materials behavior and metallurgical processes.

Reference Books:

1. Chapra, S.C. and Canale, R.P, Numerical methods for engineers, Tata McGraw Hill
2. Press, W.H, Teukolsky, S.A, Vetterling, W.T and Flannery, Numerical recipes in C++, The art of scientific computing, Cambridge
3. Szekley, J.S, Evans, J.W, and Brimakombe, The mathematical and physical modeling of primary metals processing operations, Wiley
4. Sibol, I.M, The Monte Carlo method, Little mathematics Library, Mir
5. Rajasrkharan, S and Pai, G.A.V, Neural Networks, Fuzzy logic and Genetic algorithms-synthesis and applications, Prentice Hall

Decision Science: **L-T-P-C (3-1-0-4)**

Decision making under certainty, risk and under uncertainty stations. Decision tree for decision making, Bayesian approach in decision making, Breakeven analysis under uncertainty, Investment analysis under uncertainty.

Competitive strategies, single equations models with one and two explanatory variables plus ANQVA in regression analysis, statistical forecasting techniques, Auto co-relation, Hetroscedasticity, multicollinearity and distributed lag models; simultaneous equation models, identification problems. Estimation of structural parameters by ILS, SSL.

Reference Books:

1. Vora, N.D, Quantitative techniques in management

2. Sharma, J.K., Quantitative techniques in management

3. Damodar Gujrati, Econometrics