

NED University of Engineering and Technology

Metallurgical Engineering Department

PhD Course Outlines

Sr. No	Course Code	Course Title	Course Contents
1	CT-646	Research Methodology	Research design and planning, Research methods and tools, Data analysis and interpretation. Research proposal. Literature review and report writing, Important steps in writing a technical paper, Thesis writing, Plagiarism, Origin software, Endnote software
2	MY-601	Refining of Engineering Metals	Engineering practices for the production of iron via Blast furnace and DRI. New patent of the Reduction Plant. Blast furnace operations. Phase equilibria involved in the refining reactions. Refining of irons for various engineering applications, Steel making practice. Methods of enhancing productivity and efficiency, Direct reduction, Strip casting and interface reaction, Segregation, Solidification involving a peritectic reaction, Design of engineering steel used in construction, bridges, rail, and ship buildings. Refining practices for Non-ferrous alloys. Development of commercial Nonferrous metals and alloys. Production of rare earths. Development of Rare earths for various commercial applications. Development, phase equilibrium and characterization of Metallurgical grade and Electronic grade Silicon
3	MY-602	Industrial Manufacturing Processes	Advancement in manufacturing processes, its scope and importance. Mechanical working processes, Mechanism of plastic deformation, Theory of dislocations, work hardening, Hot working & cold working. Quality control in manufacturing processes CAD/ CAM technology. Introduction to Non-conventional manufacturing processes such as water jet cutting, and lashing cutting, tool design. Material Selection and design, overview, the selection of materials, service conditions materials. Computer, prototypes and experimentation, Cost Analysis for a component, the recycling and reuse of materials. Applications of computers in manufacturing processes. 3D printing techniques.

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4	MY-603	Phase Transformations and Heat Treatment Processes	Engineering practice of the reduction of Phases and Structures formed during heating and cooling, Pearlite, Ferrite, and Cementite. Martensite and Bainite. Isothermal and Continuous Cooling Transformation Diagrams. Heat Treatments to Produce Ferrite, Bainite and Pearlite. Hardness and Hardenability. Austenite in Steels. Tempering of Steel. Residual austenite and its effect on properties, Special Heat Treatments. Surface Hardening. Surface Modification. Stainless Steels. Tool Steels. Cast Irons. Precipitation Hardening in Steels, Aluminum, copper and Nickel based alloys Relation of structural changes and kinetics of transformation to continuous heat-treatment. Applications of thermodynamics and mass transport theory. Thermo-mechanical treatment. Austempering, Martempering, Maraging, Ausforming, Zero rolling. Defect during heat treatment and their remedies. Vacuum heat treatment, Heat treatment of Special Steels
5	MY-604	Advanced Corrosion Engineering	Stoichiometric and non-stoichiometric crystals, effect of impurities, solid state electrochemistry, oxidation of metals and alloys, electrochemistry of corrosion, Pourbaix diagrams, electroplating, methods of corrosion prevention, stress corrosion, electrode kinetics, activation polarization, concentration polarization, and combined polarization, reference electrode, the three electrode cell and the E/log I plot. Mixed potential theory, mechanisms of growth and breakdown of passive films, applications of thermodynamics to corrosion. Pourbaix diagrams, crevice and pitting corrosion, intergranular corrosion, erosion corrosion, cavitation damage, de-alloying, environmental sensitive cracking, mechanism of environmental sensitive cracking, practical aspects of environmental sensitive cracking, cathodic and anodic protection, inhibitors and types of inhibitors. Corrosion control by barrier coatings.

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6	MY-605	Modern Characterization Techniques	Elemental and Functional Group Analysis, High- Temperature combustion, Inert Gas Fusion, Radio-Analysis. X-Ray Fluorescence, Resonance, Vibration and Inductively Coupled Plasma spectroscopy, Case studies. Gas Analysis by Mass Spectrometry. Diffraction Methods: X-Ray Powder Diffraction, X-Ray Diffraction Residual Stress Techniques. Stereographic projection and relative determination. Electron Microscopy Methods: Analytical transmission Electron Microscopy, Scanning Electron Microscopy, Electron Probe X-Ray Microanalysis, Low-Energy Electron Diffraction. Chromatography: Gas Chromatography, Mass Chromatography, Ion Chromatography. Other Techniques: Scanning Probe Microscopy (SPM), Scanning Tunneling Microscopy (STM) and Atomic Force Microscopy (AFM). EBSD, XPS for surface analysis, Neutron diffraction. FTIR, TGA, dilatometry.
7	MY-606	Advanced Surface Engineering Techniques	Basis of Surface engineering, Surface Energy, Thermodynamics of Surfaces, Surface Reconstruction Models, Surface tension, Wetting, Adsorption Models and Surface Area Analysis based on Absorption, Surface interactions with Ion Beams, Electron Beams and Radiations. Surface Charge Layers, Measurement of Surface Potential (Zeta Potential), Surface Analysis Techniques. Classification of Surface Coatings, Chemical Methods for Surface Coatings, Hard chrome plating, Decorative Chromium plating, Ni Plating, Electro less Ni Plating, Electro less Ni-P-Co coating. Thin magnetic coatings for magnetic applications. Zn plating, Brass plating, Silver Plating, Gold Plating. Hot dip Galvanized coating, Al coating of steel. Oxidations spray coating. Oxidation protective coatings, Phosphate conversion coating. Chromate conversion coatings, aluminum anodizing. Coatings for Mechanical Applications, Thermal Methods for Surface Coatings, High

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			Temperature coatings, high temperature coating systems, Plasma Spraying, Thin Films, PVD, CVD and PECVD techniques, Coating Growth, Coating Characterization and applications, Coatings for wear resistance.
8	MY-607	Unit operations in Non-Ferrous Metallurgy	Extractive metallurgy, Pyrometallurgy, Hydrometallurgy, Electrometallurgy. Pyrometallurgical, Bioleaching processes: Solid-state processing, Liquid-state processing, Mineral processing, roasting process, oxidative smelting and converting, Hydrometallurgical processes: leaching and chemical dissolution. Extraction of metal from ore, purification and recycling, chemical reduction, electrolytic reduction, Ferrous metallurgy, non-ferrous metallurgy, precious metals, base metals, industrial minerals, coal
9	MY-608	Advanced Physical Metallurgy	Principles of chemistry and physics applied to structure of materials, especially metals and alloys. Crystal structure of materials, Space lattice, Crystal system, Unit cell, Packing density, Coordination number, Allotropy, Rotational and Reflection Symmetries, Crystal planes and direction, Crystalline defects, Twinning, Phase transformations in metals, glasses and organic materials. Elementary physical chemistry of phases, phase diagrams and phase rule application, Binary system, Ternary system, Solid Solution, Interstitial solid solution and Substitutional solid solution, Factor affecting the limit of solubility, Ordered and Disordered solutions, diffusion in solids, structure of interfaces, nucleation and growth, Crystallization, solidification, Grain boundaries, Grain size, Cast structure, Segregation, Shrinkage defects, Solid state transformations, Iron -Carbon Diagram, Microstructure and properties of steel and Cast Iron, pearlitic, bainitic, massive and order-disorder transformations, precipitation. Elementary treatment of martensitic transformation, iron-carbon system, and heat-treatment of steels.

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			Microstructure of Copper based and Aluminum based alloys and their relationship to the properties, Metallurgical Microscope, Objectives lenses and their short comings, Polarized light microscopy. Microstructure of plastics, polymers, rubbers and composites
10	MY-609	Advances in Biomaterials	Biological response to biomaterials, types of biomaterials, processing of biomaterials, biomaterial product testing, important properties of biomaterials, Chemical properties of biomaterials: Effect of biochemical environment on biomaterials, Physical properties of biomaterials: linear, planar and volume defects and polymer crystallinity. Mechanical properties of biomaterials: introduction to biomechanics, Degradation of biomaterials: corrosion/degradation of metals and ceramics, ground rules of electrochemistry, corrosion contributions of processing parameters, mechanical and biological environments, means of corrosion control, biodegradable materials. Surface properties of biomaterials: concepts in surface chemistry and biology, physicochemical surface modification techniques, biological surface modification techniques. Materials selection for corticalbone, trabecularbone, skin, cartilage, ligaments and vasculature
11	MY-610	Welding Engineering	Welding of Stainless Steels, Joining materials for low and high temperature applications, Welding of aluminium, copper, and other non-ferrous alloys, Joining of coated steels, Welding of castings – cast steel and cast iron Joining of dissimilar metals, Wear and Protective Layers, Overview of Standards – ISO EN BS AWS ASME, Introduction to quality assurance, Weld quality standards – ISO 9000 and ISO 3834, Quality control during manufacture – weld procedure specification and qualification, Welder qualification, Introduction to Non-destructive examination (NDE) and types of weld imperfections, Fundamentals of NDE methods (dye penetrant, magnetic particle,

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			eddy current, acoustic emission, radiographic inspection), Ultrasonic Inspection. New trends in welding technology, under water welding etc.
12	MY-611	Advanced Polymers	General Introduction to polymeric materials, insight view of polymeric chains and formation, Structure of amorphous and crystalline polymeric materials; mechanical, electrical and optical properties and their modification through processing. Polymerization techniques, Life assessment and industrial applications of polymers, recycling of polymers, Biodegradable and environmental friendly polymeric materials and their comparison to environmentally hazardous polymers
13	MY-612	Metallic and Non-Metallic Coatings	Coatings techniques and their specific applicability, Electrochemical basis of metallic coating protection systems, governing phase equilibria in metallic coating systems, gas/metal reactions, reactive wetting at interfaces, microstructural development of metallic coating systems on ferrous substrates, non-metallic and composite coatings, engineering properties and practical applications of coating systems. Coatings characterization tools, Confocal, surface roughness, surface energy, contact angle, scratch testing, etc
14	MY-613	Aerospace Materials	Aerospace materials and their types. Physical, mechanical and environmental properties. Review of phase diagrams. Structure of atmosphere, its major regions with their temperature profiles. Characteristics of the space environments. Requirements for aerospace materials. Evaporation effects on materials in space. Lightweight materials and their alloys for aerospace applications. High strength steels, stainless steels, super alloys and composites. Structure-property relations. Materials for pressure vessels and cryogenic applications. Extremely high temperature materials. Ablatives and thermal barrier coatings. Adhesives, lubricants, elastomers and advanced polymeric, ceramic and metal matrix composites for

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			aerospace applications. Metallurgical assessment of space craft parts and materials. Effects of radiations on the performance of materials. Failure analysis and selection of materials.
15	MY-614	Materials for Solar Energy	The energy problem: causes, scope and scale. Solar Cells. Solar spectrum. Basic semiconductor physics: electron and hole energy bands; p-n junctions; photovoltaic effect, solar cell operation and characteristics; fill factor, efficiency; materials issues in solar cells; emerging solar cell technology; photovoltaic systems; grid tied versus battery backup; assessing energy resources.
16	MY-615	Nanotechnology	Synthesis and characterization of nanoparticles, nanocomposites and other materials with nanoscale features. Nanofabrication techniques. Zero-dimensional nanoparticles. One-dimensional nanostructures e.g. nanotubes, nanorods, nanowires and nanofibers. Two dimensional thin films. Design and properties of devices based on nanotechnology. Importance of nanostructured materials. Structure-property-processing relationship in nanomaterials and uses in electronics, photonics, magnetic applications.
17	MY-616	Advanced Powder Metallurgy	Mechanical & Chemical fabrication Electrolytic fabrication & Atomization Microstructure control, Powder Characterization Powder Characterization: Particle size measurement, BET surface area, Interparticle friction Powder packing, mixing and blending Shaping and Compaction Slurry techniques, Cold Isostatic Pressing (CIP) Sintering: Sintering theory, Solid state sintering Activated and Liquid phase Sintering Full density processing Hot Isostatic Pressing (HIP), Spark Plasma Sintering (SPS)
18	MY-617	High Temperature Materials	Introduction, Applications and Requirements Design of Alloys for High Temperature Service - Their Strengthening Mechanisms Their Creep

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			and Stress Rupture - Fatigue and Thermal Fatigue Environmental Effects on High Temperature Materials Design of Superalloys - Physical Metallurgy of Ni-Base Alloys - Physical Metallurgy of Fe-Ni-Base Alloys and Physical Metallurgy of Co-Base Alloys Processing of High Temperature Materials; Ingot Metallurgy - Powder Metallurgy and Wrought Processing Developmental Techniques Environmental Degradation Oxidation and Hot Corrosion Coatings of Ceramics and Intermetallics High Temperature Materials
19	MY-618	Design of Implants	The systematic use of cell-matrix control volumes; the role of stress analysis in the design process; anatomic fit, shape and size of implants; selection of biomaterials; instrumentation for surgical implantation procedures; preclinical testing for safety and efficacy, including risk/benefit ratio assessment evaluation of clinical performance and design of clinical trials. Student project materials are drawn from orthopedic devices, soft tissue implants, artificial organs, and dental implants.
20	MY-619	Failure Analysis of Engineering Materials	Microstructural aspects of deformation and length scale effects Elastic behavior, multi-axial loading, time-dependent behavior Yield criteria and permanent deformation Failure modes and propensity for fracture in different materials. Development of fracture mechanics. Griffith fracture theory and notion of energy release rate Linear elastic fracture mechanics, crack-tip asymptotic singular fields, and small scale yielding Non-linear fracture mechanics, J-integral methods, R-curves Experimental methods for determining fracture toughness Microstructural effects, intrinsic and extrinsic toughening mechanisms Environmentally assisted and time dependent crack growth. Fatigue characterization: Total life versus defect tolerant philosophy Cyclic stress fields, notches,

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			and short cracks Experimental methods for determining fatigue resistance Micro mechanisms of fatigue fracture. Creep Failures, recent theories in Creep mechanisms.
21	MY-620	New Trends in Composite Materials	Advanced processing and manufacturing technologies of metals, ceramics, polymers and composites. Processing of cast and wrought metals, including casting, thermomechanical processing, welding and additive manufacturing of metallic materials. It also includes processing-microstructure-property relationships in the products produced by each of these processing technologies. Ceramic processing technologies including green body shaping, solid-state sintering, liquid phase sintering and hot-pressing. It also examines additive manufacturing, sol-gel processing and thin-film growth for ceramic materials and the processing-microstructure property relationships for each of the technologies included. The processing and properties of polymers. The rheology of polymers is discussed and the factors controlling viscosity are described and related to polymer processing. Designing with polymers for specific properties, processes and applications. For composites, the types of matrices and fibres/fillers. Composite fabrication and the effect of reinforcement on properties.
22	MY-621	Metallurgy of Rare Earth Metals	Significance and scope of rare earth metals, special characteristics, properties, reactivity, aqueous systems, applications in modern industry, resources and country wise deposits; processing: beneficiation, chemical treatment, separation processes; reduction of rare earth metals: from chlorides, fluorides, oxide reduction processes, carbothermic reduction, electrolytic production and recover of rare earth metals as alloy. Latest trends in refining of rare earth metals, provacuum treatments and techniques.
23	MY-622	Superalloys & Thermal Barrier	Superalloys, types of superalloys, structure and properties of superalloys, processing of

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		Coatings	superalloys, heat treatment of superalloys. Degradation of superalloys, CMSX series, Japanese series and other superalloys. Thermal Barrier Coatings, components of TBCs, Thermally Grown Oxide (TGO), Life of TGO Bond Coat, types of Bond Coat, processing of bond coats, life of bond coats, diffusion barrier response of bond coats, ceramic coats and their common types (TBCs), Yttrium stabilized zirconia (YSZ) coatings, processing and properties of YSZ, degradation of YSZ, common applications of TBCs, future trends in TBCs.
24	MY-623	Advanced Solidification Techniques	Solidification processing of engineering materials, phase equilibria, transport, and interface phenomena governing microstructure development in liquid-solid transformations. Solidification of engineering materials by cooling; crystallization and glass transition. Heat transfer, thermodynamics and kinetics of solidification. Solute redistribution and interface stability; plane front, cellular and dendritic growth. Eutectic and peritectic solidification. Application to microstructure development in crystal growth, casting, injection molding and rapid solidification processing.
25	MY-624	Functional Materials	Metallurgical processing and performance of high-performance non-ferrous alloys: (a) Ti alloys and titanium aluminides for aerospace applications; (b) Al alloys for automotive and aerospace applications; (c) Ni base superalloys for high temperature applications. Materials science, processing and performance of monolithic ceramics and ceramic matrix composites (CMCs), for very high temperature applications. Design, engineering and performance of coatings for high temperature and abrasive environment applications. Describe the properties of different functional materials and formulate models of the

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			underlying physical and chemical phenomena. State and compare the most important properties of functional materials including accessibility, price, manufacturability, sustainability, recyclability and environmental impact. Search and critically analyze literature data on properties of functional materials. Argue for the choice of functional materials for existing and new applications. Intermetallic materials, including super alloys, memory metals/alloys, surface coating materials, Biomaterials, Advanced ceramic materials, including ferroelectric and piezoelectric materials, electric insulators, thermal barrier coatings. Magnetic materials, Electronic materials, including elementary and composite semiconductors, conductive polymers, ionic conductor. Catalytic materials properties, processing and applications.
26	MY-625	Shape Memory Alloys	Advancement of Shape memory alloys (SMAs). Design of shape memory alloy in aerospace application, biomedical and actuator. Medical and Dental application of SMAs. Aerospace application of SMAs. Crystallography of Martensitic transformation in SMAs. Mechanism of memory effect and superelasticity. Ti-Ni shape memory alloys properties, processing and new trends. Cu based shape memory alloys properties, processing and new trends. Medical and Dental application of SMAs. Issues in the future development of Nitinol properties, processing for medical device applications.
27	MY-626	Magnetic Materials	Classical and quantum mechanical model of magnetic moment of electrons, magnetic properties of free atoms. Classification of magnetic materials, Theories of Diamagnetism, Paramagnetism. Theories of ordered magnetism, Quantum theory of magnetism: electron-electron interactions, localized electron theory, itinerant electron theory. Origin of crystal field, Jahn Teller effect,

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			Magnetic dipolar interaction, Origin of exchange interaction, Direct exchange interactions, Indirect exchange interactions in ionic solid and metals, double and anisotropic exchange interaction. Development of domain theory, Bloch and Neel Wall, Domain wall pinning, Magnons, Bloch's law, Magnetic anisotropy, magnetostriction. Frustration, Spin glass, super paramagnetism, one and two dimensional magnets, Thin film and multilayers, Heisenberg and Ising models Production and measurement of field, magnetic shielding, Faraday balance, AC susceptometer, Vibration sample magnetometer, torque magnetometer, SQUID magnetometer.
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