Department of Metallurgical & Material Engineering
Ahmadu Bello University Zaria
Courses Content

100 Level Courses

ENGG 102: ENGINEERING PROFESSION AND INSTITUTION (1 CREDIT)

Development of professional engineering: history of technology and its effect on society, the engineering institutions, their objectives and functions. Data measurement, representation and interpretation, report writing and oral presentation of information.

GENS 102: ENVIRONMENTAL HEALTH (1 CREDIT)

Introducion to Engineering Health: Concept of environment: Concept of health: Concept of environmental health. Relationship between environmental hazards and their effects on health. Environmental hazards and examples. Sources of environmental hazards. Effects on Human health. Control of environmental hazard. ACCIDENT Defination, Distribution, types, human factor, causes, control of Accident, prevention should focus on, first Aid, contributions of students to environmental protection. The need, their contributions leadership.
Violence at Home and society, Defination of Violence. Type of violence. Cause of violence. Cultural values that constitute violence in the family. Prevention and control of violence
Conservation of Nattural resources. Soil Air Water relationshi. Soil Water plant relationship. Plant Animal Man relationship. Environmental friendly situation. Conservation of renewable and non renewable natural resource. Need for environmental impact assessment studies.

200 Level Courses

CVEN201: FUNDAMENTALS OF STRUCTURAL ANALYSIS (2 CREDITS)

Concept of structural analysis. Stability and determinacy of frameworks. Analysis of statistically determinate structures. Bending moment and shear force diagrams for determinate beams. Beam deflection. Framework deflections and strain energy in frames. Suspension cables. Determinate arches, stability of gravity sections.

WREN 201: FLUID MECHANICS I (2 CREDITS)

Properties of Fluids: Pressure, viscosity, surface tension, compressibility etc. hydrostatics: Variation of pressure with position in a fluid, equilibrium of a fluid of constant density, measurement of pressure, barometer, manometer, the Bourdon gauge, thrust on plane and curved surfaces, buoyancy, stability of floating and submerged bodies.
Principles of Fluid Motion: Continuity, Bernoulli's equation, energy transformation in a constant density fluid, energy correction factor, streamlines, pressure variation perpendicular to streamlines, flow through a sharp edged orifice, pilot tube, venturi meter, nozzle and orifice meter, notches and sharp crested weirs.
Momentum Equation: Momentum equation for steady flow, momentum correction factor, application of the momentum equation, force caused by a jet striking a surface, force caused by flow round pipe bend, force at a surface, force at a nozzle and reaction of a jet under short wheel as an example of a simple hydraulic machine.

MEEN 201: ENGINEERING GRAPHICS (2 CREDITS)

The principles of engineering drawing, engineering lettering, figures and types of lines (BS 308 -1972, Part 1,2,3), dimensioning, useful geometrical constructions, principles of tangency, loci-conk sections (ellipse, hyperbola, parabola); cycloids, epicycloids, hypocycloids, involutes, helices, orthographic project (1st and 3rd angle orthographic projection).

MEEN 202: ENGINEERING DRAWING (2 CREDITS)

Isometric projection; free hand sketching, sections and sectional views, auxiliary projections, interpretation of surfaces, development of surfaces, screw threaded and threaded screwed fastenings, conventional representation on the threaded elements on drawing.

MEEN 204: STRENGTH OF MATERIALS (2 CREDITS)

Direct stress and stain: tension, compression. Hook's law elastic constants, strain energy, impact load, thermal stress.
Geometrical properties of areas: centroid, first and second moments of area, parallel axis theorem, product moment of area, cross sections having and not having axes of symmetry.
Simple theory of bending: Classification, bending moment and shear force diagrams, relations between bending moments, shear force and load, bending stress section modulus, strength requirements, combined bending and tension/compression, eccentric loading, unsymmetrical bending, compound bars deflection of beams.
Simple shear force: Shear stress, shear strain, Hooke's law technical shear. Torsion of circular cross-sections: Torque diagram angle of twist, shear stress due to torsion, transmission to power by shafts, helical springs. Special problems statistically indeterminate problems, thin cylinders and spheres under pressure.

MEEN 206: FUNDAMENTALS OF DYNAMICS (2 CREDITS)

Kinematics of particles: rectilinear motion, plane curvilinear motion, appropriate choice of reference frame in solving problems. Relative motion, translating axes. Kinetics of particles: Newton's second Law of Motion, Work and Kinetic energy method for deriving equations of motion, Impulse and momentum. Kinetics of systems of particles: Defining equations, Steady mass flows, Variable mass problems. Plane kinematics of rigid bodies; Absolute motion, Relative Velocity, Instantaneous center of zero velocity, Relative acceleration. Plane kinetics of rigid bodies: General equation of motion, Translation, Fixed-axis rotation. General plane motion, Work energy relations, Impulse and momentum equations for rigid bodies.

MEEN 208: BASIC THERMODYNAMICS (2 CREDITS)

Dimensions and Units: (S.I. Units to be Introduced): Fundamental concepts: Energy i.e. Potential, Kinetic, internal; property, state, process and cycle system and surroundings; pressure; temperature, Zeroth law, arbitrary nature of temperature, scales; equilibrium reversibility, heat and work.
First Law of Thermodynamics: As applied to closed and flow systems, and in the cyclic and con-cyclic (process) forms, as well as in the differential form; Application to particular processes of constant volume; constant pressure, Isothermal, adiabatic, polytropic and throttling; the flow energy equation and its application to turbines, compressors, nozzles, boilers, condensers, heat exchangers (treated as black boxes only). ,
Second Law of Thermodynamics: Definition of heat engines, Cannot cycles, thermodynamic temperature scale, entropy (as a property) Properties of Pure Substances: Condensible fluids: T-P diagram, P-V diagram, the two-phase mixture, T-S diagram, h-s diagram, the use of property tables and diagrams Perfect Gases: Properties of perfect gas; entropy changes in perfect gases.

MMEN 201: FUNDAMENTALS OF MATERIALS SCIENCE (2 CREDITS)

Physical properties of materials: structure of atoms, bonding forces, structure of matter, including mention of wood, cement and plastics. Electrical properties of materials: electrical properties, conductors, electronic properties, semi and super-conductors, magnetic properties, dielectric properties, thermoelectricity. Mechanical properties: Tensile, hardness, impact properties of materials. Thermal properties: Thermal capacity, thermal expansion, thermal conductivity, thermo-couple phenomenon, temperature consideration in the choice of materials. Chemical properties of materials: corrosion phenomenon and its prevention. Physical Metallurgy: structure of crystalline materials, solidification, mechanical working, liquid and solid solutions, introduction to the concepts of phase and solid solutions, introduction to the concepts of phase equilibrium, micro and macro-structure of materials. Non- metallic materials: Cement, concrete, wood, ceramics (glass, ceramic ware), plastic (wood, rubber etc) and resin.

MMEN 242: INTRODUCTION TO BIOMATERIALS(2 CREDITS)

Molecular structure, polymer synthesis reactions, protein-protein interactions, multifunctional organic materials including polymer nanoreactors, conducting polymers and virus-mediated biomineralization, molecular and cellular interactions with biomaterials are analyzed in terms of unit cell processes, such as matrix synthesis, degradation, and contraction.
Wound healing and tissue remodelling following implantation in various organs. Other areas include tissue and organ regeneration; design of implants and prostheses based on control of biomaterials- tissue interactions; comparative analysis of intact, biodegradable, and bioreplaceable implants by reference to ease studies.

MATH 241: CALCULUS I(3 CREDITS)

Sequences and Functions: Infinite sequences and their limits, a short recollection of elementary functions and their properties, limits and continuity of functions of a single independent variable.
Differential Calculus: Definition of thee derivative. Differentiability of a function of one independent variable; geometrical and physical interpretation of the derivative, techniques of differentiation, Rolle's theorem and the mean-value theorem, Taylor and Maclaurin's series expansion, application of differentiation; maxima and minima of function of a single independent variable, curve sketching in Cartesian rectangular coordinates, L'Hospital rule for evaluation of limits of functions in the indeterminate forms, tangents and normals, curvatures and evolutes of plane curves, Leibniz's formula, for finding the nth differential coefficient of a product of two functions.
Integral calculus: indefinite integral, techniques of integration - change of variable, integration by parts and reduction formulae, integration of rational functions (standard integral and methods of partial fractions), the definite integral interpretation and properties; applications of integration, average value of a function, finding lengths of areas, plane areas, volumes of solids of revolution area of surface of revolution, pressure, etc.

MATH 242: CALCULUS II (2 CREDITS)

Infinite number series and their properties, tests of convergence complex number series. Improper integral: Improper integral of types I,II and III. Evaluation of improper integral, convergence of improper integral, Convergence in the Cauchy Principal value, tests of convergence.
Partial differentiation: partial derivatives of functions of two or three variables, total

differentials and applications.
Ordinary differential equations: First order differential equations with variables separable, exact equations and integrating factors: linear first order equations and those reducible to linear form. The Bernoulli equation, applications (geometrical and physical situations).

MATH 243: METHODS OF LINEAR ALGEBRA 1 (2 CREDITS)

Complex numbers: addition, multiplication, division, argand diagram, polar representation, DeMoivre's theorem. Vector Algebra: Definition of Vector and Physical examples, addition, multiplication by scalar, scalar and vector products, triple products, components, applications in geometry. Vector Analysis: Cartesian and polar coordinates in two and three dimensions. Vector functions of a real variable, continuity and differentiation, application to curves and surfaces in 3 space equation of straight lines, plane and sphere, tangent and normals to a curve, tangent plant and normal to a surface.

MATH 244: METHODS OF LINEAR ALGEBRA II (3 CREDITS)

Determinants and matrices: definition and properties of the determinant, its evaluation, matrices addition, multiplication by scalar, adjugate, inverse of non-singular matrix, rank and its evaluation. Simultaneous linear equations, consistency, linear dependence, solution (including Cramer's rule) eigen values and eigen vectors, special matrices, symmetric, skew symmetric orthogonal etc.

CHEN 202: INTRODUCTION TO MANAGEMENT (1 CREDIT)

Introduction (definition, uses and types of organization, need for management, the manager and its functions), planning, decision making, organizing, directing and leadership (motivation, communication and leadership), control.

EEEN201: ELECTRICAL CIRCUITS AND FIELD THEORY (2 CREDIT)

Field Theory:
Electric: Electric charges, Coulomb's Law, Gauss' Law. Electric field. Electric dipoles, potentials, capacitance, work energy. Magnetic: Magnetic forces between current elements, Biot-Savart Law. Ampere's Law. Lenz's law, Lorentz Law. Motor Principle. Generator principle. Work Energy

EEEN203: ELECTRICAL MACHINES, POWER AND INSTALLATION (2 CREDIT)

Transformers and Rotating Machines:
Basic Principles: Induction (Faraday’s LawS), interaction (Biot-Savart Law), and alignment. Generalized Basic Units: Magnetic, electrical, mechanical and thermal. Qualitative analysis of the production of torque and rotation of electric machines. Generalized torque equation of electric machines and simple calculations. Transformer; Constructional features, types, connections (including 3-phase type) and application of various types.
DC Machines: Constructional features, types (separately excited, shunt, series and compound), and application.
Induction Machines: Constructional features, types (single phase and 3-phase), types of rotor (squirrel cage and wound or slip-ring) and application.
Synchronous Machines: Constructional features, types (salient or non-salient poles types), and application.
Brief Introduction and Application of Special Machines: A.C. commutator machines, general purpose machines, repulsion machine, linear motors, etc. Electric Power Generation, Transmission and Distribution Types of Power stations. Power generation and transmission

problems (Flow diagram representation from generator to consumer terminals). The synchronous generation and its importance in power generation (from small types) in motor cars to huge types in power. Transmission of electric power; The H.T. overhead lines and step-up power transformers in overhead lines (330 K V lines).
Distribution of electric power using overhead lines and underground cables (show typical underground cables). The distribution transformers in power distribution and their use in the design of estates A.C. and D.C. supplies. The use of A.C. in preference to D.C., stressing the importance of the transformer. Single and three phase supplies; (delta and star connections); typical 3-phase, 4-wire distribution systems. Two wire services and typical consumer circuits. The meaning of impedance (X), volts (V), power ohms and power factor (PF) in A.C. supply systems.
Wiring System
Supply, control and distribution in buildings including; intakes, diversity, wiring circuits for lighting using loop methods, number of points on one circuit, wiring socket outlets.
Conductors and cables including; main parts of cables, types of insulators and the choice of cable sizes in various types of installation. Wiring systems including: Conduct systems, rubber and PVC soothed systems; components and accessories used in wiring systems, ceiling roses, lamp holders, switches etc.
Safety precaution including, the need for safety, the use of circuit breakers and fuses, and the importance of earthling. Illumination: Principle of illumination, definition of terms and the inverse square law. Glare and its effects. Types of lamps and lamp fittings. Principle of lighting design and illumination requirement for various types of usual tasks.

MMEN 208: STUDENTS' WORK EXPERIENCE PROGRAMME (SWEP) (3 CREDITS)

Purely practical experience to be acquired at Metallurgical/Materials, Electrical, Civil, Mechanical Engineering Departments and any other engineering department.

300 LEVEL COURSES

MMEN 311: MINERAL PROCESSING (2 CREDITS)

Introduction: Origin and formation of mineral deposits. Principal Ores of common metals. Discussion of the minerals wealth of Nigeria, their locations and types. Scope, objectives and limitations of mineral dressing.
Comminution and liberation: Theory and practice of crushing and grinding. Typical equipment used, their field of application and limitations.
Sizing and classification: Principle of sizing and classification. Equipment used for laboratory and industrial sizing. Law of settling of solids in fluids. Types of classifiers. Classification as a means of sizing and concentration.
Concentration: Gravity concentration methods using jig, spirals, tables, and heavy media separators. Application and limitations of each method. Froth flotation and physicochemical principles involved therein. Flotation machines and flotation of simple ores. Electrostatic and electromagnetic methods of concentration Dewaterinq and drying: Theory and practice of thickening, filtration and drying.
Coal/washing: Coal/shale separation, coal flotation and cleaning. Flowsheets: Simplified flowsheets for the benefication of simple ores of copper, tin, lead, zinc, iron, gold, and other ores of local importance.
Tailings disposal: Methods of tailings disposal and implications on ecosystem.

MMEN 312: THEORY OF METALLURGICAL PROCESSES (2 CREDITS)

Thermodynamics of solutions: A review of concepts of thermodynamics of ideal and non-ideal solutions.
Kinetics: Rate of reaction, collision theory, Arrhenius equation, order of reaction, cleation and growth.
Diffusion: Steady state and non-steady state diffusion. Fick's laws, simple diffusion equations, chemical potential and atomic mobiliat, temperature and concentration dependence of diffusion, Kirkendal effects, measurement of diffusion.
Metallurgical processes: Thermodynamics and kinetics of dissociation of solid oxides and carbonate; kinetics of metal oxidation; mechanism and kinetics of metallurgical slag formation; chemical reaction of metals and oxide melts; thermodynamics and kinetics of the formation of non-metallic inclusion in melts; electro¬chemistry of melts and slags.
Scope of metallurgical/materials industries
Fundamentals: Fundamental idea about decomposition, reduction and slagging. Basic principles of extraction of Cu, Zn, Pb, Al, Fe, Sn, and Au with simplified flowsheets.
Unit processes: Treatment of some important unit processes including the chemistry involved and the types of equipments used in palletizing, briquetting, sintering, roasting, smelting, converting, leaching, concentration, electrolysis and refining.

MMEN 313: THERMODYNAMICS OF MATERIALS (2 CREDITS)

Review of thermodynamics part 1, treatment of the laws of thermodynamics and their applications to equilibrium and the properties of materials. Provide foundation to treat general phenomena in materials science and engineering, including chemical reactions, magnetism, polarizability, and elasticity. Develop relations pertaining to multiphase equilibria as determined by a treatment of solution thermodynamics. Develop graphical constructions that are essential for the interpretation of phase diagrams. Treatment includes electrochemical equilibria and surface thermodynamics. Introduce aspects of statistical thermodynamics as they relate to macroscopic equilibrium phenomena.

MMEN 322: PHASE TRANSFORMATIONS (2 CREDITS) EQUILIBRIUM DIAGRAMS

Binary equilibrium diagrams: Phase rule, phase diagrams of single phase eutectic, peritectic, intermediate, monotectic and sytectic alloys. Analysis of complex phase diagrams. Study of equilibrium structures.
Ternary equilibrium diagrams: representation of the phase diagrams, horizontal and vertical sections of simple systems. Solidification: Liquid-solid transformation.
Nucleation and growth: Atomic structure of liquids, homogenous and heterogeneous nucleation. Growth forms of crystals in the melt. Plannar and dendritic growths. Growth forms of non-metals. Freezing of metals: Cooling curves from pure zinc and alloy metals. Structure of an ingot. Non-equilibrium freezing of single-phase alloys, constitutional supper cooling, cellular structures.
Freezing of eutectic alloys: Eutectic morphology. Nucleation and growth mechanism of eutectic structures and factors influencing them. Application to metal-metal, metal-non-metal and non-metal- non-metal eutectics. Ternary eutectic structures freezing and structures of peritectic and monotectic alloys, grain shape, size and grain boundary migration, phase distribution.
SOLID-SOLID TRANSFORMATION
Solid-solid phase mixtures: Structure of solid-solid interphase surfaces (boundaries) e.g. coherent, semi-coherent and non-¬coherent boundaries.
Structure of alloys: Homogeneous and heterogeneous solid solution. Primary solid solutions, intermediate phase, theory of alloy phases. Solution, stability of phases and equilibria.

Order-disorder structures: Order disorder structures in alloys. Theoretical bases for order-disorder changes. Long-range and short-range order, anti-phase domains, clustering, etc.
Nucleation process: Homogeneous and heterogeneous solid-solid nucleation. Nucleation rate and C-curve. Nucleation sequence of typical precipitation processes e.g. Al-Cu, Al-Ag, etc. Nucleation at grain boundaries.
Growth mechanisms: Military and civilian transformations, rates of transformation, TTT curves. Treatment of typical growth morphologies, single phase growth from solid solutions. Widmanstantten structures. Eutectoid transformation, pearlitic growth, bainitic transformation (lower and upper bainites). Martensitic transformation, massive transformation.
Structure modification: Homogenization, spheroidization, grain refinement, annealing, age hardening, zone refining, etc.

MMEN 324: CHRYSTALLOGRAPHY (2 CREDITS)

Structure of atoms: Components of the atom, electrons, protons, neutrons, etc. Quantum number, electronic structure of atoms, periodic table, chemical behaviour of elements, metals and non- metals.
Electronic theory: Free electron theory, atomic and molecular energy levels, energy of electronic theory in metallurgy.
Inter-atom: Aggregate of atoms, origin of inter-atom forces, homopolar and metallic bonding, structure of gases, liquid and solids.
Structure of metallic crystals: Transition from homopolar to metallic bonding, structure of crystalline solids, unit cell of the Bravais lattices, simple crystal structures, atomic packing in FCC, BCC, and HCP crystals, octahedral and tetrahedral coids, stacking faults in HCP and FCC crystals, allotropy.
Other crystals: Caesium chloride, diamond cubic, sodium chloride, zinc blend, wurtite and selenium. Ideal and real crystals, crystal imperfections.
Stereoaraphic projection: Notation, location of poles standard projections, rotation of poles, pole of a zone, standard triangles interplannar angles etc.
X-ray techniques: Properties and production of x-rays, continuous and characteristic spectra absorption of x-rays, filters, scattering microscopy. Application of x-ray techniques to precise lattice determination, phase diagram determination, chemical analysis, stress measurements, grain size determination, detection ordering, lattice defects and imperfections.
Electron techniques: Theory of electron diffraction and electron microscopy.
Metallurgical applications. Electron micro probe analyzer principle and application.

MMEN 331: MECHANICAL METALLURGY (2 CREDITS)

Elastic deformation of metals: Principles of stresses, strains in metals. Complex stresses on two planes at right angles. Mohr's circle. Principal stresses and strains, maximum shear stresses. Distortion energy and yield criteria.
Plastic deformation of metals: Concept of plastic deformation, point defects, vacancies, interstitial and impurity atoms. Line defects, slips, twins, etc.
Dislocation theory: Review of crystal geometry, crystallographic planes and directions. Stress field and strain energy of point- defects. Dislocation types and properties. Burgers vector, stress field and strain energy of a dislocation. Forces between dislocations, partial and supper dislocations, dislocation glide and climb, jogs, interaction with vacancies, interstitials and solute atoms, dislocation density.
Plastic deformation of single crystals: Deformation by slip system of FCC, BCC and HCP single crystals. Critical resolve stress, deformation by twinning, twin planes and directions. Stacking faults, deformation bands and kink bands. Lattice fragmentation, theoretical

strength of single crystals.
Plastic deformation of polycrystalline metals: Structure grain boundaries, effect of grain size and grain boundary structure on plastic flow. Theory of yielding, necking and failure, yield and ultimate strengths. Strain rate effect, Bauschinger effect, residual stresses, internal friction, mechanical working of metals, texturing (preferred orientation), stress concentration. Hardening and strengthening by point defects, (including solution hardening), second phase particles and other phase particles structures. Work hardening.
Fracture analysis: Fracture curves in single crystals and polycrystalline metals, e.g. cleavage, shear, ductile, etc. theoretical cohesive strength. Factors affecting the initiation and propagation of cracks.

MMEN 332: FUNDAMENTALS OF MATERIALS TESTING (2 CREDITS)

Introduction: General properties of metals. Full explanation of mechanical property parameters, e.g. strength, ductility, hardness, toughness, etc. Typical mechanical property values of common metals and alloys.

TESTING OF MATERIALS

Shear testing: Transverse and torsion tests, significance of shear properties of materials.
Creep testing: Creep curves, short-term and long-term creep tests, strength.
Fatigue testing: S-N curves, fatigue limit and fatigue testing machines.
Impact testing: Notch sensitivity in materials, stress concentration effects of imperfection, notches, voids and inclusion. Impact testing machines (Izod and Charpy). Transmission of temperatures of materials.
Hardness testing: Types of testing machines (indentation tester, micro-hardness tester and shore soleroscope) and their principles. Non-destructive testing: Principles, scope and limitations of radiographic, magnetic, electric, ultrasonic and fluorescent methods including their applications.

MMEN 342: METALLURGICAL ANALYSIS (2 CREDITS) PHYSICAL ANALYSIS

Electrical measurements: Resistance measurements and application to metallurgical measurements. Useful methods, potentiometer and bridge methods, application in strain, load and phase transformation measurements.
Thermal analysis: Method of temperature measurements with particular references to low, ambient and high temperature measurements, principles of thermo-electric effects, pyrometers etc.
Thermal analysis in metallurgy dilatometry and D.T.A. techniques. Optical metallography: Metallographic microscopes principle and construction. Types of lenses (objectives and eye pieces) and illumination. Use of hot stage, polarized light and phase contrast. Macro-techniques, micrographic techniques in metallurgy.

CHEMICAL ANALYSIS

Introduction: The need for analysis in the metallurgical industries. Quantitative and qualitative methods of analysis.
Preparation of solutions: For analysis of ores of Fe, Pb, Sn, Mu, Cu, Al, etc; slags, fluxes, scraps, metals and alloys.
Method of analysis: Classification methods (titrimetric and gravimetric), instrumental methods.
Titrimetric methods of analysis: Qualitative and quantity methods, simple calculations in qualitative and quantitative analyses, calculation of pit of solutions, preparation of standard solution for titration.
Gravimetric method of analysis: Analyses and identification of groups: I, II, III, IV, and V cations. Specific analysis of alloys, iron ores and their slags, tin ores and their slag, fireclay

and sand used for making refractories.
Analysis of metallurgical fuels: Solid fuels e.g. coal, liquid fuel, fuel gases.
Physical (instrumental method of analysis): Instrumental method of analysis such as: electrochemical colorimeter, spectrophotometric and spectrographic analyses, flarue emission photometry, x-ray methods etc. Only principle and the application of the methods should be covered.

MMEN 346: WOOD TECHNOLOGY (2 CREDITS)

Introduction: General definition of wood, classes of wood: traditional wood in the group of domestic and art wares, etc; engineering or industrial wood; processing of wood; structure of wood; properties of wood e.g. mechanical, physical and chemical properties; preservation of wood for industrial use; application of wood in metallurgy e.g. pattern making in foundry.

MMEN 347: CERAMICS (2 CREDITS)

Introduction: General definition of ceramics, classes of ceramics e.g traditional ceramics in the group of domestic and art wares, pottery etc; engineering or industrial ceramics e.g. bricks, tiles, abrasives, dielectric insulators, semi-conductor, glass, etc.
Clays: Formation and types of clays, structures of clay minerals such as kaolin, montrorillonite, illite, etc. Clay water system, cation exchange. Reaction of firing, finishing and testing.
Silica: Nature and occurrences, types and structures of silica inversion and conversion of silica. Effects of impurities and fluxes on the properties of silica.
Ceramics: Selection and preparation of ceramics raw materials. Mixing, moulding and drying procedures. Firing of the conventional ceramics products. Blending, mixing and sintering of special ceramic products e.g. cermets and abrasives; structure and application of ceramic abrasives, insulating, magnetic and dielectric materials etc.
Glass: Definition and general properties of glass. Types and composition of different glasses and their applications. Manufacture of glass, shaping and heat-treatment of glass products. Mechanical properties of glass. Special glasses e.g. glass-metal, glass- ceramics, photo sensitive and high refractive index glasses.
Refractory: Definition and general properties of refractory, types and composition of different refractory and their applications. Manufacture of refractory.

MMEN 391: LABORATORY COURSE WORK I: PROCESS (1 CREDIT)

MMEN 392: LABORATORY COURSE WORK II: MECHANICAL (1 CREDIT)

MATH 341: DIFFERENTIAL EQUATIONS AND TRANSFORM (3 CREDITS)

Exact equations, linear equations of first and second order with variable coefficient, geometrical interpretation, isoclines, statement of existence theorem, series solution of differential equation with non-singular points, definition of Bessel equation and Bessel function of the first kinds, definition of Legendre equation, Legendre polynomials, Fourier integral and transforms, Laplace transform and its applications to the solution of differential equations.

STAT 343: STATISTICS (2 CREDITS)

Axiomatic definition of probability, basic rules of probability, Bayes formula, Random variables, probability distributions (rectangular, hypergeometric, binomial, multinomial, poisson, normal, geometric, exponential, beta and gamma), Mathematical expectation, Mean, variance and moments, Bivariant distributions, joint, marginal and conditional distributions,

covariance. Correlation coefficient Bivariant normal distribution. Regression and correlation, method of least squares, regression curves. Random sampling, sampling distributions. Expected values, standard error and the central limit theorem. Student's t-test, X2 and F distributions. Estimates of parameters, maximum likelihood principle, confidence intervals for mean, proportion, variance, difference of means, difference of proportions and ratio of variances. Elements of tests of hypothesis, critical region significance level, type I and II errors, power functions, testing the mean of a normal population when variance is known, testing the difference of means of two normal populations having equal but unknown variances, testing the variance of a normal population, testing the ratio of variances of two normal populations, test of independence inn consistency tables, test of goodness of lift.

COSC344: BASIC COMPUTER KNOWLEDGE AND FORTRAN PROGRAMMING (3 CREDITS)

Binary, octal and hexadecimal number series, conversion, complement of numbers, representations of negative numbers, digital computers, main functional elements of a computer (memory control and arithmetic units, input-output devices, backing storage) information in the core store, binary coded decimal fixed and floating point representations, programming languages (short summary of the machine-code, assembly, machine and problem oriented languages), the flow chart language, loops, iteration, the basic Fortran, Numerical data, Arithmetic, Arrays, Input Out control statement, segmentation of programmes, statement function, function and subroutine segments common, equivalence statements.

QTYS 309: ECONOMIC ORGANISATION (1 CREDIT)

Introduction to economics: Elementary concepts, evolution of economic activity, characteristics of modern economic concepts. Basic Economics; Economics of taxation and public expenditure, business organization, industrial concentration and government control. Location of West African industry and trade: Background of West African economy, economic planning, development problems. The banking system: Money and Capital Markets, inflation, cost- benefit analysis.

400 LEVEL COURSES

MMEN411: NON-FERROUS EXTRACTIVE METALLURGY (2 CREDITS)

Fundamentals: General classification of metals, periodic table, industrial classification into heavy, light, minor, noble, refractory, rare-earth, disseminated and radioactive metals. Extraction of metals: Chemical reaction processes, chemical reaction involved in the extraction of specific metals by reduction, hydro-metallurgical, electro-metallurgical and pyro-metallurgical processes, limitations and factors influencing the choice of a refining process. Application: refining and typical flow sheets of extraction of specific metals. Particular reference being made to aluminium, copper, zinc, lead, tin, nickel, gold, magnesium, etc. Refining plants: A study of the design and operations of extraction equipment and plants. Problems encountered in various plants, e.g. environmental pollution, etc.

MMEN 413: CORROSION ENGINEERING (2 CREDITS)

Introduction: Definition of corrosion and corrosion engineering, corrosion damage, cost of corrosion, corrosion and society; monetary considerations and social implications, rust formation, environments, economic and environmental issues in corrosion engineering. Principles of corrosion: Factors affecting corrosion rates; oxygen and oxidizers, velocity, temperature corrosive concentration, Galvanic coupling, metallurgical properties, Ringworm.

Practical aqueous corrosion/electrochemical aspects of corrosion, thermodynamic aspects of corrosion reaction, adsorption heat, Faraday's law and Nernst equation, the basic wet corrosion cell, standard electrode potential, Galvanic and electrochemical series, reference electrode(s), SCE. Cell potential, the Daniel cell, kinetics of corrosion reactions, activation energy, Arrhenius equation, polarization, activation and concentration types, diffusion processes and the double layer, mixed potential theory, Evans diagram, E/log plots and E/pH (Pourbaix) diagrams.
Corrosion properties of some materials: Metals and alloys, ceramics, carbon and graphite, wood, non-metallics, thermoplastics, thermosets, composites.
Forms of corrosion: Galvanic/dissimilar metal corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching, erosion corrosion, stress corrosion, hydrogen embrittlement.
High temperature corrosion: Metal oxides, pilling bedworth (PB) ratio, breakaway corrosion, mechanisms of oxide film growth. Corrosion testing and monitoring; classification, purposes and general procedures involved in corrosion testing and monitoring. Corrosion prevention and control; materials selection, alteration of environments, changing media and inhibitors, design, cathodic and anodic protection, coating and electroplating.

MMEN 415: POLYMER ENGINEERING (2 CREDITS)

This course offers an overview of engineering analysis and design techniques for synthetic polymers. Treatment of materials properties selection, mechanical characterization and processing in design of load-bearing and environment-compatible structures are covered.
Polymer structures: Introduction, hydrocarbon molecules, polymer molecules, the chemistry of polymer molecules, molecular weight, molecular shape, molecular structure, molecular configurations, copolymers, polymers crystallinity, polymer crystals.
Mechanical and thermo-mechanical characteristics: Stress-strain behaviour, deformations of semi-crystalline polymer, crystallization, melting and glass transition phenomena, thermoplastic and thermosetting polymers, visco-elasticity, deformation and elastomers, fracture of polymers.
Polymer application and processing: Polymerization, polymer additives, polymer types, plastics, elastomers.

MMEN 447: MICRO/NANO TECHNOLOGY (2 CREDITS)

Introduction to micro/nano world: Course introduction, scaling, world in micro scale, basics of IC and micro/nano fabrication, thin film coating, oxidation, diffusion/implementation, vacuum systems, CVD, sputtering, evaporation, lithography, CMOS, Etching, IC devices, IC-based micro/nano machining; sacrificial layer concept, thin films, selective wet etching, dry etching, non-Si machining. Mechanical properties of thin films: thin films, residual stress/strain, measurement techniques. Applied techniques: combined machining, flip-up structures, encapsulation, tip sharpening, wafer bonding. Non-IC based micromachining: Micro-EDM, micro¬electroplating, micro stereolithography. Micro sensors & micro actuators, micro systems, nano/micro technology applications.

421: PHYSICAL METALLURGY (3 CREDITS)

Heat-treatment: Review of iron as a solvent, phase diagrams of binary iron-carbon alloy. A study of the effects of other alloying elements on the Fe-C phase diagram. As-cast structures of steels and cast irons. Basic principles of heat-treatment of plain carbon steels, cast-iron and commercially important non-ferrous alloys, annealing normalizing hardening and tempering treatments. Pearlitic, bainite and martensitic transformations in steels. Special treatment: austempering, martempering, mar-aging, strain ageing etc. Quench media and

mass effect. Measurement and control of the austenitic grain size, hardenability and its determination. Surface hardening methods and processes.
Alloy steels: Effect of alloying elements on the iron-cement diagram, properties of iron-carbon phases, transformation temperature, critical cooling rate, hardenability, tempering, carbide formation etc. Alloy steels and the special features of heat treatment adopted for each case. Role of impurities and non-metallic inclusions in steels. Aluminium base alloys: Casting: Al-Si, Al-Cu-Si and Al-Mg alloys. A close examination of various intermetallics such as, CuAI2, Mg2Si, Al-Fe-Si etc. Wrought: Al-Mg-Si and Al-Mg-Cu alloys.
Copper base alloys: (as cast and wrought)
Brasses: B & free-cutting, hot-hand, cold-working etc.
Bronzes: Tin bronzes, phosphor bronzes, bronzes containing zinc and lead, aluminium bronzes etc.
Copper-nickel, copper-chromium etc. Magnesium-base alloys (as- cast)
Bearing metals: Properties of bearing metals and general structure. Commercial bearing metals, Cu-base, white bearing metals, lead- base cadmium-base, zinc-base alloys etc.

MMEN 425: MICRO-STRUCTURAL ANALYSES OF MATERIALS (2 CREDITS)

This course is essentially of a practical nature and will be best taught mainly in the laboratory. It deals with the study of the microstructure and their effects on the properties of metallic alloys. The following should be covered: Review of the basic principles of metallography specimen preparation, etching, unicroscopy, photomicrography etc; as-cast structure of non-ferrous alloys of Al, Cu, Mg, Zn, Pb, Su etc; structure and properties of heat treated non-ferrous alloys; as-cast structure of plain carbon steels, and cast iron; effect of carbon content on the microstructure of plain carbon steels; microstructures of alloy structures e.g. tool steels, stainless steels etc; microstructure of heat-treated plain carbon steels and cast irons; effect of composition and microstructure on the mechanical properties of steels; microstructure of composites, ceramics and polymer.

MMEN 431: FUNDAMENTALS OF WORKING OF MATERIALS (2 CREDITS)

Mechanical working of metals: Principles of hot and cold working of metals, structural and property changes during hot and cold working, nature of stresses, strains and metal flow in various metal working operations. Heating of stock: Soaking pits and re-heating furnaces, descaling of steels, precaution to be taken during re-heating of ferrous and non- ferrous metals.

MMEN 493: LABORATORY COURSE WORK III (PHYSICAL) (1 CREDIT)

MMEN 497: STUDENTS' INDUSTRIAL WORK EXPERIENCE SCHEME (SIWES) (6 CREDITS)

Practical work experience to be acquired at accepted professional firms, industries, research institutes, and relevant public and private organizations

STAT 443: EXPERIMENTAL DESIGN AND CONTROL (2 CREDITS)

Analysis of variance, randomized blocks, Latin squares, simple factorial designs, statistical quality control, control charts for means, standard deviation, image, number of proportion of defective and defects. Acceptance sampling (sampling inspection plans - examples of single, double, multiple and sequential sampling, plants) the operating characteristics (OC) curve, producers and consumers risks, average sample number (ASN) and average outgoing quality level (AOQL), Linear programming.

QTYS421: LAW FOR ENGINEERS (2 CREDITS)

500 LEVEL COURSES

MMEN 511: IRON AND STEEL MAKING (3 CREDITS)

Ores: Classification, distribution (world and Nigeria), evaluation and beneficiation. Physical chemistry of the blast furnace: decomposition of materials, reduction of iron oxides, direct and indirection reduction of iron in the blast furnace (equilibrium diagram of Fe-O-H should be looked at), rates of reduction by hydrogen and carbon monoxide. The effect of temperature, velocity and pressure of gases on reduction. Physical and chemical properties of ores and how they affect rate of reduction as well as advantages and disadvantages. Mn, Si, P, S reduction and desulphurization in the blast furnace. Pig iron and slag formation, properties of slag, methods of blast furnace intensification. Blast furnace operation; irregularities (the peripheral furnace run, channelling, change hanging, cold and hot run of the furnace etc). Blast furnace equipment; ladles, topedos, auxiliary equipment e.g. for cleaning and utilization of blast furnace gases etc. Alternative methods of iron making; pellet production (green ball formation, its composition, binder and machine etc), sintering (flored and unflored), direct iron reduction and coke production. High Mn, pig iron production, its uses. Blast furnace design and operation; general design principle, blast furnace profile, refractories instruments, blast furnace assay calculation and thermal balance. Physical chemistry in steel making; thermodynamics oxidation reactions e.g. C, S, P, Mn etc. Deoxidation of steels by Mn, Si, Ti, Al, Si-Ca, Si-Mn etc, diffusion de-oxidation.
Deoxidation using vacuum and synthetic slags. Gases and non- metallic inclusions in steels. Steel making slags, classification of steels. Open-hearth process; principles of the open-hearth process, Bessemer processes, construction of the converters, acid and basic processes (advantages and disadvantages), modification of the processes. Oxygen process; developments of LD converters, construction of LD converter (linings and raw materials), oxidation of impurities in the LD process, steel making practice, merits and demerits of the process. Modifications KALDO, ROTOR, LD-AC processes. Electric arc furnace process (EAF), advantages of the EAF process, construction of EAF and raw materials. Technology of EAF steelmaking (basic and acid), steelmaking in induction furnaces, production of steel from sponge iron. Special treatment; iron gas (especially argon) injection, injection of powdered materials, vacuum treatment of steels (RH,DH, ladle etc). Treatment of steel with synthetic slags. Casting technology; crystallization of steel, ingot structure, types of ingots and their casting, ingot defects and their control, continuous casting of steel production and ferro¬alloy productions. Secondary steelmaking practice; vacuum EAF and vacuum induction furnace.

MMEN 512: PROCESS DESIGN (2 CREDITS)

Fluid flow: Viscosity and viscous fluid, the differential equations of fluid motion, turbulent flow, overall energy balances in fluid flow. Heat transfer: Thermal conductivity and steady state conduction, unsteady state conduction of heat, convective heat transfer, radiation heat transfer, heat transfer with phase changes. Diffusion and mass transfer: Diffusivity and steady state diffusion, unsteady state mass transfer, mass transfer coefficients, simultaneous heat and mass transfer, coupled transport phenomena. Techniques of process analysis; staged operations, continuous flow systems, similarity criteria, dimensional analysis and modelling. Metallurgical reaction systems; single particle reaction systems, packed bed and fluidized bed system, gas bubbles in liquids, gas jet liquid systems, hydro-metallurgical systems, slag-metal reactions and steelmaking.

MMEN 522: FOUNDRY TECHNOLOGY (2 CREDITS)

Introduction: Present status and scope of foundry industry in the country. Moulding and casting processes; sand mould, permanent mould, plaster mould, shell mould, centrifugal, investment and die-casting methods, shell moulding and CO_2 processes.
Sand technology: Moulding and core sands (sand aggregate, bonding materials and special additives), mechanism of bonding, testing of foundry sands. Effects of variable properties of moulding and core sands. Sand preparation method, equipment and control. Pattern; functions and classification, pattern design and materials. Casting defects; with relevance to moulding materials, gating and risers. Solidification of casting; principles of solidification of metals and alloys, directional solidification, coring and segregation. Gases in metals; oxides, nitrides and carbides, phosphorus, nitrogen and hydrogen. Their solubility with particular reference to sulphur and phosphorus. Melting; melting furnaces, melting and pouring practices. Ferrous foundry practices; melting, alloying, fluxing and casting practices of Al-base and Cu¬-base alloys. Casting defects; defects due to incorrect melting alloying practices, inspection, salvaging and finishing of castings.

MMEN 523: WELDING AND BRAZING (2 CREDITS)

Introduction: Role of welding and brazing as manufacturing processes. Welding; types of welding processes, flash, friction lector-and electro-slag welding, etc. Brief treatment of newer processes such as explosive, plasma arc and electron beam welding, welding rods and fluxes, protective atmosphere, welding defects and weldability of metals and alloys. Effect of welding processes and parameters on the structure and mechanical properties of weldments. Heat-treatment of welds.
Design and testing of welded joints: Brazing; scope and limitations, types of processes, brazing alloys, brazing of commercially important ferrous and non-ferrous metals and alloys. Soldering; processes, soldering alloys and application of soldering techniques.

MMEN532: MECHANICAL WORKING OF MATERIALS (2 CREDITS)

Rolling of metals: Rolling mills and accessories, elements of all pass design, manufacture of rolled products. Forging and extrusion; type of forging processes, forging equipment and forging defects, roll forging and rotary swaging, types of and variables in extrusion, extrusion equipment. Miscellaneous of metal working processes; wire drawing, tube making, sheet metal forming, manufacture of wheels, axles and tyres. Explosive forming, powder metallurgy (metal powder production, compacting and sintering)

MMEN 533: POWDER METALLURGY (2 CREDITS)

Introduction: Historical background of powder metallurgy, comparison of LP/M principle of forming with other methods of forming metals viz plastic deformation of hot and cold metal, casting of molten metal and machining. General principle of powder metallurgy; various stages of powder metallurgy process (process flow sheet). Equipment; plant and equipment used to implement the various stages of production, metal powder production, different methods for the manufacturer of metal powder. Powder characterization and testing; sampling of powder, chemical tests, particle size distribution, particle shape and structure. Compacting; mixing of metal powders, behaviour of metal powders under pressure, density and stress distribution within compacts under pressure in rigid dies, automatic compacting, compacting other than in rigid dies. Sintering practice; batch and continuous types of furnaces with protective atmospheres, vacuum sintering furnaces, purposes of sintering atmosphere. Description of sintering atmospheres. Thermodynamic background of sintering atmospheres. Dimensional and weight changes in sintered products, finishing operations, machining and joining of sintered parts, electroplating and electroless plating, evaporation coating, surface treatments, impregnation treatments, combination treatment. Defects in

sintered parts; special techniques to overcome limitations or defects. Product applications; application of P/M structural parts and powder forgings. Their economics and the energy requirements to produce them.

MMEN 541: FURNACE TECHONOLOGY (2 CREDITS)

Fuels; comparative study of solid, liquid and gaseous fuel and factors governing their choice, manufacture of metallurgical coke. Choice, preparation and blending of coal, types of coke ovens and recovery of by-products fuel economy, numerical calculations on combustion and fuel efficiency Furnaces; furnace as a system involving heat generation, utilization and losses. Construction and operation of melting, reheating and kiln type of furnaces. Sources of heat loss in furnaces and their prevention, insulation, recuperation, regeneration, waste heat boilers, furnace atmosphere and control. Fuel economy and thermal efficiency of furnaces, natural, induced, force and balance draft. Calculation of natural draft, regulation of primary, secondary and excess air in furnaces. Refractories; types, properties, applications and manufacture of refractories.

MMEN552: PRINCIPLE OF MATERIALS SELECTION (2 CREDITS)

A professional approach to stress the metallurgical view point of composition, micro-structure, heat treatment, influences of impurities, mechanical and environmental considerations involved in the following commercial methods and alloys and their application: Metals and alloys for heavy, medium and light castings; lightweight structural alloys of Al, Mg and Ti, structural steels (plain carbon, alloys steels and ultra high strength steels), tool steels (carbon, low alloy and high speed tool steels), bearing materials (white metals, Al and Cu base materials), materials for electrical conductors, contacts and resistance (heating elements etc), magnetic material, corrosion and heat resistant alloys, alloys for low and high temperature application, alloys for forming operations.

MMEN 543: COMPOSITES (2 CREDITS)

Historical background of composites and definition of basic terms: Particle-reinforced composites, large particle composites, dispersion-strengthened composites. Fiber-reinforced composites, influence of fiber length, influence of fiber orientation and concentration. polymer-matrix composites, metal-matrix composites, ceramic-matrix composites, carbon-carbon composites, hybrid composites, processing of fiber- reinforced composites. Principle of manufacturing with resin matrix: Fundamentals, lamination, compression moulding, pultrusion, filament winding, basic concerns. Structural composites, lamina composites, sandwich panels, test applicable to composites, physical property characterization, mechanical property characterization, micro¬mechanics, laminar stress-strain relationships, thermal analysis. Effective moduli of composites; elementary calculations, energy methods. Macro-mechanical behaviour of a laminate, classical laminate theory, structural analysis of composite materials, bending, buckling and vibration of laminated plates. Strength of unidirectionally reinforced lamina; longitudinal strength, transverse shear strength, lamina failure theory. Failure mechanisms, types of damage, lamina overload, edge effects, interior delamination.

MMEN591: RESEARCH/TECHNICAL REPORT WRITING (1 CREDIT)

Nature and types of research, research process, elements of research proposal, methods of data collection and analysis, planning scientific research. Designing and administering of experiments, technical report writing and oral presentation techniques of research reports, referencing and citation.

MMEN 599: FINAL YEAR PROJECT (6 CREDITS)

This involves a research work of a chosen and approved topic of which a student is assigned a supervisor to guide him/her in the course of the research. A written and bound copy of the write up on the research will be submitted to the department at the end of the session after having defended it before the departmental board of examiners.