MATERIALS & METALLURGICAL ENGINEERING

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Development of innovative engineering systems and processes greatly depends on the availability of high performance materials. The field of engineering materials has expanded enormously in the recent past and now encompasses a large variety of materials such as ceramics, glasses, polymers, intermetallics, semiconductors together with traditionally important metals and their alloys. Composites having metal, ceramic, intermetallic or polymer base materials as the matrix have further created a range of commercially important engineering materials so that a great flexibility exists today to create *tailor-made* engineered materials with specific properties and characteristics for specific applications. Functionally gradient materials fall in this category of materials. Both traditional as well as *engineered* materials are competing with each other in today's world. Thus, there exists a strong need for a broad-based unified approach in imparting education and carrying out research in the area of Materials and Metallurgical Engineering that has been pioneered in the country by this Department.

A relatively novel undergraduate programme in Materials and Metallurgical Engineering at IIT Kanpur aims at providing the basic understanding of principles underlying metals extraction and refining,

structural characterisation of materials at different levels, phase equilibria and phase transformations in material systems and processing-structure-property-performance relationships that exist in materials at large. Several courses on these topics have laboratory experiments built into them. All undergraduate students are thus required to do about 75 experiments related to various aspects of processing, characterisation and performance of materials as part of their compulsory departmental courses. An in-depth study in the area of interest/specialisation is undertaken through departmental electives and the project work. Departmental electives have been designed so as to incorporate new and upcoming knowledge in different areas and also the state of art technologies. The course work is further supplemented with industrial tours that are separately arranged during vacations in the third year and which have a bearing on some of the compulsory courses. The project work in the fourth year of the programme, which may be experimental or computational, enables students to carry out the required work independently, broadening their knowledge in the area of interest/ specialisation.

Developing fundamental understanding regarding materials, and their processing and structure-property- performance correlations that exist in them is the basic goal of the postgraduate programme leading to M Tech and Ph D degrees. This is achieved by offering a good number of courses in different areas of Materials and Metallurgical Engineering. Students are generally encouraged to learn inter-disciplinary aspects of engineering through course work. After a student completes his/ her course requirement for the given programme, he/she carries out research work towards the thesis in the area of his/her specialisation. Theses making original research contributions form an integral part of the programme.

Currently, the Department's areas of research interest include (a) Mineral Engineering and Extractive Metallurgy, (b) Design, Processing and Characterisation of Metallic Materials, (c) Computational Materials Science and Engineering, (d) Intermetallics, Ceramics and Composites, (e) Electron and Spin Device Materials and (f) Nano-Materials Technologies. To this end, the Department is equipped with high intensity magnetic separator, crushers and ball mills, semi-automatic floatation cells, hydro-cyclone test rig, jigging facilities, a wet chemical analysis laboratory, gas chromatograph; oil-fired, electric and induction melting furnaces, sand testing and sand casting facilities, pneumatic hammers and hydraulic presses, a swaging mill, a 2-High rolling mill, melt-atomization facility, a hot press for consolidating powder materials, heat treatment and sintering furnaces for different applications, metallography facilities and an Image Analysis System, Scanning and Transmission Electron Microscopes, Electron Probe Microanalyzer, X-Ray and DTA facilities, Instron and MTS testing facilities for mechanical testing of materials at low-ambient - and high temperatures, powder characterisation and pressing facilities for metal, ceramic and intermetallic powders. Besides having a reputation for carrying out experimental research work, the Department has also a strong tradition for working in the area of mathematical and physical modeling for materials processing using conventional numerical methods as well as methods based on artificial intelligence and neural networks.

STRUCTURE OF THE B.TECH. PROGRAMME

SEM. II	SEM. III	SEM. IV	SEM. V	SEM. VI	SEM. VII	SEM. VIII
MME 100	MME 200	MME 210 MME 250 HSS II	MME 310 MME 320 MME 330 E1	MME 331 MME 340 MME 350 MME 370 MME 390 E II	MME 410 MME 415 MME 470 DE I	MME 480 MME 499 E III DE II DE III

HSS II
Elective-I
Science-I/HSS-III
Elective II
HSS-III/Science-I
DE- I
HSS-IV/Science-II
Scence-II/HSS-IV
Elective -III
DE- II
DE- III

MME 100 Introduction to Profession
MME 200 Thermodynamics of Materials
MME 210 Metallurgical Kinetics
MME 250 Materials Characterization
MME 310 Mechanical Behaviour of Materials
MME 320 Principles of Metal extraction and refining
MME 330 Phase equilibria in Materials
MME 331 Process Metallurgy Lab.
MME 340 Phase Transformation in Materials
MME 350 Iron and Steel Making
MME 370 Fundamentals of Materials Processes
MME 390 Industrial Tour
MME 410 Electronic and Magnetic Proerties of Materials
MME 415 Physical Metallugy Lab.
MME 470 Manufacturing Processes:Selection and their Design
MME 480 Materials Degradation and its prevention
MME 499 Project II

COMPULSORY PROFESSIONAL COURSES FOR UNDER GRADUATE STUDENTS

MME 100 **INTRODUCTION TO THE PROFESSION**

L-T-P-D-[C]

2-0-0-0-[0]

Historical aspects of various materials, including some landmarks; Natural resources of materials; Cost, economics, energy, environmental and political issues relating to materials industry and applications; Importance of materials and their properties, performance and manufacturing processes in the development and growth of automotive, aerospace and railway sectors, electrical, electronic and telecommunication equipment/systems, energy sector, military hardware, structural and general engineering applications, biomedical/implant materials etc.; Demonstrations/film- shows related to selected materials and their characterization, properties and processing.

MME 200 **THERMODYNAMICS OF MATERIALS**

L-T-P-D-[C]

3-1-0-0-[4]

Heterogeneous and homogeneous systems, extensive and intensive properties, simple equilibrium; First Law of thermodynamics, constant volume and constant pressure processes; Spontaneous processes, entropy and quantification of irrversibility, properties of heat engines, thermodynamic temperature scale, Second Law of thermodynamics, criterion for equilibrium, Entropy and disorder, most probable microstate, configurational entropy and thermal entropy; auxiliary functions, Maxwell's relations, Gibbs-Helmholtz equation; Third Law of thermodynamics; variation of Gibbs energy with temperature and pressure, Clausius-Clapeyron equation; thermodynamic properties of mixtures of ideal and imperfect gases; reactions in gas mixtures; reactions of pure condensed phases with gas mixtures -standard Gibbs energy of reactions, Ellingham diagrams; Raoulfs and Henry's Law, activity of a component, Gibbs-Duhem equation, non-ideal solutions, regular solutions, quasi-chemical model of solution, activity and alternative standard states; reaction equilibrium in condensed system, Gibbs phase rule, binary systems involving compound formation, solubility of gases in metals, formation of oxide phases of variable composition; relation between chemical and electrical driving forces, Nernst equation, concentration and formation cells, Pourbaix diagrams; thermodynamics of Point Defects.

MME 210 **METALLURGICAL KINETICS** **Prereq. ESO 212**

L-T-P-D-[C]

3-1-0-0-[4]

Thermodynamics vs. kinetics, homogeneous and heterogeneous reactions; Chemical Reaction Control-rate equation, reaction rate constant, reaction order, non-elementary reactions; Solid State Diffusion -Fick's Law, mechanism of diffusion, uphill diffusion, Kirkendall effect, steady and transient diffusion; External Mass Transfer -fluid flow and its relevance to mass transfer, general

mass transport equation, concept of mass transfer coefficient, models of mass transfer -film theory and Higbie's penetration theory; Internal Mass Transfer-Ordinary and Knudsen diffusion, Mass transfer with reaction; Adsorption -physical adsorption vs. chemisorption, adsorption isotherms; Langmuir, BET, adsorption as the rate limiting step; gasification of C by CO2, dissolution of N2 in molten steel, porous solids, specific surface area and pore size distribution; Reactor Design -batch vs. continuous reactors, ideal stirred tank and plug flow reactors, mass balance in ideal reactors, residence time distribution; models of industrial reactors; Electrochemical Kinetics-concept of polarization, activation over potential, Butler-Volmer and Tafel's equation, applications in electro-deposition and corrosion, concentration over-potential, limiting current; electro-winning and corrosion.

MME 250 **MATERIALS CHARACTERIZATION**

L-T-P-D-[C]
3-1-0-0-[4]

Chemical bonding, fundamentals of crystallography, reciprocal lattice, structures in metals, inorganic compounds, polymers, silicates and glasses, stereographic projections; Production, characterization, and interaction of X-rays with matter, Bragg's Law and Laue's equations, Ewald's construction, diffraction techniques and applications; Optical principles of microscopy -resolution, magnification, depth of focus; electron diffraction, imaging (various contrasts), determination of crystal structure, burgers vector, electron beam-specimen interactions and other applications of Transmission Electron Microscopy; Applications of Scanning Electron Microscopy and, Electron Probe Micro- Analyser; Principles of Quantitative Microscopy: volume density, surface density, length density, numerical density, particle and grain size; Overview of other characterization techniques such as Auger electron spectroscopy, Scanning Tunneling Microscopy, Atomic Force Microscopy.

MME 310 **MECHANICAL BEHAVIOUR OF MATERIALS** **Prereq. ESO 204**

L-T-P-D-[C]
3-0-3-0-[5]

Stress tensor and stress transformation equations, Principal stresses; Strain tensor and strain transformation equations; Isotropic and anisotropic elasticity, elastic strain energy; Yield criteria and constitutive relationships; Work hardening, plastic instability and its significance; Crystallographic aspects of plastic deformation; Dislocation theory - edge, screw and mixed dislocations, resistance to dislocation motion and elastic properties of dislocations, dislocation interactions, multiplication and dissociation; Strengthening mechanisms; Creep -characteristics of creep curve and steady-state creep, mechanisms and creep mechanism maps, creep under complex stress-states, prediction of long- time properties; Fracture toughness and fatigue -Griffith's crack theory, energy release rate analysis, modes of loading, stress analysis of cracks, fracture toughness, Low- and High-cycle fatigue, Fatigue crack initiation and propagation, structural aspects of fatigue, fatigue under complex stress-states, environmental assisted cracking and fatigue; Some case studies related to design.

MME 320 **PRINCIPLES OF METAL EXTRACTION AND REFINING** **Prereq. MME 200**

L-T-P-D-[C]
3-1-0-0-[4]

History and importance of metal extraction; Introduction of mineral dressing: Communition, Tabling, Jigging and flotation; Metallurgical fuels and the energy scenario; Pyrometallurgical operations -roasting, agglomeration, smelting, refining and secondary refining; Principles of Hydro Metallurgy; Principles of Electro Metallurgy -Aqueous solution and fused salts; Flow sheet design of important non ferrous metals based on materials and heat balance.

MME 330 **PHASE EQUILIBRIA IN MATERIALS** **Prereq. MME 200**

L-T-P-D-[C]
3-0-3-0-[5]

Phase rule, lever rule and Free energy of phase mixtures; Binary isomorphous systems -Equilibrium solidification, non-equilibrium solidification, dendritic growth, coring, Cu-Ni alloys and Zone refining; Binary Eutectic and Peritectic Systems -solidification of eutectic, hypo-eutectic, and hyper-eutectic alloys; solidification of peritectic, hypo-peritectic, and hyper-peritectic alloys; morphologies of eutectic systems, Binary Monotectic and Syntectic Systems; Stability of regular solution and miscibility gas, intrinsic stability of solution and spinodal; Hume-Rothery rules and intermediate phases e.g., laves, sigma, electron compounds; Binary eutectoid, peritectoid, metatectic and monotectic systems; Iron-carbon phase diagram and microstructures of plain carbon steel and cast iron: non-equilibrium structures; Binary ceramics systems: SiO2AbOa, NiO-MnO, etc.; Ternary phase diagrams -Gibbs triangle, isothermal and vertical sections, polythermal projections, two-phase equilibrium, concept of tie lines, rules for construction of tie lines, three phase equilibrium, concept of tie-triangle, four phase equilibria; Multi-component alloy systems: Stainless steels, high-speed steels, Hadfield steels, superalloys, light metal alloys, refractory systems, (AbOa-SiO2-MgO) , sialanes.

MME 331 **PROCESS METALLURGY LABORATORY** **Prereq. MME 200 & MME 320**

L-T-P-D-[C]
0-0-3-0-[2]

Laboratory techniques of temperature and flow rate measurement and calibration: Experiments on Mineral Engineering, Metallurgical Thermodynamics and Kinetics, Fuels and Furnaces, Iron making, steelmaking, pyro-, hydro-, electro-metallurgy in extraction of non-ferrous metals and metallurgical analysis.

MME 340 **PHASE TRANSFORMATIONS IN MATERIALS** **prereq. MME 330**

L-T-P-D-[C]
3-0-0-0-[4]

Thermodynamic order of transformations; Theory of nucleation -Kinetics of homogeneous, transient and heterogeneous nucleation; Theory of Thermally Activated Growth: Interface controlled growth, Diffusion controlled growth, Interface instability and Widmanstatten growth, Eutectoid growth, Discontinuous precipitation, Massive transformation; Transformation Kinetics -Johnson-Mehl equation, Avrami model, Transformation kinetics in diffusion-controlled transformations, Isothermal and continuous cooling transformation diagrams;

Precipitation and Particle Coarsening; Kinetics of recrystallization, Theory of grain growth, Effect of second phase particles; Martensitic transformation - Nature of martensitic transformations, Bain distortion, Nucleation, and growth of martensite, Athermal, isothermal and burst transformations, Thermoeleastic martensitie; Spinodal Decomposition -Diffusion equation in spinodal region, Effect of gradient energy and elastic strain energy; Solidification -Nature and growth of solid-liquid interfaces, Rapid solidification, Glass transition, metallic glasses; Heat Treatment -IT and CCT Diagrams in steels, quench hardening and tempering of martensite, hardenability of steels, surface hardening processes, tool steels and their heat treatments, heat treatment of cast irons, heat treatment of Ni-base superalloys and Ti alloys, Thermo-mechanical treatments.

MME 350 **IRON AND STEELMAKING, 3-1-0-0-4** **Prereq. MME 200 & MME 210**

L-T-P-D-[C]
3-1-0-0-[4]

Refractories for iron and steel; Design and profile of an iron blast furnace and its auxiliaries; Performance evaluation of bast furnace -Iron ore reduction, fuel rate calculations, BF aerodynamics and hot metal quality control; Energy and materials balance calculations in steelmaking processes; Physical chemistry of steelmaking and secondary steelmaking deoxidation, ladle and tundish metallurgy, ingot and continuous casting of steel; Emerging trends in iron and steelmaking.

MME 370 **FUNDAMENTALS OF MATERIALS PROCESSING** **Prereq. TA 201**

L-T-P-D-[C]
3-0-0-0-[4]

Overview of various processing methods for materials; microstructural evolution during solidification and effect of cooling rate on cast microstructures, micro- and macro-segregation in alloys, directional solidification, rapid solidification; Elements of casting mold design -solidification shrinkage and its role in riser design, fluid flow fundamentals and metal fluidity, elements of mold design; Fundamentals of deformation processing -State of stress during various metal working operations, friction and its role in bulk metal forming operations, microstructural evolution during deformation processing, workability of metals, superplastic forming; Metal flow and aspects of design during bulk forming operations, elementary load calculations during various bulk-metal working operations; Sheet metal forming -State of stress during sheet metal forming processes, forming limit diagram, ehancement of sheet metal formability; Fundamentals of powder processing -Basics of metal and ceramic powder productions and characterization, design aspects during powder consolidation; solid and liquid state sintering, driving force and mechanism of si ntering , selection of sintering atmosphere for different systems, characterization of sintered products, full density processing.

MME 390 **INDUSTRIAL TOUR, 0 UNIT**

L-T-P-D-[C]
3-0-0-0-[4]

Visit to industries in and around Kanpur or elsewhere primarily of interest to Materials and Metallurgical Engineering.

MME 410 **ELECTRONIC AND MAGNETIC PROPERTIES OF MATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

DC conductivity of metals, Hall effect and magnetoresistance, AC conductivity of metals, thermal conductivity and specific heat of metals, Thermopower of metals; Review of quantum mechanics and free electron theory, failures of free electron theory and introduction to the role of lattice; Review of reciprocal lattice, Brilouin zone, Free electron band diagrams, potential in a crystal, electron dynamics and concept of holes, conductivity in relation to band structure, band structures of metals and semiconductors; empirical estimates of conductivity in metals and alloys; Semiconductors -band diagrams, direct and indirect band gap, applications of semiconductors; Degenerate and non- degenerate semiconductors, intrinsic and extrinsic semiconductors, determination of dopant levels and mobility measurements; Ionic conduction -review of defect equilibrium and diffusion mechanisms, theory of ionic conduction, conduction in glasses, effect of stoichiometric and extrinsic defects on conduction, applications in sensors and batteries; Dielectric Materials -Dielectric constant and polarization, linear dielectric materials, capacitors and insulators, polarization mechanisms, non-linear dielectrics pyro-, piezo- and ferro-electric properties, hysterisis and ferroelectric domains and applications; Optical Materials -electron-hole recombination, solid-state LED's, lasers and IR detectors, band gap engineering; Light interaction with materials -transparency, translucency and opacity, refraction and refractive index, reflection, absorption and transmission; Magnetic field, flux density, susceptibility and permeability; Orbital and spin, permanent magnetic moment of atoms, diamagnetism, paramagnetism and Pauli-paramagnetism, ferro, anti-ferro and ferri magnetism, Fe, Co and Ni and alloy additions, ferrites, magnetic hysterisis, soft and hard magnet materials.

MME 415 **PHYSICAL METALLURGY LABORATORY** **Prereq. MME 250**

L-T-P-D-[C]
0-0-3-0-[2]

Laboratory techniques for studying phase transformations in materials, recrystallization and grain growth, eutectoid transformations in steels, hardenability, tempering of martensite; resistivity of metals, conductivity of semiconductors, conduction in ionic solids, dielectric measurements in BaTiO3, reflection, absorption and transmission measurement on various metals.

MME 470 **MANUFACTURING PROCESSES: SELECTION & DESIGN** **Prereq. MME 370**

L-T-P-D-[C]
3-0-3-0-[5]

Overview of manufacturing systems; role of traditional and near-net shape processes in manufacturing industry; Basic attributes of manufactured products -size and shape complexity, machining requirement and machining losses, dimensional tolerances, surface condition, mechanical properties and manufacturing costs, expendable mold and permanent mold shape casting processes; Open die and closed die forging processes and design considerations; Manufacturing processes for making products such as sheets, round/sectioned bars, seamless

tubes/rings and wires; Criteria for selection of metal and ceramic powder production processes for a given application; Powder processing equipments and their selection; Joining processes, selection and design; Case studies with CAD/ CAM aspects.

MME 480 **MATERIALS DEGRADATION AND PREVENTION**

L-T-P-D-[C]

2-0-0-0-[2] Types of processes leading to degradation of materials, viz Oxidation, Corrosion, Wear, Creep and fatigue; review of basics of thermodynamics and kinetics related to oxidation and corrosion studies, Pourbaix diagram, Polarization, Mixed potential theory, Passivity, Characteristics of passivation; Various types of degradation: atmospheric, galvanic, intergranular, dealloying, crevice and pitting corrosion, microbiological, stress corrosion cracking, hydrogen damage, radiation damage; Oxidation and hot corrosion of materials at high temperatures; Wear of materials, analytical models of wear; Prevention of materials degradation -alloying, environment conditioning, design modification, cathodic and anodic protection, metallic coating, inorganic coating, organic coating, inhibitors and passivators, wear resistant materials -structural modifications, wear resistant coatings.

Electives for UG and PG Students

MME 421 **MINERAL ENGINEERING**

L-T-P-D-[C]

3-0-0-0-[4] Status of mineral engineering with regard to sister disciplines: Some concept in geology and mineralogy: Mineral resources in India: Liberation: Com munition and sizing: Hydrodynamics of movement of solids in fluid and gravity separation of different kinds: Coal washing: Magnetic and electrostatic separation: Surface chemistry and other principles of froth floatation: Mill calculation and selectivity index: Typical mineral Engineering flow sheets and case studies.

MME 422 **SCIENCE AND TECHNOLOGY OF NON-FERROUS METAL EXTRACTION**

L-T-P-D-[C]

3-0-0-0-[4] State of non-ferrous industry in India, Present industrial practice: Recent advances and future trends in extraction and refining of non-ferrous metals: Reclamation of metals from scrap and industrial wastes: Flow sheet analysis of commercial extraction units: Environmental considerations.

MME 423 **SECONDARY STEELMAKING**

L-T-P-D-[C]

3-0-0-0-[4] Secondary steel making principles and practices: Ladle metallurgy: Outline of inert gas stirring: CAS/CAS(OB), Ladle furnace vacuum degassing of steel and related processes: Transport phenomena in ladles: Tundish metallurgy: Evaluation of tundish hydrodynamic performances: Solidification phenomena: Conventional, continuous and near net shape casting phenomena.

MME 424 **MODELLING OF STEELMAKING PROCESSES**

L-T-P-D-[C]
3-0-0-0-[4]

Brief review of fundamentals of steel making processes: Brief review of fundamentals of transport processes: Mathematical modeling fundamentals: Successful modeling examples.

MME 425 **PROCESS PLANT DESIGN FOR METALLURGICAL ENGINEERING OPERATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Identification of process flow sheet: Preliminary estimate of resources and facilities: Materials and energy balance, detailed plant flow sheet: Equipment selection and specification, economic selection and specification: environmental impact analysis: Report presentation, case studies of typical metallurgical plant operation.

MME 426 **FUELS, REFRACTORIES AND FURNACES**

L-T-P-D-[C]
3-0-0-0-[4]

Conventional and newer sources of energy, energy management problems in metallurgical industries, role of high temperature systems and materials; Deposits, manufacturing, properties and testing of solid, liquid and gaseous fuels; Principles of fuel combustion and burner design; Classification of refractories, manufacturing and properties of common refractories such as silica, fire clay, high alumina, dolomite, magnesite and chrome refractories; Design of high temperature furnaces, waste heat utilization, heat recuperators and regenerators, stack design, gas cleaning, heat balance diagrams; furnace dynamics and fluid and heat flow calculations; Fuel fired furnaces, electric arc furnaces, vacuum, electron beam, plasma, laser furnaces.

MME 428 **ADVANCES IN IRONMAKING**

L-T-P-D-[C]
3-0-0-0-[4]

Recent advances in science and technology of iron making: Developments in blast furnace iron making: Sponge iron making: New emerging coal-based iron making for liquid iron: Gas-solid and slag-metal reactions: Analysis of iron making processes and reactors: Emphasis on application of fundamentals: Term paper on short analysis/design projects.

MME 430 **FURANCE TECHNOLOGY**

L-T-P-D-[C]
3-0-0-0-[4]

Definition and classification of furnaces; Principles of heat generation in fuel fired furnaces and combustion, Flame temperature, Burners for liquid and gaseous fuels, Movement of gases in furnaces, ducts and chimneys, Heat generation in electric furnaces, resistance, induction, are, plasma etc. Metallic and non-metallic heating elements. Furnaces, resistence, induction, are, plasma etc. Metallic and non-metallic heating elements. Furnace construction materials: Manufacture and uses of different types of refractories and insulators, critical

insulation thickness, criteria of section of refractory material. Heat balance of a furnace and thermal efficiency, Waste heat recovery systems and their designs, Atmosphere in furnaces. Fuel economy measures in furnaces. Constructional, operational and design features of different types of furnaces like soaking pits, pusher type, walking beams, forging furnaces etc.

MME 441 **STRUCTURAL CHARACTERIZATION TECHNIQUES AND THEIR APPLICATIONS,**
L-T-P-D-[C] **Prereq. MME 250**

3-0-0-0-[4]

Hierarchy in structure -nano-to macro-scale, structural defects and structural property correlations, overview of characterization need and challenges.
Physical phenomena and basic concepts: Waves particle beams, radiation-matter interactions, concepts likes resolution, lens defects, depth of focus, depth of field, detection limits etc. Neutron diffraction. XRD, electron diffraction. ESBD and their applications. Principles of microscopic techniques like TEM, HRTEM, SEM, OIM, SPM etc., and their applications. Nanometer scale design and fabrication using STM and AFM. Fundamentals of EPMA, ESCA, AES, SIMS, EELS etc., and applications.

Case studies: Super alloys, HSLA, FGM, device structure, structural ceramics, high T_c superconductor, CNT, polymeric L-B films.

MME 452 **SURFACE COATING TECHNOLOGY** **Prereq. #**
L-T-P-D-[C]
3-0-0-0-[4] Purpose and scope of surface coatings: Surface coating processes and characterization of coatings: Flame spraying: Detonation spraying: Spray and fuse welding: Clading: Electroplating: Electrophoretic deposition: Chemical vapour deposition: Metallizing etc.; Factors affecting the choice of coating material and process: Testing of surface coatings.

MME 455 **ADVANCES IN POWDER METALLURGY**
L-T-P-D-[C]
3-0-0-0-[4] Advances in metal powder production methods, Characterization of metal powders: Chemical composition and structure: Particle size and their shape and their determination: Powder flow, compressibility and porosity measurements: Treatment of metal powders: Behaviour of powder during compaction: Die compaction: Types of presses: Tooling and design: Modern methods of powder consolidation, Isotactic pressing: Roll compaction, Powder extrusion and forging, Slip casting, evaluation of sintered products.

MME 456 **MECHANICAL PROCESSING OF MATERIALS**
L-T-P-D-[C]
3-0-0-0-[4] Fundamentals of metal working: Metal working processes such as forging, rolling, extrusion, drawing, sheet metal forming: Automation and recent advances in Metal working technology: Polymer working processes such as extrusion, moulding, thermoforming and callendering: Advances in polymer working technoloy.

MME 461 **INTRODUCTION TO TECHNICAL CERAMICS**

L-T-P-D-[C]

3-0-0-0-[4]

Powder preparation, forming and consolidation, non-powder processing routes: Structural ceramics: Elastic behaviour, toughness, strength, creep and plastic deformation: Electronic magnetic and optical properties: Conductivity, dielectric, piezo-and pyro-electric materials, magnetic ferrites, transparent and non-linear optical ceramics.

MME 464 **REFRACTORIES**

L-T-P-D-[C]

3-0-0-0-[4]

Raw materials, manufacture testing and properties of heavy and special refractories, silica, silicous alumino-silicate, high alumina, magnetisite, chrome, chrome-magnesite, dolomite, forsterite, chemically bonded basic, carbon and insulating refractories and special purpose oxides, carbide nitride refractories: application and causes of destruction of ferrous, non-ferrous, ceramic and glass furnaces.

MME 467 **Materials for Semiconductors Industry**

Semiconductor fundamentals, band structure, indirect and direct band gap, optical properties, carrier statistics, semiconductor material purification and crystal growth, epitaxy, CVD and MBE, P-N Junction, Schottky and MaS device structures, specific material requirements, Doping by implantation and diffusion, dielectric and insulators, ohmic and barrier contacts, band edge behaviour, empirical rule, alloy design.

MME 471 **METAL JOINING, 3-0-0-0-4**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction, classification of joining processes, soldering and brazing, arc welding processes such as SMAW, GMAW, GTAW, FCAW, EGW, ESW and PAW, Electron beam and Laser beam welding, solid state welding processes, Adhesive and diffusion bonding of materials, heat flow, residual stresses, welding defects and testing, welding metallurgy of carbon steels, alloy steels, stainless steels, aluminium alloys and copper.

MME 472 **ADVANCES IN FOUNDRY TECHNOLOGY**

L-T-P-D-[C]

3-0-0-0-[4]

Casting design: casting with ferrous, non-ferrous and superalloys: net-shape casting: advances in molding materials, melt treatment and casting techniques: modeling of casting, solidification: automation and quality control, foundry pollution and control.

MME 478 **FAILURE ANALYSIS**

L-T-P-D-[C]

3-0-0-0-[4]

Type of failures, buckling, fracture in brittle and ductile materials, fractography, mixed mode, and fatigue failures environmental effects, wear, creep, and

yielding phenomena, high strain rate failures, case histories of component failures.

MME 481 ENGINEERING APPLICATIONS OF METALLIC MATERIALS

L-T-P-D-[C]
3-0-0-0-[4]

Effect of modification in composition, structure and processing on properties; underlying metallurgical principles, microstructure-property correlation; Criterion in materials selection, Material property charts, Processing maps; Concept of strain ratio, forming limit diagram, transformation induced plasticity and superplasticity, strengthening mechanisms, thermo-mechanical processing, controlled cooling; Inclusin type/shape control, Grain boundary engineering, single grain processing, directionally solidified materials, textural effects;

Important groups of metallic meterials - Carbon, alloy and Stainless steels: Electrical and Magentic steels and alloys, coated sheets; Cast Iron; Light metal and alloys, Copper and its alloys, Nickel, Iron, Cobalt base superalloys Titanium, Zirconium alloys.

Applications to focus on Transport, Energy and Chemical Plant Sectors highlighting criteria for material selection.

MME 482 ADVANCES IN HEAT TREATMENT TECHNOLOGY

L-T-P-D-[C]
3-0-0-0-[4]

Hardenability, Selection and specification of steels: New technology such as thermo-chemical and thermo- mechanical and thermocycling treatments: Quantitative approach to heat-treatment: Failure analysis of heat treated products: Applications tailoring and computer harmonizing techniques.

MME 484 COMPOSITE MATERIALS

L-T-P-D-[C]
3-0-0-0-[4]

Classification of composite materials, Dispersion strengthened, particle-reinforced and fiber-reinforced composites, laminates, properties of matrix and reinforcement materials: Micromechanics and principle of strengthening, elastic properties, stress-strain relations, fracture be-haviour, Fabrication methods and structural applications of different types of composite materials.

MME 485 STRUCTURAL MATERIALS FOR AEROSPACE APPLICATIONS

L-T-P-D-[C]
3-0-0-0-[4]

Design of gas turbine aero-engines: Creep, fatigue and corrosion as limiting factors for high-temperature application of materials: Development of Ni and Co based super alloys, special steels, Ti alloys, intermetallics, ceramics and their composites, New high strength-high modulus materials, ablative materials.

MME 486 PARTICULATE MATERIALS

L-T-P-D-[C]

3-0-0-0-[4]

The particular state: attributes and morphology of particles: Distribution of particles in a single attribute: expectation as a measure of global properties of particular ensembles, Analysis of static and dynamic particulate systems by transformation in attributes and measures, Production of particles by mechanical and thermo-chemical means, Particulates in suspension, stability, rheology and settling, Size analysis, Particles in natural phenomena and man- made processes.

MME 498 PROJECT I, 0-0-4-0-2

MME 499 PROJECT II, 0-0-10-0-5 Prereq. MME 498

MME 600 ADVANCED THERMODYNAMICS

L-T-P-D-[C]

3-0-0-0-[4]

Advanced treatment of the thermodynamic properties of metallurgical systems, properties of solutions: Thermodynamics of interfaces: Irreversible Thermodynamics: Defect structures in solids: Non-equillibrium solid state phase transformations: Gas-metals & slag-metal reactions.

MME 602 ELECTROCHEMISTRY AND CORROSION

L-T-P-D-[C]

3-0-0-0-[4]

Advanced theory of electro-chemical kinetics and corrosion, theory of electro-deposition and allied processes, stress corrosion behaviour of materials (important metals, alloys etc.) in various environments, corrosion testing: Metal-gas reaction at high temperatures, corrosion by liquid metals.

MME 604 SURFACE PHENOMENA IN CHEMISTRY AND METALLURGY

L-T-P-D-[C]

3-0-0-0-[4]

Physical aspects of interfaces, thermodynamics of surfaces, anisotropy effects, adsorption mechanism, electrical phenomena at interfaces, theory and properties of electric double layer, application to problems in chemistry and metallurgy.

MME 607 COMPUTING APPLICATIONS IN METALLURGY

L-T-P-D-[C]

3-1-0-0-[5]

Fortran fundamentals: Applications of regression analysis and curve fitting techniques, computer calculations of phase diagrams: Numerical of partial differential equations pertinent to heat, mass and momentum transfer: Computer applications in solidification, potential energy diagrams and experiment in metallurgy.

MME 608 COMPUTER APPLICATION IN MINERAL ENGINEERING

L-T-P-D-[C]

3-0-0-0-[4]

Mass balancing, data reconciliation, problem solving with a material balance software package: Quantitative description of mineral processing units and its computer implementations: Introduction to a general purpose modular simulator for process analysis.

MME 609 **SOFT COMPUTING METHODS IN ENGINEERING PROBLEM SOLVING**

L-T-P-D-[C]

3-0-0-0-[4]

Working principles of genetic algorithms, artificial neural nets, fuzzy logic technique, soft computing techniques like fuzzy regression, fuzzy coded GA, fuzzy neural nets, ANN-fuzzy information system, Fuzzy-ANN-GA; case studies in process control and optimization.

MME 610 **HYDROMETALLURGY**

L-T-P-D-[C]

3-0-0-0-[4]

Thermodynamic and kinetic principles involving solid solution equilibria: Various unit operations in Hydrometallurgy, such as, pretreatment of raw materials, leaching, solvent extraction, ion exchange, gaseous reduction, cementation, precipitation, electro-winning, etc.: Technological aspect of typical hydrometallurgical plants.

MME 613 **ELECTROCHEMICAL TECHNOLOGY IN MATERIALS PROCESSING**

L-T-P-D-[C]

3-0-0-0-[4]

Thermodynamic of electrolyte, electrochemical potential, conduction of ions in solution, overpotential, absorption, phase formation: Economics of an electrolytic process, principles of cell design, Electrochemical technology: Elactowinning, electro refining and metal electroforming, electrochemical machining, electroplating, anodizing, pickling, electrophoretic painting, electrochemical treatment of minerals, batteries and fuel cells, water treatment and environmental protection.

MME 619 **PHYSICO-CHEMICAL BE-HAVIOUR OF MATERIALS AT HIGH TEMPERATURE**

L-T-P-D-[C]

3-0-0-0-[4]

Salient features of physico-chemical behaviour of inorganic materials at high temperatures including interaction with environment, gas composition and pressure dependent phase stability diagrams for non-metallic and metal-nonmetal systems. Nonstoichiometry and defect equlibrium in oxides: Structure and physico-chemical measurements at high temperatures: Vapour and plasma states: Reaction kinetics at high temperatures with specific emphasis on reactivity of solids.

MME 620 **ADVANCED MINERAL ENGINEERING**

L-T-P-D-[C]

3-0-0-0-[4]

Mathematical model of comminution and classification systems: Kinetics of floatation and leaching: Design of comminution circuits: floatation cells and thickners: Filteration, drying and control systems: Coal washing in India: Computer simulation of mineral engineering operations: Flowsheet and economic analysis of mineral processing plants.

MME 622 **MATERIAL SEPARATION AND PURIFICATION**

L-T-P-D-[C]

3-0-0-0-[4]

Differential physico-chemical properties of materials as the basis of separation and purification leaching, solvent extraction, foam fractionation, ion exchange,

zone refining, etc: Computation of length transfer unit, making of ultrapure metals: Advanced techniques of analysis, growth of single crystals.

MME 624 **ADVANCED CHEMICAL METALLURGY**

L-T-P-D-[C]
3-0-0-0-[4]

Structure, physical properties and thermodynamics of solutions: Ternary and multicomponent systems: High temperature physico-chemical measurements: Heterogneous reaction equilibria at high temperatures: Stabilities of high temperature materials: Special topics: Theory of reaction rates and applications.

MME 626 **HEAT AND MASS TRANSFER**

L-T-P-D-[C]
3-1-0-0-[5]

Review of the basic concepts in heat,mass and momentum transfer: Advanced topics in convective heat and heat transfer: Radiative heat transmission: Simultaneous heat and mass transfer: Selected topics in metallurgical engineering, Reaction kinetics.

MME 627 **INJECTION METALLURGY**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to processes and treatment based on injection: Fundamentals of injection metallurgy: Gas and powder injection: Design of lances, nozzles and dispensers: Heat and mass transfer, Technological applications in refining and recycling processes and product developments and quality control and assurance.

MME 628 **APPLICATION OF TRANSPORT PHENOMENA IN METAL PROCESSING**

L-T-P-D-[C]
3-0-0-0-[4]

Review of heat mass and momentum transfer fundamentals: Turbulence phenomenon and heat and mass transfer in turbulent flows: Dimensional analysis and reactor design: Free convection phenomena and bubble/gas driven systems: Applications of transport phenomena to (1) gas stirred ladle systems (2) desulphurization of pig iron using Mg vapour (3) alloy addition kinetics (4) soaking and reheat furnaces.

MME 629 **PHYSICAL AND MATHEMATICAL MODELLING OF STEELMAKING PROCESSES**

L-T-P-D-[C]
3-0-0-0-[4]

Brief review of scientific fundamentals such as thermodynamics, kinetics and transport phenomena of relevance to steel making: Mathematical modeling techniques: Principles of physical modeling: Successful modeling examples including converter steel making, gas stirred ladles: Alloy addition kinetics, tundish operations and continuous casting.

MME 630 **ADVANCES IN IRON AND STEEL MAKING**

L-T-P-D-[C]
3-0-0-0-[4]

Recent trends in iron and steel making: Gas-solid and slag-metal reaction: Sponge iron making: Continuous steel making: Continuous casting: Vacuum degassing and electroslag remelting: Advances in agglomeration, blast furnace and steel making, analysis of iron and steel making processes and reactors: Deoxidation and impurity control: Emphasis on application of physical chemistry and transport phenomena.

MME 631 **ADVANCES IN ALLOY STEEL MAKING**

L-T-P-D-[C]
3-0-0-0-[4]

Classification and properties of alloy steels, raw materials for alloy steel making: Manufacture of ferro-alloys, electrical and mechanical design of electric arc furnaces and induction furnaces and induction furnaces for steel making, manufacture and testing of graphite electrodes: Physical chemistry of alloy steel making, developments in stainless steel making, secondary steel making: Refractories foe alloy steel making: Continuous casting of alloy steels: Mini steel plants in India.

MME 632 **ANALYSIS OF PARTI-CUALTE SYSTEMS**

L-T-P-D-[C]
3-0-0-0-[4]

Characterization and statistics of small particles: Distribution in single and multiple particle attributes: Transformation of attributes: Statistical, empirical, and series distribution and their statistical properties: Evolution of particulate spectra in size reduction, agglomeration, coagulation, crystal and grain growth, floatation, etc.: Moments, similarity and approximate methods for the solution to the particle population equation.

MME 633 **MINERAL AND METALLURGICAL WASTES RECYCLE AND RESOURCE RECOVERY**

L-T-P-D-[C]
3-0-0-0-[4]

Properties and characterization of major waste products in mining, mineral benefications, pyro-and hydrometallurgy and ceramic processes: Recycle of waste in the parent process: Problems of particulate solids, briquetting and agglomeration of fines: Utilization of wastes for cements, building materials, light weight aggregates, ceramics, filters, fertilizers etc.: Miscellaneous applications.

MME 635 **MATHEMATICAL MODELLING OF METALLURGICAL AND MINERAL PROCESSES**

L-T-P-D-[C]
3-1-0-0-[5]

Introduction to mathematical modeling and simulation: Basic concepts in mathematics and numerical analysis, optimium experimental design, smoothing and generation of data: Time series analysis: Development and analysis for empirical model -estimation of parameters, error analysis: Mathematical modeling and simulation of some of the metallurgical and mineral engineering processes.

MME 636 **PROCESS CONTROL IN METALLURGY AND MINERAL PROCESSING**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to and incentives for process control: Design aspects of a process control system, role of mathematical modeling and development of mathematical models for control purposes: Linearization of non-linear systems, transfer function and the input-output models: Dynamics behaviour of first and second order systems: Introduction to feedback control: Feed forward and ratio control: Adapture and inferential control: Control hard wares and instrumentation: Case studies of process control in metallurgy and mineral engineering.

MME638 **PROCESS METALLURGY**

L-T-P-D-[C]
3-0-1-0-[5]

Introduction to metallurgical processes: Physical separation methods for ore penetration:Principles of pyro-, hydro-and electrometallurgy:Basic furnace technology:Extraction and refining of common non-ferrous metals such as aluminium,copper,lead,zinc etc.:Iron and steelmaking laboratory exercises.

MME 639 **PHYSICAL METALLURGY**

L-T-P-D-[C]
3-0-1-0-[5]

Crystallography, X-ray diffraction, defects, diffusion, phase diagrams, metallography, phase transformation,heat treatment,plastic deformation, creep, fatigue and fracture, minerals processing.

MME 640 **SOLID STATE TRANSFORMATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Classification of transformation based on thermodynamics, mechanism and kinetics: Homogeneous transformation: Nucleation and growth phenomenoa: Spinodal decomposition: Crystallographic features of transformation.

MME 641 **ORDER-DISORDER TRANSFORMATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Occurrence of different types of ordering in metals and alloys, property changes due to ordering, statistical theory of ordering: Bragg-Williams and Bathe theories of LRO and SRO, thermodynamics of order-disorder transformation, detection of order by X-ray, electron and neutron diffraction, antiphase domains, long periods superlattices, kinetics of order-disorder transformation.

MME 642 **QUANTITATIVE MICRO-SCOPY**

L-T-P-D-[C]
3-0-0-0-[4]

Mathematical treatment of prediction of microstructure: Estimation of size distribution of inclusions from measurements on a two dimensional section: Image analysis through computers.

MME 643 **THEORY OF ALLOYS**

L-T-P-D-[C]

3-0-0-0-[4]

Structure and physical properties of elements: Alloys formation: primary solid solution, intermetallic compounds, concept of atomic size factor, normal valance compounds, electron compounds in noble metals and transition metal systems, size compounds, borides, carbides and silicides of metals: Experimental methods for the study of alloying behaviour of metals.

MME 644 **PHYSICAL METALLURGY OF STEELS**

L-T-P-D-[C]

3-0-0-0-[4]

Mechanical Behaviour of steels: Iron-carbon phase equilibria: Structure and property relationship in steels: High strength low alloy structural steels: Medium-high carbon ferrite-pearlite steels: Tool steels, stainless steels, surface hardening of steels, welding of steels.

MME 645 **INTERFACIAL PHENOMENA IN METALS AND ALLOYS**

L-T-P-D-[C]

3-0-0-0-[4]

Phenomenology of solid surface free energy, Equillibrium shape: Wulff theorm: Gibb's adsorption isotherm, interphase-interfaces in heterogeneous systems: Grain and twin boundary equilibria and multiphase equilibria: Determination of surface free energy: Temperature coefficients, interfaces fracture, interface embrittlement, grain boundary migration and sliding, sintering mechanism, solid-liquid transition, nucleation and growth.

MME 646 **X-RAY CRYSTALLOGRAPHY-I & II**

L-T-P-D-[C]

3-0-0-0-[4]

Elemental compound and alloy crystals, modes of bonding, crystal types, density of packing, atomic stacking, inter- atomic voids, coordination polyhedra, Pauling's rules, symmetry elements, space and point groups, group theoretical formulation, diffraction or radiation.

MME 647 **ELECTRON MISCROSCOPY AND ELECTRON DIFFRACTION**

L-T-P-D-[C]

3-1-1-0-[5]

Interaction of electrons with matter: Electron optical systems: Kinematical theory of electron optical systems and electron diffraction: Contrast effect due to lattice particles: Electron diffraction, double diffraction: Fine structure of diffraction patterns: preparation of replicas and thin foils: Analysis of electron micrographs and diffraction patterns.

MME 648 **DIFFUSION IN SOLIDS**

L-T-P-D-[C]

3-0-0-0-[4]

Diffusion equations and mathematical solutions: Phenomenological diffusion theories: Atomic theory of diffusion, theoretical and experimental investigation of diffusion phenomena: Diffusion in ionic solids and semiconductors: Grain boundary and surface diffusion, thermal and electro-diffusion.

MME 649 **DEFORMATION PHENO-MENA**

L-T-P-D-[C]

3-0-0-0-[4]

Stress and strain tensors: Anisotropic and isotropic elastic stress-strain relations: Dynamic elasticity: Anelasticity, visco-elasticity: Phenomenological aspects of plastic deformation in crystalline materials: Creep and Fatigue: Types of Fracture: Griffith theory of brittle fracture and its modification: Ductile fracture: Notch effect in fracture: Fracture mechanics.

mme 650 **fundamentals of stereology and applications to microstructural analysis**

L-T-P-D-[C]

3-0-0-0-[4]

Concepts and language of stereology; geometrical probability; fundamental operations in stereology; averaging with respect to orientation; basic stereological parameters on true 2-D sections and thick sections; topological parameters of microstructure; error analysis; applications of analysis of optical, scanning and transmission electron micrographs; numerical density and size distribution of particles and grains of various shapes and sizes; stereological analysis of anisotropic microstructures; fractal description of various microstructures; fractal dimensions and its significance; applications to characterization of martensitic, polycrystalline and other structures and fracture surfaces.

MME 651 **X-RAY CRYSTALLOGRAPHY II** **Prereq. MME 342 or equivalent**

L-T-P-D-[C]

3-0-0-0-[4]

X-ray diffraction: Diffraction theory, atomic scattering factor, integrated intensity of diffracted beams, temperature factor, line broadening: Techniques: Laue, powder and rotating crystal techniques, techniques for studying bent crystal, texture, order-disorder changes etc.

MME 655 **MODERN TRENDS IN METAL FORMING PROCESSES**

L-T-P-D-[C]

3-0-0-0-[4]

Limitation of conventional metal forming methods: Powder rolling and its various variants, spray rolling, direct strip process: Powder, spray, rotary and isothermal forging: Hydrostatic and powder extrusion: Conform process: Applications of these processes for making conventional and speciality products.

MME 656 **TEXTURE IN METALS AND ALLOYS**

L-T-P-D-[C]

3-0-0-0-[4]

Concepts of texture: Pole figure, inverse pole figure, inverse pole figure and O.D.F. methods: Experimental techniques in texture analysis-Schultz reflection, transmission, offset quadrant, spherical specimen and neutron diffraction methods: Specimen preparation for texture measurements: Random samples and normalizing procedures: Origin and development of textures on mechanical, physical and magnetic properties: Industrial texture control.

MME 657 **MATHEMATICAL THEORY OF DISLOCATIONS**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction to Volterra dislocation and disclinations -dispirations in crystal - isotropic and anisotropic stress fields: Fast moving dislocations and instability-dislocation intersection and relation of properties in microstructure.

MME 659 **ENGINEERING APPLICATION OF DISLOCATION IN MATERIALS**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction to dislocation, disclinations, dispirations: Isotropic and anisotropic stress fields and energies of dislocations: Stability of dislocation in crystal structure: Interaction between dislocations, impurities, microparticles and related topics in deformation and relation of properties to microstructure.

MME 660 **PROCESS CERAMICS-I: CRYSTAL STRUCTURE, PHASE EQUILIBRIA AND MICROSTRUCTURE DEVELOPMENT**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction to ceramics, common ceramic crystal structure, silicates, clay minerals, graphite, carbides etc.: Pauling rules, crystal binding and cohesive energy co-ordination, structural imperfections, diffusion, ceramic phase equilibrium diagram, nucleation, grain growth, sintering and vitrification, microstructure development of ceramics whitewares, refractories, technical ceramics and abrasives.

MME 661 **PROCESS CERAMICS II: FABRICATION TECHNOLOGY**

L-T-P-D-[C]

3-0-0-0-[4]

Classification and application of ceramic materials: Raw materials preparation and characterization of ceramic powders: Mixing, packing, compaction enlargement of powders: Uniaxial and isotatic pressing: Plastic jiggering, forming and extrusion: Injection molding: Slip casting, hot pressing methods: Drying, calcination and firing, solid state reaction and kinetic models, machining: Grinding and finishing of green and fired bodies: Glazing and enamelling: Quality control and testing.

MME 662 **TRIBOLOGY OF MATERIALS**

L-T-P-D-[C]

3-0-0-0-[4]

Background and importance of Tribology; A system approach to Tribology; Characterization of tribosurfaces; mechanics of solid contacts; theory of friction and frictional heat generation; role of contact temperature; Different modes of wear;Tribological testing techniques and analysis of the worn surfaces; Lubrication; Importance and properties of lubricants; Different wear resistant materials; Recent research results illustrating the performance of surface coatings, bulk materials and composite materials in tribological contacts.

MME 663 **ELECTRICAL AND MAGNETIC PROPERTIES OF CERAMIC MATERIALS**

L-T-P-D-[C]

3-0-0-0-[4]

Structure of oxides: Ionic diffusion in oxides: Defect structure of non-stoichiometric compounds: Conductivity dependence on partial pressure of oxygen: Macroscopic characterization of dielectric materials: Electronic, atomic dipole, space charge polarization: Relaxation phenomenoa-Debye equations: Ferroelectrics: Diamagnetism, paramagnetism and ferromagnetism, exchange ferromagnetic domain: Structure and properties of ferrites.

MME 666 **SCIENCE AND TECHNOLOGY OF MAGNETIC MATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

Magnetic units: Magnetic moments: Dia, para and pauli-para magnetism: Molecular field: Ferro, antiferro and ferrimagnetism: Alloying effect on transition metals and intermetallics: Stability of domain structure: Origin of magnetic anisotropy and its application: Effect of inclusions, internal stress, magnetostriction and preferred orientation on magnetization: Susceptibility and coercivity calculations: Magnetic thin films-amorphous and crystalline, soft and permanent magnets: Technological aspects of magnetic materials.

MME 667 **SELECTION AND DESIGNING WITH ENGINEERING MATERIALS**

L-T-P-D-[C]
3-0-0-0-[4]

Overview of the design process: concepts and stages of engineering design and design alternatives to develop materials with tailored properties; Performance indices of materials; function, objective and constraints in design, "specific stiffness-limited" and "strength-limited" design for maximum performance, Performance indices for thermal, mechanical, thermo-mechanical applications, damage tolerant designs for structural applications; Basic concepts of materials science: processing-structure-property-performance correlation; overview of conventional and advanced materials; Brief overview of the elements of chemical bonding, crystal structure, defect structure of different material classes, Brief introduction to the manufacturing processes for metals, polymers, ceramics, glasses and composite materials; design for manufacturability, Ashby's material property charts; Decision matrices and decision matrix techniques in materials selection, relationship between materials selection and processing; Case studies: designing of Metals and alloys, ceramics and glasses, composite materials (MMC, CMC and PMC/ FRC) for specific applications.

MME 668 **MATERIAL FOR BIOMEDICAL APPLICATIONS**

L-T-P-D-[C]
3-0-0-0-[4]

Introduction to basic concepts of Materials Science; Salient properties of important material classes; Property requirement of biomaterials; Concept of biocompatibility; cell-material interactions and foreign body response; assessment of biocompatibility of biomaterials, important biometallic alloys; Ti-based, stainless steels, Co-Cr-Mo alloys; Bioinert, Bioactive and bioresorbable ceramics; Processing and properties of different bioceramic materials with emphasize on hydroxyapatite; synthesis of biocompatible coatings on structural impant materials; Microstructure and properties of glass-ceramics; biodegradable polymers; Design concept of developing new materials for bio-implant applications.

MME 671 **ANALYSIS AND APPLICATIONS OF SOLIDIFICATION**

L-T-P-D-[C]
3-0-0-0-[4]

Nucleation, nature of solid/liquid interface: Growth morphologies: heat flow considerations: Solute redistribution in alloy solidification: Zone melting: Effect of growth parameters on microstructure: Segregation and homogenisation: Manipulation of structure and properties: Metal matrix composites.

MME 672 **ADVANCED STRUCTURAL CERAMICS**

L-T-P-D-[C]
3-0-0-0-[4]

Fundamentals of Material Properties and the importance of Ceramic materials; Glass and glass-ceramic; Processing and properties of different ceramic monoliths-Fundamental Sintering mechanisms, various advanced sintering techniques (e.g.

Hot Isostatic Pressing, Spark Plasma Sintering, Microwave sintering); Mechnacial behaviour of Structural ceramics-Brittleness of ceramics, Concept of fracture toughness and different toughness measurement techniques, Elastic modulus, Strength measurement and Weibull theory of strength variability, Concept of various toughening mechanisms; Processing and Properties of ceramic composites-Examples of toughened particle reinforced composites, Whisker reinforced composites, Fibre reinforced composites; Recent advances in Structural Ceramics-Functionally graded ceramic composites, Bioceramics and composites.

MME 673 **SINTERING AND SINTERED PRODUCTS**

L-T-P-D-[C]

3-0-0-0-[4]

Stages of sintering, driving forces for sintering, mechanism of sintering, liquid phase sintering, hot processing: Sintering furnaces and atmosphere: Iron, copper and aluminium base P/M alloys: Porous materials: Friction and Antifriction materials: Brushes, Heavy alloys, Cemented carbides: Cermets, Electrical contact materials.

MME 674 **DESIGN OF SINTERED PRO-DUCTS**

L-T-P-D-[C]

3-0-0-0-[4]

Factors affecting design-materials and geometry: Specific design of products like permeable materials, structural parts, bearings and cutting tool materials: conditioning of metal powders to influence processing parameters: Product properties evaluation and their standardization.

MME 675 **SINTERED TOOL MATERIALS**

L-T-P-D-[C]

3-0-0-0-[4]

Classification of cutting materials-tools steels, cemented carbides, ceramic tools and diamond tools: Production method of raw materials powder steel, tungsten carbide, cobalt, A12O3, Si3N4 etc.: Consolidation of shaped products, sintering mechanism liquid phase sintering, cold and hot isostatic pressing: Reclamation of tool materials, Evaluation of sintered tool material.

mme 678 **HIGH TEMPERATURE OXIDATION AND CORROSION**

L-T-P-D-[C]

3-0-0-0-[4]

Introduction experimental techniques: Oxide and defect structure: Thermodynamics, Ellingham diagrams, vapor species diagrams, isothermal stability diagrams: kinetics, rate laws, Wagner's theory of parabolic rate laws, mechanism of oxidation: Oxidation of pure metals, multiple scale formation, scale cracking, oxygen dissolution: Oxidation of alloys, internal oxidation, catastrophic oxidation, stresses in oxides: Hot corrosion, acid fluxing, basic fluxing, High temperature materials, superalloys, intermetallics: Protection against oxidation, coatings, atmospheric control: Conclusions.

MME 684 **NUCLEAR MATERIALS**

L-T-P-D-[C]

3-0-0-0-[4]

Nuclear radiation, microscopic flux and microscopic cross-section, attenuation of radiation fission, elastic collision slowing down infinite multiplication constant:

Fuel and breeder materials manufacture and properties: Structural materials: Radiation damage in fuel elements: Structural coolant and control rod materials: Nuclear power; present and future states.

MME 685 THIN FILM: PHYSICS AND APPLICATIONS

L-T-P-D-[C]
3-0-0-0-[4]

Surface science; experimental techniques to study surfaces; kinetics of surface processes -impingement of atoms, scattering, adsorption, sticking coefficient; Film nucleation and growth mechanisms, critical radius of nuclei, computer simulation of film growth, microstructure evolution; Film growth by evaporation, sputtering, chemical vapour deposition, atomic layer epitaxy, liquid phase epitaxy, sol-gel technique etc, Electrical, optical, magnetic and mechanical properties of thin films and their applications.

MME 687 PHYSICAL METALLURGY, PROCESSING AND APPLICATIONS OF REFRACTORY METALS AND ALLOYS

L-T-P-D-[C]
3-0-0-0-[4]

Characteristics of Pure Refractory Metals- crystal structure, recrystallization behavior, compatibility of refractory metals and alloys with various materials; Physical, chemical, mechanical and thermal properties of refractory metals; Alloys of Refractory Metals- phase equilibria in major refractory alloy systems, alloy design principles, physicochemical interaction of refractory metals with elements of periodic system, interaction of refractory metals with interstitial impurities; Mechanism of Deformation and Strengthening in Refractory Metals- solid-solution strengthening, dynamic strain aging, effect of dispersed second phases, thermo-mechanical treatment, grain size and grain-shape strengthening; Solidification processing, mechanical treatment, powder processing of refractory metals and alloys; Structure and Properties of Refractory Alloys- substitutional alloy, doped Wand Mo, dispersion-strengthening alloys, tungsten heavy alloys, composites reinforced with refractory metal-fibers, refractory-metal cermets, amorphous refractory alloys; Application of Refractory Metals & Alloys: general applications, requirements for special applications, porous metals, refractory alloy for electrical contacts, refractory metals for superconductors, requirements of use in themo-nuclear reactors, refractory alloys for thermal-management applications, refractory alloys for wear-resistant applications; case studies; Novel Processing Techniques

MME 690 SEMINAR PARTICIPATION

MME 691 SEMINAR PRESENTATION

MME 699 M. TECH. THESIS,

MME 799 Ph. D. Thesis