**UNIVERSITY OF NIGERIA, NSUKKA**

**Faculty of Engineering**

**Department of Mechanical Engineering**

**Revised Postgraduate Degree Programmes in Mechanical Engineering**

**2021**

1. **INTRODUCTION**

The Mechanical Engineering postgraduate programmes bring together academics, professionals and students into a community of scholars in pursuit of innovation, creativity and advanced professional study. In line with modern trends in curriculum development in Mechanical Engineering, the programmes include basic courses necessary for every Mechanical Engineer, as well as courses in some specialised areas of the discipline.

1. **PHILOSOPHY**

In keeping with the philosophy of the University of Nigeria, the postgraduate programmes of the Department of Mechanical Engineering are designed to train innovative and creative engineers that are capable of advancing professional engineering practice. Graduates of the programmes will be able to understand and practice engineering beyond the knowledge acquired during their undergraduate studies. The programmes are organized in five specialist areas namely: Thermofluids Engineering, Renewable Energy, Materials Technology and Mechanics, Design and Production Technology, and Industrial Engineering and Management. It seeks to provide a great opportunity for advanced study and investigation through interactions among academics and professionals by sharing knowledge and research results. It is
also designed to present an opportunity for personnel who had been out of the profession to connect back to it.

1. **OBJECTIVES**

The main objective of the programme is to produce graduates who can bring their academic and practical background to bear the problems of industries in Nigeria and beyond. Specifically, the programme is designed to achieve the following objectives:

\* To produce qualified engineers in specialist areas
\* To build capacity in advanced engineering science and industry capability
\* To produce competent graduates proficient in research and development in the mechanical engineering field

\* To afford experienced engineers the opportunity to extend the boundaries of their profession.

\* To prepare the students to be able to assume technical and academic leadership in the engineering world.

1. **ADMISSION REQUIREMENTS**
	1. **M.Sc (Master of Science) programmes**

Graduates of the University of Nigeria or any other recognised universities with B.Sc. (Physics, Chemistry and Mathematics) and minimum CGPA of 3.5/5.0 are eligible for admission into the M.Sc (Mechanical Engineering) programme.

* 1. **M.Eng (Master of Engineering) programmes**

Graduates of the University of Nigeria or any other recognised universities with B.Eng degrees and a minimum CGPA of 2.5/5.0 are eligible for admission into the M.Eng (Mechanical Engineering) programme.

* 1. **Ph.D (Doctor of Philosophy) programme**Candidates who have completed their Master’s programmes (course work requirements and project) in Mechanical Engineering may apply for admission into the PhD Programme. Only students who scored a minimum GPA of 3.50 in their Master’s programmes may be admitted to the PhD programme.
	A candidate who has completed the coursework requirements for a Master’s in Mechanical Engineering with a coursework GPA of 4.00, but who has not completed the project requirement, may also apply for admission to the PhD programme.
1. **AREAS OF SPECIALIZATION**
	1. Thermofluids Engineering (M.Eng and M.Sc)
	2. Renewable Energy (M.Eng and M.Sc)
	3. Materials Technology and Mechanics (M.Eng and M.Sc)
	4. Design and Production Technology (M.Eng only)
	5. Industrial Engineering and Management. (M.Eng and M.Sc)
2. **DURATION OF PROGRAMMES**

**M.Sc/M.Eng.:**

i.) Full-time: Minimum of three (3) semesters. ii.) Part-time: Minimum of five (5) semesters.

**Ph.D:**
i.) Full-time: Minimum of six (6) semesters. ii.) Part-time: Minimum of eight (8) semesters

1. **SCOPE**

The programme covers coursework and research work. A project report or a thesis is required depending on the level of the programme.

**Requirement for graduation**
**M.Sc/M.Eng.:**
To be awarded an M.Eng degree a student must have taken and passed the prescribed number of compulsory and required courses selected from the approved list, a total minimum of 33 credit units as follows:

Taught courses 21 units
Research 6 units
Seminars 3 units
Project/dissertation courses 3 units

The 21 credits of course work will consist of 9 units of compulsory courses and 12 units of core courses selected from other areas of concentration. However, the total number of courses selected must be such as to emphasize a particular area of specialization. There shall be a total of two seminars for the Master’s programme namely: the proposal, and the research findings seminar.

**Ph.D:**
To be awarded a Ph.D degree a student must have taken and passed a total of 33 credit units as follows:

Research/thesis 12 credit units,
Seminar presentations 6 credit units,
Thesis courses 3 credit units
Taught courses 12 credit units

The seminar presentations consist of 2 presentations and will cover the proposal seminar, work in progress seminar and research findings seminar. The Ph.D thesis must be defended before an external examiner duly nominated for that purpose and appointed by Senate. At the start of the Ph.D programme, the department will select a thesis supervisor who will discuss and agree upon a thesis topic with the candidate. The department will also select a thesis committee of not less than three members. At least one of the committee members must be from outside the research group with which the candidate is associated. Qualified people from the Industry may be invited to serve as additional members of the committee. The Ph.D thesis will normally consist of a theoretical and an experimental investigation. It must be original and creative, and will generally result in the development of a new technique, process or correlation, as well as in the advancement of knowledge beyond the current frontier. Within the first year of the programme, a qualifying exam will be administered. The qualifying exam will consist of written and oral parts in three subjects at postgraduate level selected by the candidate from the core area. The student must make a minimum average of 60% in the qualifying exam to be able to continue with the Ph.D programme.

Note: The award of postgraduate degrees will be based on the satisfaction of the requirements as stipulated in the Postgraduate Studies Regulations. The passing grade for postgraduate courses is “C” or 50% and a minimum CGPA must be obtained before a degree is awarded.

1. **LIST OF APPROVED SUPERVISORS**

EMERITUS PROFESSORS

S. O. Onyegegbu, Energy & Power Technology
O. C. Iloeje, Energy & Power Technology

PROFESSORS:
O.V. Ekechukwu, Solar Energy *B.Sc. (Ibadan), Ph.D (Cranfield)*
S. O. Enibe, Energy & Power Technology *B.Sc. (Nig), M.Sc. (Reading), Ph.D (Nig.)*
S. O. Edelugo, Design & Production *B.Eng. (Asutech), M.Eng, (ESUT), Ph.D (Nig.).*
G. O. Unachukwu Energy & Power Technology *B.Sc. (Nig.), M.Eng, (UniPort), Ph.D (Nig.)*
S. C. Nwanya, Industrial Engineering & Mgt *B.Eng. (FUTO), M.Eng (Nig.) Ph.D (Udinese)*
C. A. Mgbemene, Energy & Power Technology *B.Eng. (Nig.), M.Eng. (Nig.), Ph.D (Nig.)*
H. O. Njoku, Energy & Power Technology *B.Eng. (Nig.), M.Eng. (Nig.), Ph.D (Nig.)*

READERS:

J. I. Ume, Process Design & Optimization *B.Sc. (Lagos), M.Sc. (Lagos), Ph.D (Penn. State)*
E. C. Okoroigwe, Energy & Power Technology *B.Eng. (FUTO), M.Eng (Nig.) Ph.D (Nig.)*
P. A. Ozor, Industrial Engineering & Management *B. Eng. (ESUT), M.Eng. (Nig.), Ph.D (Nig.)*

SENIOR LECTURERS:
S. A. Ugwu, Design & Production *B.Eng. (Nig), M.Sc. (ABU)*
C. O Agbo Design & Production *B. Eng. (Nig),M.Eng. (Nig), Ph.D (Nig)*

C. G. Ozoegwu, Design & Production *B. Eng. (Nig), M.Eng. (Awka), Ph.D (Awka.)*
M. N. Eke, Energy & Power Technology *B. Eng. (FUTO), M.Eng. (Nig.), Ph.D (Nig.)*
P.U. Akpan, Energy & Power Technology *B. Eng. (Nig.), M.Eng. (Cranfield), Ph.D (Cape Town)*

LECTURERS I:
N. Ononiwu Design & Production *B. Eng. (Nig.), M.Eng. (), Ph.D (Johannesburg)*
C.K. Oluah, Energy & Power Technology *B. Eng. (Nig.), M.Eng. (Nig.), Ph.D (Johannesburg)*

COURSE OUTLINE

First Semester

**M.Eng and MSc Courses**

Course No. Title Units

*Compulsory*

MEE 690 M.Eng. Project (for M.Eng candidates) 6
MEE 691 M.Sc Project (for M.Sc candidates) 6

MEE 699 Analytical Methods in Engineering (for all candidates) 3
PGC 601 Research Methodology and ICT in Engineering (for all candidates) -

*Compulsory for candidates in the Thermofluids Engineering Option*

MEE 661 Advanced Thermodynamics I 3

MEE 671 Advanced Heat & Mass Transfer 3

MEE 651 Advanced Fluid Mechanics 3

*Compulsory for candidates in the Renewable Energy Option*

MEE 621 Renewable Energy Resources 3

MEE 622 Solar Thermal Conversion 3

MEE 623 Solar Photovoltaics 3

*Compulsory for candidates in the Materials Technology and Mechanics Option*

MEE 631 Advanced Mechanics of Materials 3

MEE 632 Mechanical Properties of Metals and Alloys 3

*Compulsory for candidates in the Design and Production Technology Option*

MEE 611 Engineering Design and Systems Analysis 3

MEE 612 Production Technology 3

*Compulsory for candidates in the Industrial Engineering and Management Option*

MEE 681 Engineering Organization and Management 3

MEE 682 Operations Research Models in Industrial Engineering 3

Second Semester

Candidates in the Thermofluids Engineering option are to chose any 2 courses from either the Energy and Power Technology sub-option or any 2 courses from the Fluids Engineering option. Candidates in other options are to choose any 3 courses from within their options. In addition, all candidates are to choose one additional course from outside their options.

**Course No. Title Units**
*(Thermofluids Engineering Option – Energy and Power Technology)*

MEE 662 Advanced Thermodynamics II 3
MEE 663 Advanced Air-Conditioning and Refrigeration 3
MEE 664 Cryogenics and Gas Liquefaction 3
MEE 665 Direct Energy Conversion 3
MEE 667 Energy Management 3
MEE 668 Turbine Plant Performance (Gas and Steam Turbines) 3
MEE 672 Two Phase Flows & Heat Transfer 3
MEE 673 Conduction 3

MEE 674 Solar Energy Conversion 3
MEE 675 Reactor Design and Control 3
*(Thermofluids Engineering Option – Fluids Engineering)*

MEE 652 Low Speed Flow 3

MEE 653 One Dimensional Gas Dynamics 3

MEE 654 Multi-Dimensional Gas Dynamics 3

MEE 655 Boundary Layer Theory 3

MEE 656 Computational Fluid Dynamics 3

MEE 657 Turbomachinery 3
MEE 658 Propulsion 3
*(Renewable Energy Option)*

MEE 624 Wind Energy Conversion 3

MEE 625 Biomass Energy 3

MEE 626 Hydro and Tidal Energy Conversion 3

MEE 627 Energy Economics 3
MEE 628 Energy and Environment 3

*(Materials Technology And Mechanics)*

MEE 633 Process and Extraction Metallurgy 3

MEE 634 Physical Metallurgy 3

MEE 635 Industrial Metallurgy & Fabrication 3

MEE 636 Composite Materials 3

MEE 646 General Dynamics 3
MEE 647 Advanced Vibrations 3
*(Design and Production Technology Option)*

MEE 613 Machine Tool Engineering 3

MEE 614 Analysis of Manufacturing Processes and Machines 3

MEE 615 Design of Control System Components 3

MEE 616 Dynamic Problems in Design 3

*(Industrial Engineering and Management Option)*

MEE 683 Inspection, Quality Control & Reliability 3

MEE 684 Industrial Production Systems Design 3

MEE 685 Analysis of Capital Investment 3

MEE 686 Organization & Management of Human Resources 3

**Ph.D**
**Course No. Title Units**

*Compulsory*

MEE 790 Ph.D Thesis 12

MEE 701 Advanced Engineering Computation and Programming 3

PGC 701 Synopsis and Research Grant Writing 3

*Electives (One elective should be chosen corresponding to the candidate’s specialization)*

MEE 702 Special Problems in Energy and Power Technology 3

MEE 703 Special Problems in Renewable Energy 3

MEE 704 Special Problems in Materials Technology and Mechanics 3

MEE 705 Special Problems in Design and Production 3

MEE 706 Special Problems in Industrial Engineering and Management 3

Second semester courses

COURSE DESCRIPTION

MEE 791 Seminar I 3
MEE 792 Seminar II 3
MEE 793 Seminar III 3

3.2 MASTER OF ENGINEERING/SCIENCE (M.Eng/M.Sc) COURSES

**MEE 601 Advanced Thermodynamics I**Equilibrium. First law. Second law. State principle, Zeroth law. Criteria for equilibrium. Temperature, Entropy and Exergy Analysis, Exergetic (Second law) efficiency, Chemical Exergy. Maxwell Relations. Open systems. Phase rule. Systems of one and two components. Idealized and real gases, mixtures, and solutions. Equations of state. Thermodynamic potentials. Heats of formation. Chemical Reactions. Chemical equilibrium and combustion in complex reacting systems. Frozen states in gas dissociation. Real gas dynamic applications. Emission of pollutants. (3 units)

**MEE 602 Advanced Thermodynamics II**
Statistical thermodynamics: Systems and ensembles. Third law. Kinetic theory. Maxwell’s transfer equation. Thermodynamics equilibrium and viscous, heat conducting gases. Boltzmann statistics, quantum statistics. Dilute gas properties. (3 units)

**MEE 603 Advanced Air Conditioning and Refrigeration**
Psychiometry and its application to design problems on comfort air conditioning and to problems involving heat and mass transfer in spray equipment. Cooling load estimates. Accommodation of solar gains to buildings. Extended surface coils for cooling and dehumidification. Typical air conditioning equipment and control systems will be considered in relation to specific problems, including solar dryers, heaters, and coolers Project. (3 units)

**MEE 604 Cryogenics and Gas Liquefaction (Low Temperature Refrigeration)**
Thermodynamic processes for producing low-temperature refrigeration. Problems of heat exchangers, insulation and rectification. Application of oxygen and nitrogen. Liquefaction of Natural Gas. Transport and Storage of cryogenic fluids. Low temperature thermometry. Properties of cryogenic fluids. Properties of Materials at low temperatures. Laboratory projects on related topics. (3 units)

**MEE 605 Direct Energy Conversion**
Introduction to semiconductors. Basic ideas of quantum physics, energy bands, intrinsic and extrinsic semiconductors. The Hall effect, thermoelectric effects and optical effects. Analysis and design of thermoelectric devices (generators and coolers), thermionic converters, fuel cells, photovoltaic generators, and magnetohydrodynamic (MHD) power system. (3 units)

**MEE 606 Solar Energy Conversion**
Review of Heat Transfer. Fundamentals of Solar Energy: extraterrestrial irradiance and atmospheric extinction. Insolation correlations, total transmittance into buildings and irradiance on inclined surfaces. Solar energy collection and storage; selective surfaces Eutectic salts. Direct use of Solar Energy: STEG and Solar cells. Solar Collectors, types, performance and ratings. Solar Refrigeration and Cooling of Buildings: active and passive coolers. Heating applications. The Solar powered organic vapour cycles. Open Air Space and the Legal implication of Solar Energy use in urban area. (3 units)

**MEE 607 Energy Management**
Energy Resources. Energy use. Elements of Heat Transfer-Conduction, Convection and radiation. Sources of energy waste in Buildings and Industrial systems. Equipment efficiency. Measurement of energy loss. Energy conversion measures. Regeneration. Insulation. Used for waste heat and cold. Temperature control – the thermostat in heating and cooling applications. Power factor. Total Energy systems. Case study – The University of Nigeria. Energy policy. Class projects. (3 units)

**MEE 608 Advanced Heat and Mass Transfer**
Review of Modes of Heat Transfer, and one-dimensional steady state conduction. Transient 1-D conduction. Internal Heat generation. Ablation. Review of Momentum transfer in Lamina and Turbulent Flows. Solutions for simple Geometries. Navier-Stokes Equations. Universal velocity Distribution and Empirical Correlations. Heat Transfer in Laminar Flow. Free and forced convection. Simple solutions and Correlations. Heat Transfer in Turbulent Flows. The Momentum-Heat Transfer Analogy. Analytical Solutions. Experimental Results for Forced and Free Convection. Thermal Radiation. Radiation Networks. Heat Transfer Correlations in Boiling and Condensation. Heat Exchangers, boilers, condensers, coolers. NTU and other Design Methods, Mass Transfer in Stationery, Laminar and Turbulent Flows, Numerical and Analog Methods in Steady and Unsteady problems. (3 units)

**MEE 609 Two Phase Flows and Heat Transfer**
Definitions of Terminology. Flow regimes and Regimes Boundaries. Continuity, Momentum and Energy Equations in Two Phase Flows. Bubbly, slug, separated and Dispersed Flows. Counter-current flows and phenomena. Boiling. Nucleation. Effect of surface characteristics. Pool Boiling and the Boiling curve. Pool Boiling Correlations. Flow Boiling. Flow Regimes in Flow Boiling on a vertical Tube. Flow boiling Correlations. Flow Film Boiling. Rewet in Pool and Flow Boiling. Condensation-Dropwise and Film Condensation. Effect of surface conditions. Empirical Correlations in Condensation. (3 units)

**MEE 610 Conduction**
Brief review of one-dimensional conduction. Lumped, Internal and Differential Formations. Steady-one dimensional problems. Principle of superposition. Heterogeneous solids. Power series solutions and Bessel functions. Steady 2 and 3 dimensional problem solutions by Laplace Transform. Variational Formations and Approximate Profile Techniques. Differences and Differential Formations and Solution Techniques. (3 units)

**MEE 611 Turbomachinery**
General equations of flow (continuity, energy, momentum); definitions of efficiency, dimensional analysis. One-dimensional design of axial compressors and turbines; two-dimensional potential flows. Three-dimensional flow; radial equilibrium equations; actuator-disc theory; miscellaneous topics; design example. (3 units)

**MEE 612 Turbine Plant Performance (Gas and Steam Turbines)**
Gas Turbine Plant: plant components, Optimization of compression ratios, Regeneration, Reheat and Inter-cooling. Steam Plant: Plant components, Optimization of fed trams. Reheat cycles, Effect of increasing maximum pressures and temperature. (3 units)

**MEE 613 Propulsion**
Thrust, Propulsive Efficiency, Thermal Efficiency and Overall efficiency of Air-breathing engines and rockets. Turboprops, turbofans, Turbojets and Ramjets: Cycle analysis including irreversibilities, Supersonic flight, and Shock losses. (3 units)

**MEE 614 Reactor Design and Control**
The programmes would include reactor theory, reactor shielding, reactor materials, nuclear waste management, fuel reprocessing, reactor plant systems, and removal of heat energy from nuclear reactors. Thermal Hydraulics of Nuclear Reactors. (3 units)

**MEE 620 Advanced Mechanics of Materials**
Theory of Stress, Yield Criteria. Theories of failure. Theory and measurement of strain. Matrix & Tensor notation. Stress-Strain-Temperature Relations for elastic solid. Strain Energy, St. Venant’s Principle. Superposition. Energy Theorems. Stress Functions for two-dimensional problems, torsion problems, and axially symmetric problems. Approximate Methods. Plasticity. Deformation, Theory of rigid/plastic materials, and application. Theormoelasticity. (3 units)

**MEE 621 Mechanical Properties of Metals and Alloys**
A review of the Phenomenology and mechanisms of creep, fatigue and fracture in pure metals and alloys. Discussion of the basic theory dealing with the nature, generation, Kinetics and properties of dislocations in metals and their interactions with precipitates in alloys including the theory of diffusion. A detailed examination of the yield point phenomenon in pure metals and alloys including work-hardening processes. (3 units)

**MEE 622 Process and Extraction Metallurgy**
(Physical chemistry of Metallurgical Processes). Procedures of the various extraction processes are described. Oxidation and reduction processes, hydrometallurgical processes. Methods of steel-making and the principles of hydro-and electrometallurgy extraction processes. (3 Units)

**MEE 623 Physical Metallurgy**
The course discusses a detailed study of precipitation from super-saturated soil solution. The directional solidification and solidification of eutectic structures, thermal stability and the mechanical enquiry of such structures. Transformations in steels: eutectoid, bainitic and martensitic transformations. The metallurgy of special alloy steels including stainless and maraging steels. (3 units)

**MEE 624 Industrial Metallurgy and Fabrication**
The concept of this course is to examine the basic and fundamental principles of Industrial fabrication processes such as forging, extrusion, rolling, wire and deep drawing, stretch forming, powder and welding metallurgy. The philosophy of non-destructive testing of materials and its application in engineering. (3 units)

**MEE 625 General Dynamics**
Review of rigid body dynamics, moments and products of inertia, the symmetrical top, the gyroscope and applications. Lagrangian mechanics, canonical transformations. Hamilton-Jacobi theory. Perturbation methods. Stability and resonance of dynamical systems. Applications to particle and rigid body space mechanics. (3 units)

**MEE 626 Advanced Vibrations**
Brief review of mechanical vibrations with one degree of freedom. Variational mechanics. Lagrange’s equations, Hamilton’s principle. Multi-degree of freedom systems; approximate methods of calculating principal frequencies. Holtzer’s method; Self-excited Vibrations. Nonlinear vibrations. Vibrations of continuous elastic systems, bars, beams, shafts, plates. (3 units)

**MEE 640 Advanced Fluid Mechanics**
Continuum model; macroscopic properties of fluids, Thermodynamic relationship. Basic equations, methods of describing fluid motion; continuity equation, forces, stress tensor, strain and rotation; strain tensor, stress-rate of strain relation; Navier-Strokes and Energy equations. Special Equations; Non-dimensional equations, viscous, compressible and incompressible flows, creeping flows, inviscid compressible and incompressible flows, boundary conditions; boundary layers and turbulence. Some solutions of the equations. Inviscid, incompressible flow around a circular cylinder; steady viscous incompressible pipe flow. Oscillating flat plate in a viscous incompressible fluid. (3 units)

**MEE 641 Boundary Layer Theory**
Fluid motion with friction, outline of boundary layer theory, Navier-Stokes equations, some exact solutions. Laminar boundary layers: on a plate, exact solutions for 2-dimensional, axially symmetric, 3-dimensional incompressible boundary layers, unsteady layers, approximate solutions, boundary layer control, thermal layers, compressible boundary layers. Boundary layer transition: experimental results, stability of laminar flow, comparison between theory and experiment. Turbulent boundary layer: Fundamental theoretical models, in pipes, skin-friction drag, rotating discs, roughness, positive and negative pressure gradients, free turbulent flows jets and wakes. (3 units)

**MEE 642 Low Speed Flow**
Introduction, Language, Terminology and Basic Concepts. General Properties of Irrotational Flow, Two-Dimensional Irrotational Flow. Three-Dimensional Irrotational Flow. Rotational Flow. Perturbation Methods. (3 units)

**MEE 643 One-dimensional Gas Dynamics**
Some basic thermodynamic concepts and definitions. The compressible fluid. Basic concepts of Gas Dynamics – vorticity, the Bernoulli Equation, The Continuity Equation, Entropy, The Energy Equation, Steady Isentropic Flow of a perfect gas along a Streamline, The Stagnation Conditions, The Compressibility Effect, The Speed of Sound. (3 units)

**MEE 644 Multi-dimensional Gas Dynamics**
Basic Equation of Multi-Dimensional inviscid Adiabatic Flow. Croclo Theorem, Croclo Number, Velocity Potential and Stream Function, Basic Equations, Methods of solving governing equations. Oblique shock waves. Exact solutions of the Basic Equations – Prandtl-Meyer solution, control flows with axial symmetry (Taylor-Maccoll Solution), Hodograph method. The method of characteristics; Small perturbation theory. Higher great approximations. (3 units)

**MEE 660 Production Technology**
An analysis of the physical, chemical and mathematical principles underlying modern manufacturing processes and processing equipment and technology, and the economics of shaping and joining materials in the liquid, plastic and solid phases. Basic plasticity. Melting and casting of metals. Fusion and sintering of metals. Hot forming of metals, cold forming of metals, explosive and hydro forming. Plastics and their manufacture. Joining of metals – Metal cutting principles, cutting tool geometry and tool materials. Tool wear mechanisms. Milling and broaching, metal grinding principles. Economics of metal removal: electrochemical, electro?erosion and laser machining. Ultrasonic machining. Vibration characteristics of machining operations. (3 units)

**MEE 661 Machine Tool Engineering**
History of machine tools, classification of conventional machine tools and machining techniques: introduction to precision engineering. Analysis of conventional machine tools-main structure, primary and auxiliary motions: geometric surface generation; power transmission and gear diagrams; machine tool kinematics-analysis of kinematic schemes and constraints; development of a machine tool from determined principal design specifications; selection of max to min range of cutting speeds and feeds using geometric and/or Arithmetic series, Design of Gear boxes and power units, stepless drives; Design of spindles, spindle bearings, and clutches. Design of mechanisms for rectilinear motion, periodic (intermittent) motions, reversing devices. Design of Beds, columns, tables, cross rails, carriages and ways, Design of elements of machine tools control systems, Dynamic calculation and analysis in machine tool design. Methods of static and dynamic tests, machine tool building and rebuilding technology. Introduction to advanced machine tools. (3 units)

**MEE 662 Analysis of Manufacturing Processes and Machines**
Classification of industrial manufacture, analysis of machinery requirement, the concept of design for manufacture; theory of power absorption at tool point, merchant’s chip formation theory, built up edge phenomena and frictional behaviour on the rake face, chipless machining techniques; techniques; Abrasive machining and super finishing. High energy forming methods; Engineering metrology, statistical quality control; design of jigs, fixtures, press tools and dies. The concept of automation, selection of power medium and control techniques for automation, cam dependent mechanized systems, sequence controlled systems, camless automatics. In-process error sensing techniques and adaptive control, Processing of non-metals. Numerically controlled machines, economics of NC machines, NC machining centres. Programming techniques, Tooling, and auxiliary equipment for NC. Materials handling techniques for automated manufacture of multi component products, logic and sequencing, introduction to robotics. Trends in modern manufacturing techniques. Development of industrial manufacturing machinery and systems in the context of a developing country. Planning for manufacture. Philosophy for investment or industrial machines. (3 units)

**MEE 663 Engineering Design and Systems Analysis**
Philosophy of Engineering Design: techniques of analysis, synthesis and evaluation; the creative process: Design in the Corporate Environment: engineering research, marketing, finance and other corporate functions, - and comprehensive design. Development Engineering; post-initial design development of new products, value engineering; development testing Vs experimental research; case studies. Integrated treatment of mathematical modeling and analysis of mechanical systems. Modeling linear and non-linear systems, and their performance under transient, periodic and random loads. Theory of design, material considerations, optimization techniques, similitude, stability, design of experiments and evaluation of results. (3 units)

**MEE 664 Design of Control System Components**
Electronic components. General considerations in the characterization of system components. Steady-state analysis of systems containing strongly nonlinear components. Application of the above to the study of electronic systems. Laboratory consisting of construction, on the analogue computer, of vibrators, modulators, other basic electronic devices. Hydraulic and pneumatic components and systems. Reading of descriptive material concerning fluid power control. Techniques for the simulation of dynamic systems by digital computers. Project consisting of the development and use of digital computer simulation of a complex hydraulic power control system. Control theory reduced to engineering practice through the analysis and design of actual systems in the laboratory. Experiments with pneumatic and electro-mechanical logic circuitry, and with mechanical, hydraulic, and electro-mechanical servo system. Systems analysis and synthesis applied to a variety of positioning speed control, and regulating system. (3 units)

**MEE 665 Dynamic Problems in Design**
Analytical methods for solution of typical vibratory and balancing problems encountered in mechanical systems. Special emphasis on methods of suppression and control. Design and analysis of rotating machines. Some important mechanical problems found in turbines and other high-speed rotating machinery such as: steady stresses from centrifugal forces; vibration problems; and dynamic stability of high-speed rotors. Mathematical techniques readily adaptable to computer solution. (3 units)

**MEE 670 Process Engineering for Brewers**
Kinetics of Enzymes. Reactions. Rate theories, analysis of rate equations, mechanisms of reactions, first order reactions, chain reactions, rate constants and equilibrium. Thermodynamics of aqueous reactions: First and second laws of thermodynamics. Concepts of internal energy, enthalpy and entropy. Heat of reaction, exothermic processes endothermic processes. Concepts of Heat and Mass Transfer. Unit Operations in Brewing. Fermentations, Distillations etc. Economy of chemical processes. Material cost estimation, process cost estimation, total cost, variable const and chemical process optimization. Design and control of fermentation equipment/processes. Materials for construction. Application of (1) and (2) to the design and control of fermentation/distillation processes. Instrumentation. (3 units)

**MEE 681 Organization & Management of Human Resources**
Personnel system and industrial relations: the recruitment, selection, utilization and development of human resources, with special emphasis on union-management relations, staffing – manpower planning recruitment, testing, selection, placement, orientation, training, promotion, compensation and performance Evaluation – Wage and Salary administration, job evaluation, performance standards and appraisal, employee benefits. Seminar on Personnel and industrial relations: Analysis of problems and policies in personnel and industrial relations in these areas, personnel philosophy, ethics, role of personnel, department; breadth of personnel department’s responsibilities, implementation of personnel programs, collective bargaining, and contribution of personnel department to the organization. (3 units)

**MEE 682 Operations Research Models in Industrial Engineering**

Deterministic models of operations research; Linear Programming, Network models, critical path scheduling, integer programming, branch-and-bound techniques, and dynamic programming. Stochastic models of operations research: Queuing theory, inventory theory, Markov chains, and computer simulation. (3 units)

**MEE 683 Inspection, Quality Control and Reliability**
Statistical aspects of quality control; sampling plans for acceptance inspection, and for the control of production processes, adaptive; quality control, design of quality control systems. Engineering reliability. Analysis of failure data, estimates of hazard rates and failure distributions for the reliability of components and/or systems, acceptance sampling plans for quality control. (3 units)

**MEE** **684 Industrial Production Systems Design**
Theory of Design: Logic underlying strategies for achieving various activities. Relationship of system definition, evaluation tools, modeling, and computational methods to strategies. Satisfying vs. optimizing goals in design. Searching for alternatives: Means-end analysis, Heuristic methods, and resource allocation. Complete design of an industrial engineering system in one or two technology settings, e.g. manufacturing, hospital, communications, environment, transportation etc. design, scheduling and control of production systems based on mathematical, computational and other modern mathematical techniques. Design and selection of production systems, creation of new facilities, and the determination of plant location and size, Methods of system modeling using Markov chains, illustrated with a wide range of applications with special emphasis on control systems. Use of the statistics obtained from the Markov formulation estimation methods, tests of hypothesis for fitting data, state reduction techniques, model validation and control, optimization with policy interaction and linear programming. Problems in factory planning, materials handling, production line techniques, automation, plant facilities. (3 units)

**MEE 685 Analysis of Capital Investment**
Decision and cost Analysis: economic analysis of capital investment decisions. Accounting system as a data source for such decisions. Decision analysis as an aid in processing data, for management decisions. Analytical methods for choosing between competitive engineering proposals; general decision models and decision strategies. Decisions under risk and uncertainty, replacement, inventory, budding and purchasing models. (3 units)

**MEE 691 Seminars**
The student must present at least two separate seminars on the research proposal and research findings. The seminars must be PowerPoint presentations. (3 units)

**MEE 699 Analytical Methods in Engineering**
Numerical Methods-Polynomial interpolation and approximation, numerical integration, roots of equations, simultaneous linear equations and matrix inversion, Eigenvalues, numerical solution of ordinary differential equations. Partial Differential Equations – Quasi linear first order partial differential equations, second orde4r partial differential equations – Diffusion, wave and Laplace-type partial differential equations, Fourier and related transform methods, heat transfer, mechanics and gas dynamics applications. Practical techniques for ordinary differential equations, Laplace transform applications, asymptotic expansions, regular and singular perturbation expansions, examples in heat transfer and fluid mechanics. Statistical methods. (3 units)

**MEE 690 M.Eng. Project**
The project report is considered to be the centerpiece of a student’s graduate experience. A student must complete an acceptable M.Eng. project report under the supervision of an approved supervisor. The report must be an in-depth study of a chosen topic in the area of specialization. It must be an original work of research, design and development. (6 units)

**3.3 DOCTOR OF PHILOSOPHY (Ph.D) COURSES**

MEE 703 Applied Numerical Methods and Continuum Mechanics

Review of advanced techniques and computational software for the modeling, simulation and
optimization of engineering systems, such as MATLAB, Engineering Equation Solver (EES),
Mathematics, Maple, Spreadsheets, etc. Application of one or more of these software to the
solution of common problems in engineering, such as systems of linear algebraic equations,
interpolation and curve fitting, roots of equations, numerical integration, initial value problems,
 boundary value problems, eigenvalue problems, parametric analysis and optimization.
 (3 units)

MEE 791 Seminar I

The student must present at least two separate seminars on the research proposal and work in
progress. The seminars must be PowerPoint presentations. (3 units)

MEE 792 Seminar II

The student must present a seminar on showing the research findings. The seminar must be
PowerPoint presentations. (3 units)

MEE 790 PhD Thesis

The PhD thesis is a principal component of the doctoral program in Mechanical Engineering. It
is a major, original work, carried out in the student’s area of specialization, and must makes
significant contributions to knowledge. This part serves as the major indicator of the candidate’s
abilities and demonstrates that the candidate has got full understanding of the subject matter. It
must be done under the supervision of an approved senior academic and a select thesis
committee of not less than three members. (12 units)