

**UNIVERSITY OF NIGERIA NSUKKA**  
**FACULTY OF ENGINEERING**  
**DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING**

**PGD, M.Eng AND Ph.D. DEGREE ACADEMIC PROGRAMMES**

**2017**

## **PGD, M.Eng AND Ph.D. DEGREE ACADEMIC PROGRAMMES**

### **DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING UNIVERSITY OF NIGERIA NSUKKA**

#### **1. Philosophy and objectives of the programmes**

The subject of materials is ubiquitous and underpins technology that enters everyone's daily lives. It is the key to addressing societal challenges in the environment and climate change, advanced manufacturing, renewable and sustainable energy, materials efficiency, healthcare, biotechnology, aerospace and transport, communications and information technology, amongst others.

Here at the Department of Metallurgical and Materials Engineering, University of Nigeria, Nsukka, we study not only the materials for large manufacturing of parts, but also understands and control the atomic behaviour and structure to produce world class research that impacts directly on society and industrial processing. The range of materials and approaches this incorporate is vast and include metallurgy, ceramics, composite materials, polymers, glass, bio-inspired materials, materials for bioengineering, materials for energy applications, "functional" materials, nanotechnology and surface technology.

The philosophy and aim of our postgraduate programme is to train productive and technological capable 21<sup>st</sup> century engineers that are well equipped to understands, develop and control the atomic behaviour and microstructural challenges of materials, through sound experimental and theoretical investigations. By understanding the scientific properties of materials, the engineering performance and the processing, we can seek to improve existing materials and discover or create new materials. The programme is also geared towards the conduct of pure and applied research required for accelerating the growth and meeting the needs of some relevant sectors of the nation's economy e.g. iron and steel, ceramic, health and allied sectors, plastic and polymer industries, communications and information technology, foundry and oil sectors, amongst others.

#### **2. Objectives**

The major objective of the post graduate programme is to equip graduate students with sufficient background and training to enable them go into allied industries, research institutes etc. with sufficient knowledge of local conditions and modern trends. The specific objectives of the programme are:

- (i) To provide the necessary high level manpower for the nations metallurgical and materials industries that are rapidly developing and expanding.
- (ii) To produce materials engineers who are capable of effecting changes in foreign technology to meet local needs through research and development.

- (iii) To provide manpower for the development and sustenance of materials science and engineering programmes in the nation's institutions of higher learning.
- (iv) To provide a solid academic base for the pursuit of higher degrees (M.Sc., M.Phil. and Ph.D.)
- (v) To identify the limitations of the students and to make a real effort to provide compensating corrective measures and
- (vi) Make continuing reappraisal of our curriculum to ensure its consistency with the goal of training for national development that the given parameters of time and financial outlay will permit.

### **3. List of Programmes**

- (i) Post graduate diploma (PGD) in Metallurgical and Materials Engineering
- (ii) Master's degree in Metallurgical and Materials Engineering
- (iii) Ph.D. in Metallurgical and Materials Engineering

### **4. Scope of the Programmes**

The PG.D, M.Eng. and Ph.D. degree programmes of the Department of Metallurgical and Materials Engineering are guided by the awareness that the development of the indigenous human resources into world class technological capable Engineers is the key to any sustainable national and regional development. The postgraduate programmes of the Department are therefore, a conscious attempt to discharge its educational and professional responsibility to the nation in its efforts to develop the Metallurgical and Materials Engineering sector. The programmes are to fulfill this role by furthering the effective application of appropriate engineering principles and technology.

The postgraduate courses cover a wide range of Metallurgical and Materials Engineering specialization areas, namely; extractive/ chemical metallurgy, advanced materials Engineering, physical and mechanical metallurgy, steel research, biomedical engineering, nanotechnology and thin film , ceramics and composite , welding and corrosion and surface engineering.

The study for the PG.D and M.Eng degree in Metallurgical and Materials Engineering is done by course work with research work to be presented in a project report. The study for the Ph.D. degree is by a comprehensive research to be embodied in a thesis. The M.Eng and Ph.D students may specialize in any of the areas listed in section 8 below.

### **5. Entry Requirements**

#### **5.1 Postgraduate Diploma,(PGD)**

The prospective candidates for the programme must possess any of the following academic qualifications:

- i. Higher National Diploma (HND) in Metallurgical and Materials Engineering with a minimum of upper credit grade from recognized Polytechnic
- ii. Bachelor of Science degree in a related physical science discipline (i.e. physics and chemistry) with a minimum of Second Class Lower division from a recognized University.
  
- iii. B.Sc. or B.Eng. in Metallurgical/Materials Engineering, Mechanical Engineering or any other related engineering discipline with at least a Third Class (Hons.) degree with CGA not less than 2.0 on a 5-point scale or its equivalent a from a recognized University.

## **5.2 Master of Engineering Degree (M.Eng)**

- i. Applicants must possess B.Sc. or B.Eng. degree with at least second class honours of minimum CGA of 2.5 on a 5-point scale, or an equivalent qualification, in Metallurgical and Materials Engineering or a related field of Engineering to qualify for admission into the M.Eng programme.
- ii. A bachelor's degree from a recognized University plus at least a **Credit** or **Merit** pass in the Postgraduate Diploma (PGD) in Metallurgical and Materials Engineering from a recognized University provided the University matriculation requirements are satisfied.

## **5.3 Doctor of Philosophy Degree (Ph.D.)**

Candidates must possess M.Sc. or M.Eng degree in Metallurgical and Materials Engineering or a related Engineering discipline with a CGA not less than 3.5 on a 5-point scale.

## **6. Mode of Study and Credit Units**

PG.D, M.Eng and Ph.D of Metallurgical and Materials Engineering programmes will be by course works and research Project.

## **7. Mandatory duration of programmes**

### **PGD Eng. programme**

Full Time: A minimum of two semesters and maximum of four semesters

Part Time: A minimum of four semesters and maximum of six semesters

However, candidates from non-engineering (i.e. related physical sciences, such as physics or chemistry) are required to take some remedial undergraduate courses that may lead to additional semesters to augment their Engineering studies deficiencies.

### **M.Eng programme**

Full Time: A minimum of three semesters and maximum of five semesters

Part Time: A minimum of five semesters and maximum of eight semesters

## **Ph.D. programme**

Full Time: A minimum of six semesters and maximum of ten semesters

Part Time: A minimum of ten semesters and maximum twelve semesters

## **8. Areas of Specialization**

The Department of Metallurgical and Materials Engineering offers the following areas of specialization for the Master of Engineering (M.Eng) and Doctor of Philosophy (Ph.D.) degrees:

### **(a) Physical / Mechanical Metallurgy**

- (i) Structure-property relationships; Phase transformations and mechanisms of microstructural change
- (ii) Strengthening mechanisms and failure analysis,
- (iii) Coatings: Chemical vapor deposition; Coating materials, films and applications; Epitaxial growth; Interfacial science; Physical vapor deposition; Surface mechanics; Surface physics; Tribology of thin films and coatings.
- (iv) Fatigue behavior of steels; Fracture Mechanics;
- (v) Steel research: Advanced high strength steels; Advanced steel coatings; Carburized steels; Deformation behavior of steels; Fatigue behavior of steels; Forging steels; Fracture behavior of steels; microalloyed steels; Nickel-based Superalloys ; Quench and partitioned steels, Alloy design and micro-alloyed steel;
- (vi) Welding engineering and development: Brazing of ultra-wide gaps; Explosive processing of materials; Laser welding and processing; Levitation for kinetics and surface tension evaluation; Materials joining processes; Pyrochemical kinetics studies using levitation; Underwater and under oil welding; Welding and joining science; Welding rod development; Welding stress management; Weld metallurgy Weld wire development.
- (vii) Reactive metals properties
- (viii) Combustion synthesis
- (ix) Powder metallurgy

### **(b) Extractive/ Mineral Processing Research**

- (i) Chemical and physical processing of materials;
- (ii) Mineral Processing:-Electrometallurgy; Hydrometallurgy; Pyro metallurgy
- (iii) Recycling and recovery of materials;
- (iv) Thermo-chemistry and Thermodynamics,
- (v) Thermal plasma processing.
- (vi) Corrosion science and engineering

### **(c) Advanced Materials Science Research**

- (i) Advanced polymeric materials and Thin Film: Advanced polymer membranes and thin films; Biopolymers Living/controlled polymerization; Organic-inorganic hybrid materials; Self- and directed-assembly
- (ii) Biomaterials: Structural medical alloys; Bio-mimetic and bio-inspired materials engineering; Failure of medical devices; Interfaces between materials and tissue; Tissue as a composite material; Structural medical alloys; Drug delivery.

- (iii) Experimental Methods: Computer modeling and simulation; Mathematical modeling of material processes; 3D atom probe tomography; Atomic force microscopy; Electron microscopy; Nanoindentation; Non-destructive evaluation; X-ray diffraction
- (iv) Composites
- (v) Ceramics engineering: Ceramic processing; Ceramic-metal composites; Functional materials; Ion implantation; Modeling of ceramic processing; Solid oxide fuel cell materials and membranes; Transparent conducting oxides; Porous structured materials
- (vi) Nanomaterials and nanotechnology techniques
- (vii) Nuclear materials characterization: Nuclear materials processing; Nuclear materials properties

## 9. Stress Areas

Foundation courses	0
Laboratory courses	1
Chemical/extractive metallurgy/ manufacturing processes& Foundry Eng.	2
Physical Metallurgy/Transport phenomenon in Materials Engineering	3
Mechanical/production Metallurgy/ Engineering Alloys	4
Ceramic Engineering/Coal and coke Technology	5
Polymer Engineering & Corrosion Eng./ Materials Selection & Design	6
Paper Production Technology	7
Special Materials/Electron Microscopy	8
Seminars/Project/Thesis	9

## 10. COURSE OUTLINE

### FIRST SEMESTER: - PG.D IN MME PROGRAMME

Couse Codes	Course Title	Units
PGC 0601	Analytical tool for research in Engrs.1	3
MME 0611	Production Metallurgy	2
MME 0617	Mineral Processing	2
ENGR. 0605	Engineering Mathematics	2
MME 0619	Extractive Metallurgy	2
MME 0613	Experimental Techniques	2
ENGR. 0603	Statistics for Engineers	2
MME 0615	Introduction to Polymer Engineering	2
Total		17

**SECOND SEMESTER: - PG.D IN MME PROGRAMME**

<b>Course Codes</b>	<b>Course Title</b>	<b>Units</b>
MME 0624	Metallurgical Thermodynamics	2
MME 0690	Seminar (Technical Report Writing)	2
MME 0614	Physical Metallurgy	2
MME 0616	Fuel, Furnaces and Refractories	1
MME 0691	PGD. Project Work	6
Total		13

**Some remedial Engineering Courses for PG.D students from related physical science discipline (i.e. physics and chemistry)**

**FIRST SEMESTER: - REMEDIAL COURSES FOR PG.D IN MME PROGRAMME**

<b>Course Codes</b>	<b>Course Title</b>	<b>Units</b>
ENGR. 101	Introduction to Engineering	2
MME 201	Materials Science	2
MEC 211	Engineering Drawing 1	2
MME 331	Physical Metallurgy 1	2
Total		8

**SECOND SEMESTER: - REMEDIAL COURSES FOR PG.D INMME PROGRAMME**

<b>Couse Codes</b>	<b>Course Title</b>	<b>Units</b>
MME 302	X-Ray Diffraction and Electro-Optical Technique	2
MME 332	Structure, Properties and Heat Treatment of Alloys	2
EGR. 301	Engineering Analysis	2
Total		6

**FIRST SEMESTER: - M.ENG. PROGRAMME****Compulsory/General Courses**

<b>Couse Codes</b>	<b>Course Title</b>	<b>Units</b>
PGC 601	Research methodology & application of ICT in research	3
MME 790	Seminars 1 & 2	2
MME 767	Environmental Impact Assessment	2
MME 709	Computational Materials Sci. Technique. & App.	2
MME 711	Advanced corrosion and Surface Engineering	2
MME 713	Design and Manufacture of Composites	2
MME 715	Advanced Materials Characterization Methods	2
MME 717	Advanced Physical Metallurgy of Materials	2
MME 791	M.Eng. Project	6
Total		23



## **SECOND SEMESTER: - M.ENG. PROGRAMME**

**Elective/ Specialization Courses:** The candidates are expected to take at least four courses from their specialization areas in the second semester.

### **A. Physical/Mechanical Metallurgy of Materials**

<b>Course Codes</b>	<b>Course Title</b>	<b>Units</b>
MME 716	Diffusion in solid	2
MME 712	Fracture mechanics	2
MME 714	Industrial manufacturing	2
MME 718	Advanced Dislocation theory	2
MME 722	Advanced Phase Transformation	2
MME 720	Metal Processing Case studies	2
MME 724	Deformation, Fabrication & Welding processes	2

### **B. Chemical and Extractive Metallurgy**

<b>Course Codes</b>	<b>Course Title</b>	<b>Units</b>
MME 731	Non-Ferrous Extractive Metallurgy	2
MME 732	Metallurgical Thermodynamics & Kinetics	2
MME 734	Ferrous Extractive Metallurgy	2
MME 736	Ferro Alloy Technology	2
MME 738	Electroplating Technology	2

### C. Advanced Materials Engineering

Course Codes	Course Title	Units
MME 742	Physical and Structural Properties of Polymers	2
MME 744	Processing/ Formulation of Industrial Polymers, Additives & Adh.	2
MME 749	Introduction to advanced biomaterials	2
MME 752	Design of Medical Devices and Implants	2
MME 756	Advanced electronic & Photonic Materials & devices	2
MME 758	Ferroelectric Ceramics & Dielectric Materials	2
MME 760	Structure of glass and Glass Formation	2
MME 764	Nanotechnology & Thin Film Tech	2
MME 766	Self-assembling nanostructured molecular materials & dev.	2
MME 772	Industrial Ceramics Physics	2
MME 746	Design and Manufacture of Polymer Nanocomposites	2

#### **FIRST SEMESTER: - Ph. D. PROGRAMME**

##### **Compulsory/General courses**

Course Codes	Course Title	Units
MME 801	Computational Materials Science II	3
ENGR. 803	Advanced Experimental Tech. In Mat. Sc.	4
PGC. 701	Synopses and research grant writing	3
MME 802	Advanced Tech. Report Writing	3
MME 890	SEMINAR 1 & 2 (Research proposal)	3

## **SECOND SEMESTER: - Ph. D. PROGRAMME**

### **Compulsory/General courses**

<b>Course Codes</b>	<b>Course Title</b>	<b>Units</b>
MME 802	Analytical tools for research in engineering	3
MME 891	SEMINAR 3(Research Finding report)	3
MME 808	Modeling & simulation of metall. processes	4
MME 892	PhD Thesis	12

## **SECOND SEMESTER: - Ph. D. PROGRAMME**

### **Elective/ Specialization courses**

A Ph.D. student may be required to take some elective courses in any of specialization areas in section 8, if need be by the supervisor(s) in addition to the compulsory courses.

### **11. COURSE DESCRIPTION/OUTLINE**

#### **12.1. PGD COURSE DESCRIPTIONS**

##### **MME 0611: Production metallurgy**

Stress-strain relation in bulk deformation processes. Holloman equation. Forces and work of deformation. Hot deformation and superplasticity. Cold working upsetting, extrusion, rolling, and drawing. Materials joining processes, Weldability of metals. Weld nature, quality, microstructure and properties, welding speed and defects. Brazing, soldering; Metal sheet forming, deep drawing, ironing, effect of anisotropic properties on formability; Power metallurgy and metal casting methods. (2 units)

##### **MME 0617: Mineral Processing**

Occurrence and nature of major metallic ores. Comminution theory; criteria for selection of crushing, grinding and screening equipment, metallurgical accounting, laboratory size analysis. Classification. Mineral concentration techniques: gravity concentration, heavy medium separation, froth floatation, magnetic and electrostatic separation; selection of mineral concentration equipment. Dewatering and tailing disposal. Design, testing and evaluation of

mineral beneficiation flow sheets. Computer application in mineral process, application of mineralogy to mineral processing. . (2 units)

### **ENGR. 0605 – Engineering Mathematics II**

Complex variables; function, deviation, language series, Taylor series, Cauchy theorem, Cauchy formula, Cauchy integrals. Analytical functions, singular points, Residual problems, conformal problems and mapping. Special functions; Gamma, Delta, Beta and error functions. Fourier integral, Fourier transforms for solving partial differential equations.(2 units)

### **MME 0619: Extractive Metallurgy**

Review of raw materials for ironmaking, Post-production treatment of the products of the Iron Blast Furnace. Direct reduction – process description reactions and products, process control. Electric Arc Steelmaking – Reactor design, continuous feeding, power programme, process and quality control; Secondary Steelmaking, non-ferrous extractive process (2 units)

### **MME 0613: Experimental Techniques**

Principles and techniques of optical microscopy, electron microscopy and scanning- probe microscopy. X-ray diffraction and neutron diffraction. Materials Analytical techniques and instruments: principles and applications X-ray spectrometry, Atomic Absorption spectroscopy, Pyrometry. Experimental stress analysis; statistical design of experiments and interpretations of results. (2 units)

### **MME 0603: Statistics for Engineers**

Introduction to statistical methods and analysis used in engineering and science. The importance of statistical science in engineering education is a subject that no longer merits discussion. The constructivist approach in its teaching, the need to teach using problem solving, and the contribution of modern technologies to optimize engineering approach is the focus of this course.(2 units)

### **MME 0615: Introduction to Polymer Engineering**

Chemistry polymerization processes: –condensation, polymerization. Addition polymerization. Expoxidepo-polymerization (Fibre glass, carbon fibre materials) synthetic rubbers. Styrene-butadiene rubber. Thermoplastics and thermosetting plastic techniques including steam-mould for expanded polystyrene. Compression moulding. Projection moulding, extrusion moulding calendaring solid state forming.(2 units)

### **MME0623: Metallurgical Thermodynamics**

Review of thermodynamics function. Ellingham’s diagrams for metal-oxide, metal-chloride and metalsulphide systems. Theory of solutions: ideal, actual and dilute solutions. Deviations from

ideal behaviour. Raoult's and Henry's laws. Activity in multi-component system. Phase equilibria of two-component systems. Free energy composition diagrams and application in the construction of phase diagrams. Reactions between different phases i.e. slag/metal or slag/metal/gas. (2 units)

#### **MME0614: Physical Metallurgy**

Wave theory of the atom. Schrodinger wave equation and simple applications. Wave particle duality. Uncertainty principle. Electron diffraction. Nucleation of phase changes: homogeneous nucleation and heterogeneous nucleation. Diffusion in solids. Grain growth. Crystal imperfection. Theoretical strength of crystals; Strengthening mechanisms and processes: mechanical treatments, ion implantation. (2 units)

#### **MME0616: Fuels, Refractories & Furnace Technology**

Classification and properties of fuels. Fossil fuels analyses, coal and coke. Charring chemistry, heat treatment and pyrolysis. Flames, chemical kinetics, heat and mass transfer, mathematical models, burning velocities, flame, temperatures. Classification of metallurgical furnaces reactors, e.g. reverberatory furnaces, converters, fluidized-bed reactors. Refractories: Classification, properties and manufacturer. (2 units)

#### **MME 0690 Seminar (Technical: Report Writing)**

Fundamental principles of technical writing. Format of different types of reports – outlines, purpose and scope, technical discussion details, role of appendix, function of figures, tables and illustration. Literature search, reference (citing and listing). Nature of recommendations and conclusions. Guides of writing memoranda, business letters. Oral presentation of technical reports. (One or two team papers to be prepared on assigned work). (2 units)

#### **MME 0691: PGD Project Work**

Basic and independent research, which must make a distinct contribution to knowledge in an area of Metallurgical and Materials Engineering. The project work must be submitted in approved format and defended in an oral presentation in partial fulfilment of the PGD degree requirements. (6units)

## 12.2. M.ENG. COURSE DESCRIPTIONS

### **PGC 601: Research Methodology and Application of ICT in Research**

In-depth research work aimed at acquiring full knowledge and presentations in scholarly writing of the concepts, issues, trends in the definition and development of the study area from African and Western perspectives. Major steps in research: Selection of problem, Literature review, Design, Data collection, analysis and interpretation, Conclusions. Study of various research designs, Historical, case studies, Surveys, Descriptive, Cross sectional, Experimental, etc. analysis, surveys and synthesis of conceptual and philosophical foundations of different disciplines. Identification of research problems and development of research questions and or hypotheses. Detailed treatment of methods of collecting relevant research data and format for presenting research results (from designing the table of contents to referencing, bibliography and appendix). Data analysis and result presentation in different disciplines using appropriate analytical tools. Methods of project/dissertation writing. Application of appropriate advanced ICT tools relevant in every discipline for data gathering, analysis and result presentation. Essentials Spreadsheets, Internet technology, and Internet search engines. All registered Masters Degree students must attend a solution-based interactive workshop to be organised by the School of Postgraduate Studies for a practical demonstration and application of the knowledge acquired from the course, conducted by selected experts. (3 Units )

### **MME 767: Environmental Impact Assessment**

1. The definition and legal basis of the Environmental Impact Assessment (EIA) Process: Definition and scope of EIA, Institutional Arrangement - EIA legislation & Lead Agencies.
  2. Classification and categorization of Environmental Impact Assessment (EIA) Classification of EIA, Other categorization of EIA
  3. Key elements of Environmental Impact Assessment (EIA): Scoping; screening; identifying and evaluating project alternatives, Mitigating measures, EIA report and certification.
  4. Basic guidelines and procedures of Environmental Impact Assessment (EIA): Preliminary activities, Impact identification, Baseline study, Impact evaluation, Mitigation measures, Documentation, decision making & Post audits.
  5. Role and function of Environmental Impact Assessment (EIA): Role of EIA, Function of EIA.
- (2 units)

**MME 709: Computational Materials Sci. Technique & Applications.**

1. Introduction to atomistic simulation, 2. The molecular dynamics method-algorithms Verlet and velocity Verlet 3. Getting numbers out of molecular dynamics simulations-radial distribution functions, diffusion constants, velocity autocorrelation functions, 4. Constant pressure and constant temperature methods, 5. Monte Carlo methods; the Ising model.(2 units)

**MME 711: Advanced Corrosion and Surface Engineering**

Types and Forms of Corrosion. Corrosion prevention, Electroplating, Principles – Throwing power and its evaluation. Commercial plating of Cu, Ni, Cr, Cd, Zn, Ag, Au. Electro-deposition of alloys plating structure of Electro deposits and testing of deposits. 4) Anodic oxidation of Aluminum and its alloys. Commercial anodizing process. Faults in the anodic coating and the remedies. Treatment after anodizing. 6) Cathodic and Anodic protection.(2 units)

**MME 713: Design & Manufacture of Composite Materials**

Classification of composite materials; Fibre-Matrix Interface: Theories of Adhesion Adsorption and wetting, Interfacial bonding, Measurement of bond strength. Unidirectional laminae continuous fibres; short fibres; short fibre composites: strength of unidirectional laminae and laminates; strength of short fibre composites. Toughening Mechanisms: Crack bowing, Crack deflection, Debonding, Pull-out, Wake toughening, Microcrack toughening, Transformation toughening.(2 units)

**MME 715: Advanced Materials Characterization Methods**

The emphasis will be on microstructural characterization techniques, including optical and electron microscopy, X-ray diffraction, and thermal analysis and surface analytical techniques, including Auger electron spectroscopy, secondary ion mass spectroscopy, X-ray photoelectron spectroscopy, atomic force microscopy.(2 units)

**MME 717: Advanced Physical Metallurgy of Materials**

Nucleation of phase changes: homogeneous nucleation and heterogeneous nucleation. Diffusion in solids. Grain growth. Crystal Imperfection: Strengthening Mechanisms and Processes: Mechanical treatments; Solid solution hardening, Precipitation and Dispersion hardening, Fibre reinforcement, Thermochemical processing, Diffusion coating or Metallic cementation Radiation strengthening, Ion implantation.(2 units)

**MME 716: Diffusion in Solid**

The concept of diffusion to describe mass transport in solid materials. The energy required for this motion depends on specific details of the atomic-level structure, such as: substitutional vs. interstitial travel; number/strength of bonds to break; amount of free volume in close-packed bulk vs. grain boundaries vs. glass with different levels of network formers.

(2 units)

**MME 712: Fracture Mechanics**

Theoretical Cohesive Strength of materials. The Griffith Crack Theory; Plane Stress and Plane Strain. Orowan Modification and Irwin's crack extension force. Crack propagation modes. Effects of plate thickness. Crack tip plastic zones. Plane strain fracture toughness testing. Notch strengthening. The Charpy Impact Test. Fracture of brittle non-metallic. High temperature fracture. Intergranular. Creep fracture. Failure in superplastic materials. Design and materials considerations. (3 units)

**MME 714: Industrial Metallurgy**

*Fundamentals of metal working*, forging defects and powder metallurgy forging. Rolling of metals: Rolling processes, forces and geometrical relationship in rolling, simplified analysis of rolling load, rolling variables, theories of cold rolling and hot rolling, problems and defects in rolled variables, torque and horsepower. Extrusion: Classification of extrusion processes; Drawing of tubes, rods and wires: Introduction, wire drawing dies, tube drawing processes, analysis of wire and tube drawing. Sheet metal forming; Forming methods, bending, stretch forming, deep drawing, forming limit criteria, defects in formed parts. Advanced metal forming process: High Energy rate forming operation, electromagnetic forming. The philosophy of non-destructive testing of materials and its application in engineering. (2 units)

**MME 718: Advanced Dislocation Theory**

Yield strength of perfect crystals, Dislocation Motion – Glide, climb, and cross-slip, line tensions and Elastic Energy of Dislocations. Forces between dislocations. Dislocation Reactions in crystals. Intersections of moving dislocation. Dislocation sources and multiplication. Discolorations and stacking fault Energy. Jogs and prismatic loops. The pearls Navarro stress. Dislocations and low angle boundaries. Interactions of dislocations with point defects and second phase particles. Dislocations and plastic Deformation, strain hardening, recovery and recrystallization. Dislocations in ionic crystals, geometrically necessary dislocations statistically stored dislocations. (2 units)



### **MME 720 Metal Processing Case Studies**

The aim of the present course is to give an overview of the main metal forming processes and to provide some understanding of the complicated relations between a forming process and the microstructure of a metal on the one hand and between this microstructure and the mechanical properties on the other hand. The aim of the case studies is to provide practical illustrations and in depth insight of certain aspects of metal processing and thermo-mechanical processing. At the end of this course the student should be able to consult and understand professional and scientific literature about metal processing.(2 units)

### **MME 722: Advanced Phase Transformations of Materials**

Phase transformations in condensed metal and non-metal systems are discussed. Fundamental theory of diffusional phase transformations in solid metals and alloys. Applications of thermodynamics to calculation of phase boundaries and driving forces for transformation. Application of thermodynamics and of nucleation and growth theory developed above to the principal experimental systematic of precipitation from solid solution, the massive transformation, the cellular and pearlite reactions, martensitic transformation and the question of the rate of shear in diffusional phase transformation.(2 units)

### **MME 724: Deformation, Fabrication & Welding Engineering**

Dislocation sources, Dislocation point defect interaction and pileups. Plastic deformation of single crystals. Grain size, Hall-Petch equation. *Metallurgical aspects of welding*. Theories and applications of arc, gas, resistance and solid state welding processes. Modern methods of welding. Examination of macro-and micro-structure of welds and the heat affected zones (HAZ), solidification mechanics, residual stress effects, distortion control. Weldability criteria for ferrous and non-ferrous alloys.(2 units)

### **MME 731: Advanced Non-Ferrous Extractive Metallurgy**

Factors governing the choice of extraction process route. Condensation of metal vapours and associated problems. Simple blast furnace and reverberatory processes. Principles of Metal Refining. Methods available for metal refining e.g. converter methods, vapour transport refining, fractional distillation etc. Principles of electrochemistry. Principles of electro-winning and electro-refining. Theories of slag and their roles in extraction and refining. Structure and properties of slags.(2 units)

### **MME 732: Advanced Metallurgical Thermodynamics & Kinetics**

Partial and integral for metal-oxide thermodynamics functions. Gibbs-Durhem equations. Ellingham's diagrams for metal-oxide, metal-chloride and metal sulphide systems. Theory of solutions: ideal, actual and dilute solutions. Deviations from ideal behaviour. Raoult's and Henry's laws. Activity in multi-component system. Phase equilibria of two-component systems. Free energy composition diagrams and application in the construction of phase diagrams. Reactions between different phases i.e. slag/metal or slag/metal/gas. (2 units)

### **MME 734: Advanced Ferrous Extractive Metallurgy**

Hydro-and Electrometallurgy physical and chemical principles involved in the extraction and refining of metals by hydro and electrometallurgical techniques. Discussion of unit processes in hydro metallurgy, electro-refining. Analysis of integrated flow sheet of recovery of non-ferrous metals. Pyro metallurgy. The extraction and refining of metals. Modern practice changes required by anti-pollution regulations and by energy restrictions. Analysis and design of processes and role of economic consideration.(2 units)

### **MME 736: Electroplating Technology**

Introduction to surface engineering. The industrial market for engineering coatings ;Surface cleaning and preparation; Friction and wear; Tribological mechanisms ;Coatings tribology ;Coating growth and morphology ;Engineering coatings and processes; Thermochemical surface treatments ;Engineering coating selection. (2 units)

### **MME 736 Ferro-alloy Technology**

Types of Ferro alloys and their uses. Physicochemical aspects of ferroalloys. Production by various methods. Types of furnaces, its design and refractories. Mechanical equipment, auxiliaries, electric power in to heat. Furnace power supply. Working voltage, power factor and efficiency. Production of ferro-silicon, ferro -manganese (high and low carbon). Ferrochrome (high and low carbon), Production: Ferro-molybdenum, Ferro-tungsten, ferro-titanium are ferro-vanadium. Lay out of a ferro alloy plant and its production economics(2 units)

### **MME 744: Processing & Formulation of Industrial Polymers**

Polymer chemistry and solution properties of polymers, Polymer physics, Dry rubber Technology, Latex Technology plastic Technology, rubber processing, Polymer characterization, conducting polymer, speciality polymer, polymers for energy applications.

Mould and die design: Rubber pounding and processing. Rubber resin blends. Adhesive bonding; mechanism of adhesive bonding. Typical and chemical classification of adhesives, thermoplastic and thermoset adhesives. Adherents and bonding of substrates. Industrial applications. Modelling and simulation to polymers. Wood board technology. (2 units)

#### **MME 746: Design and Manufacture of Polymer Composites**

Thermoplastic and thermosets matrix composites: Synthetic and natural fiber reinforced polymer composites. Application, Processing, experimental characterization and chemical analysis of nanocomposites. Failure and damage mechanism of composites. Methods for failure prediction, Failure criteria and damage analysis. Analytical solution for simple structure surface beams, plates and tubular structure. Numerical & empirical prediction of composite properties. Simple classical Laminate theorem. Common manufacturing and forming methods for plastics and fiber composites. Material selection and empowering design properties of polymer and composites. Hydrothermal and Physico-mechanical properties of conventional fiber and particulate polymer composites, polymer nanocomposites, Fillers for polymer composite physical & chemical modification of polymer composites. (2 units)

#### **MME 750: Introduction to Principles and Properties of Biomaterials**

Natural biological materials: structure and properties. Biocompatibility: tissue response to biomaterials; corrosion. Testing of biomaterials: Metallic materials in medical application: Ceramics and glasses-bioceramics: nearly inert ceramics, bio-reactive glasses and glass ceramics, porous ceramics; Calcium phosphate ceramics: grafts, coatings Physico-chemical surface modification of materials used in medicine. Composites - reinforcing systems-fabrication, mechanical properties, absorbable matrix composites, non-absorbable matrix composites, Implants: internal fracture fixation. Joint replacement, shape memory alloys. (2 units)

#### **MME 752: Design of Medical Devices and Implants**

Topics include properties of materials used in medicine, synthesis and properties of polymeric materials, polymeric biomaterials, natural and recombinant biomaterials, biodegradable materials, hydrogels, stimuli-sensitive materials, and characterizations of biomaterials. The laboratory course concentrates on synthesis, processing and characterization of materials for biomedical applications, and characterization of cell-materials interaction. (2 units)

### **MME 756: Advanced Electronic & Photonic Materials & Devices**

Theory, design, fabrication and application of photonic materials and devices. Surrey of optical material design for semiconductors, dielectric and polymers. The course examines ray optics, electromagnetic, optics and guided wave optics, physics' of light-matter interactions and device design. Principles of LEDs, lasers, photodetectors. Modulators, fibres and waveguide interconnects optical filters and photonic crystals.(2 units)

### **MME 758:Ferroelectric Ceramics & Dielectric Materials**

Ferroelectricity – Dielectric Properties, Ferroelectric hysteresis loop. Perovskite structure eg. Barium Titanate Structure and Applications. Examination of the physics of microelectronic semiconductor device for silicon integrated circuit applications. Semiconductor fundamentals, p – n junctions, metal-oxide semiconductor structure, metal-semiconductor junctions. MOS field effect transistor and bipolar junction transistor. The course emphasizes physical understanding of device operation through energy band diagrams and short channel MOSFET device design. Model device scaling.(2 units)

### **MME 764: Nanotechnology and Thin Film Technology**

Development of quantitative understanding of the different intermolecular forces between atoms and molecules and how these forces give rise to interesting phenomena at the nanoscale, such as flocculation, wetting, self-assembly in biological (natural) and synthetic systems Preparation of Nanoscale Materials: Precipitation, mechanical milling, colloidal routes, self-assembly; vapour phase deposition, MOCVD, sputtering, evaporation, molecular beam epitaxy, Chemical spray pyrolysis atomic layer epitaxy, microelectronics. Patterning and Lithography for Nanoscale Devices: Optical/UV, electron beam and X-ray lithography systems and processes, wet etching, dry (plasma/reactive ion etching), etch resists.(2 units)

### **MME 766: Self-Assembly Nanostructure Molecular Materials & Device**

Principles of self-assembly: surfactant solutions, importance of non-covalent forces, the hydrophobic effect, co-operativity, statistical mechanics of one-dimensional self-assembly.: Biological self-assembly: coded self-assembly in living cells, proteins, microtubules, viruses, DNA, membranes.: Supramolecular chemistry: chemists' attempts to exploit biological-like self-assembly.: Principles of self-organisation: behaviour of hard spheres and rods. Liquid crystals: structures, properties and applications of thermotropic and lyotropic liquid crystals. Self-assembly in polymer melts and solutions. Templating self-assembly.(2 units)

### **MME 772: Industrial Ceramics**

Ferro electricity – Dielectric Properties, Ferro electric hysteresis loop. Perovskite structure eg. Barium Titanate Structure and Applications. Electrical, optical, magnetic and mechanical properties of metals, semiconductors, ceramics and polymers Role of bonding, Structure (crystalline, defect energy band and microstructure) and composition in influencing and controlling physical properties are discussed. Case studies drawn from a variety of applications: semiconductor diodes and optical detectors, sensors, thin films, biomaterials composites etc. (2 units).

### **MME 791: M.Eng Research Project**

The project work shall embody original scholarly and independent research, which must make a distinct contribution to knowledge in an area of Metallurgical and Materials Engineering. The thesis must be submitted in approved format and defended in an oral presentation in partial fulfilment of the M.Eng. Degree requirements. (6 units)

## **12.3. Ph.D. COURSE DESCRIPTIONS**

### **PGC 701: Synopsis and Grant Writing**

Identification of types and nature of grant writing; mining of grants application calls on the internet. Determining appropriate strategy for each grant application. Study of various grant application structures and contents and writing of concept notes, detailed project description, budgeting and budget defense. Study of sample grant writings in various forms and writing of mock research and other grants. Identification of University of Nigeria synopsis structure and requirements, (Introduction, Methodology and Results). Determining the content of each sub-unit of the synopsis. Steps in writing of synopsis from the Dissertation/Thesis document. Structural and language issues. Common errors in synopsis writing and strategies for avoiding them. The roles of the student and the supervisor in the production of a synopsis. Writing of mock synopsis. All registered Ph.D students must attend a solution-based interactive workshop to be organised by the School of Postgraduate Studies for a practical demonstration and application of the knowledge acquired from the course, conducted by selected experts(3 Units)

### **MME 801: Introduction to Advanced Materials Simulations**

The course is intended as a companion to introductory course in finite element modelling.

**Course Content:** 1. Introduction to atomistic simulation: (a): Density functional theory (DFT), and (b) Use of different materials studios. 2. The molecular dynamics method-algorithms Verlet and velocity Verlet. 3. Getting numbers out of molecular dynamics simulations-radial distribution functions, diffusion constants, velocity autocorrelation functions. 4. Constant pressure and constant temperature methods. 5. Monte Carlo methods; the Ising model. (2 units)

### **MME 802: Advanced Technical Report Writing:**

This course include: Role of technical reports in engineering projects. Fundamental principles of technical writing. Format of different types of reports outlines, purpose and scope, technical discussion details, role of appendix, function of figures, tables, and illustration. Literature search, reference (citing and listing). Nature of recommendations and conclusions. Guides of writing memoranda, business letters. Oral presentation of technical reports. (One or two term papers to be prepared on assigned work). (Optical); Quantifying roughness; Structure of real surface. Experimental Stress Analysis; Statistical design of experiments and interpretations of results. (3 units)

### **MME 808: Modeling & Simulation of Metallurgical Processes**

Introduction to computer programming with MATLAB; Use of Simulink, Neural Network, FIS and ANFIS in MATLAB for metallurgical problems. Introduction: System, environment, input and output variables; State variables and their transition; Hierarchy of knowledge about a system; System identification – structure and parameter identification; Deterministic and stochastic systems; Static and Dynamic Systems; Objectives of modeling and simulation. Physical Modeling: Dimension analysis, Dimensionless grouping of input and output variables to find empirical relations, similarity criteria and their application to physical models. (4 units)

### **MME 803 Experimental Techniques in Materials Engineering**

**Diffraction** - At the end of this part of the course the students will be able to: Explain what X-rays are and describe their importance in structure determination;

### **Focused Ion Beam instruments and Secondary Ion Mass Spectrometry-On successfully**

Discuss ion-solid interactions for incident ion energies from 1keV to 50keV and the production of secondary particles including neutral atoms and atomic and molecular ions, electrons and photons. This topic includes the modelling program, SRIM.

### **Electron Microscopy**

Describe the design and operation of scanning (SEM) and transmission (TEM) electron microscopes, with particular reference to electron sources.

### **Scanning Probe Microscopies**

Discuss the lateral imaging range and sensitivity to structure and properties; specifically describe the theory, use and operation of the STM and AFM including strengths and weaknesses of each technique; Discuss applications of SPM to materials characterization.

### **Thermal analysis**

At the end of the course the students will be able to: Describe the different types of thermal analysis techniques available; Interpret DSC, TG and DTA data for simple materials. (4 units)

### **MME 892: Ph.D Thesis**

The thesis shall embody original scholarly and independent research, which must make a distinct contribution to knowledge in an area of Metallurgical and Materials Engineering. The thesis must be submitted in approved format and defended in an oral presentation in partial fulfillment of the PhD requirements.(12 units)