NATIONAL UNIVERSITIES COMMISSION

BENCHMARK MINIMUM ACADEMIC STANDARDS

FOR POSTGRADUATE PROGRAMMES IN

ENGINEERING & TECHNOLOGY

IN

NIGERIAN UNIVERSITIES

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PREFACE

A major function of the National Universities Commission is quality assurance. The Education (National Minimum Standards and Establishment of Institution) (Act) No. 16 of 1985 as amended by National Universities Commission (Amendment) (Act) No. 49 of 1988 empowers the Commission to lay dawn minimum standards for all degrees, awards and use the same standards to accredit them. The Commission, in collaboration with the universities, developed the first set of Minimum Academic Standards for the undergraduate degree programmes under the thirteen disciplines taught in all Nigerian Universities. The documents were approved by the Federal Government in 1989 and became major reference instrument for the establishment and accreditation of all undergraduate academic programmes.

After over a decade of use, the National Universities Commission commenced the process of review of the Minimum Academic Standards in 2001. The review sought to accommodate new frontiers of knowledge in all the academic disciplines, the impact of information and communication technologies and inclusion of languages and entrepreneurial studies to ensure response to current realities, global competitiveness and relevance. The documents also enunciated the Benchmarks for Learning Outcomes and Competencies expected of the graduates, making the standards not only content-based but also result-oriented.

With the success recorded in the development and use of Benchmark Minimum Academic Standards (BMAS) for undergraduate programmes, the Commission proceeded to establish the standards for postgraduate programmes. This started with a meeting of the Provosts and Deans of Postgraduate Studies in all Nigerian Universities, in 2004. The process was followed by a Needs Assessment Survey. The purpose was to determine the Expected Learning Outcomes, Entrepreneurial Skills and Competencies in Research and Developed in the same year. The first workshop was held in 2005 to produce BMAS for Master of Business Administration (MBA); as the pilot. The final product was approved in 2006 and has since been used to accredit the MBA programmes in all universities.

The experiences encouraged the Commission to convene the next workshop to develop the BMAS documents for all the other programmes. This was towards the end of 2006 and the drafts produced were sent to all universities for their comments and inputs. The comments and inputs generated were incorporated into the draft at another workshop held in 2008. The final workshop on the production of error-free documents was convened in 2009 and 2010, when academic experts took yet another look at the documents, and any programme that was omitted was included. Finally, in 2011 the drafts were subjected to editorial scrutiny of experts so as to prepare them for printing.

Although the process had been long and arduous, the Commission is delighted to present the first set of postgraduate BMAS for all identified postgraduate programmes taught in Nigerian Universities for learning and accreditation of the programmes.

On behalf of the National Universities Commission, I wish to express sincere gratitude to all the Nigerian Universities and their staff who participated in the development of these documents.

PROFESSOR JULIUS A. OKOJIE
EXECUTIVE SECRETARY
NUC, ABUJA. November, 2011

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BENCHMARK MINIMUM ACADEMIC STANDARDS FOR PGD, M.Eng./M.Sc. AND Ph.D IN ENGINEERING PROGRAMMES OFFERED IN NIGERIAN UNIVERSITIES

1. INTRODUCTION

The National Universities Commission (NUC), as a regulatory agency for University Education in Nigeria, has as one of its mandates, the definition and maintenance of academic standards. The Commission has in the past organized the definition of Minimum Academic Standards and, subsequently, accreditation for all approved undergraduate programmes, offered in Nigerian Universities. For postgraduate programmes, NUC has commenced the process of defining benchmarks and minimum academic standards as a follow up to the success recorded in the undergraduate programmes. This Benchmarks and Minimum Academic Standards (BMAS) for the Post Graduate Diploma (PGD), M.Eng./M.Sc. and Ph.D in engineering programmes are to serve as a guide to all Nigerian Universities wishing to mount postgraduate programmes in Engineering.

2. BENCHMARK MINIMUM ACADEMIC STANDARDS

The Benchmark statements contained herein, describe the minimum requirements each university in Nigeria is to attain in its Engineering postgraduate programmes. Individual university may modify them provided they do not go below the minimum benchmark.

2.1 Philosophy

The philosophy of the postgraduate programmes in Engineering is to develop highly skilled professionals for the public, private and international organizations, as well as for teaching and research in Tertiary Institutions and for global competitiveness.

2.2 Aims and Objectives

The aims and objectives of the postgraduate programmes in Engineering are geared at:

- Providing students with knowledge and competitive skills to enhance their performance and to enable them to assume broader responsibilities in the rapidly changing environment in the context of the global and contemporary knowledge economy;

- Producing high level practitioners who are capable of applying appropriate engineering principles and techniques for solving problems in the local, national and international environment viz-a-viz teaching, research and industry.

- Producing socially responsive and functional engineers capable of positively driving the engine of Nigeria's economy through accelerated technology development.

- Providing opportunity for University graduates in relevant science disciplines and HND holders to convert and aspire to higher degrees in Engineering; and

- Producing Engineers in ICT having entrepreneurial skills and leadership qualities, including sound professional ethics.

3. ADMISSION REQUIREMENTS

The criteria for admission into the Postgraduate Engineering programmes are as follows:

3.1 Basic Requirements

All candidates must have five Credit passes including English, Mathematics, Physic, and Chemistry O'Level.

a. **Postgraduate Diploma, PGD**

A graduate from a recognized University with at least a pass degree or a holder of a minimum of upper Credits in the Higher National Diploma HND, from a recognized institution. Holders of the HND at lower Units with a minimum of five (5) years post-qualification relevant experience may be considered.

b. **Masters Degree**

i. A candidate with a first degree in a relevant Engineering discipline from a recognized University with minimum of a second class lower division may be admitted provided the University matriculation requirement is satisfied.

ii. A candidate with an upper credit pass in the Postgraduate Diploma (PGD), in a relevant Engineering discipline, from a recognized University may also be admitted to a Masters Degree Programme provided the University matriculation requirements are satisfied.

c. **Doctor of Philosophy (Ph.D) Degree**

A candidate who holds a Masters degree, with a minimum CGPA of 3.50 on a 5-point scale or an average of 60%, which includes coursework and research thesis in a relevant Engineering discipline, from a recognized university may be admitted provided the university matriculation requirement is satisfied.

d. **Completion of programme**

Each department shall specify all additional prerequisites for completion of the programme.

3.2 Mandatory Duration of Programmes

A uniform duration for the programme for all universities, making allowance for minor individual university variation shall be adopted as follows:

a. **Postgraduate Diploma Programme**

i. Full-time: Minimum of four (4) semesters and a maximum of six (6) semesters.

ii. Part-time: Minimum of six (6) semesters and a maximum of eight (8) semesters.

b. **Master's Degree Programme**

i. Full-time: A minimum of three (3) semesters and a maximum of six (6) semesters

ii. Part-time: A minimum of four (4) semesters and a maximum of eight (8) semesters.

c. **Ph.D Programme**

i. Full-time: A minimum of six (6) semesters and a maximum of twelve 12 semesters.

ii. Part-time: A minimum of eight (8) semesters and a maximum of sixteen (16) semesters.

3.3 Staffing Requirements

Teachers of postgraduate courses, except the PGD, should normally be holders of a Ph.D, provided that those who teach Ph.D courses are of the rank of at least Senior Lecturer.

3.4 Requirements for Student Supervision

Subject to individual University peculiarities, requirements for supervision of postgraduate students shall be as follows:

a. At least one supervisor for each postgraduate student on the masters and the PGD and at least two (2) for the Ph.D programme shall be appointed.

b. All lecturers qualified to teach postgraduate courses and who are not registered postgraduate students shall be eligible to supervise PGD and Masters programmes. For the Ph.D, supervisors must be of a rank not lower than senior lecturer and must not be registered postgraduate students.

c. A supervisor shall guide a student in his/her studies and the department shall keep a record of the candidate's progress and submit a regular progress report through the Dean to the Board of Postgraduate Studies.

d. A supervisor may be changed where and when necessary subject to the approval of the board of Postgraduate Studies.

e. Where a student does part or all his required courses in another institution, the external supervisor shall only be required to submit a written report on the candidate at the end of the programme. Such a supervisor shall not normally be required to participate in the oral examination of the candidate.

4. EXAMINATIONS

4.1 Course Work

a. For all postgraduate coursework, the minimum pass score shall be 50%; continuous assessment shall constitute not less than 30% of the examination for each course;

b. Any student who fails in any course, shall repeat such a course; and

c. Any student whose Cumulative Grade Point Average (CGPA) falls below 2.50 at the end of 2 consecutive Semesters shall be required to withdraw from the programme.

The scoring and grading of courses shall be as follows:

Marks	Letter Grades	Grade Points
70 and above	A	5
60 -69	B	4
50 -59	C	3
0 -49	F	0

4.2 Thesis or Dissertation

A panel of examiners shall be composed to orally assess a thesis or dissertation according to individual University regulations, but the examination shall at least be guided by the following:

a) Postgraduate Diploma Project Report: An external examiner shall read and grade the report. The final grade for the project report shall be the average of the separate grades of an internal assessment process and the external examiner's assessment.

b) Master Thesis: The minimum composition of the examination panel shall comprise:
   i. External Examiner;
   ii. Head of Department;
   iii. Supervisor;
   iv. Co-supervisor (if any); or at least one other member of the Department (if no co-supervisor); and.
   v. One member appointed by the Postgraduate School.

   Note that all masters degree programmes shall be subject to external examination and moderation.

c) Ph.D Thesis: The minimum composition of the examination panel shall comprise:

   i. External Examiner;
   ii. Head of Department who must be a Ph.D holder;

iii. Supervisor;
iv. Co-supervisor;
v. One other member of the Department who is not below the rank of a Senior lecturer or an academic staff from a related Department within the Faculty who must be a Ph.D holder; and
vi. A representative of the Board of the School of Postgraduate (PG) Studies.

4.3 Graduation

For the PG programmes, classification of certificates shall be based on the following:

CGPA	4.50	-	5.00 ----------	Distinction
	3.50	-	4.49 ----------	Upper Credit
	2.50	-	3.49 ----------	Lower Credit
	1.50	-	2.49 ----------	Pass

5. ACADEMIC STANDARDS

5.1 Academic Regulations

a. **Academic Session**

An academic session consists of two semesters. Each semester normally comprises 15 weeks of teaching and two weeks of examinations.

b. **Modular System**

All engineering programmes shall be run on a modular system, commonly referred to as Course Unit system. All courses should therefore be sub-divided into more or less self-sufficient and logically consistent packages that are taught within a semester and examined at the end of that particular semester. Unit weights should be attached to each course.

c. **Definition of Units or Unit:**

Units are loads attached to a course. One Unit load is equivalent to one hour per week per semester of 15 weeks of lectures or two hours of tutorials or three hours per week of term paper work or laboratory practical per semester of 15 weeks.

5.2 Programme Requirements

a. **Registration Procedure**

Students shall normally complete registration for courses for the semester not later than two weeks after the start of the semester. A student cannot withdraw from a course after a third of it has been delivered without permission, according to the regulations of the University. A student who withdraws after this time or who fails to sit for the final examination without reasons acceptable to the Senate shall be deemed to have failed that course.

b. **Student Academic Status**

A student's academic status shall be determined on the basis of his/her performance at the end of the semester examinations.

c. **Good Standing and Probation**

To be in good standing, a student must in each semester have a Cumulative Grade Point Average (CGPA) of not less than 2.50. A Student who is not in good academic standing shall be deemed to be on Probation.

d. **Transfer**

Students who transfer from other universities shall be unitized with only those courses deemed relevant to the programmes, which they have already passed prior to their transfer. Such students shall however be required to meet the minimum number of sessions he/she has spent in the Faculty; provided that the student shall satisfy the residency requirements of the University. Students who transfer for any approved reason shall be unitized with those Units passed that are within the curriculum. Appropriate decisions on transfer cases shall be subjected to the approval of Senate on the recommendation of the Faculty. If anyone is on probation for 2 consecutive semesters, he/she shall be required to withdraw from the programme.

e. **Withdrawal**

A candidate whose CGPA is below 2.50 at the end of 2 consecutive Semesters shall be required to withdraw from the University.

5.3 Attendance

In order to be eligible for examination in a particular taught course, a student shall have attended a minimum of 75% of the total periods of formal instructions delivered for the course.

5.4 Course Evaluation

a. **Attainment Levels**

In Engineering programmes, assessment of students' should be based on a combination of performance in some or all of the following areas:

- Examinations;
- Continuous assessments;
- Oral presentations and Seminars and problem solving exercises;
- Assignments;
- Group project works; and
- Thesis/Dissertations.

b. **Continuous Assessment**

Continuous assessment shall be done through essays, tests, term papers, tutorial exercises, quizzes and home works. Scores from continuous

assessment shall constitute at least 30% of the final marks for courses which are primarily theoretical.

5.5 External Examiner System

The external examiner system shall be used in the final year of the graduate programme to assess final year courses and projects, and to certify the overall performance of the graduating students, as well as the quality of facilities and teaching.

6. GENERAL COURSE REQUIREMENTS

Courses specified for engineering disciplines are just suggestions of common courses in the various fields of engineering. Each Department (or University) offering listed programmes is free to add as many optional or required courses as it deems fit.

6.1 Ph.D Requirements

For Ph.D programmes, candidates shall be required to have taken the core/compulsory courses prescribed for the M.Sc./M.Eng. as prerequisites. This is in addition to the minimum 21 units which include research and seminars prescribed for the Ph.D.

6.2 M.Sc/M.Eng./M.Tech. Requirements

A minimum of 31 Units comprising 24 Units of Coursework, 1 unit of Seminar and 6 Units of Research.

6.3 M.Phil. Requirements

A minimum of 36 Units comprising 24 Units of Coursework, 3 unit of Seminar and 9 Units of Research.

7. RESOURCE REQUIREMENTS FOR TEACHING AND LEARNING IN THE PROGRAMMES

7.1 Academic Staff

a. **Teacher to Student Ratio**

For effective teaching and learning the engineering programmes shall have a teacher to student ratio of 1:10. However, the PGD programmes shall maintain the same ratio of 1:15 applicable to undergraduate programmes.

a. **Staffing**

A minimum of six full-time equivalent staff on ground in the department shall be Ph.D holders of the rank of Senior Lecturer for Masters and Ph.D programmes.

7.2 ICT Compliance

Both academic and non-academic staff should be ICT competent.

7.3 Physical Space Requirements

a. **Professional Physical Facilities Requirements**
Computer Room and Virtual Library facilities.

b. **Office Accommodation**
The standard space requirements as shown below shall apply.

Item	m^2
Professor's office	18.50
Head of Department's office	18.50
Tutorial Teachng Staff's office	13.50
Other teaching Staff Space	7.00
Technical Teaching Staff Space	7.00
Secretarial Space	7.00
Science Staff Research Laboratory	16.50
Engineering Staff Research Laboratory	14.00
Seminar Space/per student	1.85
Drawing office Space (A.I Board per student)	3.70
Drawing Office Space (A.O.Board per student)	4.60
Laboratory	7.50

c. **Classroom Space and Examination Theatres**

- Adequate classrooms should be provided with enough chairs and tables
- Examination halls and theatres should be provided to minimized the rate of examination malpractice

7.4 Library Facilities

There must be adequate library facilities to cater for the interest of all the courses in the programmes. These include current journals, handbooks, textbooks, manuals, codes of practices, standards and specifications, etc, in sufficient numbers; in addition to a good library building. The library should be up to date in current books and journals and should also be online.

i. GENERAL COMMON COURSES TO AL PGD PROGRAMMES

Engineering mathematics I (3 Units)

Review of matrix operation including inversion, Eigen values, Eigen vectors and Canonical transformations and application. Three dimensional vector representations, vector calculus, gradient, divergence and curl line, surface and volume integrals, laplacian operations. Green's, Stoke's and Divergence theorems and applications. Ordinary and partial differential equations, applications and physical problems. Complex variables, numerical analysis, special functions and integral, problem formulation, simple method of solution.

Engineering Mathematics II (2 Units)
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.

Numerical Methods and Computer Programming (3 Units)
Gaussian elimination, Gauss-Seidel methods and Newton-Raphson Heraton methods of solving linear equations. Forward and backward difference tables, central difference formula, Finite difference solution to partial differential equations. Solutions of ordinary differential equations (1^{st} and 2^{nd} order) using Runge-Kutta method. Flow charting, Algorithms, input and output, Basic, Fotran and Modern languages. Computer software analysis, Highway/Transportation, geotechnical, Hydraulics/Hydrology problems and Construction Management.

Statistical Methods (2 Units)
Descriptive Statistics: Central tendencies and dispersion. Elementary probability theory, conditional probability, Baye's theorem, probability distributions and applications. Elementary theories of sampling and estimation. Test of hypothesis and significance. Curve fitting, Linear and Multiple regression analysis; Linear correlation, analysis of variance, time series analysis. Statistical quality control for mean, standard deviation, range, number of defects etc., sampling number, stochastic processes.

Engineer-in-Society (2 unit)
Philosophy of Science, History of Engineering and Technology. Safety in engineering and introduction to risky analysis. The role of engineers in nation building. Invited lectures from Professionals.

Technical Report Writing (2 Units)
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).

Law, Management and Entrepreneurship (3 Units)
Principles of Management, Industrial group and organisational behaviour, Motivation, Industrial Law, Legislation on wages, Trademarks and patents, Laws of contract and sales of goods. Liability for industrial injuries , Industrial relations, Trade Unions, employer Associations, Wages bargaining and the role of the State, Relevant topics on entrepreneurship designed by the National Universities commission for Nigerian Universities.

8. POSTGRADUATE PROGRAMMES

8.1 CIVIL ENGINEERING

Introduction

Civil engineers plan and design, construct, operate and manage, or conduct research and development on engineering systems. These systems include buildings, bridges, tunnels, power plants, highways, airports, harbours, water supply and water treatment systems, housing and mass transit facilities, and protection of man and his environment.

The civil engineering programme offers postgraduate programmes of course work and research leading to the award of the following degrees:

a. Postgraduate Diploma (PGD)
b. Master of Engineering (M.Eng.), Master of Science (M.Sc.)
c. Doctor of Philosophy (Ph.D)

Objectives

The Postgraduate Diploma Programme (PGD) in Civil Engineering is to provide a bridging course for HND holders of Polytechnics to be registrable with COREN or aspire to higher degrees, if they perform to acceptable standards. In addition, graduates of some physical or chemical sciences could be convertible to engineers via the PGD programmes.

The M.Eng./M.Sc. accords the engineer the opportunity to apply recent technological developments to the solution of emerging Civil Engineering problems. The objective is to provide opportunities for the development of the student's professional Engineering competence and scholarly potentials. It is structured so that the student can attain academic mastery in one of the areas of study within the Civil Engineering disciplines.

The PhD degree in all disciplines of Civil Engineering is to develop the engineer to the highest level possible for decision making and particularly research. It trains the student to consider and handle complex problems and also initiate students into research.

8.1.1 Postgraduate Diploma

Admission Requirements:

a. Higher National Diploma (HND) in Civil Engineering with at least, lower credit; or
b. B.Sc., B.Eng., or B.Tech. degree in Civil Engineering with at least third class (Hons) or pass degree; or
c. B.Sc. in Building with a minimum of second class (lower); or
d. Higher national Diploma (HND) in Water Resource Engineering with at least, a Lower Credit; or
e. B.Sc./B.Eng. in Water Resources Engineering with at least a third class (Hons) degree.

Graduation Requirements

To qualify for the award of Postgraduate Diploma, a candidate must have been unitized with at least 64 units of compulsory courses which include the project report.

YEAR ONE

COURSE TITLE	CONTACT HOURS			UNITS
	L	T	P	
YEAR ONE: First Semester				
Engineering Mathematics I,	2	2	0	3
Numerical Methods & Computer Programming,	1	2	3	3
Engineer-in-Society	1	2	0	2
Structural Analysis I,	2	2	0	3
Soil Mechanics,	1	2	3	3
Fluid Mechanics,	1	2	3	3
Civil engineering Materials,	1	0	3	2
Total				19
Year One: Second Semester				
Engineering Mathematics II MTH602	1	2	0	2
Statistical Methods	1	2	0	2
Technical Report Writing	1	2	0	2
Structural Analysis II,	2	2	0	3
Geotechnical Engineering I,	2	2	0	3
Hydrology,	1	2	0	2
Civil Engineering Practice	2	2		3
Transportation Engineering I,	1	2	3	3
Total				**20**
Year Two: First Semester				
Design of Reinforced. Concrete Structure	2	0	3	3
Hydraulic Engineering	2	2	0	3
Transportation Engineering II	2	2	0	3
Environmental Engineering,	1	2	3	3
Construction Management	2	0	0	2
Total				**14**
Year Two: Second Semester				
Law, Management & Entrepreneurship	1	2	0	2
Geotechnical Engineering II	1	2	0	2
Design of Structure in Steel & Timber	1	2	0	2
Water Resources engineering	1	2	0	2
Project	0	0	18	6
Total				**14**

ii. STRUCTURAL ENGINEERING

Structural Analysis I (3 Units)

Review of statistical/Kinematic indeterminacy; Determination of internal, external forces and deformations in structures using MDM, Slope deflection, energy equations, three moment equations, moment – area theorems, double integrations, strain energy etc. Influence lines.

Structural Analysis II (3 Units)

Matrix methods of structural analysis: Flexibility and stiffness methods, plastic analysis of structures. Finite difference and finite element techniques. Analysis of plates and thin shells. Introduction to structural dynamics.

Design of Reinforced Concrete Structures (3 Units)

Limit state design theory, codes of practice, Design of reinforced concrete elements: beams, columns, slabs, foundation, multi-storey building. Introduction to prestressed concrete: Definitions, pretensioning and post tensioning, advantages/disadvantages, losses in prestress, analysis and design of prestressed elements.

Design of Structures in Steel and Timber (3 Units)

Review of design of steel members in tension, compression and bending, Design of structural steel connections. Design of beams, compound beams, columns, compound columns, industrials column and column foundations. Analysis of lattice girders: trusses, portal frames, General frames, masts, towers etc. Types and properties of Timber species in Nigeria. Review of design of Timber members in tension, compression and bending. Design of Timber connections, beams, trusses, columns, towers, masts etc.

iii. GEOTECHNICAL ENGINEERING

Soil Mechanics (3 Units)

Review of classification techniques based on size, G. I. soil classification systems including AASHTO, USCS etc. Phase relationships in soils (consistency/atterberg limits). Field exploration stages, techniques, boring and sampling tools/equipment, disturbed/undisturbed sampling, SPT, Dutch cone, Vane plate loading tests, Report writing. Soil properties, consolidation and settlement, Ground water flow and seepage (permeability, flow net), laboratory tests to determine shear strength of soils.

Geotechnical Engineering I (3 Units)

Review of Structural foundations; types, choice and design, Slope stability analysis; Total stress, Parallel slope, Tension crack, Swedish circle, Taylor's technique, Bishop conventional, simplified and resource methods, Factor of safety. Bearing capacity: Ultimate, safe and allowable.

Geotechnical Engineering II (2 Units)

Earth pressure design: types of walls, limiting equilibrium equations, earth pressure at rest candling active and passive pressure equations and applications to gravity and counterfort walls. Coulomb methods and applications. Sheet pile walls: Cantilever and propped/ anchored, revised safety factor, examples of design. Reinforced earth theory

and application to walls. Pile foundations: types, design approaches, empirical and analytical design, skin frictions, piles in clay and granular soils. Buried structures and tunnels. Ground improvement techniques.

iv. HYDRAULIC ENGINEERING

Fluid Mechanics (3 Units)

Fluid properties, statics and buoyancy and stability of floating and submerged bodies. Fluid flow concepts and basic equation. Dimensional analysis, dynamic similitude. Flow of real fluids: viscous effects, resistance, compressible flows. Ideal fluid flow: rotational and unrotational flows, velocity potential, Bernoulli equation, stream functions and flows nets. Application of fluid mechanics, fluid measurement, turbo machinery, steel closed – conduct flows, steady flow in open channels. Unsteady flows.

Hydrology (2 Units)

Hydrologic cycle, History of hydrology, scope and application of hydrology, climatic measurement, precipitation and precipitation analysis, analysis of hydrologic data including statistical inferences, infiltration, Evaporation and Evapotranspiration, run off and hydrograph analysis, stream and reservoir routing, Ground water exploration and well hydraulics, Design criteria for hydrochloric projects, sediment transport. Ground water exploration.

Hydraulic Engineering (3 Units)

Types of flows in open channels and closed conducts, turbulent flows. Water waves and wave characteristics. Steady and unsteady, uniform and non-uniform flow in open channels, Natural streams back water curve. Hydraulic jumps and energy dissipation. Hydraulic similitude and application to hydraulic models. Water hammer, water turbines and centrifugal pumps.

v. ENGINEERING PRACTICE

Civil engineering Materials (2 Units)

Concrete: physical and rheological properties of concrete. Properties of components of concrete: cement, aggregates, water and admixtures. Mix design. Methods of production of Asphalts, Tars, Bitumen and Emulsions: properties and uses. Properties of Timber, Glass, Plastics, Asbestos, clay bricks, Steel and other construction materials. Alternatives to cement, Lime and Soils.

Civil Engineering Practice (3 Units)

Civil Engineering as a profession: functions, training and responsibilities. Requirements for registration with professional bodies, roles and responsibilities of parties in Civil Engineering Projects. Stages of Engineering project execution including conception, feasibility studies, detailed design, preparation of Civil Engineering quantities, BEME, types of contracts, preparation of contract documents, tendering procedures, evaluation and award, Law of contracts, Arbitration Law.

Construction Management (2 Units)

Structure of the construction Industry: Organisation Structure, Construction Planning and Administration. Earthworks and Earth moving equipment. Total quality

management in construction. Application of operation research techniques in construction work. Network analysis (CPM and PERT), Bar charts, progress report and charts, Labour laws, site safety, law of Torts.

vi. ENVIRONMENTAL/WATER RESOURCES ENGINEERING

Environmental Engineering (3 Units)

Examination of Water and Wastewater. Collection, treatment, protection and distribution (including design of facilities) of water, municipal and industrial Wastewaters. Fundamentals of Solid Waste Management, Air Pollution Control, Stream Pollution.

Water Resources Engineering (2 Units)

Urban hydrology, Drainage and Land reclamation, Dam and reservoirs, spillways and stilling basins, Design of Irrigation Canals, Hydropower, River Basin Planning, Water Supply Engineering.

vii. TRANSPORTATION ENGINEERING

Transportation Engineering I (3 Units)

Introduction of different modes of transportation: Highways, Railways, Air transport and Airports, Water transport, dock and habours, pipelines, conveyor belts. Traffic flow theory, traffic management and control, Road safety/accident analysis, Highway lighting.

Transportation Engineering II (3 Units)

Route location and design, Geometric design of highways, pavement design and construction (flexible and rigid), Highway materials, Drainages and Earthworks.

Project (6 Units)

A guided/supervised individual investigation of a civil engineering problem in the student's chosen area of specialisation under a staff direction. Student should demonstrate creative engineering ability and it will culminate into a written dissertation that will be examined and approved by a panel of examiners.

8.1.2 M.Eng./M.Sc., M.Phil and Ph.D Programmes

The department shall run M.Eng./M.Sc. degrees in the following Civil Engineering disciplines:

a. Geotechnical Engineering;
b. Structural Engineering;
c. Transportation Engineering;
d. Water Resources Engineering; and
e. Environmental Health Engineering.

Duration of Programme

The duration shall be as specified for all Engineering programmes.

Admission Requirements

An applicant whose degree is in another field of engineering or sciences may be required to take some makeup course work in Civil Engineering, in additional to the curriculum

prescribed in this document. This will be determined by the departmental postgraduate committee. The basic admission requirements shall be:

i. Candidates with a Bachelor's degree with at least a Second Class Honours or its equivalent in Civil Engineering from a recognized University.
ii. Candidates having a Bachelor's degree with at least a Second Class Upper Honours or its equivalent in allied fields such as Building from a recognized university and a Postgraduate Diploma, (PGD), with at least an Upper Units pass in Civil Engineering from a recognized university.
iii. Candidates with a Bachelor's degree with at least a Third Class in Civil Engineering and a PGD with at least an Upper Units Pass in Civil Engineering from a recognized university
iv. Candidates having HND with at least a Lower Credit pass in Civil Engineering and a PGD with at least an Upper Credit pass from a recognized University.

A. GEOTECHNICAL ENGINEERING

This course comprises a study of the physical and mechanical properties of soils and soft rocks in relation to civil engineering problems, and of the principal theoretical methods and their application in practices to foundations, earth pressures, tunnels, slope stability, embankment and dams etc. The preparation of a dissertation on some particular aspects of soil mechanics and laboratory classes in soil mechanics and rock mechanic form part of the course. Field trips and site visits should be arranged in the year.

List of Courses	Units
Soil Properties	3
Seepage	2
Stability of Soil and rock slopes	2
Foundations on soils	3
Earth Pressure	3
Theory and Measurement of shear strength & deformation	3
Embankment and Dams	3
Laboratory and Field techniques I	2
Engineering Geology of Sediments	3
Environmental Geotechnique	3
Geosynthetics	3
Total	

Electives

List of Courses	Unit
Laboratory and Field Techniques II	2
Rock Strength and Failure	3
Soil Dynamics	3
Total	8

Electives

Soil Properties (3 Units)

The principle of effective stress in saturated and partially saturated soils. Deformation and pore pressure changes in soil under stress. The measurement of pore pressure, shear strength and deformation in the laboratory; triaxial apparatus, shear box, torsion shear and vane tests. Failure criteria in terms of total and effective stress.

Seepage (2 Units)

Steady and unsteady seepage of water through porous incompressible media. Analytical, numerical and graphical methods for solution of practical problems.

Consolidation (2 Units)

One dimensional consolidation of clays. Non-homogeneous strata. Moving boundary problems. Three-dimensional consolidation; theories of Terzaghi and Biotechnolgy Design of sand-well installations. Secondary consolidation.

Stability of Soil and Rock Slopes (3 Units)

Morphological and geotechnical classification of landslides and other mass movements. Methods of stability analysis for two- and three – dimensional failures in granular and cohesive soils and in rocks. Toppling failures. Short-term, intermediate and long-term conditions. Back-analysis techniques. Case records. Shear strength parameters, Site investigation of landslides, Slope development, Stabilisation measures.

Foundations on Soils (3 Units)

Principles of foundation design. Heave and collapse of desiccated soils. The estimation of ultimate bearing capacity and settlement of footings, rafts and piles constructed in free draining and non-free draining soils.

Earth Pressure (3 Units)

Earth pressure in the at-rest, active and passive states in sands and clays. The influence of ground water. The initial and long-term stability of earth-retaining structures. The design of gravity and sheet pile walls. The stability of strutted and slurry trenches. Earth pressure on rigid structures.

Theory & measurement of shear strength & deformation (3 Units)

Properties of a three-dimensional space, stress path and correlation of drained and un-drained test results. In-situ strength and the sampling problem, field and laboratory tests. Anisotropy and sample size efforts. Rate effects and creep. Residual strength and progressive failure. Failure criteria and the influence of the intermediate principal stress; compression, extension, plan strain etc. Stress-strain theories for soils and their application.

Embankment and Dams (2 Units)

Principle of design and stability analysis; stress distribution and deformation. Prediction of pore pressures during construction, steady seepage and rapid draw-

down. Properties of earth and rock fills. The control of cracking and the design filters.

Laboratory and Field Techniques I (3 Units)
Principles of the laboratory measurement of load, stress, strain and Porewater pressure. Measurement with electronic sensors. Model analysis. Site investigation. Soil sampling and drilling. Sounding Test. In-situ strength. In situ stresses. Earth pressure cells. Displacement monitoring. Piezometers. Field loading tests.

Laboratory and Field Techniques II (2 Units)
Strain waves in rock. Microseimic techniques. Rock sampling and drilling. Core orientation and borehole structural logging. Shear measurement of rock masses. Field loading tests. In- situ strength. Ground water flow.

Rock Strength and Failure (3 Units)
The behaviour of rock material in uniaxial and multiaxial compression test – the influence of test conditions and testing system stiffness. Tensile behaviour of rock. Fracture and yield criteria for rock material. Shear strength and deformation of discontinuities in rock. Failure mechanisms and strength of jointed rock masses – the single plane of weakness theory, Ladanyi's shear strength theory, empirical strength theories.

Engineering Geology of Sediments (3 Units)
The relationship between the geology of sediments and their engineering properties, including classification and description. Brief case histories. Mass, Structural, textural and mineralogical composition of sediments. Tropical soils, Residual soils. Weathering processes and Products. Pure and applied clay mineralogy and subsequent composition, depositional environments and subsequent geological changes on the behaviour of sediments. The origin of naturally occurring structurally unstable soils.

Environmental Geotechnique (3 Units)
Physio-Chemical properties of clays, chemical effects on soils, site investigation for chemical sensitivity, contaminate fate and transport environmental regulations, in-situ and laboratory tests; design of dewatering, containment, remediation systems including slurry/reactive walls, linear, covers, case studies.

Geosynthetics (3 Units)
Material properties, standard test data soil-geosynthetic interaction; design of reinforced soil structures (walls, slopes, embankments); design of filtration and drainage works; design of geomembrane-lined waste containment facilities; regulatory requirements, case history applications.

Soil Dynamics (3 Units)
Seismic loading and its effect on earth structures; dynamic response of single and multi-degree of freedom systems and continuous systems; behaviour of soil under

dynamic loading; pore pressure generation and liquefaction effects; seismicity and seismic design parameters; dynamic analysis of earth structures; seismic design of soil-structure systems.

B. **STRUCTURAL ENGINEERING**

It covers subjects required by reinforced and pre-stressed concrete designers and concrete technologist. It provides training in the art of structural steel design and timber technology

List of Courses	Units
Advanced Reinforced Concrete design	3
Advanced Engineering analysis I	3
Advanced Structural Analysis	3
Analysis and design of Plates and Shells	3
Analysis and design of Prestressed concrete	2
Concrete materials	3
Advanced Fracture Mechanics	3
Plasticity in Steel Structures	2
Connections and Plated structures	3
Advanced Design of Steel and Composite Structures	3
Properties and Utilization Timber	3

Electives

List of Courses	Units
Deterioration and preservation of Timber	**3**
Special Steel Structures and Products	**3**

Advanced Reinforced Concrete Design (3Units)

Aims of structural design. Factors in design function, safety, economic. Successive stages in the design process. Excellence in design, Innovation in design. The designer and the profession. The designer and the society. Basic behaviour of reinforced concrete, leading to elastic and inelastic methods of design. Introduction to limit state concept. General review of design recommendation of BS 8110 (The structural use of concrete); comparison with ACI, DIN, NCP and other codes, where appropriate. Concept of the equivalent stress block. Design of sections in bending, shear, and a combination of axial load and bending. Design for torsion. Basic analysis of shear. Design of non-prismatic sections. Column with bi-axial bending. Design of two-way slabs by yield-line method, curtailment of positive and negative reinforcement, practical examples. Application and worked examples on the ultimate load design of continuous structures. Design of flat slab by the yield-line methods, practical examples. Point-load and line-load on slabs introduction to the optimum design of continuous beams. Full analysis of shear. Introduction to the design of two-way slabs by the strip beam method. Design of deep beams cracked flexibility and deflection of beams. Characteristics of materials as seen from the designer's

point of view; mass reinforced and pre-stressed concrete. Summary account of structural types, design factors and typical problems in bridges, harbour works, aircraft runways and roads, machinery, framework and foundations, large-span roofs in buildings. Typical and notable failures.

Advanced Engineering Analysis I (3 Units)

Reduction of matrices to triangular form by elementary matrices. Factorisation by choleski's method. Schmidt orthogonalisation. Existence of solutions of linear equations. Green's theorem., Eigenproblems. Basic numerical integration and differentiation. Structural systems considered as assemblages of discrete structural elements; application to two – dimensional solids, folded plates; axisymmetric shells and free – form shells; solution techniques for large systems and for extension to dynamic analysis studies of numerical methods for structural analysis with examples, e.g. bridge decks.

Advanced Structural Analysis (3 Units)

Review of elementary statics and kinematics. Contragredience. Static-kinematics duality. Introduction to the mesh method of elastic analysis. Introduction to the analytical methods appropriate when wind, blast and seismic loads are treated as time - varying. Types of dynamic loading. One-degree-of-freedom systems. Free and forced undamped vibrations. Resonance. Vibratory motion of support. Some half wave and rectangular impulses. Damping, free and forced viscously-damped vibrations. General impulse loading and the convolution integral. The response spectrum. Generalised coordinates. Rayleigh's method. Multi-degree-of-freedom systems. Flexibility and stiffness coefficients, D'Alembert's principle, Hamilton's principle, Lagrange's equations. Introduction to random vibration spectral analysis.. The nodal method of elastic analysis. Elasto-plastic deformation analysis. Applications of mathematical programming methods to plastic analysis, elastic synthesis and plastic synthesis of skeletal structures. Finite element method.

Analysis and Design of Plates and Shells (3 Units)

Introduction to continuum mechanics: three-dimensional theory of elasticity, basic equations and theorems. Two-dimensional elasticity plates under in-plane loading. Rectangular and circular plates in flexure: the methods of Navier and levy, the theory of membrane applied to plate bending, plates on elastic foundation. Anisotropic plates with special reference to reinforced concrete slabs. Stability and vibration of plates and plate systems. Large deflexion theory. Variational techniques: the methods of Ritz Galerkin and kantorovitch. Introduction to shell theory; membrane hypothesis, cylindrical shells, shells of revolution, translational shells, shallow shell theory; the static – kinematic analogy of Gol'denveiser, Lur'e and Calladine; the two-surface theory with numerical applications. Stability and vibrations of shells. Advanced shell topics.

Analysis and Design of Prestressed Concrete (2 Units)

Phases of design. Design philosophy. General requirements of limit state design. Thick-walled and thin-walled beam theory. Design and analysis of sections

subject to bending, torsion, axial force and shear for the limit state of cracking and for the ultimate limit state. Design and analysis of statically determinate structures for the limit state of deflection. Examples of the above applied to prismatic and non-prismatic statically determinate beams with constant and varying prestressing force. Review of recent research in the characteristics of prestressed members. End-block design.

Concrete Materials I (3 Units)

Properties and methods of testing cements, aggregates, water and admixtures. Properties of fresh and hardened concrete. Method of testing fresh and hardened concrete. Statistics and quality control. Design of concrete mixes. Field control, of concrete. Specifications, inspection and testing in the filed. Vacuum and ready-mixed concrete. Construction techniques including formwork, joints, water-retaining structures, surface finishes, repair and maintenance. Application of concrete properties to structural problems and implication of BS 8110. Nature, behaviour and properties of real material. Rheological properties of fresh concrete. Structure and properties of hardened cement paste. Structure and properties of mortars and concretes. Engineering properties of materials. Engineering properties of concrete including time-dependent behaviour and environmental effects. Criteria for the fracture and failure of concrete under simple and combined stress states. Special concretes and processes including lightweight, heavy, fire-resistant, refractory polymer. Methods of testing. Evaluation of concrete quality in structures. Case studies of actual site investigations.

Advanced Fracture Mechanics (3 Units)

Methods of manufacturing steel. Properties of steel, including qualitative treatment of brittle fracture, fracture mechanism and fatigue. Methods of Fabrication, tolerance and workmanship; Connection Philosophy, Welding Technology, corrosion, Fire Protection. Brittle fracture and transition temperatures. Linear-elastic fracture mechanics. Yielding mechanics. Crack opening displacement design curves. Fatigue crack propagation. Non-destructive testing. Calculation of permissible defects. Calculation of fatigue lives.

Plasticity in Steel Structures (2 Units)

Incremental collapse and alternating plasticity of beams and plane frames. Grillages in bending only. Yield criteria, flow rules, normality plates under normal loading only, plates under combined in-plane and normal loading. Torsional behaviour of thin-walled members of open and closed cross section. Pure and restrained torsion, shear, centres. Element behaviour and design. An introduction to the design members under new code provisions covering tension members, axially loaded compression members, beams and columns with biaxial bending and lateral torsion buckling. Inelastic stability concepts in modern design, compact section provisions, imperfection sensitivity, moment relaxation, inelastic lateral torsion buckling provisions and the design of bracing. Beam-column behaviour and design under sway and no-sway conditions.

Connections and Plated Structures (3 Units)

Introduction to principles of connection design. Bolts, rivets, types and technology. Behaviour of individual bolts and rivets, static behaviour and design of bolted/riveted connections. Fatigue in bolted and riveted connections. Welds, behaviour of unit welds, behaviour and design of welded connections. Design of other components within the connection. Design of tubular connections. Interaction of connection and structural behaviour, e.g. simple, semi-rigid and rigid frames. Plant stress; plant strain; shear lag, stress diffusion, stress concentrations. Small deflections theory for orthotropic plates, orthotropic plate rigidities for stiffened plates. Linacarised theory for combined loading. Large deflection theory. Critical buckling of plates in compression and/or shear; post-buckling of perfect plates. Buckling of geometrically imperfect plates; effect of residual stress. Strength of imperfect plates in compression, and/or shear. Plate assemblages and interacting plate buckling modes; bases for slenderness limitations for stiffeners; bases for design of compression flanges, webs and diaphragms in box girders. Design of plated members. Plate and box girders.

Advanced Design of Steel and Composite Structures I (3 Units)

Principles of Composite Construction: Composite plates, composite beams, elastic and plastic design, composite columns. Shear connection. Static and fatigue loading. Single-storey buildings: introduction, structural forms, portal frames, plastic design, secondary effects. Behaviour and design of eccentrically restrained beams and columns. Built-up members, trusses and built-up columns. Bracing requirements. Methods of cladding, stressed skin design. Cranes and crane girders. Multi-Storey Buildings: introduction, classification of steel multi-storey buildings and framing. Braced, core, hull and sway structures. Behaviour and analysis of sway frames and restrained columns. Simple, semi-rigid and rigid design methods. Design of composite frames. Bridges: Types of structure, loading, practical fatigue design. Plate girder design. Box girder design, composite bridges.

Special Steel Structures and Products (3 Units)

Structural forms., special steel structures such as: masts and towers; orthotropic bridges decks; tubular structures; space frames; cable stayed bridges; cable roofs; bins, hoppers and tanks; curved bridges; very tall building; offshore structures. Types and technology of structural steel

Properties and Utilization of Timber (3 Units)

Botanical aspects: Structure, identification, natural defects, strength properties of timbers; tension, compression, shear, bending. Factors affecting strength: defects, moisture content, density, temperature, duration of load. Grading; end use, appearance, visual and mechanical stress grading. Derivation of basic and grade stresses. Seasoning: moisture relationships, methods of drying. Biodeterioration: fungal decay and insect attack. Woodworking properties. Manufacture and utilization of panel products: plywood, chipboard, fibre board. Structural forms of timber buildings: housing, industrial, educational, farming. Elementary structural analysis: beams, columns, simple trusses. Jointing methods: nails screws, bolts,

connectors, adhesives. Housing requirements and standards: needs, resources, government policies and programmes, standards and economic development. Low-cost housing: methods of cost limitation, urban-rural philosophy and materials. Housing construction: frame, post and beam, cross wall. Preservation: requirements, types, methods of application.

Deterioration and Preservation of Timber (3 Units)

Types of degrade and defects: fungal and insect attack, natural degrade and defects, conversion and seasoning. Specification: species and use, equilibrium moisture content and variation. Protection against: weather, condensation, rising damp. Fire effect and hazard: fire resistance and fire protective construction. Termite resistant construction: poisoning, treatment and design considerations. Earthquake and hurricane resistant construction. Protection by treatment: uses of preservative treatment, surface finishes. Durability of timber: natural durability, effect of drying, toxic extractives, fungal and insect attack: moulds, stains, soft rot, brown and white rots, wood-boring insects, termites and marine bores. The process of fungal decay: spectrum of interaction between fungi and wood, association and succession of fungi. Wood preservative chemicals: tar oils, water-borne types, organic solvents. Application of preservatives; surface treatments, impregnation by vacuum and pressure, diffusion processes.

C. **TRANSPORTATION ENGINEERING**

This course is to provide a thorough understanding of the movement of people and goods and techniques for analyzing transport problems and evaluating measures for resolving them. It is designed to equip numerate graduates from a variety of disciplines for work in the transport field in planning, engineering operations, design and construction, policy and research.

List of Courses	**Units**
Transport and its Context	3
Quantitative Methods in Transport Studies	3
Transportation Engineering	3
Transportation Economics and Policy	3
Forecasting and Modeling of land-use and Movement	3
Transportation Engineering and Operations	3
Operations of Existing and Alternative transport Systems	3
Transport in Developing Countries	3
Pavement Analysis and design	2
Advanced Surveying and Photogrammetry	2
Total	

Electives

Advanced Transport Modeling	3
Transport and the Environment	3
Systems Engineering Techniques in Transport Studies	3
Total	

Transport and its Context (3 Units)

Transport and land use: the town planning context and its evolution; social, economic, spatial and environmental effects of transport; the scale and causes of movement of people and goods; basic characteristics and roles of various forms of transport; reasons for current dependence on the motor vehicle. Legislation and administration: powers and duties of Nigerian local authorities in respect of transport, including highways; the roles of central government; financial arrangements; passenger and freight transportation operations; professional responsibilities in an interdisciplinary context; public consultation. Evolution of transportation planning: early developments, major land-use-transportation studies, changing attitudes and more recent approaches; influence of the professions, the public and government policy.

Quantitative Methods in Transport Studies (3 Units)

Introduction: Quantitative aspects of decision – making and research; scientific methods; description and hypothesis testing; estimation, optimization and simulation. Data collection and analysis: types of data; variability and error; sampling; design and execution of surveys; analysis and interpretation of results; data bases and their availability. Probability and statistics: discrete and continuous distributions, estimates and standard errors; inference and hypothesis testing; regression; analysis of variance; analysis of time-series. Operational research methods: optimization, objective functions and constraints; linearity and convexity; linear models and linear programming; methods for non-linear problems; graphs and networks. Computing: programming in Basic, Fortran, C+, C++ and modern languages; use of subroutines and sub-programs, graphics; use of library programmes and packages/software.

Transportation engineering (3 Units)

Introduction to general transportation systems. Surveys. Earthwork calculations. Geometric design. Compaction and stabilization. Pavement materials, structure and design. Airport and Railway Engineering. Highway planning and traffic engineering, Intersection design. Traffic management. Design of traffic control system.

Transportation Economics and Policy (3 Units)

Introduction to economic theory: application of economic concepts to transport etc. Economic evaluation, policy. Comprehensive evaluation of plans and policies.

Forecasting and Modeling of Land-use and Movement (3 Units)
The conventional modeling approach: zones and networks, data on population and economic activity etc. Alternative modeling approaches: disaggregate models, including multinomial legit models, attitudinal models, etc.

Transportation Engineering and Operations (3 Units)
Engineering and operational characteristics of different means of transport: track, vehicle and their interaction; power, acceleration, speed, breaking, and guidance; carrying capacity, costs including maintenance and fuel consumption; risk of accident and injury. The road system: range of functions; parameters of traffic flow; capacity and level of service; junction delay; design of highways and free-flow junctions; design and operation of priority junctions, roundabouts and traffic signals; provision for pedestrians, cyclists, parking and loading, traffic management and control. Railway systems: range of functions; aspects of operations more relevant to transport planning. Passenger transport. Freight transport.

Operations of Existing and Alternative Transport Systems (3 Units)
Operation of existing systems: Bus services, Rail services. Role and function of para-transit operations. Interchanges. Park and ride. Airport interface considerations. Scope and potential of alternative systems: comparative characteristics, roles and potential benefit of light rail systems; High speed trains, monorails; tracked hover craft; personal rapid transit systems; pedestrian conveyors; Aerial ropeways; pipelines and conveyors; Airships.

Advanced Transport Modeling (3 Units)
Introduction conceptual and theoretical developments. Modeling transport demand and supply. Estimation techniques. Further topics.

Transport and the Environment (3 Units)
Environmental effects of transport. Environmental factors in design. Environmental assessment of transport schemes.

Transport in Developing Countries (3 Units)
Introduction. Transport problems, planning and modeling, project evaluation. Choice of technology. Issues in transport policy.

Systems Engineering Techniques in Transport Studies (3 Units)
Introduction. Elements of system design. Simulation. Decision analysis. System analysis and social choice.

D. **M.SC. WATER RESOURCES OR ENVIRONMENTAL HEALTH ENGINEERING (THREE OPTIONS)**

i. **First Semester (compulsory Courses)**

List of Courses	**Units**
Hydraulics I	2
Engineering Hydrology	2
Numerical Methods	3
Water Law, Management and Economics	2
Principles of Water Quality	3
Seminar	1
Total	13

ii. Second Semester (Option A): Hydraulics & Engineering Hydrology

List of Courses	**Units**
Hydraulics II	2
Dams Design and Reservoir Operations	2
Catchment Modeling	2
Surface Water Hydrology	2
Hydrodynamics	2
Environmental Impact Assessment	2
Seminar	1

iii. (**Option B): Irrigation and Drainage**

List of Courses	**Units**
Hydraulics II	2
Dams Design and Reservoir Operations	2
Design of Irrigation Systems	3
Ground Water Hydrology	2
Land Drainage Conservation and Reclamation	3
Environmental Impact Assessment	2
Seminar	1

iv. (Option C): Environmental Health Engineering

List of Courses	**Units**
Environmental Impact Assessment	2
Wastewater treatment and disposal	3
Environmental Pollution Control	3
Elements of Public Health	3
Water treatment and supply	3
Seminar	1

v. Electives (Pick at least 6 Units)

List of Courses	**Units**
Aspects of Occupational Health and Safety	2
Hazardous waste processing technology	2

List of Courses	Units
Small Watershed System Design	2
Waste Resource Infrastructure	2
Urban and Regional Planning	2
Applied Statistics	2
Systems Analysis in Water Resource Management	2
Bioremediation	2

COURSE DESCRIPTION

Hydraulics I (2 Units)

Water flow in open channels: review uniform flow and energy principles in open channel flows. Varied flows; classification and computation of water surface profile; direct integration and direct step methods etc. Problem related to canal design; hydraulic jump; surges though channel transitions. Flow in pipes; friction factors etc. Empirical formulae for flow in pipes, pipe branching, pipes networks. Hardy-Cross method, valves and hydrants; reservoirs, standpipes and elevated tanks; hydraulics of sewers. Water pumps: power and efficiency of pumps etc. Hydraulic similitude: Reynold's number Law, Froude number Law, Weber number law. Models: Open channel, hydraulic, distorted river and channel models.

Engineering Hydrology (2 Units)

Atmosphere circulation; sources of rainfall. Hydrological oyele. Measurement and analysis of rainfall data. In filtration and soil moisture measurement. Stream flow gauging methods; hydrograph analysis; instrumentation. Aquifers; types and properties; flow nets; hydraulics of wells; pumping test analysis of ground water follows.

Numerical Methods (3 Units)

Course given in Civil Engineering Department or other appropriate Department.

Water Law, Management and Economics (2 Units)

Legislation relating to water resources. National water Policy. Management of water resources. Trans boundary waters. River authorities, their organization and responsibilities. Water boards/utilities, their organization and function; Contract and land acquisition laws for water resources development. Planning for water Resources development for different uses. Balancing water supply and demand. Project formulation. Multiple purpose projects. Systems analysis. Cost allocation. Economics of water resources development.

Principles of Water Quality (3 Units)

Physical, chemical and microbiological aspects of water resources planning. Surface and groundwater quality. Principles of chemical analysis of water. Instrumental procedures for quality assessment. Standards for water for different purposes. Refractive substances in water and their affects on water usage. Microbiology of biological water treatment processes.

Hydraulics II **(3 Units)**

Unsteady flows: Water hammer. Basic differential equations. Mechanisms of wave reflection. Arithmetic integration, surge control. Theory of mass oscillation. Surge tanks.

Hydrodynamics **(2 Units)**

Eulers equations. Narvier – Stokes equations. Effects of viscosity. Laplace equation. Waves (deep-water, short and long tidal waves). Dynamics of fluids. Sediment transport in open channels. Bedload and suspended load. Duboys-type equations. Einsteins bedload equation. The total load. Canals in regime. Meandering of rivers. Measurement of sediments. River and channel models.

Catchments Modeling **(2 Units)**

Hydrologic, mathematical/modeling techniques. Black box models. Rainfall run-off models. Deterministic and water budgeting models. Parameter optimization; modeling of component processes and channel flow. Forecasting models. Parameter updating. Time series models. Box and jenkins models. Other long memory models.

Surface Water Hydrology **(2 Units)**

Meteorology and hydrometry. Precipitation and run-off. Stream flow measurements. Evapotranspiration Catchments flood-producing characteristics. Drought occurrence. Empirical methods and rational formula of drought prediction. Unit hydrograph, S-curves. Instantaneous unit hydrograph. The Nash model. Hydrological forecasting and data fitting techniques. Probable maximum precipitation and probable maximum flood methods. Methods of routing floods through open channels and reservoirs, Simplified hydraulic routing methods. Statistical and stochastic hydrology.

Hydrology **(2 Units)**

Geophysical investigations. Geochemical methods. Hydrology of an area including estimation of recharge. River – aquifer interactions. Pumping tests, analytical and numerical methods. Mathematical modeling of aquifers. Sensitivity analyses. Pollution of groundwater. Remedial action in aquifers. Artificial recharge. Case study of groundwater flows in sedimentary aquifers.

Dams Design and Reservoir Operations **(2 Units)**

Types of dams. Investigation of dam sites. Requirements for stability of gravity dams. Design procedure for gravity dams. General principles for designing rock and earth fill dams. Seepage through dams. Seepage line in earth dams of composite cross-section. Effect of drainage on line of seepage. Foundations – types and treatment. Slope protection. Typical design of embankment dams, and methods of construction. Hydropower plants. Types of plants, Penstocks, tunnels and water turbines. Physical characteristics and capacity of reservoirs. Sedimentation. Reservoir capacity for given yields. Site selection for river reservoirs. Wind set up and waves on reservoirs. Flood routing through reservoirs. Flood mitigation, direct supply and regulating reservoirs. Pumped storage

reservoirs. Conjective use schemes. Control rules. Simulation-Evaluation criteria for comparing alternative. Seasonal effects and correlations. Spillways, gates and outlet works. Overflow (ogee), chute, side-channel, siphon and shaft spillways. Spillway crest gates. Vertical lift, radial, rolling, drum gates and high pressure outlets. Gates and valves. Needless valves. Protection against scour below dams. Basins and energy dissipaters. Hydraulic model studies. Fish ways at dams.

Irrigation Systems and Water Conservation (2 Units)

Irrigation water (general considerations). Crop water requirements. Water holding properties of soils. Crop response to salts and water. Components of water distribution systems. Control of irrigation water. Water application systems. Environmental and social aspects of irrigation schemes. Management of irrigation projects. Case studies feasibility studies of small and large scale irrigation schemes.

Land Drainage Conservation and Reclamation (2 Units)

Sources of drainage problems in humid and semi-arid regions. Drainage surveys and investigations. Design of surface and subsurface drains. Drainage by vertical works. Reclamation and management of saline and alkaline soils. Numerical solution of drainage problems.

Environmental Pollution control (2 Units)

Water pollution: Sources and characteristics of pollutants. Effects of pollutants on the properties and ecology of receiving waters. Natural self-purification of streams. Oxygen, nitrogen and phosphorus balance in streams. Europhication, stream standards. Determination of the required degree of water treatment. Interrelationship between wastewater treatment and self-purification potential of streams and river.

Air Pollution: Composition of air, sources and nature of air pollutants. Pollution in municipal, industrial, agricultural and commercial areas. Measurement of air pollution. Effects of pollutants on Public Health. Principles, processes and systems of air pollution control.

Noise Pollution: Sources of noise in the environment. Characteristics of noise from different sources. Background noise. Measurement of noise. Decibel. Effects of noise on public health. Noise control measures and devices. Appropriate legislation for noise pollution control.

Solid Waste Management: Definitions. Characteristics of solid wastes. General principles of waste collection, storage, transportation and disposal. Waste minimization at source. Appropriate technologies for waste collection, storage, transportation and disposal. Waste reclamation and reuse. Recycling solid wastes. Strategic, Integrated, sustainable solid waste Management (Principles, concepts and process).

Environmental Impact Assessment (2 Units)

Concept of environmental consequences of development projects. Methods of impact analysis. Physical sociological, legal, economic, environmental and public

health implications of human activities. Effects of changed environments on man. Examples of impact assessment (EIA, SIA etc.) with particular reference to developing countries. Role of environmental engineering in preventing or reducing environmental stress. Planning and policy, administration and organization of natural resources development and public health. Land use planning and landscape design.

Elements of Public Health (2 Units)

Epidemiology and vital statistics. Epidemiology models. Public health and the environment. Communicable and non-communicable diseases. Spread and control of diseases. Disease vectors. Water borne, water based, water washed and water related insect vector diseases. Epidemiology models. Helminthic diseases. Control of communicable diseases Hazards of man-made lakes and other engineering works. Housing and occupational hygiene. Physiological requirements for light, air, heat and space in house. Principles of design of lighting, ventilation, heating and air-conditioning for domestic and industrial housing.

Wastewater Treatment and Disposal (2 Units)

Basic Wastewater treatment systems and schemes for municipalities of different sizes. Factors affecting the selection of treatment scheme. Plant layout and sizes. Factor affecting the selection of treatment scheme. Plant layout and hydraulic profiles. Unit operations and processes in wastewater treatment and sludge handling (domestic, municipal, industrial). Advanced theory and design of physical, chemical and biological treatment facilities – equalization, lamella sedimentation screening and micro screening, aerobic and anaerobic filters (biological). Wastewater treatment in hot climates; Stabilization ponds, aerated lagoons, oxidation ditches, rotating biological contactors, biological fluidized bed filters, etc. sludge: anaerobic digestion, thickening, vacuum centrifuging, pressure dewatering air drying and heat treat. Incineration and wet oxidation of sludge. Tertiary treatment of wastewater: Nutrients removal (phosphorus, nitrogen and suspended solids).

Design principles for Separate, combined and semi-separate sewers. Estimation of dry weather and storm water flows for rainfall of difference duration and intensity. Lloyd-Davies method. Area-time diagram and tangent methods. Sizing and construction of sewer pipes. Manhole chambers and storm water over flows. Pumping stations, screens and inverted siphons. Corrosion in sewers. Sewer maintenance.

Water Treatment and Supply (2 Units)

Basic concepts for the design of water supply systems for domestic; municipal, industrial use and rural areas. Design period population, flow rates for water supply systems. Factors affecting water consumption and variation in demand. Fire demand and coincidental draft. Design of water distribution systems. Distribution components. Methods of analyses for optional distribution network design. Estimating storage requirements. Types of distribution reservoirs and

design parameters. Design of pumping stations. Pumping schedules. Management, operation maintenance of water supply facilities. Specific water treatment processes for boilers, cooling systems and other industrial supplies – cold and hot softening, demineralization, aeration, deaeration, degasification and decontaminating of steam. Corrosion of pipes and boilers. Silica removal. Removal of boiler scales.

Aspects of Occupational Health and Safety (2 Units)
Relationship between worker health and safety and the work environment. Analysis of industrial health and safety problems. Practices likely to create hazards to the workforce. Safety regulation in work environments. Prevention of industrial and occupational hazards and accidents. Emergency management and first-Aid.

Hazardous Waste Management (2 Units)
Characterization, treatment and final disposal of hazardous wastes. Relevant regulation and legislation for hazardous waste management. Hazardous waste minimization. Hazardous waste treatment options. Clean-up of contaminated sites. Case studies.

Small Watershed Systems Design (2 Units)
Hydrologic design of water management systems. Hydrologic design and the production of agricultural and other biological materials. Analysis and design of composite systems for watersheds.

Water Resources Infrastructure (2 Units)
Case history/studies of local infrastructure use for controlling and utilizing water – e.g hydro-electric projects, development of alluvial fans and floodplains. Management of transportation corridors with emphasis on engineering and environmental aspects.

Urban and Regional Planning (2 Units)
Urban climate. Urban development and effects on catchment response. Design of storm water drainage systems. Sewer and storm water inlets. Problems of natural resources, industrialization and engineering aspects of environmental pollution. Transportation, structural development and housing.

Applied Statistics (2 Units)
Theory of probability and statistics. Principle of maximum entrop and its use in the specification of prior probabilities. Baye's theorem. Confidence internals, regression and special applications relevant to engineering.

Systems Analysis in Water Resources Management (2 Units)
The optimal management of water resources system requires that the natural distribution of water resources be subjected to structural and non-structural measure such that the objectives of management are achieve in an optimal manner. Systems analysis provides a framework within which this can be

achieved. The basic principle of this course is resource management. Optimization techniques for systems analysis. Application of systems analysis to problems of design and operation of water resources systems. Mathematical modeling of complex water resources systems and its use in decision making in water resources management.

Bioremediation (2 Units)

On-site and off-site remediation of wastes with biological systems. Kinetics of bioremediation using different micro-organisms. The use of micro-organisms in remediating oil spills in the environment – water and soils. Bioremediation in groundwater pollution. Enhancement of bioremediation through genetic engineering.

8.2 MECHANICAL ENGINEERING

8.2.1 Postgraduate Diploma

Admission Requirements:

a. Higher National Diploma, (HND) in Mechanical Engineering or related Engineering and Science disciplines with at least, Lower Credit pass.

b. B.Sc., B.Eng., or B. Tech. degree in Mechanical Engineering or related Engineering and Science disciplines with at least third class (Hons) or pass degree.

Graduation Requirements

To qualify for the award of Postgraduate Diploma, a candidate must have been unitized with at least 64 Units of compulsory courses which include the project report.

Course Outline

The courses are grouped into two:

a. Core courses and
b. Elective courses

Core Courses

First Semester

List of Courses	Units
Engineering Mathematics I	**3**
Engineer-in- Society	2
Engineering Materials and application	3
Engineering Thermodynamics	3
Engineering Graphics	3

Second Semester

List of Courses	Units
Engineering Mathematics II	**2**
Computer Programming & Numerical Methods	2
Technical Report Writing	2
Statistics	2
Strength of Materials	3
Fluid Mechanics	3

Third Semester

List of Courses	Units
Engineering Law, Management & Entrepreneurship	3
Mechanic of Machines Mechanical Engineering Design I	3
Mechanical Vibration	3
Heat and Mass Transfer	3

Fourth Semester

List of Courses	Units
Engineering Design	**3**
Automatic Control	3
Project	6
Engineering Maintenance	3
Elective I	3
Elective II	3

Elective Courses

List of Courses	Unit
Manufacturing Process, Intro to CAM an Tools and Jigs Designs	3
Internal Combustion Engines	3
Metrology	3
Energy Studies	3
Air-Conditioning and Refrigeration and other Building Services	3
Foundry Technology	3
Engineering Metallurgy	3

All 3 Units courses which have laboratories should have 2 Units lecture and 1 unit laboratory.

List of Laboratories

Fluid Mechanics
Thermodynamics and Heat Engines
Engineering Mechanics and Mechanisms
Instrumentation
Vibration and Automatic Control
Engineering Drawing and Design Studio
Metrology
Strength of Materials
Foundry Technology

Course Contents

Mechanics of Machines (3 Units)

Dynamics of Rigid Body: Analyses of inertia forces and torques. Advances Kinematics of mechanisms. Two dimensional rigid body problems. Governors and Operation principles: Construction and operations of different engine governors. Calculation of forces and range of speeds of governors. Balancing of rotating masses: analyses of the balancing of rotating masses in the same and in different planes. Determination of primary and secondary and secondary balancing forces and moments of reciprocating machines, compressors. Effects of balance on the applications: Principles of operation

of various cams; analyses of off-set roller and tangent cam with roller followers: Calculations on cams (e.g. displacement of follows, velocity, angles, etc.) Gyrosocope and its applications: Analyses of forces and moments acting on a gyroscope. Determination of the gyroscope couple and acceleration for a plane disc. Effects of gyroscopic couple on the whirling of shafts. Applications of gyroscope in automobile, ships, aero planes and locomotives.

Strength of Materials (3 Units)

Thick shells: Determination of stresses and strains in single and compound cylinders under internal and external pressures. Stresses in axially thin, long and variable thickness rotating discs. Columns and struts: Theoretical analysis for short and long columns (e.g. the Euler's formula, J.B. Johnson formula, cook column formula, etc.). Derive and explain buckling heads of columns for pin jointed built-in ends and combinations of both. State the limitations of the theory and apply empirical equations to determine the buckling loads. Bending of beams and circular plates: Determination of stresses in bars of large and small curvatures and combined bending and direct stress. Shear centres of unsymmetrical beams. Formulation of plastic hinge, collapse loads, simple supported and fixed beams. Stresses and deflections in bending of thin circular plates with small deflections. Plastic theory of bending. Torsion of shafts: Combined bending and torsion in shafts. Stresses in non-circular shafts. Wrapping function in the torsion of non-circular shafts. Riveted and bolted connections: Types of riveted joints and their classifications. Determination of strength of rivet and plate. Strength and efficiency of joints. Stresses due to eccentric loading of joints under torsional loading. Mode of failure of joints. Elasticity theory: Stresses – strain relations. Two dimensional stress and strain. Analysis of stresses in three dimensions using Mohr's cycle. Experimental stress analysis: Model analysis. Scale factors and materials. Principles of electrical strain gauge for strain measurement. Basic introduction to photo elasticity – birefringence, isoclinics, isochromatics, stress – optic law.

Control Systems (3 Units)

Mathematical modeling of dynamic system: Dynamic equations of mechanical (translational and rotational), electrical, electromechanical, hydraulic, thermal and pneumatic systems). Transfer function of control systems). Transfer function of control system components; Transfer function of mechanical devices (simple lever, compound lever, differential lever, gyroscope, gears); electrical and electronic circuits, (field controlled and armature – controlled d.c. motors, servo – motor, operational amplifier circuits), pneumatic components (bellows flapper – valve, relay, actuator), hydraulic components (valve, linear actuator). Block diagram and linear graphs. Time-response analysis: Standard test signals (step, ramp or impulse signals) time response of first-order and second order systems. Steady-state errors and error constants. Frequency – response analysis; Nyquist and Bode plots – by sketching and use of experimental data. M – and N – circles. (Closed – loop frequency response). Analysis of system stability; Concept of system stability. Routh – Hurwitz criterion and applications Nyquist stability criteria. Gain margin and phase margin. Relative stability using Nyquist criterion. Root locus method: The root locus concept. Construction of roof loci. Interpretation of the root locus diagram. Introduction to Systematic Control Design (System compensation): Need for system compensation. Preliminary design considerations. Series and parallel (feed

bask) compensation. Compensation using lead, lag and lead-lag devices and their practical realization in mechanical, pneumatic and hydraulic systems. Effect of proportional (p), integral (I) and derivative (D) control actions on system performance. System compensation using the root – locus of Bode approach. Analogue computer simulation: Need for computer simulation. Analogue computer elements. Analogue computer simulation of control systems. Computer operating modes. Amplitude and time sealing.

Mechanical Engineering Design (3 Units)

Failure theories combined loading: fatigue and fatigue design. Shaft design. Power transmission: Gear, belt, rope, and chain drives. Types of joints. Analysis, synthesis and evaluation procedure in creative design. Use of codes, standards, charts, tables and empirical data. Thick and thin walled pressure vessels. Rotating cylinders. Creative group design project.

Advanced Mechanical Engineering Design (3 Units)

Thermal stresses in cylinders. Bucking theory for cylinders, design for external pressure. Pipe flexibility analysis. Smooth and mitred pipe bends. Flanged design, Plastic analysis of shell structures – yield surfaces and applications to circular plates and cylinders. Design of pressure vessel ends – flat and dished ends. Design of branch reinforcement, particularly nozzles in spheres. Introduction to CAD/CAM.

Mechanical Vibration (3 Units)

Free and forced vibration of lumped mass – spring systems with and without damping in single, double and multi-degrees of freedom. Response to harmonic periodic, and non-periodic excitations. Matrix methods and Eigen value problems, natural frequencies, modes of vibration and resonance. Transverse vibration, whirling of shafts and torsional vibration. Vibration Isolation.

Engineering Materials and application (3 Units)

National and international standards for the classification of engineering materials. Classes of materials; High temperature materials, packaging materials, high strength materials, optical and magnetic materials, automotive materials, tool steels, stainless steels, the ceramics, polymers, cement, petrochemical materials. Structures, phases, chemical composition and mechanical properties of engineering materials. Mechanism of deformation and fracture at elevated temperatures. Creep and fatigue theories. Yield criteria. Strengthening mechanisms of super alloys and refractory materials. Environmental effects on materials.

Engineering Metallurgy (3 Units)

Crystal structures of metals and alloys: binary and ternary phase diagrams. Characteristics of alloy micro-structure. Nucleation and growth, solidification. Metallurgical microscopes, and techniques for microscopic observation. Alloys and alloy steels. Classification and grading of alloy steels. Normalizing, annealing, hardening and tempering treatment for steel, surface hardening, precipitation hardening of steels. Austempering and martempering of steel. Heat treatment for copper and aluminum alloys. Corrosion and oxidation phenomenon. Mechanical working of metals.

Thermodynamics (3 Units)

Review of fundamentals of Thermodynamics (including laws, processes and cycles) selected issues: Closed and open systems, Energy degrading. Thermodynamics control surface and volume analysis. Vapour and gas power cycles. Internal combustion engines. Properties of mixtures. Advanced treatment of fundamental combustion processes. Mechanism of heat transfer and heat exchanger designs. Vapour and absorption refrigeration systems. Application of thermodynamic theory and design principles for comfort and cooling, food refrigeration and cryogenic systems. Properties of refrigerant. Refrigeration control systems, Gas dynamics: Internal flows (pipes, nozzles, etc.) external flows (aircraft, projectiles, etc.) waves (elastic, shock). Available and unavailable energy of systems.

Fluid Mechanics (3 Units)

Kinematics and dynamics of fluid motion. Applications to fluid machinery, fluids, propulsion systems, Elementary hydrodynamics. Properties of real fluid, Incompressible and compressible fluid flow, ideal, viscous and compressible fluids under internal and external flow conditions. Inviscid flows, boundary layer, normal and shock wave and flow machines.

Refrigeration, Air Conditioning & Other Building Services (3 Units)

Review of psychometrics. Air conditioning equipment/components, boilers and chillers, cool towers, heat pumps – characteristics, design and selection techniques. Cryogenics, types and application of pipes. Pipe fitting. Lighting – sources, characteristics, design and applications. Heat gain from solar and other sources. Factors influencing solar gains. Air conditioning load due to solar gain through glass, infiltration, heat gains through lighting, occupants, and other appliances. Fire fighting systems, equipment's code and regulation. Environmental pollution. Vertical transportation system.

Mechanical Engineering Maintenance (3 Units)

Importance of maintenance organization: Factors of maintenance (primary & secondary). Types of maintenance; breakdown, preventive, predictive etc. strategies for effective maintenance. Maintenance of industrial mechanical equipment (practical maintenance); types (preventive, repair or corrective, project improvement). Mechanical maintenance of generators: fuel injection systems, engine starting procedures, causes of engine failures (faults/remedies). Machine tools maintenance definition, maintenance characteristics, advantages of maintenance (economic, technical, organizational and human), maintenance systems (schedule and procedures, lubrication, cleanliness, fault indications –vibrations, chatter, overheating and intermittent operation of equipment). Mechanical maintenance of compressors; types, maintenance (mounting and alignment-foundation, anchor bolts, alignment, and misalignment) belt driven installation. Maintenance of mechanical drives; friction and mesh drives (types and maintenance). Hydraulic and pneumatic system maintenance: definition, components and types of maintenance. Types and properties of hydraulic fluids.

Energy Studies (3Units)

Analysis of energy demand in society. Types, grades, and applications, sources and resourced. Energy conservation, Conversion, combustion, Nuclear fission and fusion.

Hydro-energy alternative sources of energy. Solar, geothermal, wind and tides power generation. Economic, environmental, political and social considerations.

Internal Combustion Engines (3 Units)

Review of basic thermodynamic principles. Hydrocarbon fuels, structures properties and test methods. Alternative fuels for internal combustion engines. Combustion: Stoichiometry, effects of dissociation, residual; fraction, etc. Fuel-air cycle analysis using combustion charts/piston engine combustion phenomena, pre-ignition, detonation and knock Exhaust gas emissions, formation characteristics, effect, methods of measurement and reduction. Legal requirements. Fluid mechanics of internal combustion engines, fuel metering, injection and exhaust systems. Alternative engines: gas turbine, wankel, Sterling electric etc. characteristics method of measurement and reduction. Design of engine components. Tube charging, Engine Tests.

Technical Report Writing (2 Units)

Introduction to the principles of effective communications with attention to the importance of emphasis, emotion, contact and style. Principles of technical writing Organisation and preparation of technical report (including proper referencing). Technical correspondence. Data assisting and deduction in presentation. Oral presentation of technical reports. Technical aids in presentation.

Foundry Technology (3 Units)

Pattern making technology; Materials, machines, and tools for pattern making; Mould and core making technology: Sands used for molding: Molding processes Machine molding; Core sands core making; Casting procedure. Solidification. Gating & Risering systems; casting design; Melting furnaces, refractories for melting unit; Metallurgical characteristics of cast metals; Casting defects & detection methods; Pollution control in foundries.

Metrology (3 Units)

General Principles of instrumentation and measurement Precision and accuracy measurement of lengths light rays; block gauges, comparison with known lengths, graduate scales rotation of screwed shaft, angular measurement – combination angle gauge sine base author collimator angle décor, precision level: Determination of straightness of surface. Measurement of form – optical measurement of screw threads: major/minor diameter, simple effective diameter, thread pitch, thread form, virtual.

Heat and Mass Transfer (3 Units)

Steady states conduction; review of fundamentals; application to engineering services. Convective heat transfer: Forced convection heat transfer in Laminar and turbulent flow; thermal boundary layer; and plate heat transfer. Design aspects of heat exchangers: Basic types; design and selections; fundamentals of mass transfer; molecular mass transfer; diffusion coefficient; convective mass transfer. Steady state molecular diffusion: One dimensional mass transfer: diffusion through a stagnant layer.

Engineer-in-Society **(2 Units)**

Definitions of Engineer-in-Society

- Growth and effect of Technology on Society
- Industrial revolution
- Modern development – power, transportation, communication etc.
- Professional bodies and Engineering Societies
- Ethics, Cannons, Codes, standards of engineering Society
- The Roles and responsibilities of engineering personnel in Technological development and nation building.
- Education and Training of Engineering personnel's.

Engineering Graphics **(3 Units)**

Reviewing of rotations of surfaces in various planes; Intersections programming. Assembly draining. Introduction to Computer-Aided drafting.

8.2.2 M.Sc/M.Eng. and Ph.D Programmes

The M.Sc/M/Eng, and Ph.D programmes to be offered are as follows: Applied Mechanics, Thermo-Fluids and Energy, Production, Mechatronics, and Marine Engineering. Electives may be sourced from options other than area of specialization or from Materials and Metallurgical engineering or management.

A. **Applied Mechanics**

Core Courses

Advanced Numerical Analysis, Linear Elasticity/Continuum Mechanics, Linear Vibrations.

List of Courses	Units
Linear Elasticity	3
Introduction to Continuum Mechanics	3
Theory of Plasticity	3
Acoustic and Vibrations	3
Linear vibration	3
Analytical Dynamics	3
Advanced Numerical Analysis	3
Optimal Mechanical Design	3
Orthopedic Biomechanics	3
Robotics, Kinetics, Dynamics and Control	3
Non-Linear Vibrations	3

Linear Elasticity **(3 units)**

Stress and strain in three dimensions, fundamental field equations of linear elasticity; equilibrium, compatibility, Hooke's law; Papkovitch-Neuber solution, Plane Stress and plane strain; torsion, torsion of thin-walled members with warping restraint; plate theory.

Introduction to Continuum Mechanics (3 units)
Cartesian tensors, transformation and invariants of stress and strain, equations of motion and equilibrium, boundary conditions, constitutive equations for elastic, viscous and visco-elastic materials, plastic yield conditions and associated flow rules.

Theory of Plasticity (3 units)
Yield conditions and flow rules; upper and lower bound theorems; elastic-plastic analysis of circular disks, thick-walled cylinders and spheres; torsion; slip-line fields; rigid-plastic analysis of plates and shells.

Acoustics and Vibration (3 units)
Fundamentals of acoustics and vibrations, measurement, instrumentation, interpretation of data, industrial standards, and control. Wave properties; the decibel; hearing deafness and hearing protectors; noise criteria and regulations; sound measurement; sound source characterization; real noise sources; sound propagation outdoors, in ducts and pipes and in rooms; sound transmission; silencers; sound absorbers; partitions.

Linear Vibrations (3 units)
Transient and steady state vibration analysis of continuous and discrete mechanical systems. Lagrange's equation and Hamilton's Principle. Measurement of vibration. Machinery health monitoring. Frequency domain analysis. Experimental modal analysis. Vibration of rotating machinery.

Analytical Dynamics (3 units)
Newtonian mechanics; generalized co-ordinates and analytical mechanics; Lagrange equations; Hamilton's Principle; rotational motion and rigid body dynamics; Gyroscopic motion; phase space, equilibrium, and stability of motion; stability chrematistics of autonomous systems; Hamilton-Jacobi method; applications.

Advanced Numerical Analysis (3 units)
Interpolation, numerical integration, Non-linear equations, numerical solution of ordinary and partial differentia; equations. Numerical analysis of matrices, including solution of linear systems and eigen value/eigen vector calculations. Practical computational methods emphasized and basic theory developed through simple models. Review of finite element theory in linear static and dynamic analyses. Theory and element selection. Development of computer programs for simple problems. Utilization of existing computer packages. Application to mechanical engineering problems. Material and geometric non-linearity, various formulation and solution methods, convergence. Fracture mechanics problems. Non-linear transient conduction, convection, and radiation boundary conditions. Fluid flow problems.

Optimal Mechanical Design **(3 units)**

Formulation of optimal design mechanical problems, unconstrained and constrained problems, search and quasi-Newton methods, finite element formulation for optimal design problems, optional design of mechanical dynamic systems, interactive design optimization, applications.

Orthopedic Biomechanics **(3 units)**

Musculoskeletal anatomy. Static and dynamic analysis of the musculoskeletal system. Gait. Musculoskeletal tissue mechanics. Biomaterials. Advanced study of relevant problems in orthopaedics, including joint replacement, fracture fixation, and spinal disorders.

Robotics: Kinematics, Dynamics and Control **(3 units)**

Definitions and classification Kinematics: homogeneous transformations, manipulator kinematic equations, forward and inverse kinematic solution methods, differential kinematic equations motion trajectories. Dynamics: Lagrange-Euler formulations, Newton-Euler formulation. Control: methods of control, robot control hierarchy, control of single joint and multiple link manipulators, advanced control methods.

Non-Linear Vibration **(3 units)**

Phase plane representation, singular points, exact solutions, equivalent linearization, perturbation method, averaging method, variation of parameters, forced vibration, self-excited vibration.

B. **Thermo-Fluids and Energy**

Core Courses

Advanced Numerical Analysis, Advanced Thermodynamics, Advanced Fluid Mechanics, Computational methods

List of Courses	**Units**
Advanced Computational Methods	3
Advanced Thermodynamics	3
Advanced Fluid Mechanics	3
Fuel Cell Systems	3
Convection Heat Transfer	3
Radiation Heat Transfer	3
Materials for Clean Energy Technologies	3
Radiation Heat Transfer	3
Materials for Clean Energy Technologies	3
Combustion	3
Advanced Internal Combustion Engines	3
Theory of Ideal Fluids	3
Low speed Aerodynamics	3
Experimental Fluid Mechanics	3

Advanced Computational Methods (3 Units)
Selected advanced topics in CFD, typically chosen from: Finite volume methods on curvilinear meshes and structured mesh generation. Finite volume methods on unstructured meshes. Multigrid methods for elliptic PDE's. Reynolds-averaged form of the Navier-Stokes equations and turbulence modeling. Three-dimensional flows. Compressible flows.

Advanced Thermodynamics (3 Units)
Thermodynamic principles, Maxwell relations, availability, irreversibility, and equilibrium. Introduction to statistical mechanics.

Advanced Fluid Mechanics (3 Units)
Governing equations; viscous incompressible flow, incompressible potential flow; incompressible boundary layers, stability and turbulence; compressible potential flow.

Fuel Cell Systems (3 Units)
Energy system architecture and electrochemical energy conversion; fuel cell thermodynamics and electrochemistry; Proton Exchange Membrane Fuel Cells(PMFCs) and Solid Oxide Fuel Cells (SOFCSs); hydrogen production, storage, and distribution.

Convection Heat Transfer (3 Units)
Governing equations for laminar and turbulent flow. Forced convection in internal and external flow. Free, and combined free forced convection. Heat transfer at high velocities, in rarefied gases and in two-phase flow. Mass Transfer.

Radiation Heat Transfer (3 Units)
Monochromatic and goniometric surface properties. Energy exchange of grey, non-grey, diffuse, directional, or specular surfaces, Absorption coefficient and radiation intensity in gas radiation. Radiation between a gas and its enclosure. Radiation of luminous flames.

Materials for Clean Energy Technologies (3 Units)
Introduction to operation of gas turbines and fuel cells. Diffusion and migration in solids. Fundamental basis of ionic, electronic, and mixed conductivity in fuel cell materials. Thermal barrier coatings for gas turbines. Material constraints in wind turbines.

Combustion (3 Units)
Thermodynamics of combustion, stoichiometry, heat of formation and reaction. Equilibrium composition and adiabatic flame temperature. Chemical kinetics of combustion. Flames in premixed gases; laminar and turbulent flame propagation. Diffusion flames, pollutant emissions and combustion in IC engines.

Advanced Internal Combustion Engines (3 Units)
Analysis of spark and compression ignition engines. Calculation of fuel economy, power and emission. Practical considerations in engine design.

Theory of Ideal Fluids (3 Units)
Topics selected from the kinematics and dynamics of inviscid incompressible fluids in steady and non-steady motion; two-dimensional and axisymmetric potential flows; applications of conformal mapping; free streamline flows; vortex motions.

Low speed Aerodynamics (3 Units)
Circulation, vorticity and Kelvin's Theorem. Potential flow theory and the Kutta-Joukowski Law 2D Vortex Panel. Method Laminar and turbulent boundary layer computations. Lifting line theory. Vortex Lattice Method. High lift devices. Total airplane drag.

Experimental Fluid Mechanics (3 Units)
Modeling Test facilities. Wind tunnel force measurement. Theory of conventional and modern manometry. Classical velocimetry. Hotwire anemone-metry. Theory and application of laser Doppler velocimetry. Particle image velocimetry. Flow visualization techniques. Thermometry.

C. **Production Engineering**

Core Courses

Advanced Numerical analysis, Production and Operations management, Engineering Economics, Production Engineering.

List of Courses	Units
Production and Operations Management	3
Engineering Economics	3
Quality Control and Management	3
Fracture Control for Design	3
Fatigue	3
Manufacturing Automation	3
Advanced Manufacturing Technology	3
Machine Tool structures and Vibrations	3
Metal Removal Processes	3
Computer-Integrated Manufacturing	3

Production and Operations Management (3 Units)
Introduction. Location Selection and Plant Layout. Design of Manufacturing. Systems. Factory Dynamics. Just-in-Time Production. Theory of Constraints. Demand Forecasting. Inventory and Materials Management. Production Planning Models. Methods and Measure. Operations Schedule. Advanced Topics.

Engineering Economics (3 Units)
Rationale: All engineering and management decisions have economic consequences, such as profitability and risk. This course is aimed at providing the necessary background and techniques for economic evaluation of decision alternatives. Topic such as time value of money, depreciation and taxation, cost estimation and cost control, risk and uncertainty in decision-making, and replacement analysis are included. Basic Concepts in Engineering Economics. Economic Evaluation of Alternatives. Replacement Analysis. Accounting Concepts. Depreciation and Taxation. Product Costing and Cost Estimation. Risk and Uncertainty. Deterministic Capital Budgeting Models.

Quality Control and Management (3 Units)
Rationale: To present quality as a strategic business weapon, and to detail the ways and means of achieving it in an organization. The managerial aspects and statistical procedures of quality control are treated in depth. Catalog Description: Quality System, Quality Management System, Planning and Operations for Quality, Statistical Methods for Quality Control.

Fracture Control for Design (3 Units)
Transition temperature, linear-elastic and elastic-plastic theory, experimental testing methods, fracture-resistant design methodology, application to mechanical and structural components.

Fatigue (3 Units)
Review of smooth-body fatigue: high-cycle; cumulative damage; cycle counting methods; cracked-body fatigue theory; effects of load history and stress ratio; numerical crack-growth prediction models; application to components and structures; crack detection methods.

Manufacturing Automation (3 Units)
Review of mechanics of metal cutting. Machine tool structures, static deformations, forced and self-excited vibrations and chatter. Design principles of CNC machines; state space and transfer function models of feed drivers, dc servo motors and amplifiers. Contouring analysis in multi-axes machining. Unmanned manufacturing topics: Sensors, adaptive control, and monitoring in metal-removing processes.

Advanced Manufacturing Technology (3 Units)
Basic metal removal processes. Introduction to the mechanics of the processes. Economics of simple processes. Introduction to machine selection, flexibility, and automation. Organization of manufacturing, process planning, group technology, facilities layout, and production scheduling.

Machine Tool structures and Vibrations (3 Units)
Review of metal cutting mechanics, milling, static deformations of machine tools. Machine tool vibrations, forced and self excited vibrations in machining, chatter,

stability. Sensors for machine tool monitoring and adaptive control. Sensor assisted intelligent machining techniques.

Metal Removal Processes (3 Units)
The basic mechanics of metal removal, experimental evidence and extension of force models to practical processes. Tool wear processes, tool life equations and the optimization of single and multiple pass processes. Introduction to the optimization of process plans.

Computer-Integrated Manufacturing (3 Units)
Objectives and elements of Computer-Integrated manufacturing, information control, computer/device networks. Sensor and sensor fusion, layout and material handling issues. Production line design, and design for manufacturing. Flexible automation, virtual manufacturing, rapid prototyping, quality control and reliability issues and Artificial Intelligence applications.

D. **Mechatronics**

Core Courses
Advanced Numerical Analysis, Modeling of Mechatronic Systems, Introduction to Sensors and Actuations, Control Sensors and Actuators.

List of Courses	**Unit**
Modeling of Mechatronics Systems	3
Introduction to Sensors and Actuators	3
Control Sensors and Actuators	3
Mechatronics System Instrumentation	3
Introduction to Microelectromechanical Systems	3
Intelligent Control	3
Intelligent Robotic Systems	3
Experimental Methods in Mechanics	3

Core Courses
Advanced Numerical Analysis, Modeling of Mechatronic Systems, Introduction to Sensors and Actuations, Control Sensors and Actuators.

Modeling of Mechatronics Systems (3 Units)
Modeling of mechanical, electrical, fluid elements and mixed mechatronic systems. Signal processing, signal conditioning. Sensors, data acquisition systems, actuators. Undergraduate courses in Circuit theory and electronics will be encouraged for those who don't have that background.

Introduction to Sensors and Actuators (3 Units)
Measurement of motion, stress, force, torque, temperature, flow and pressure; Principles of sensors and signal conditioning methods; selection and sizing of actuators.

Control Sensors and Actuators (3 Units)
Review of control, instrumentation and design. Performance specification of control components, component matching, error analysis. Operating principles, analysis, modeling, design considerations of control sensors and actuators such as analog sensors for motion measurement, digital transducers, stepper motors, DC motors, induction motors, synchronous motors, and hydraulic actuators. Control techniques pertaining to actuators. Applications.

Mechatronics System Instrumentation (3 Units)
Architecture of mechatronics devices; integration of mechanical, electronics, sensors, actuators, computer and real time software systems; PLC and PC based systems; discrete and continuous automation system design.

Introduction to Microelectromechanical Systems (3 Units)
Fundamentals of MEMS (MicroElectroMechanical Systems). Micro-fabrication of MEMS with solid-state technology. LIGA and micro injection molding. Physics of MEMS. Operational principles of various MEMS devices. Micro-fabrication of MEMS: solid-state technology and other micromachining techniques Engineering principles of various MEMS devices.

Intelligent Control (3 Units)
Review of traditional control techniques and comparison with intelligent control; methods of representing and processing knowledge; conventional sets and crisp logic; fuzzy logic control; hierarchical fuzzy control; control system turning; industrial applications

Intelligent Robotic Systems (3 Units)
System components and organization. Modeling and advanced and control techniques. Vision, tactile, laser and proximity sensing. Task planning, part technique planning, planning with uncertainty. Robot learning. Online application collision avoidance, object interception, robotic assembly. Students will be required to present a research seminar.

Experimental Methods in Mechanics (3 Units)
Operating principles of transducers for measuring typical quantities; the construction of transducers and factors controlling their measurement accuracy; electronic signal conditioning equipment and computerize data acquisition system.

E. **Marine Engineering**

Core Courses
Advanced Numerical Analysis, Marine Hydrodynamics, Turbulent Sheer Flow.

Marine Hydrodynamics (3 Units)
Fundamentals of model testing, ship frictional resistance. Laminar boundary layer theory, turbulent flow on a flat plate. Ship wave resistance. Thin ship theory. Direct measurement of wave resistance.

Dynamics of Marine Vehicles (3 Units)
Water waves, motion of a body in an inviscid fluid, concepts of added mass, damping. Uncoupled and coupled motion of platforms, irregular seaway, dynamic effects, motion, stabilization.

Advanced Marine Vehicles (3 Units)
Design of advanced marine vehicles such as air cushion vehicles, hydrofoils, autonomous underwater vehicles, interfaced vehicles. Principles of operation, stability, powering, control and maneuvering. Individual or group design exercise.

Turbulent Shear Flow (3 Units)
The basic equations of fluid motion; introduction to hydro-dynamic stability; Reynolds' equations; energy equations for turbulent motion; intermittency; similarity near a solid boundary and in free turbulence; approximate methods for predicting the growth of turbulent boundary layers and free symmetrical shear flows.

8.3 METALLURGICAL AND MATERIALS ENGINEERING

8.3.1 Postgraduate Diploma

Admission Requirements

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

i. Higher National Diploma in Metallurgical and Materials Engineering with a minimum of Lower Units grade from recognized Polytechnic.
ii. Bachelor of Science degree in a related Science discipline with a minimum of Second Class Lower Division from a recognized University.
iii. B.Sc. or B.Eng. in Mechanical Engineering with Third class (Hons) degree from a recognized University.

Graduation Requirement

To qualify for the award of Postgraduate Diploma, a candidate must have been Unitised with at least 64 Units of compulsory courses which include the project report.

First Year

First Semester

COURSE TITLE	L – T – P	UNITS
Elements of Engineering Materials	2 – 2 – 0	3
Physical Metallurgy	2 – 0 – 3	3
Mineral Processing and Extractive Metallurgy	2 – 2 – 0	3
Engineering Mathematics I	2 – 2 – 0	3
Engineering Drawing	1 – 0 - 3	2
Experimental Techniques	1 – 0 – 3	2
Numerical Methods and Computer Programming	2 – 2 – 0	3
TOTAL		19

Second Semester

COURSE TITLE	L – T – P	UNITS
Iron and Steel making	2 – 0 – 0	2
Metallurgical Thermodynamics	2 – 2– 0	3
Heat and Mass Transfer	2 – 0 – 0	2
Foundry Technology	1 – 0 – 3	2
Polymers	2 – 0 - 0	2
Heat Treatment of Metals	1 – 0 – 3	2
Technical Report Writing	1 – 0 – 3	2
Engineer- in- Society	1 – 2 – 0	2
Engineering Mathematics II	1 – 2 – 0	2
Metallurgical Laboratory	0 – 0 – 3	1
TOTAL		20

Second Year
First Semester

COURSE TITLE	**L – T - P**	UNITS
Materials laboratory	0– 0 – 3	1
Production Management	2 – 0 – 0	2
Non-Ferrous Extractive Metallurgy	2 – 0 – 0	3
Metals and Materials Process Plant Design	2 – 0 – 3	3
Fuel, Furnaces and Refractories	2 – 0 - 0	2
Statistics for Engineers	1 – 2 – 0	2
Project	0 – 0 – 9	3
TOTAL		16

Second Semester

COURSE TITLE	**L – T - P**	**UNITS**
Materials selection and Economics	2 – 0 – 0	2
Corrosion Engineering	2 – 0– 3	3
Composite Materials	2 – 0 – 0	2
Production Metallurgy	2 - 2– 0	3
Ceramics and Glasses	2 – 0 - 0	2
Fracture mechanics and failure analysis	2 – 2 – 0	3
Project	0 – 0 – 9	3
TOTAL		18

COURSE CONTENTS

Elements of Engineering Materials (3 Units)
Atomic and crystal structure. Crystal imperfections. Simple phase diagrams of alloys. The relationship between structure and properties. Mechanical properties – engineering and true stress-strain curves, ultimate strength, ductility, impart strength, hardness and torsion. Creep and fatigue failure. Electrical properties – conductivity, semi-conductivity and super-conductivity. Optical and magnetic properties of materials. Stability of materials in the service environment, corrosive media, sub-zero and elevated temperature, irradiation. Basic criteria for the selection of materials for engineering applications. Engineering properties of wood, concrete polymers, ferrous and non-ferrous metals and alloys; cryogenic, corrosive media and nuclear applications.

Iron and Steel Making (2 Units)
Ironmaking: Review of raw materials for ironmaking. Iron Blast Furnace – Design, reactions and processes control. Post-production treatment of the products of the Iron Blast Furnace – Slag granulation and uses, gas cleaning, flue dust removal and hot metal treatment, e.g. desulphurization, dephosphorisation and desiliconisation; Direct reduction – Process description, reactions and products, process control. Steelmaking: Review of raw materials for steelmaking. Basic Oxygen Steelmaking – Design of the converter, physico-chemical reactions, process and quality control. Electric Arc Steelmaking – Reactor design, continuous feeding, power programme, process and quality control.

Alloy steel production e.g. stainless steelmaking – process and quality control; AOD. Secondary Steelmaking: Clean steel production processes e.g. vacuum induction melting, electroslag remelting, degassers. Other secondary steelmaking processes e.g calcium treatment and steel desulphurization. Stirring and injection techniques. Deoxidation of steel: Thermodynamic principles and methods.

Production Metallurgy (3 Units)

Stress-strain relation in bulk deformation processes. Holloman equation. Forces and work of deformation. Hot deformation and super plasticity. Cold working and hot working. Concept of recrystalization. Bulk deformation process; upsetting, extrusion, rolling, and drawing (wire, tube and bar). Materials joining processes: basics of welding processes, Classification of welding processes: pressure and fusion welding. Weld ability of metals. Weld nature, quality, microstructure and properties, welding speed and defects. Brazing, soldering. Metal Sheet forming processes: formability, shearing and bending. Spinning, stretch forming, deep drawing, ironing, effect of anisotropic properties on formability. Powder Metallurgy. Metal casting.

Metallurgical Thermodynamics (3 Units)

Chemical reaction equilibrium: Review of thermodynamics function. Fugacity and Activity. Free Energy and variation with temperature. Partial and integral molar thermodynamics functions. Gibbs-Durhem equations. 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.

Mineral and Extractive Metallurgy (3 Units)

Occurrence and nature of major metalliferous 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 tailings disposal. Design, testing and evaluation of mineral beneficiation flow sheets. Computer application in Mineral process, application of mineralogy to mineral processing.

Heat and Mass Transfer (2 Units)

Basic heat transfer equations and mechanisms. Steady and unsteady state heat transfer. Application of Dimensional Analysis to heat flow. Basic equation of Mass Transfer. Mass Transfer Coefficients and Models. Mass Transfer in process multiple phases. Applications of principles of heat and mass transfer in process metallurgy e.g. continuous castings, casting in general, heat and reheating of slabs and ingots etc. Use of Finite Element method of estimating heat distribution in a slab.

Foundry Technology II **(2 Units)**

Patterns: Types, materials and making, defects associated with pattern. Molding: Types, materials and peculiarities. Defects associated with molding Melting furnaces, characteristics and areas of application; defects associated WITH melting. Ladle metallurgy: special treatment of melts, refining, gases in metals, degassing, Desulphurization, liquid metal cleanliness, inoculation, benefits of ladle practice. Fluidity: influence of molten metal characteristic and casting parameters. Solidification of Casting: Solidification of pure metals and alloys, solidification shrinkage, Solidification defects. Safety in foundry. Application of computer in Foundry.

Engineering Drawing **(2 Units)**

Introduction – use of drawing instruments, paper sizes, scales and drawing layout. Lines and lettering, electric diagrams. Geometrical drawings – place geometry, conics and cyloids. Dimensioning and tolerances. Orthographic projection. Sectional views. Fastening devices – rivets and screw fasteners. Conventional practices. Isometric projections, Oblique projections. Free hand sketching. Graphic charts and diagram. Auxiliary projections. True lengths, size and shapes. Simple developments, Interpenetration and development. Mechanical drawing of machine parts – cams, gears, couplings, bearings pipe joints and valve. Structural drawing – materials representation, dimensioning of structural details, and welds structures wood, concrete structural detail, shop drawings and sketches. Simple assembly drawing. Introductory pen work; lettering and tracing of completed drawings.

Polymers **(2 Units)**

Review of organic chemistry related to polymer processing. Introduction: Definition of polymers, classes of polymers viz. thermoplastics; thermoset; and elastomers. Structure of polymers: Chemical composition, polymerization, cross-linking and chain branching, molecular weight and molecular-weight distribution, chemical and steric isomerism and stereoregularity, blends, grafts and co-polymers. Physical structure: Rotational isomerism, orientation and crystallinity. Introduction to the basic mechanical properties of polymeric materials. Relationship between structure and properties such as mechanical, viscoelasticity, electrical and optical properties. Engineering and domestic applications of polymers. Biomaterials.

Experimental Techniques **(2 Units)**

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 of X-ray spectrometry, Atomic Absorption Spectroscopy, Pyrometry. Temperature measurement and control. Techniques of surface examination (touch, microscopy (optical and electron), surface profilometry (contact and optical); Quantifying roughness; Structure of real surface. Experimental Stress Analysis; Statistical design of experiments and interpretations of results.

Heat Treatment of Metals **(2 Units)**

Heat treatment processes: annealing, normalizing quenching, tempering austempering, case hardening, precipitation hardening, solution treatment. Basic principles of selection of heat treatment conditions using the phase diagram. Heat treatment of ferrous metals

and alloys, cast irons, carbon steels, low alloy steels, tool steels, stainless and heat resisting steels. Heat treatment of non-ferrous metals, aluminum and alloys, copper and alloys. Heat defects. Safety considerations in heat treatment plant.

Technical Report Writing (2 Units)

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).

Materials Laboratory (1 Unit)

Mettalography: Sample preparation; Qualitative and quantitative microscopy; Introduction to photography and photomicrograph. Metallographic study of as-cast structures. Experiments in mineral identification and beneficiation. Simple experiments on extraction processes. Mechanical Testing: Tensile, compression, torsion, hardness and creep. Recrystallisation kinetics. Foundry – sand testing and characterization of foundry materials. Factors affecting the grain structure in cast metal using aluminum.

Physical Metallurgy (3 Units)

Wave theory of the atom. Shroedinger 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; actual strength of crystal Point defects; effect of point defects on mechanical properties; observations of point defects. Line defects; dislocation theory; observation of dislocations; behaviour of dislocation stress field around dislocation; energy of curved dislocations; forces acting on dislocation; dislocation forces. Slip phenomena. Planar defects; grain boundaries, domain boundaries, stacking faults, twin and twin boundaries. Strengthening Mechanisms and Processes: Mechanical treatments (e.g. work hardening, shotpeening), Solid solution hardening, Precipitation and Dispersion hardening, Fibre reinforcement, Thermochemical processing, Diffusion coating or Metallic cementation Radiation strengthening, Ion implantation.

Corrosion Engineering (3 Units)

Principles of Corrosion: Definition, classification, mechanism, factors affecting corrosion and types of corrosion. Concepts of Polarization, Passivation, Pourbaiz diagram and corrosion kinetics. High temperature oxidation: Piling Bedworth ratio. Corrosion monitoring and testing techniques: guarimetric, resistance and electrochemical methods of testing for corrosion. Corrosion control and Protection techniques: Design Coatings, inhibitors, materials selection, cathodic and anodic protection. Case studies: Corrosion in the atmospheres, rebar corrosion, microbial corrosion, corrosion in oil and gas industries, etc.

Production Management (2 Units)

Basic management theory. Decision theory. Use of economic and cost accounting data in planning. Production planning, control, and management. Marketing theory and management. Human resources management. Mathematical programming, queuing theory, critical path analysis, work study, total and marginal cost analysis, etc. With applications in the materials industries.

Composite Materials (2 Units)

Introduction: Classification of composite materials; Fibres and Matrices: Introduction, carbon fibres; glass fibres, organic fibres; Thermosetting resin, thermoplastics, ceramics, and metals; Particulate and whisker reinforcements. 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.

Non-Ferrous Extraction Metallurgy (2 Units)

Raw materials preparation – blending, roasting, agglomeration. Factors governing the choice of extraction process route. Assessment of the application of carbon, silicon, hydrogen and other reductants in metallic production. Condensation of metal vapours – associated problems. Simple blast furnace and reverberatory processes. Principles of Metal Refining. Methods available for 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.

Materials Selection and Economics (2 Units)

Principles of Materials Selection: Introduction, general factors, mechanical properties, stability in services, fabricability, availability, corrosion resistance, properties of unique interest, economics. Types of materials – metals, ceramics, polymers, composites, semiconductors. Relationship between properties, structure and service conditions. Properties and Selection – Chemical properties, physical properties, mechanical properties, dimensional – Chemical properties. Ferrous and non-ferrous metals and their alloys: General characteristics, alloy designations, alloy selection. Ceramics and their Engineering Applications, Polymeric Materials and their Engineering Application. Composite Materials and Applications. Casting, weldability; inspection of welds metal, forming processes: Materials selection and manufacturing methods. Economics consideration in materials selection. Example of Selection Process.

Metals & Materials Process & Plant Design (3 Units)

Technical and economic problems of planning, commissioning and operation of material and mineral processing plants with particular reference to developing countries. Fundamental principles of material process and plant design. The design steps; definition of the design problem; development of the basic design module; information sources; conceptualization; development of flow diagrams; selection of processes and equipment;

evaluation of design. Materials-design interaction. Decision Theory. Optimization of design. Linear programming, replacement stock control and scheduling problems. Problems of safety, hazardous effluent disposal and environment pollution in material plant. Computer-Aided-Design (CAD) and Computer-Aided-Manufacturing (CAM). Alloy design. Selected case studies in mineral processing, furnace design, plastic forming of ceramic products, pyrometallurgy, glass fibre manufacture, electroplating, mechanical metallurgy and extrusion of plastics.

Fracture Mechanics & Failure Analysis (2 Units)

Introduction: Types of fracture; Crack initiation and propagation. Linear Elastic Fracture Mechanics: Stress concentrators; Griffth theory of brittle fracture; Orowan/Invin relationship; strain-energy release rate; stress intensity factor; fracture toughness and its determination. Fracture Mechanics for Ductile Materials: Plastic zone correction; crack-opening displacement; J-contour integral; R-curve Fatigue crack growth. Failure of materials in service: Corrosion, oxidation, wear, creep, fatigue, plastic deformation, fracture. Types of fracture: Ductile and brittle fractures; dislocation theories of fracture, crack initiation and propagation theories. Estimation of fracture toughness of materials. Theoretical and experimental techniques in failure prediction, monitoring and analysis. Fractography. Fatigue crack growth. Selected case studies.

Fuels, Refractories & Furnace Technology (2 Units)

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 temperature. Classification of metallurgical furnaces reactors, e.g. reverberatory furnaces, converters, fluidized-bed reactors. Refractories: Classification, properties and manufacture aluminosilicates. Polymorphic transformations in Si02. Important refractory materials: alumina, silica, magnesite, graphite and silicon carbide.

Ceramics And Glasses (2 Units)

Introduction: Structure ceramic materials; Structure of glass; Transformation Temperature of glass. Fracture strength; Impact resistance and toughness; statistical variations in strength and Weibull distribution. Thermal shock resistance and Thermal spalling resistance; Refractoriness. Glass transition temperature. Glass-Ceramics: Properties and Applications. Deterioration: Chemical attack (e.g. on concrete) at high temperatures (e.g. on ceramic refractories); Nuclear radiation damage.

Metallurgical Laboratory (2 Units)

Heat Treatment: Effect of heat treatment on the microstructures of low carbon steels; Metallorgraphy of phase transformations. Production Metallurgy: Solidification analogue. Determination of the moisture and clay content of green sand. Determination of heat conduction shape factor by electrical analogue method. Non-Destructive Testings (NDT). Macrostructures and defects. Experiments on refractories: Testing of refractories. Measurements of thermal and electrical conductivity. Experiments on corrosion and wear.

Mineral Processing and Extractive Metallurgy (3 Units)

Ore preparation-Drying, roasting, sintering and heat balance. Ellingham diagram and its application. Flotation- Solution chemistry and surface chemistry as related to froth flotation. Absorption interfacial energy, flocculation and dispersion and flotation kinetics. 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.

Pyrometallurgy – 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

8.3.2 M. Eng./M.Sc. and Ph.D Programmes

Core Courses for M.Eng and M.Sc.

Programmes to be offered include: Phase Transformations, Corrosion, Materials processing, Fracture and Failure analysis, Mineral processing.

Advanced Physical Metallurgy, X-ray Crystallography, Advanced Corrosion. Advanced Mineral Processing, Environmental Impact Assessment, Composite Materials or or Electronic Materials or Biomaterials or Biomimetic materials

List of Courses	Units
Advanced Metallurgical Thermodynamics	3
Advanced Physical Metallurgy	3
X-Ray Crystallography	3
Advanced Metallurgical Thermodynamics	3
Advanced Physical Metallurgy	3
X-Ray Crystallography	3
Transport Phenomena	3
Advanced Chemical Metallurgy	3
Advanced Process metallurgy	3
Electronic Materials	3
Advanced Corrosion	3
Advanced Mineral Processing	3
Solidification Processing	3
Dislocation Theory	3
Advanced Fracture Mechanics	3
Powder Metallurgy	3
Fine Particles Technology	3
Flotation Theory and Practice	3
Iron and Steel Making	3
Hydrometallurgy	3
Biomaterials	3
Advanced Biomaterials	3

Composite Materials	3
Biomimetic Materials	3
Interfacial Phenomena	3
Advanced Welding Technology	3
Advanced Structure and Properties of Materials	3

Elective courses related to each student area of specialization are to be taken from other departments subject to approval.

COURSE DESCRIPTION

Advanced Metallurgical Thermodynamics (3 Units)

Review of basic principles of thermodynamics, advanced treatment of the thermodynamics properties of materials. Application of thermodynamics to the chemical behaviour of elements, compounds and solutions; free energy-composition diagrams. Application of thermodynamic principles to the development and use of phase diagrams.

Advanced Physical Metallurgy (3 Units)

Description of metallurgical microstructures and their effect on physical properties such as mechanical and magnetic properties; development of microstructures by phase transformations and plastic deformation. Thermal stability of various microstructures. Nucleation phenomena; growth kinetics; transformations. Advanced dislocation theory:

X-Ray Crystallography (3 Units)

Properties of X-Ray: Production, absorption, scattering; physics of diffraction and interpretation thereof. Instrumentation and interpretation of diffraction patterus; the Laue, Debye-scherrer, weissemberg and precission techniques. Experimental methods; analysis of noncrystalline materials.

Transport Phenomena (3 Units)

Fluid flow, heat and mass transport with applications to metallurgical processes. Dimensional analysis, modeling and predication of process behaviour in industrial systems such as steelmaking, continuous casting, vacuum degassing, heterogeneous processes and heat treatment.

Advanced Chemical Metallurgy (3 Units)

Physical chemistry principles and application to chemical metallurgy with emphasis on kinetics and mechanisms of important reactions in chemical metallurgy systems; recent advances in science and technology of chemical metallurgy systems; recent advances in science and technology of chemical metallurgy and their actual or potential application to metal recovery.

Advanced Process Metallurgy (3 Units)

Study of integrated metallurgical systems involving the major unit processes of pyrometallurgy, hydrometallurgy, electrometallurgy. Extractive metallurgy of the more common metals such as iron, copper, zinc, lead, tin, aluminum, as well as the less common ones such as titanium, molubdenum, silver, gold, chromium and niobium. Refining processes including precipitation, segregation, distillation, etc.

Electronic Materials **(3 Units)**

Materials and physics of aspects of semiconductor, optical and magnetic devices; energy bandstructure, crystal structure, crystal defects and impurity effects, relationship of material characteristics and physical properties; production of electronic materials and devices; single crystal growth, epitaxy, metallization, iron implantation, lithography and etching, characterization techniques; X-ray diffraction, photoluminescence.

Advanced Corrosion **(3 Units)**

Emphasis on corrosion damage and its underlying principles. The thermodynamics and kinetics of electrochemical corrosion of metals and alloys. The eight forms of corrosion-uniform attack, galvanic corrosion, pitting, intergranular, selective leaching, erosion corrosion and stress corrosion are discussed extensively, together with their prevention techniques. Materials selection for use in corrosive environments. Treatment of environmental degradation of non-metals (Ceramics, silicate glasses, concrete, etc) and polymers.

Advanced Mineral Processing **(3 Units)**

Analysis of mineral concentration operations with emphasis on the metallurgical, economic and environmental aspects of the processes; surface chemistry (electrical double layer, zeta potential, Gibb's equation, chemisorption, etc), chemistry of flotation, flotation of oxides, sulphides and silicates. Tailings disposal.

Solidification Processing **(3 Units)**

Principles of control of structure, properties and shape in processes involving liquid-solid and vapour-solid transformation. Heat flow, fluid flow, solute redistribution, nucleation and interface kinetics, thermodynamics of solidifications, processing and properties and relationships. Applications in metal casting, Zone refining, rapid solidification technology RST), and welding.

Dislocation Theory **(3 Units)**

Basic concepts of dislocation; glide and climb, perfect/impact dislocation, stacking faults, jogs. Stress around dislocation, pile-ups and cracks. Energy of dislocation and effect on mechanical properties. Interactions in straight and loop dislocations; effect of dislocations; effect of dislocations on thermal properties of crystals, the line tension of dislocations and boundary condition problems. Application of dislocation theory to metallurgical processes like work-hardening, strain ageing, creep etc.

Advanced Fracture Mechanics **(3 Units)**

Advanced treatment of Hooke's Law. Fracture of single and polycrystalline materials; fracture mechanics, brittle and ductile fracture, fracture and fatigue characteristics. Advanced mechanical testing – simulative and non-simulative tests. The dependent failure of engineering materials. Non-destructive test (NDT). Lubrication, wear and metrology.

Powder Metallurgy **(3 Units)**

Powder metallurgy production techniques and their advantages, powder grading sizing blending, compaction and sintering technology, heat treatment of components produced

by powder metallurgy technique; application of powder metallurgy in protection and repair of worn and corroded components.

Fine Particles Technology (3 Units)
Physical, chemical and engineering aspects of size reduction, communition theories, determination of breakage and selection functions, fine particle characterization and processing, filtration, thickening and classification, fluidization in extractive metallurgy and slurry pipeline systems.

Flotation Theory and Practice (3 Units)
Study of the relationship between surface properties and the flotation behaviour of metallic and non-metallic minerals; types of collectors, frothers and modifiers, mechanism of collection, flotation kinetics, commercial flotation equipment and industrial flowsheet; auxiliary operations including dewatering, tailings disposal, materials handling, etc.

Iron and Steel Making (3 Units)
Iron Ore benefication, agglomeration techniques, palletizing, balling, sintering, briquetting; fluxes for iron and steel making; fuels for iron and steel making; analysis of blast furnace and direct reduced iron technology; cast and wrought iron production; refining of steel; open-hearth, converter, and electric arc processes; de-phosphorization and desulphurization reactions, degasification; ferro-alloys and alloy steel production.

Hydrometallurgy (3 Units)
Extraction of non-ferrous metals from ores, concentrates and secondary metals by wet processes; thermodynamics, kinetics, electrochemical and mineralogical aspects of leaching; practical leaching systems including bacterial aided ones; recovery of metal values from leachates by chemical precipitation gaseous reduction, cementation, ion exchange and solvent extraction.

Biomaterials (3 Units)
Engineered materials in medical applications with an emphasis on material properties, functionality, design, and material response in biological environment.

Advanced Biomaterials (3 Units)
Formation and structure-function relations of biological materials, the interaction of tissue-synthetic biomaterials, advanced biomaterials design, biomimetic processing and current progress in drug delivery systems and biomedical devices.

Composite Materials (3 Units)
Understanding the properties and mechanical behaviour of composite materials. Emphasis on analysis, design, and manufacturing

Biomimetic Materials (3 Units)
A comprehensive study of the structure-function relation of biological hard tissues, and their application to the design and processing of novel materials and devices.

Interfacial Phenomena **(3 Units)**

Thermodynamics of interfaces (liquid/liquid, liquid/vapour, liquid/solid, solid/solid, solid/vapour); interfacial free energy (surface tension measurements in liquids); structure of solid surfaces and interfaces; kinetics of interfacial reactions, electrical double layer theory, theory of flocculation, coagulation and dispersion of collordal suspensions; applications in flotation, agglomeration, liquid surfactant membranes, emulsion and foaming.

Advanced Welding Technology **(3 Units)**

Study of processing variables in joining materials by welding, brazing and adhesive banding. Theories and applications of arc, gas, resistance and solid state welding processes. Modern methods of welding, examination of macro-and micro-structures of welds and the heat affected zones (HAZ). Solidication mechanics, residual stress effects, distortion control. Weldability criteria for ferrous and non-ferrous alloys.

Advanced Structure and properties of materials **(3 Units)**

Introduction to modern ceramic engineering. Quantitative treatment of oxides, nitrides, silicates, borides, carbides, electro-ferroceramics, glass, polymers, biometrical and composite materials. Physical, thermal, electrical, magnetic and optical properties. Mechanical properties and their measurement. Time, temperatures and environmental effects on properties. Applications.

8.4 MINING ENGINEERING

8.4.1 Postgraduate Diploma

Admission Requirements

The admission requirements for the programme are:

a. A 3rd class first degree qualification in Mining Engineering/Metallurgical & Materials Engineering/Chemical Engineering/Geology/Geophysics.

b. HND with at least Lower Units in Mining Engineering/Metallurgical-&-Materials Engineering/Chemical Engineering/ Geology/ Geophysics

Course Outline

Graduation Requirement

To qualify for the award of Postgraduate Diploma, a candidate must have been Unitsed with at least 64 Units of compulsory courses which include the project report.

Year One: First Semester

Title	L	T	P	U
Oil and Gas Well Drilling Technology	3	0	0	3
Engineering Mathematics I	3	0	0	3
Strength of materials	3	0	0	3
Surface Mining	3	2	0	3
Mineral processing	1	2	0	2
Mine survey	1	2	0	2
Engineering Drawing	1	0	3	2
Numerical methods and computer program	2	0	0	2
Total				20

Year One: Second Semester

Title	L	T	P	U
Technology Policy and Development	2	0	0	2
Underground mining	2	2	0	3
Mineral Economics	2	2	0	3
Mine Design	2	2	0	3
Mine Ventilation	2	0	0	2
Mine Management, Law, Entrepreneurship	3	0	0	3
Engineering Maths II	2	0	0	2
Total				18

Year Two: First Semester

Title	L	T	P	U
Seminar	0	0	3	1
Engineer-in-society	2	0	0	2
Field work	0	0	3	3
Drilling and Blasting	1	0	3	2
Electives	3	0	0	3
Project	0	0	9	3

Technical Report Writing	1	0	3	2
Statistics for Engineers	2	0	0	2
Total				18

Year Two: Second Semester

Title	L	T	P	U
Rock mechanics	1	0	3	2
Mine Equipment and machinery	2	2	0	3
Petroleum Reservoir Engineering	2	0	0	2
Reclaimation and Environment	2	0	0	2
Project	0	0	9	3
Mine Construction	2	0	0	2
TOTAL				14

Electives to be taken in the Year Two, First Semester

Title	L	T	P	U
Mine Organization and Planning	3	0	0	3
Operation Research	3	0	0	3

Oil and Gas Well Drilling Technology (3 Units)

Modern techniques for oil and gas well drilling. Drilling rigs; equipment, hoistins, drill string, casing and drill bits. Circulating system, drilling, fluids, muds, drilling hydraulics. Well head equipment, drilling and casing programs. Drilling performance, offshore drilling rigs.

Engineering Mathematics I (3 Units)

First and second order differential equation with constant coefficient. Simple treatment of partial differential equation. Laplace transformation. Element of probability and probability distribution. Normal, Poisson, binomial and geometric distributions. Test of Hypothesis, F. distribution, regression, correlation and analysis of variance. Contingency table.

Underground Mining (3 Units)

Detail study of different underground mining methods to include adit, drift, open stopains, Borehole, level etc. The design of typical mining methods for each operations. Cost estimation in production, transportation and scale underground equipment, drainage ventilation and control of subsidence.

Strength of Materials (3 Units)

Study of different type of materials relevant to mining industries: iron, steel, aluminum, ceramic, wood etc. Bending moments and shear force in beam; failure theories in iron, steel, wood and rock, mohr circle. Type of failure in rock: plane, circular, wedge mode of slope failure. Support systems in surface and underground mines.

Drilling and Blasting (2 Units)

Classification of drilling and penetration methods. Theories of rock penetration, Basic parameter affecting bench drilling i.e. height, burden, spacing and drilling pattern. Choice

of drilling equipment. Type of Explosive: Black powder as low explosive, Ammonium Nitrate explosive like dynamite, military explosives, Blasting methods, Explosive Accessories and construction of magazines. Blasting pattern and disturbance created by blasting.

Surface Mining (3 Units)

Introduction to mining, development of mining technology, opening of a mine, stages in the life of a mine, classification of mining techniques, analysis of surface mining operations. Type of surface of mining techniques, similarities and differences; ore estimation, grade control, reserve estimation short and long range planning. Advantages and disadvantages of surface mines.

Mine Reclamation & Environment (3 Units)

Stripping ratio determined: Overburden and ore characteristics, strength of overburden and ore. Venn and massive type of ore in underground mines. Method of entry. Adit, shaft etc. Underground ore reserve estimation methods, planning and development of underground mine opening. Advantages and disadvantages of underground mines.

Underground Mining (3 Units)

A study of environment problems associated with exploitation of minerals, Reclamation practices, mine atmosphere, detection of mine gases. Pollution monitoring and control, environmental impacts of oil exploitation in the Niger Delta Area, Ozone layer depletion, global warning etc.

Engineer-in-Society (2 Units)

Philosophy of science, engineering technology. History of Engineering and Technology, Safety in Engineering, Professional practice (bodies) – NSE, COREN, COMEG, MNGS, Technology transfer, Nigerian – SAT 1 and it's application to Mining Engineering.

Petroleum Reservoir Engineering (2 Units)

Introduction to hydrocarbon reservoir. Rock and fluid prospectics. Mechanics of fluid flow in porous media. Reservoir drive mechanism. Composition of petroleum, material balance applied to oil reservoirs. Introduction to enhanced oil recovery methods. Well completions. Well tests, and roofing tests, steady and unsteady flow equations.

Rock Mechanics (2 Units)

Rock strength and failure criteria. Common laboratory strength tests: Uniaxial, Triaxial, Brazilian, Flexural tests, stress-strain behaviour in compression. The mohr-Columb failure criterion, the effect of water; the influence of the principal/stress ratio on failure. Empirical criterion of failure. Elastic properties. Application of rocks mechanics in engineering or underground openings. Rock slope stability support systems, design and selection – caving and subsidence.

Mineral Processing (2 Units)

Ore sampling techniques and communition theory, Dewatering, Flocculation and dispersion, theory and practice of thickening, Filtration and drying, criteria for selection of grinding and screening equipment for mineral concentration techniques, and Design,

testing and evaluation of mineral benefaction flow sheets for copper, tin, lead, zinc, iron, gold and other ores of local importance. Material handling method and tailing disposal.

Course Seminar **(1 Unit)**
Review of literature in the area of Mining Engineering. Students write up will be supervised and graded by assigned lecturer for score up to 40 while the seminar is 60, making a total of 100.

Technology Policy and Development **(2 Units)**
History of Technology and its development, utilization of technology as an economic resource in Nigeria. Science, technological knowledge and productive capacity. Implication for planning in a developing economy. The role of Research and Development to the development of a nation.

Mine Design **(3 Units)**
Design of surface and underground excavation methods, Design of drilling and blasting methods, Design of Roadways, shaft, ventilation system, drainage system and magazines. Individual student design work to be carried out.

Surface Mining **(3 Units)**
Analysis of elements of surface mining operations. Design of surface mining systems with emphasis on minimization of adverse environmental effects. Surface excavation, ore estimate, grade control, short and long-range planning unit operations, equipment selection, cost estimation, and slope stability, ore handling equipment, case studies of typical surface mines, coal metals and non-metallic mines.

Mineral Economics **(3 Units)**
Role of mineral industries in national development with emphasize on developing countries like Nigeria. Variation in ore grade, non-renewable asset, increases in funding with increase in depth; wealth conservation. Global production and consumption pattern of major mineral commodities. Structures of established mineral market, supply and demand, mineral pricing. Projecting and fire lasting methods, market research, mine legislation and the mineral industry. Public and the mineral act, Mineral disposal system, mineral taxation policy.

Mine survey **(2 Units)**
Instrument use in topographical mine survey. Traversing on surface and underground mines. The work of mine surveyor. Estimation of results.

Mine Planning and Organization **(3 Units)**
Basic concepts. Routing planning of mining works, Drilling and blushing extraction cooding houlage and waste disposal use of organization network in mine planning and organization.

Operational Research Minerals Industry (3 Units)
Overview of operations research. Application of operations research techniques in mining and mineral processing network analysis, decision theory, guiding theory, linear programming, replacement theory, critical path analysis investment appraisal etc.

Mine Ventilation (2 Units)
Fundamentals of mine ventilation. Techniques for the control of dust, temperature, humidity, gas. Physiological effects and dangers of poor mine ventilation. Basic principles of mine ventilation design. Simple calculations of instrumentation and air measurements. Evaluation of efficiency of ventilation systems. Testing of refrigeration equipment, test of air-conditioning equipment, lack detection methods: Charging and other service procedures for refrigeration and air – conditioning systems. Trouble shooting. Construction of air ducts.

Mine Construction (2 Units)
Factors affecting the sitting of shafts, audits etc. Shaft sinking, tunneling and construction of roadways, drifts, headings etc. Drainage systems in surface and underground mines.

Mine equipment and Machinery (3 Units)
Pumps and their characteristics, excavators, dredges selection of support systems. Different type of transport machines. Coal cutters.

8.4.2 M.Eng./M.Sc and Ph.D Programmes

Core Course For M.Eng and M.Sc.

Applied Underground Rock Mechanics	3
Mine Economics and Finance	3
Mine Ventilation	3
Treatment of Mineral Industry Effluents	3
Rock Fragmentation	3
Environmental Impact Assessment	3

With the approval of the Department, the student is free to take the balance of the required Units load in courses related to the chosen area of specialization.

Mine Management (3 Units)
Human relations in an organization; types of organizations; personnel evaluations and job rating systems; impact of manpower planning on decision-making; union negotiations; public responsibilities to society and employees.

Processing Precious metal Ores 1 (3 Units)
Processing alternatives and mineralogical considerations; physical and chemic recovery technologies; environmental protection; flow sheet studies.

Coal Preparation Technology (3 Units)
Thermal and metallurgical coals: objectives of their cleaning; coal washability and floatability fundamentals; coal preparation unit operations; performance characteristics of coal washing equipment; product dewatering; plant flowsheet.

Applied Underground Rock Mechanics (3 Units)
Study of design methods; underground engineering of openings, pillars and support; Emphasis on design with input being stress, structure and rock mass employing analytical, empirical and numerical tools.

Mining Geostatistics (3 Units)
Basic geostatistical concepts. Applications of geostatistical techniques and stochastic simulations to ore body modeling and grade control.

Mine Economics and Finance (3 Units)
Mine valuation using discounted cash flow analysis and option pricing methods; sources of mine finance and requirements. Sensitivity and risk assessment. Introduction to metals marketing, hedging and risk management.

Rock Slope Engineering (3 Units)
Geologic investigations and field and laboratory testing; detailed review of the mechanisms of rock slope instability; the influence of geology, ground water and blasting on rock slopes stability; design of stable rock slope; monitoring of rock slopes behaviour; stabilization of rock slope failures.

Integrated Mining and Processing Systems (3 Units)
Methods and systems for integrated mining and processing, conceptual model development, simulation, economic and technical evaluation.

Mine Ventilation (3 Units)
Mine air conditioning, ventilation network analysis, radioactivity in mining, case studies in mine ventilation and control of dust, fumes and diesel exhausts.

Mine Shafts and Hoisting (3 Units)
Shaft layout, guide and bunton selection. Hoist rope properties and characteristics. Drum, reel and friction hoisting. Loading and dump arrangements. Head frame layout. Incline hoisting. Signaling and safety devices. Shaft inspection and maintenance. Sinking hoists and stages.

Equipment Selection (3 Units)
Methods of selection of equipment for underground and surface mining. Case studies and applications.

Rock Fragmentation (3 Units)
Theory of practice of drilling and blasting; explosive types and strengths. Blast pattern design for underground and surface operations.

Advanced Coal Preparation (3 Units)
Thermal and metallurgical coals. Desulphurization theory of coal beneficiation. Dense media separation. Coal surface properties and their effect on fine coal processing by flotation and oil agglomeration; coal/water/slurries. Plant performance testing and instrumentation.

Processing of Mineral Fines (3 Units)
Particulate systems; role of particle size and interfacial phenomena in properties of disperse systems. Stability of colloids and suspensions DLVO (Dejaguin-Landau-Vervey-Overbeek).

Treatment of Mineral Industry Effluents (3 Units)
Characteristic of mineral dispersions in gases and in water; dust suppression in mining and in mineral transport facilities; solid-liquid separation; removal of noxious chemicals; waste disposal systems.

Mining Environment Case Study (3 Units)
Regulatory requirements for mine-mill environmental protection in design, operation and closure. Studies of environmental impact statement and closure plans.

Mathematical Modeling of Mineral Processes (3 Units)
Emphasis on crushing, grinding, screening, classification and flotation

Processing of Precious Metal Ores II (3 Units)
Advances in science and technology for recovering gold, silver and platinum group elements.

Acid Rock Drainage (3 Units)
Lectures and seminars on topics of importance in acid rock drainage including fundamentals of ARD generation, prediction, prevention, control, treatment and monitoring for waste management and regulatory control in the mining industry.

Environmental Technologies 7 Issues in Mining (3 Units)
Advanced topics related to mining environment selected in consultation with the instructor.

Maintenance Engineering (3 Units)
The analytical foundation for maintenance of industrial plant equipment and mobile equipment in various production environments. Reliability theory, sensing technology and theory, Risk Analysis, and operations research applied to maintenance management.

Mining and Society (3 Units)
Discussion of social, political and technical topics concerning mining – related activities.

Energy From The Earth: Renewable Versus Conventional (3 Units)
Coal, oil, gas, uranium, hydro, wind, geothermal and geosolar

Special Advance Topic **(2-6 Units)**
A special advanced course may be arranged upon the approval of the department head. Prerequisite: Permission of instructor is required.

Engineering Project **(6 Units)**
A project involving laboratory, pilot plant or fieldwork is to be completed in close collaboration with an academic advisor. For M. Eng. Students only.

Seminar **(2-4 Units)**
Topics in mining and mineral processing for Ph.D. students. At least three seminars required for Ph.D.

MINE 699 THESIS. **(12 Units)**

8.5 ELECTRICAL AND ELECTRONICS ENGINEERING

8.5.1 Postgraduate Diploma

Admission Requirements

a. Higher National Diploma, (HND) in Electrical/Electronics Engineering or related Engineering and Science disciplines with at least, Lower Credit pass; or .

b. B.Sc., B.Eng., or B. Tech. degree in Electrical/Electronics Engineering with at least Third class (Hons); or

c. B.Sc. in Science related discipline with at least a Second class B.Sc., (Hons) degree.

Graduation Requirements

To qualify for the award of Postgraduate Diploma, a candidate must have been unitized with at least 64 units of compulsory courses which include the project report.

Course Outline

Course Title	L	T	P	Units
Year One: First Semester				
Engineering Mathematics I	2	2	0	3
Numerical methods & Computer Programming	2	2	0	3
Circuit Theory I	2	0	3	3
Electrical/Electronics Engineering Materials	2	2	0	3
Engineering Economics	2	0	0	2
EM Fields and Waves	2	2	0	3
Engineering Drawing	0	0	6	2
TOTAL				**19**
Year One: Second Semester				
Engineering Mathematics II	1	2	0	2
Electrical Power Principles	2	0	3	3
Circuit Theory II	2	0	3	3
Electrical/Electronics Measurements and Instrumentation	2	0	3	3
Digital Electronics	2	0	3	3
Electronic Devices and Systems	2	0	3	3
Technical Report Writing	1	0	3	2
TOTAL				**19**
Year Two: First Semester				
Control Systems Engineering I	2	0	3	3
Power Systems Engineering	2	0	3	3
Communication Principles	2	0	3	3
Electrical Machines	2	0	3	3
Project I	0	0	9	3
Reliability Engineering	2	0	0	2

Course Title	L	T	P	Units
The Engineer in Society	1	2	0	2
TOTAL				**19**
Year Two: Second Semester				
Control Systems Engineering II	2	0	3	3
Law, Management, Entrepreneurship	2	2	0	3
Project II	0	0	9	3
Power Electronics	2	0	3	3
Digital Signal Processing	2	0	3	3
TOTAL				**15**
Electives				
Microcomputer Hardware and Software Techniques	2	0	3	3
High Voltage and Switchgear Engineering	1	0	3	2
Communications Systems	2	0	3	3
Microwave Engineering	2	0	3	3
Energy Systems	2	0	0	2
Solid State Electronics	2	0	3	3
Data Communications	1	0	3	2

COURSE DESCRIPTION

Circuit Theory I **(3 Units)**

Elementary signals. Dynamic circuit behaviour, oscillations. First and second order systems. Laplace and Fourier transforms. Time and frequency domain solutions of circuit equations. Stability. Transfer function concepts. Applications of network theorems. Single-phase and three-phase circuits. Two-port network analysis. Introduction to computer-aided analysis.

Circuit Theory II **(3 Units)**

Laplace and Fourier transforms revisited. Application of Laplace transform to transient analysis of RLC circuits. Non-sinusoidal periodic waveforms. Non-periodic signals. Different methods of network synthesis including Cauer, Foster, Long Division method, partial fractions, etc. Conditions for Realizability. Synthesis of non-linear resistive circuits. Computer applications in the analysis and synthesis of linear and non-linear circuits.

Computer Programming **(3 Units)**

Flow-Charting and Algorithm formulation, Coding with (C++, Visual Basic). High Level Languages (e.g. C++, Linux, visual Basic). Applications to Solution of Engineering Problems.

Electrical/Electronics Engineering Materials (3 Units)
Review of Atomic Theory. Electronics configuration of engineering materials. Band-bond theory of solid semiconductor devices. Dielectric and Magnetic materials. Masers and Lasers. Superconductivity; Magnetic alloys; ferrites. Optics.

Engineering Economics (2 Units)
Break-even analysis. Time value of money. Interest ratios (P/F, P/A, P/G, etc). Evaluation single alternative (PW, AW, FW, IRR, etc). Decision making Among Alternatives (PW, AW, FW, IRR, etc). Equal lives and Unequal Lives. Depreciation methods.

Electromagnetic Fields and Waves (3 Units)
Review of electromagnetic laws in integral form: Gauss' Law, Ampere's and Faraday's laws. Electrostatic fields due to distribution of charge, magnetic fields in and around current – carrying conductors. Time varying magnetic and electric fields. Conduction and displacement currents. Maxwell's equations. Poynting vector, energy propagation, and boundary conditions.

Electrical Power Principles (3 Units)
Generation: Sources of Energy (thermal, hydro, nuclear, solar, wind, etc) Economics of Power supply (Tariffs, Load curves, Power factor correction, etc). Power generation, Transmission and Distribution. Corona. Types of cables. Insulators. System protection. Performance charts.

Electrical/Electronics Measurements and Instrumentation (3 Units)
Principles of measurements: Measurement accuracy. Terminology. Signals, Potentiometers, and bridges. Instrument types: Voltage, current, power, energy, and resistance measurements. Electronic and electrical instruments. The cathode ray tube (CRO). Transducers; magnetic effects measurements. Data recording; Spectrum analyzers.

Digital Electronics (3 Units)
Review of Boolean Algebra and Logic Circuits Simplifications; Flip-flops. Counters, Registers, Memory Devices. Semiconductor Technologies: MSI, LSI, etc. Interfaces. Digital converters, e.g. ADC, DAC, series/parallel converters, etc. Microprocessors. Digital Test and Maintenance Equipment.

Electronic Devices and Systems (3 Units)
Diode Circuits. Analysis of Single stage Amplifier circuits. Multistage Amplifiers. Oscillators. Power Supply Circuits. Wave-shaping circuits. Integrated Circuits (ICs). OP Circuits.

Control Systems Engineering I (3 Units)
Open and closed loop systems. Modeling of Physical systems. Dynamic equations of electrical, mechanical, thermal and fluid flow systems. Transfer functions of control

system components. System response and classification. Stability. Nyquist, Bode, Root Locus Analysis. Systems specifications and introduction to design.

Control Systems Engineering II (3 Units)
Analogue computers. State space representation of control systems. Stability of linear and non-linear systems. Linearization of non-linear systems. Describing functions. Sampled data systems. Digital control.

Communications Principles (3 Units)
A general communications system including source, transmission channel, and destination. Analogue Modulation systems. AM, FM, Phase Modulation. Pulse Modulation: PAM, PWM, PPM, PCM. Introduction to Digital Modulation Techniques. Bandwidth considerations. Devices and systems for communications.

Electrical Machines (3 Units)
Electromechanical Energy Conversion systems. DC machines, Transformers. Synchronous and Induction machines. The machine as a generator and as a motor. Analysis of electromagnetic torque.

Reliability Engineering (2 Units)
Reliability concepts. Elementary Reliability Theory. Measures of reliability Failure Time Distribution Models. Exponential, Weibull model). Fault tree analysis (FTA)). Failure Mode, Effect and Criticality, Analysis. Reliability growth. Maintainability and Availability.

Engineering Management (3 Units)
Organization concepts; human resources management. Financial management. Production Management. Company Policy development strategies. Entrepreneurship. Patents, inventions, trade marks and copyrights.

Power Electronics (3 Units)
Controlled rectifiers. Converters. Switching characteristics of diodes, transistors, and t-resistors. Analysis of circuits using transistors as switches, power control circuits, characteristics of switching transformers, ac-dc converters. Power semiconductor devices protection. Waveform synthesis.

Digital Signal Processing (3 Units)
Basic concepts and areas of applications. Discrete-time signals and systems; linearity, shift-invariance, causality, stability, convolutional sum and frequency response. Response. Review of sampling theory and Z-transform digital system realization Finite-impulse response (FIR) and infinite-impulse response (IIR) filter design. Discrete Fourier Transform (DFT) and Fost Fourier Transform (FFT).

Project (6 Units)
Project titles are to be selected from an approved list of suitable topics. The actual work is to be carried out under the supervision of a member of academic staff. The standard of work must demonstrate the ability of the student to undertake independent work at a

professional level of competence. Each student is required to give a project defense seminar his/her work.

High voltage and switch gear Engineering (2 Units)

Methods of generation and measurement of high voltages. Type and tests on switchgears. Mechanisms of dielectric breakdown in gases, liquids and solids. Protection against over voltages. Switchgear construction. Oil switches. Air blast, SF6, Vacuum circuit breakers.

Energy Systems (2 Units)

Global energy assessment. Primary and secondary energy sources. Renewable and non-renewable energy resources. Energy needs of the country. Energy conversion techniques. Energy conservation. Energy management and auditing. Cost of energy.

Microwave Engineering (3 Units)

Microwave Devices and Circuits: Variation Diode, Parametric amplifiers, tunnel diodes, schottky diode. Gunn oscillators, frequency multipliers and up-converters. Microwave Theory and Techniques; transmission lines and waveguides, passive microwave devices: resonators, magic tee, TWT, etc.

Communication Systems (3 Units)

Telephony: Antennas and wave propagation mode. Radar systems. Satellite communication systems. Broadcasting systems (analogue and digital). Introduction to Wireless Communication Systems. Regulations. Telecommunication systems planning.

Data Communications (3 Units)

Introduction to Data communication systems: Digital signals and characters, data signals, band rate, serial and parallel data transmission. Networks and Network topology. Baseband Analysis, Modulated carrier signals (ASK, PSK, QPSK, FSK, MSK, GMSK, etc). Coherent and non-coherent detection of binary signals. Error rate comparison. OSI model and functions of the layers. TCT/IP model and functions of the layers. Network management; Telecommunication Network Management. International Standards.

Solid State Electronics (2 Units)

Physics and properties of semiconductors including high field effect, carrier injection and semiconductor surface phenomena. Devices Technology: bulk and epitaxial material growth and impurity control. Metal-semi conductor interface properties, stability, and methods of characterization. Controlled and surface-controlled devices.

Microcomputer Hardware and Software Techniques (3 Units)

Elements of digital computer design; control unit, programming, bus organization and addressing schemes, microprocessor, system architecture, bus control, instruction execution and addressing modes. Machine codes, assembly language and high level language programming, microprocessor interfacing: input/output technique, interrupt systems and direct memory access; interfacing to analogue systems and application to D/A and A/D converters. System development tools: simulators, EPROM programming

assemblers and loaders. Microprocessor and microcomputers Operating Systems and compilers. Microprocessor applications.

8.5.2 M.Sc/M.Tech/M.Eng and Ph.D Programmes

Some possible postgraduate degree programmes in Electrical Engineering and related disciplines include: (i) Electrical Engineering (ii) Electrical and Electronics Engineering (iii) Computer Engineering (iv) Information and Communication Technology

OPTION I: M.Sc/M.Tech/M.Eng and Ph.D Electrical Engineering

Electrical Engineering has a number of specialization areas. Some are:
(i) Electronics (ii) Power systems (iii) Electrical Machines (iv) High Voltage (v)Control & Instrumentation (vi) Computer & Control (vii) Telecommunications

Electronics, Control & Instrumentation and Communications Option

Core Course	Unit
Microwave Electronics and Systems	**3**
Semi Conductors Microelectronics	**3**
Communications Electronics	**3**
Advanced Logic Design	**3**
Inegrated Circuits and VLSI Technology	**3**
Advanced Engineering Mathematics	**3**
Modern Control Theory	**3**

Elective Courses

Core Course	Unit
Microcomputers and Applications	**3**
Advanced Research & Development Techniques	**2**
Advanced Digital Signal Processing	**3**
Advanced Test and Measurement Intruments	**3**
Computational Intelligence Techniques	**3**
Computer Organization and Design	**3**
Computer Control Systems	**3**
Power Electronics and Industrial Drives	**3**
Intelligent Agents	**3**
System Modelling and Analysis	**3**
Advanced Antena Theory	**3**
Wireless Communication Syetems	**3**
Wireless Management	**3**
Project Management	**2**

Power, machines and High Voltage Option

Core Courses

Core Courses	Unit
Power System Operation and Control	**3**
High Voltage Engineering	**3**
Power System Analyses	**3**
Power Electronics and Industrila Drives	**3**
Electrical Machines, Design and Analysis	**3**
Advanced Engneering Mathematics	**3**

Elective Courses

Core Courses	Unit
Rotating Machine Analysis	**33**
Advanced Research & Development Techniques	**3**
Advanced Machines Theory	**3**
Statistical Methods in Power System Reliability	**3**
Renewable Energy Systems	**3**
System Modeling and Analysis	**3**
Linear Control Systems	**3**
Modern Control Systems	**3**
Computational Intelligence Techniques	**3**
Intelligent Sensors	**3**
Power System Planning and Extension	**3**
Poer Electronics	**3**
High Voltage Measurement Techniques	**3**
Project Management	**3**

The Synopsis of some of the courses listed are as stated below.

COURSE DESCRIPTION

Advanced Engineering Mathematics (3 Units)

Revision of linear algebra, ordinary differential equation, and laplace, fourier, and z-transforms. Complex variable, analysis, and applications. Fast computational methods for linear algebra and integral transform algorithms. Short time fourier transform and applications, Wavelet transform. Green's function, Bessel functions, gamma function. Euler transform. Metric spaces, and algebraic structure. Linear spaces: Bannch and Hilbert spaces; operators in Hilbert spaces. Singular value decomposition vs eigenvalue decomposition and applications. Graph theory and applications. Residue number system and applications. Numerical methods in solving engineering problems.

Advanced Research & Development Techniques (2 Units)

Introduction: Definition of research, characteristics of research, types of research, research process, research as a way of thinking, application of research. IT Impacts: The 'automate' imperative and the 'informate' imperative in the emergence of a new research and development tool. The Research Proposal. The Introduction. The Problem. The

Objective of the Study. The Hypothesis to be Tested. The Study Design. The Setting. Measurement Procedures. Sampling. Analysis of Data. Structure of the Report. Problems and Limitations. Work Schedule. Formulating a Research Problem: Reviewing the literature. Formulating a Research Problem. Identifying Variables. Constructing Hypothesis. Conceptualizing a research Design: The Research Design. Selecting a Study Design. Constructing an Instrument for data collection and Sampling: Selecting a Method for Data Collection.

Modern Control Theory (3 Units)

Brief history and comparison of classical control with modern control. Revision of linear algebra in control theory: Matrix operations, types of matrix, elementary operations, rank, determinant, inverse, transpose. Eigenvalues-distinct, repeated, complex and their eigenvectors, diagonalisation of matrix. Computation and applications of eigenvalues and eigenvectors. State space description of dynamic systems, linear system response, transfer function matrix. Analysis of linear system, stability, observability, and controllability. Smith McMillan form. Optimal Control: Linear regulator problem, linear quadratic methods, state regulation, state estimation, Ricatti equations. Dynamic programming, Calculus of variation, Pontragin principle. Kalman Filter & Extended Kalman Filter: State space model, state estimation, applications. Digital control system: Ztransforms, transfer functions, Difference state space models, stability, Jury test, linear regulator design.

Computational Intelligence Techniques (3 Units)

Fuzzy logic control: Linguistic variables, fuzzy sets and operators, knowledge rules, system analysis, design and implementation, applications of fuzzy logic in control system. Neural Network: Introduction to mathematical analysis of neural network and learning rules, applications of neural network to control systems. Genetic algorithm and applications to control system. Introduction to robotic kinematic.

Core Courses	Units
Advanced Engineering Mathematics	**3**
Modern Control Theory	**3**
Advanced Research & Development Techniques	**3**
Advanced Computer Architecture	**3**
Software Engineering	**3**
Technopreneurship & Cyberlaw	**3**
Project	**6**
Optional Courses	
Advanced digital system design	**3**
Advanced software and firmware development techniques	**3**
Digital image processing	**3**
Speech processing	**3**
Prototyping Techniques	**3**
Advanced microprocessor and microcontroller systems	**3**
FPGA design and programming	**3**
Pattern recognition principles	**3**

Embedded system design & programming	**3**
Project management & Quality assurance	**3**
Advanced Assembly language programming	**3**
Cryptology and computer security	**3**
Artificial Intelligence based systems	**3**

Project Management (2 Units)

Management principles. Project management definition and constraints. Project life cycle. Project planning and scheduling. Project management tools. Critical Path method, CPM: principles, computation, and applications. Project Evaluation & Review Technique, PERT: principles, computation, and applications. Linear programming and application in CPM/PERT. Gannt's chart and applications. Contract law and bidding.

OPTION II: M.Sc/M.Tech/M.Eng and Ph.D Computer Engineering

Specialization Areas

Some common specialization areas in computer engineering are:
(i) Computer System Architecture (ii) Software & Firmware Engineering (iii) Intelligent Robotics & Automation

COURSE OUTLINE

Advanced Engineering Mathematics (3 Units)

Revision of linear algebra, ordinary differential equation, and Laplace, Fourier, and z-transforms. Complex variable, analysis, and applications. Fast computational methods for linear algebra and integral transform algorithms. Short time Fourier transform and applications, Wavelet transform. Green's function, Bessel functions, gamma function. Euler transform. Metric spaces, and algebraic structure. Linear spaces: Bannch and Hilbert spaces; operators in Hilbert spaces. Singular value

Wireless Communications (3 Units)

Wireless LAN. Modem technologies, xDSL, cable modem. IP over different networks and internetworking. Internet Applications Model: Applications models: Remote login (TELNET, Rlogin), File transfer and access (FTP, TFTP, NFS), Electronic Mail (SMTP, POP, IMAP, MIME), World wide web (HTTP), Voice and Video over IP (RTP), Internet management (SNMP). Streaming technologies. W AP (Wireless Application Protocol). Internet Security and Electronic Commerce Technology: Internet security and firewall design (IP sec). Encryption standards. Electronic cash and transaction models. Internet business models and technology development.

Mobile & Personal Communications (3 Units)

Introductory Concepts: Overview of digital communication and radio communication characteristics; Cellular concepts and frequency reuse; Cellular geometry; Co-channel interference and frequency planning; Signal quality, traffic capacity and cell sizing; hand-offs and mobility management; cell splitting; other forms of wireless communication. Signal Impairments and Countermeasures: Path losses; Multipath propagation; Delay

spread and ISI; Fading characteristics; Far-near and shadowing effects; Adaptive detection for processing severely distorted signals; Source and channel coding; Diversity techniques; Co-channel interference reduction techniques; Directional antennas; Sectored cells; Adaptive antennas. Cellular Systems:

Satellite Communications (3 Units)

Elements of satellite communications: Satellite frequency bands, transmission and multiplexing schemes, trans-multiplexing, multiple access schemes. Communication satellites: Satellite orbit, laws governing satellite motion, satellite paths, geostationary satellites, non-geostationary constellations, satellite subsystems, launching of geostationary satellites. Earth stations: Earth station antennas: types of antennas, antenna gain, pointing loss, gain-noise temperature ratio, effective isotropic radiated power (EIRP); high power amplifiers; low noise amplifiers; up and down converters: conversion process, polarization hopping, redundancy configurations; earth station monitoring and control. Satellite link design: Basic link analysis, attenuation, sources of interference, carrier to noise and interference ratio, system availability, frequency reuse, link budget, link design. Multiple access techniques: FDMA

Techno entrepreneurship & Cyber law (2 Units)

Technology Creativity Innovation and commercialization: Entrepreneurship Overview: Establishing & Financing new venture: Marketing and product strategy: Business and technology strategy: Case studies on important technology-based companies E-Commerce: Principles of doing business on the Internet. Advertisements on the Internet. Simulation and using Internet as showroom. Marketing on the Internet. Technical support via Internet. Basic law: Contract law. Cyber law. Cooperative bargaining, conflict resolution. Entrepreneurship case studies:

Advanced Research & Development Techniques (2 Units)

Introduction: Definition of research, characteristics of research, types of research, research process, research as a way of thinking, application of research. IT Impacts: The Research Proposal. The Introduction. The Problem. The Objective of the Study. Analysis of Data. Sampling; Selecting a Method for Data Collection. Establishing the Validity and Reliability of a Research Instrument. Sampling. Data collection, analysis, inference, and presentation. Data mining: Models, tools, and applications. Prototyping. Intellectual-Property Issues: Protecting the intangible, Patents Infringement, Changes to watch for, Patent searches over the Internet), Copyrights Changes to watch for, Software piracy, Plagiarism), Trade secrets (What is eligible to be a trade secret?, Using a trade secret, Infringement), Reverse engineering.

Network Security & Management (3 Units)

Network security: Cryptographic Techniques: Security Protocols: General security architectural concepts, transport layer security protocol, network layer security protocol, IEEE LAN security protocol, OSI upper layers architectural overview, upper layers security model, security exchanges. Directory Systems Security Network management: Fault management; Performance management process, accomplishing performance management, reporting performance information. Accounting management; Network

Management Protocols.

Optical Communications (3 Units)

Introduction: Basic optical communications, generations, merits and limitations of optical fiber communications. Optical Fibre: Geometry, wave propagation, dispersion, nonlinear effects, loss characteristics. Optical Receivers: Block diagram, P-I-N and Avalanche photodiode receivers, noise, sensitivity, bit error rate performance analysis, and design. Coherent Light wave Systems: Principles of coherent and non-coherent detection. ASK,PSK,FSK,PPM,DPSK modulation formats. synchronous and asynchronous demodulation. Bit error rate performance analysis. Performance degradation due to laser phase noise, group velocity dispersion, self phase modulation, polarization mode dispersion, relative intensity noise, effect of timing jitter. Doped fibre amplifiers, Brillouin amplifiers, Fiber Raman amplifiers; Amplifier noise; Amplifier gain characteristics; Amplifier performance analysis; Optical time division multiplexing (OTDM).

Modern Control Theory (3 Units)

Brief history and comparison of classical control with modern control. Revision of linear algebra in control theory: Matrix operations, types of matrix, elementary operations, rank, determinant, inverse, transpose. Eigen values-distinct, repeated, complex and their eigenvectors, diagonalisation of matrix. Computation and applications of eigen values and eigenvectors. State space description of dynamic systems, linear system response, transfer function matrix. Analysis of linear system, stability, observability, and controllability. Smith McMillan form. Optimal Control: Linear regulator problem, linear quadratic methods, state regulation, state estimation, Ricatti equations. Dynamic programming, Calculus of variation, Pontragin principle. Kalman Filter & Extended Kalman Filter: State space model, state estimation, applications. Digital control system: Z transforms, transfer functions, Difference state space models, stability, Jury test, linear regulator design. Fuzzy logic control: Linguistic variables, fuzzy sets and operators, knowledge rules, system analysis, design and implementation, applications of fuzzy logic in control system. Neural Network: Introduction to mathematical analysis of neural network and learning rules, applications of neural network to control systems. Genetic algorithm and applications to control system. Introduction to robotic kinematic.

Advanced Computer Architecture (3 Units)

Overview of Computer Fundamentals: Development history of computer hardware and software. Contemporary computers. Storage and Input/Output Systems. Operating System: Overview of operating system, dimension and type of operating system, high level scheduling, short-term scheduling, I/O scheduling, memory management, virtual memory, window base operating systems, UNIX/LINUX based operating system. Arithmetic system: Fixed point vs floating point system and implementation. Instruction Set and Register, Machine instruction characteristics, types of operands and operations, instruction functions, addressing modes, instruction formats, register organization, instruction pipelining. Control Unit: Micro-operations, control of the CPU, hardwired implementation, control unit operation, microinstruction sequencing and execution, micro programmed control.

Techno entrepreneurship & Cyber law (2 Units)

Overview: Entrepreneurship management and ownership, Entrepreneurs: their characteristics, starting a new business, business planning I strategic planning and strategic management, site selection and layout Establishing & Financing new venture: Opportunities for entrepreneurship, product identification in various fields, risk management Business plan development What is a business plan? The need for a business plan. Preparing a business plan: a) Forecasting developments and charting an action plan. b) Identifying the product/service c) Evaluating the business venture d) Market research and feasibility study. Sources of debt financing, sources of equity financing, financial controls. Marketing and product strategy: Marketing strategy: market analysis - customer and competitor profiles, product differentiation, strategic product timing, product platform strategy, pricing strategies - pricing for profit, market evolution, market development strategies, product development strategies, customer valuation and loyalty.

Advanced Research & Development Techniques (2 Units)

Introduction: Definition of research, characteristics of research, types of research, research process, research as a way of thinking, application of research. IT Impacts: The 'automate' imperative and the 'informate' imperative in the emergence of a new research and development tool. The Research Proposal. The Introduction. The Problem. The Objective of the Study. The Hypothesis to be Tested. The Study Design. The Setting. Measurement Procedures. Sampling. Analysis of Data. Structure of the Report. Problems and Limitations. Work Schedule. Formulating a Research Problem: Reviewing the literature. Formulating a Research Problem. Identifying Variables. Constructing Hypothesis. Conceptualizing a research Design: The Research Design. Selecting a Study Design. Constructing an Instrument for data collection and Sampling: Selecting a Method for Data Collection.

Digital Image Processing (2 Units)

Introduction: definition, problems, and applications of digital image processing. Digital image acquisition devices. Digital image formats. Edge detection techniques, segmentation methods. Image Morphology. Image enhancement. Image restoration techniques. Morphology. Fourier transform and Wavelet transform in image processing. Image registration techniques. Shape analysis. Image understanding. Artificial neural network and image understanding. Colour representation standards, equations, processing, quantization, and dithering. Case study: practical application of image processing to face recognition, fingerprint, iris, etc. Introduction to image compression techniques.

Advanced Assembly Language Programming (2 Units)

Revision of assembly language programming of INTEL 8086/87 and Motorola 68000 microprocessors. Advanced programming of 32bit INTEL microprocessors: Programmer's models of 80x86/Pentium, Protected Mode programming. The floating programming of Intel 80x87/Pentium. MMX, SSE/SSEx programming. Assembly language Windows DLL programming. Advanced Motorola microprocessors programming. Hexadecimal file loaders. MIPS Risc machine programming.

Advanced Microprocessor & Microcontroller System (3 Units)

Introduction to superscalar processor, parallel processor. High performance RISC microprocessor Architecture and interfacing e.g. Intel i960, and Motorola PowerPC microprocessor. Digital signal processing microprocessor architecture and programming. Microcontroller system: Intel 8051/8031 Micro-controller architecture, interfacing and programming; Motorola M6812 microcontroller architecture, interfacing and programming. Introduction to PIC microcontroller: general architecture, applications and selection of microcontroller, advantages, low-end, and high performance PIC. Specific PIC microcontrollers: Features, architecture, block diagram, pin configuration, on-chip memory, and peripheral. Instruction set and Assembly language programming. Serial I/O interfacing: 12C, and SPI interfacing and programming. Memory interfacing: external memory interfacing, EEPROM and Flash memory interfacing. Design exercises using development system.

Prototyping Techniques (2 Units)

Introduction: Grounding, ground plane, digital ground, analogue ground, power decoupling, inductance and capacitive effects, feed through capacitors. RF effects & shielding. Soldering techniques for pass-through and surface mount components, desoldering. Breadboarding, veroboarding. Wire wrapping techniques. Radio Frequency design and implementation techniques. Printed Circuit Board techniques, and production of PCB. Use of PCB CAD packages. Construction exercises using different prototyping techniques. Packaging techniques. Documentation and Manual writing.

OPTION III: M.Sc/M.Tech/M.Eng and Ph.D Information & Communication Technology

Specialization Areas

Some common specialization areas in computer engineering are:
(i) Internet Engineering (ii) Mobile & Personal Communication (iii) Cryptology

Core Courses	Units
Advanced Engineering Mathematics	**3**
Internet Engineering	**3**
Advanced Research and Development Techniques	**3**
Advanced Signal Processing	**3**
Mobile & Personal Communication	**3**
Techno Entrepreneurship and Cyber law	**2**
Communication Policies and Standards	**3**
Project	**6**
Optional Courses	
Satellite Communication	**3**
Network Security and Management	**3**
Microwave Communication Devices	**3**

Optional Courses	
Optical Communication	**3**
Internet Programming	**3**
Software Development In Telecommunication	**2**
Telecommunication Database	**2**
Multimedia Technology & Programming	**3**
Cryptology Principles And Applications	**3**
Alternate Energy Sources	**3**
Antenna Design	**3**
Radio Propagation & Fading	**3**

Course Outline

Internet Engineering (3 Units)

Internet Technology: Communication Networks: Narrowband ISDN: ISDN standards, interfaces and functions. ISDN services. Frame Relay and Broadband ISDN: Background; Protocols and services. B-ISDN standards, services and architecture; SOH. A TM networks. Cellular Networks: Overview, standards, network architecture. (OFDM), wavelength division multiplexing (WDM), Optical Code division multiple-access (OCDMA), subcarrier multiplexing (SCM); WDM components: WDM multi/demultiplexers, addand drop multiplexers (ADM), star couplers, Optical cross-connects, wavelength converters; performance analysis of multi-channel systems. Crosstalk. WDM systems. Free space Optical Links: Atmospheric optical channel, effects of atmosphere on optical beams, on direct detection receivers, heterodyning over atmospheric channel, optical inter satellite links. Optical Networks: Topology, WDM networks. Optical LAN, WAN. Broadcast and select optical networks. Wavelength routed optical networks. Future Trends in Optical Fibre Communications

Microwave Communications (3 Units)

Microwave Devices: Overview of performance characteristics and applications. Microwave Diodes. Microwave bipolar transistors, hetero junction bipolar transistors, Field Effect Transistors. Transferred Electron Devices. Avalanche Transit-Time Devices. Microwave tubes. Applications in microwave circuits. Network Analysis: Transmission Line Equations and Solutions, Smith Chart, ABCD Matrix, S-Parameter Matrix, Signal Flow Graphs. Impedance Transformation and Matching Impedance Measurements, Single-stub Matching, Double-stub Matching, Triple-Stub Matching, Impedance Matching with Lumped Elements, Waveguide Reactive Elements, Quarter-wave Transformer, Binomial Transformer, Chebyshev Transformer, Tapered Transmission Lines Waveguide and Coaxial Components: Rectangular, bends and twists, ridge, fin Line, terminations, attenuators, phase shifters, Circular Polarizers. Coaxial-to-Waveguide Transitions. Baluns. Stripline Circuits: Substrate materials, stripline, micro strip, terminations, attenuators, couplers, power dividers, isolators, resonators, filters. Power Measurements: Introduction, Types of Power Measurements, Sensors, Meters, Specifications.

Advanced Digital Signal Processing (3 Units)

Review of fundamentals of DSP: Discrete-time signals and systems, sampling and reconstruction, Z-transform, transform analysis of linear time-invariant systems, structures for discrete -time systems, Fourier analysis of signals using DFT, FFT. Digital filters: Digital and analog filtering, Filter specifications, Magnitude and phase responses, IIR and FIR filters, Design of IIR and FIR filters; Rational parametric models of random signals, Autoregressive models, Yule-Walker equations, Levinson-Durbin algorithm, Lattice filters, Schur algorithm. Adaptive FIR filters, Error-performance surface, Steepest-descent algorithm, LMS algorithm, Convergence properties, Gradient adaptive lattice filter, Method of least squares, Recursive least squares algorithm, Applications in telecommunications, image processing, video compression, audio system, etc. DSP Hardware: Fixed point and floating point DSP, merits, demerits, and applications.

FPGA design and Programming (3 Units)

FPGA architecture and data path design for digital filters, multirate filters, and spectrum channelisation using digital down converter. Implementation of FPGA DSP design using VHDL and visual dataflow methodologies; FGPA Programming.

Software Development in Telecommunication (2 Units)

Telecommunication software development: Introduction. Examples of life cycles (V life cycle, Y life cycle, spiral life cycle, etc. Methods and tools for: requirement capture, analysis, specification, architecture, design and development. Finite state machines: the SDL language. Programming: Overview of programming languages (C, C++, Java) in telecommunication. Real-time programming. Programming for embedded systems. Performance and memory management. Configuration management. interfaces definition: Problem overview. Transparency of distribution. Distributed 00: the COREA solution, the Java solution. Interface specification in TMN. System tests: Unit tests. Software integration tests. Hardware integration tests. Embedded software tests. Performance and conformance tests. Testing of 00 software. CASE to test: Attols, Insure, Hindsight, etc.

Telecommunication Database (2 Units)

Introduction: Database in telecommunication systems. The Switch example. Constraints on a Switch database (size, real-time aspects, security, etc). Database environment: Traditional file based systems, database approach, roles in database environment, the history of database systems, advantage and disadvantage of database systems The three level ANSI-AP AC architecture, database languages, data models and conceptual modeling, functions of a DBMS, concepts of a DBMS, multi-user DBMS architecture, data dictionary. Relational Databases: Database trends in telecommunication: Real-time database, Multimedia database, WWW servers and database, 3D image handling in database, multimedia and existing RDBMS. Standardization trends.

Multimedia Technology (3 Units)

Multimedia and supporting technologies: Multimedia definitions, multimedia services, trends of market, issues of multimedia information circulation, communication technologies, LAN technologies, personal computer technologies, internet home appliance technologies, future multimedia services. Basic technologies of multimedia

information circulation: E-mail, common gateway interface between WWW and database, java, active X, virtual reality modeling language, push type service provision. Application technologies of multimedia information: Circulation directory, community of interest platform, fusion of internet and existing telecommunication technologies, computer telephony integration security and transaction, electronic data exchange, agent communication. Network configuration of the information superhighway, SONET, SDH, ATM copper access network, CATV access network, wireless access network, fiber access network. Video communication technologies in multimedia: Video coding standards, rate control, TV conference, quality of service transfer of pre-recorded video. Architecture and algorithms for controlled quality of service: Programmable quality by ATM network, QOS routing, traffic performance of multimedia services, quality measurement method, quality evaluation method, traffic control. Multimedia protocols: Protocol over ATM networks, object oriented transport protocol, synchronization protocol.

8.6 PETROLEUM ENGINEERING

8.6.1 Postgraduate Diploma

The Post-Graduate Diploma in Petroleum Engineering is designed to prepare candidates whose first degrees are in Science and other Engineering disciplines for a career in the petroleum industry. This programme is also recommended as a necessary preliminary for engineers from disciplines other than petroleum engineering, who wish to specialize in any of the areas offered in the master of engineering degree programme in petroleum engineering. This programme has been designed to satisfy the Council for the Regulation of Engineering in Nigeria (COREN) minimum standards for petroleum engineering.

Admission Requirements

Candidates for the Post-Graduate Diploma in Petroleum Engineering must possess a Bachelor's degree in Engineering, Physics, Geology, Chemistry, Mathematics or Computer Science with a minimum of Third Class Honours.

Duration

The Post-Graduate Diploma in Petroleum Engineering shall last for a minimum of twelve calendar months of full-time study or twenty-four calendar months of part-time study.

List of Courses

Year one First Semester

List of Courses	Units
Drilling &. Well Engineering	3
Petroleum Production Engineering	3
Reservoir Analysis I	3
Chemical Engineering Thermodynamics	3
Basic Engineering I	3
Transport Phenomena I	3
Engineer–in-Society	1
Engineering Mathematics I	3
Engineering Drawing	2
Total	24

Year Two Second Semester

List of Courses	Units
Applied Petroleum Geology	3
Well Complretions and Workover	3
Reservoir Analysis II	3
Natural Gas Engineering	3
PertoleumEconomics and Property Valuation	3
Transport Phenomena II	3
Research Project I	3
Technical Report Writing	2
Management and Law	2
Total	25

Electives

List of Courses	Units
Petroleum Engineering Design projects	3
BasicEngineering II	3

Criteria for the Award of the Post-Graduate Diploma

In addition to the general University requirements for the award of Post-Graduate Diploma, candidates must complete and pass all the courses recommended by the department.

Course Description

Drilling and Well Engineering (3 Units)

This course covers drilling engineering. Specifically, the following topics are covered. Comprehensive picture of modern drilling operations, practices, equipment, both onshore and offshore. Well drilling methods, rheology of Newtonian and non-newtonian fluids, chemical properties and carrying capacity of drilling fluids, rotary drilling hydraulics, prediction and control of abnormal pressures: pressure loss calculations in rotary drilling, surge and swab pressures and hole problems encountered in drilling operations. Coiled Tubing Drilling, Slim hole and monobore, Aerated fluid drilling. Casing and Cementing operations

Petroleum Production Engineering (3 Units)

Analysis, specification and characteristics of production systems. Well analysis; inflow performance relationships. Study of flow in pipes; sucker rod pumping; gas lift; submersible pumping, hydraulic pumping. Production logging; offshore technology; Formation Damage Assessment; Production Optimization; Analysis and evaluation of surface production processing, fluid separation, storage, measurement, treating, custody transfer, transmission, disposal, corrosion, other operations.

Reservoir Analysis I (3 Units)

This course covers rock and fluid properties, reservoir engineering and the water and gas flooding aspects of enhanced oil recovery. Participants are exposed to the petro-physics of reservoir rocks. Discussion of porosity, permeability, saturations, electrical conductivity, capillary pressure, and relative permeability. Reservoir fluid properties and behaviour under high pressure and relatively high temperature. Gas laws, pressure-volume-temperature (PVT) characteristics of binary and complex hydrocarbon systems, equation of state. The K¬value concept and its use in stage separation. The use of fluid properties in reservoir engineering. Description and classification of natural underground oil and gas reservoirs. Fluid flow in porous media. Reservoir drive mechanisms. Engineering calculations of fluid content of reservoirs and predicted recoveries of oil, natural gas, geothermal, and water reservoirs, material balances, steady and unsteady flow equation. Water flooding and gas injection aspects of enhanced oil recovery.

Applied Petroleum Geology (3 Units)

This covers introductory geology, petroleum geology and formation evaluation:

specifically, the following areas are emphasized: Geologic map interpretation. Simple geologic structures. Orogenic movements, volcanism and mountain building. Introduction to paleontology and stratigraphy, historical geology. Introduction to petrology. Elementary geology of Nigeria. Economic minerals of Nigeria. Applied aspects of geology. Physical and chemical characteristics of petroleum, reservoir geology. Chemistry and origin of formation water. Origin, migration and accumulation of petroleum. Structural stratigraphic and combined traps. Basin analysis and the Niger Delta Petroleum Prospect. Other Nigerian Petroleum deposits. Global distribution of petroleum in time and space. The energy problem. Subsurface methods in petroleum exploration and exploitation. Well-logging methods and interpretations. Open-hole and cased-hole logs, their mechanics and manipulations. This course will be accompanied by labs, and/or field trips.

Well Completions and Workovers (3 Units)

Participants are exposed to the following areas: Casing design and selection, tubing design and selection, primary and secondary cementing methods, perforation, stimulation, acidizing, hydraulic fracturing, formation testing, sand control and workovers.

Reservoir Analysis II (3 Units)

Mathematical basis for pressure transient tests. Theory and practical of pressure testing techniques for oil and gas wells. Pressure build-up, pressure draw-down; pressure fall-off, interference, multi-rate, injectivity and pulse testing. Determination of average reservoir pressure, reservoir heterogeneities and rock properties. Test design, etc.

Natural Gas Engineering (3 Units)

This course covers Natural Gas Engineering and Processing. Specifically, the following topics are emphasized: Production and transportation of gas, metering, compression, well performance, estimation of reserves, utilization and conservation. Field handling of natural gas. Sour gas problems. Study of gas condensate fields, underground storage. Application of the concepts of thermodynamics, transport phenomena, and phase behaviour in processing and conditioning of natural gas and its liquids. Absorption, adsorption and fractionation processing; gasoline plant design; Liquefied Petroleum Gas (LPG); Liquefied Natural Gas (LNG). Other sources of gas.

Valuation Petroleum Economics and Property (3 Units)

Profitability analysis in oil and gas investments: interpretation of technical and economic data; evaluation of risk and uncertainty in oil and gas exploitation. Decision tree analysis; Monte Carlo Simulation; Preference theory; pricing and bidding strategies; optimum development of oil and gas fields.

Petroleum Engineering Laboratory (1 Unit)

Experiments in rock and fluid properties, drilling fluids, cementing and well completion fluids, flow measurements and instrumentation.

Petroleum Engineering Design Project **(2 Units)**

The projects will cover field and/or laboratory studies. Every student is required to submit a project report on the solution of an integrated petroleum engineering problem.

Chemical Engineering Thermodynamics **(3 Units)**

A study of energy, entropy and equilibrium; their interrelations and the engineering relationships to which they give rise. Thermodynamics of energy conversion and fluid flow. Physical and chemical equilibria in multi¬component systems. Partial molar gibbs free energy and the chemical potential. Ideal and non-ideal solution behaviour. Phase separation and equilibrium between phases for non reacting systems. Phase eq2uilibrium between phases for reacting chemical and electrochemical systems. Surface chemistry.

Basic Engineering I **(2 Units)**

This course is divided into two sections namely:

Engineering Mathematics: Partial differentiation, directional derivative, gradient differential, infinite series, matrix algebra, solutions of systems of linear equations and numerical techniques.

Strength of Materials/Engineering Mechanics*:* Basic concepts and principles of Mechanics, definition of movements and couples. Friction problems, determination of forces structures (frames, machines) shear forces, moment of inertia.

Transport Phenomena I **(3 Units)**

Fluid Mechanics. Momentum transfer in fluids in laminar and turbulent flow. Microscopic and macroscopic material, momentum and energy balances. Rheology. Dimensional analysis: flow in conduits, pumps: fluid metering. Heat and mass transfer: heat transfer rate: conduction, convection and radiation mechanisms of heat transfer; heat exchanger design. Molecular diffusion, mass transfer mechanisms, phase mass transfer coefficients, prediction of mass transfer
rates.

Transport Phenomena II **(3 Units)**

Momentum, energy and mass transfer in solids, in laminar and turbulent fluid in and between two phases; theory of molecular, and eddy viscosity, thermal conductivity and diffusivity, microscopic and macroscopic equations of motion, radiant heat transfer.

Basic Engineering II **(2 Units)**

Engineering Drawing: Fundamentals of engineering drawing, language of engineering, use of scale, link work, lettering, geometrical constructions. Projection of points, line surfaces and solids in space. Principles of orthographic projection, true lengths and gradients. Free hand sketching of machines.

8.6.2 M.ENG. PROGRAMME

Candidates with a first degree in Petroleum Engineering (minimum second class lower degree) or candidates with the Post-Graduate Diploma, (PGD,) in Petroleum engineering (CGPA not below 3.00).

The required post-graduate courses, depending on the area of specialization, are as follows:

Courses For Students with Engineering Background:
M.Eng. Petroleum Engineering (Reservoir Engineering)

First Semester

List of Courses	Unit
Mathematical Techniques in Petroleum Engineering	3
Advanced Reservoir Engineering	3
Advanced Evaluation of Oil and Gas Properties	3
Improved Recovery Method.	2
Total	11

Second Semester

List of Courses	Unit
Well Test Analysis	2
Numerical Reservoir Simulation	3
Graduate Seminar in Petroleum Engineering	1
M. Eng Thesis	6
Total	12

Elective Courses

List of Courses	Unit
Advanced Reservoir Analysis	3
Advanced Gas Engineering	3
Multiphase Flow in Pipes	2
Well Test Analysis	2
Artificial Lift Methods	2
Total	12

M. Eng. Petroleum Engineering (Production Engineering)
First Semester

List of Courses	Unit
Mathematical Techniques in Petroleum Engineering	3
Multiphase Flow in Pipes	3
Advanced valuation of Oil and Gas Properties	3
Petroleum Engineering Electives	3
Total	12

Second Semester

List of Courses	Unit
Advanced Formation Evaluation	2
Artificial Lift Methods	2
Graduate Seminar in Petroleum Engineering	1
M.Eng. Thesis	6
Total	11

Elective Courses

List of Courses	Unit
Advanced Reservoir Analysis	3
Advanced Gas Engineering	3
Drilling Optimization	3
Well Test Analysis	3
Rock Mechanics	3
Total	15

M.Eng. Petroleum Engineering (Petroleum Economics)

First Semester

List of Courses	Unit
Micro Economics	3
Mathematical Techniques in Petroleum Engineering	3
Advanced Evaluation of Oil and Gas Properties	3
Alternative Hydrocarbon Sources (Oil, Shale, Coal, Tar sands).	2
Petroleum Engineering Electives	3

Second Semester

List of Courses	Unit
Micro Economics	2
Production Management	2
Risk Analysis in Petroleum Ventures	3
Graduate Seminar in Petroleum Economics	1
M.Eng Thesis	6
Total	

Elective Courses

	Unit
Advanced Reservoir Analysis	3
Advanced Gas Engineering	3
Advanced Gas Engineering	3
Multiphase Flow in Pipes	3
Advanced Formation Evaluation	3
Coal Conversion Processes	3
Thermal Recovery Methods	3
Total	21

M.Eng. Petroleum Engineering (Gas Engineering)

First Semester

List of Courses	Units
Mathematical Techniques in Petroleum Engineering	3
Advanced Gas Engineering	3
Advanced Evaluation of Oil and Gas Properties PNG Petroleum Engineering Elective	3
Total	9

Second Semester

List of Courses	Units
Coal Conversion Process	3
Lng Processing	3
Graduate Seminar in Petroleum Engineering	1
M.Eng Thesis	6
Total	13

Elective Courses

List of Courses	Units
Advanced Reservoir Analysis	3
Multiphase Flow in Pipes	3
Alternative Hyrocarbon Sources Coal, Tar Sands)	2
Well Test Analysis	2
Numerical Reservoir Simulation	3
Artificial Lift Methods.	2
Total	

M.Eng Petroleum Engineering (Drilling Engineering)

First Semester

List of Courses	Units
Mathematical Techniques in Petroleum Engineering	3
Advanced Evaluation of Oil and Gas Properties	3
Drilling Optimization	3
Petroleum Engineering Elective	3
Total	

Second Semester

List of Courses	Units
Advanced Formation Evaluation	2
Rock Mechanics	3
Graduate Seminar in Petroleum Engineering	1
M.Eng Thesis	6
Total	12

Courses For Students Without Petroleum Engineering Background
For other candidates without degree in Petroleum Engineering the courses to be taken are as follows:

Specialization in Reservoir Engineering
First Semester

List of Courses	Unit
Mathematical Techniques in Petroleum Engineering	3
Rock and Fluid Properties	3
Formation Evaluation 1	2
Petroleum Geology	3
Improved recovery	3
Method Well Testing	2
Total	16

Second Semester

List of Courses	Unit
Advanced Well Testing	2
Numerical Reservoir Simulation	3
Fundamentals of Reservoir Engineering	3
Advanced Formation Evaluation	3
Graduate Seminar in Petroleum Engineering Specialization in Gas Engineering	1
Total	12

Specialization in Drilling Engineering

First Semester

List of Courses	Unit
Mathematical Techniques in Petroleum Engineering	3
Multiphase Flow in Pipes	3
Rock and Fluid Properties	2
Drilling Engineering II	3
Well Completion and workover	2
Formation Evaluation I	2
Total	

Second Semester

List of Courses	Unit
Advanced Formation Evaluation	3
Drilling Engineering 1	3
Drilling Fluid Technology	2
Rock Mechanics	3

Graduate Seminar in Petroleum Engineering	1
Total	

COURSE DESCRIPTION

Mathematical Techniques In Petroleum Engineering (3 Units)

Philosophy of solution of Engineering Problems. Construction, solution and interpretation of mathematical models applicable to the study of petroleum engineering problems. Operational calculus, curve fitting, Fourier transform, green's function and method of images approaches. The application of mathematical Techniques to solve the partial differential equation of steady and unsteady state flow in porous media.

Advanced Reservoir Analysis (3 Units)

Mathematical development and calculations of reservoir behaviour and flow of oil, gas and water. Treatment of performance calculations, for depletion gas cap, water, gravity and combination drives water recharge theory. Development and use of fluid displacement equations.

Advanced Gas Engineering (3 Units)

Transient flow of gas in reservoirs, testing of gas wells. Gas reservoir material balance, water drive (recharge) gas reservoirs, tight gas reservoirs, production matching and forecasting, reserve estimation, gas storage reservoirs. Optimum development of gas reservoirs. Current developments in gas engineering.

Multiphase Flow in Pipes (2 Units)

Development of equations and correlations utilized to predict pressure loss in multiphase flow of gases, and liquids in verticals, horizontal and inclined conduits, and across restrictions. Analysis techniques and design of total systems.

Advanced Formation Evaluation (2 Units)

Advanced logging systems, planning, and computer aided interpretation. Proper combination of well bore logs with computer analysis of digitized data to provide a more detailed inspection of formations. Use of cross-plots in comprehensive formation interpretations. Production logging.

Advanced Evaluation of Oil and Gas Properties (3 Units)

Selected topics of current research and development in petroleum production economics. More extensive work on evaluation of oil and gas properties. Optimization empirical and statistical methods applied to technical problems and management decisions. Actual field and leases will be used. Economics of oil and gas production. Profit indicators and decision criteria in oil and gas business. Oil and gas value chain International oil and gas business determinants

Well Test Analysis (3 Units)

Development of solutions to the diffusivity equation, Application of the solutions to pressure build-up, draw-down, and fall-off; identification of well bore storage and fractured wells; evaluation of stimulation treatments; pressure interference in multiple

well reservoirs; well deliverability. Transient flow of gas in reservoirs and analysis of gas well test data. Pressure behaviour in anisotropic systems and heterogeneneous reservoirs.

Numerical Reservoir Simulation (3 Units)
Development of the equations for multiphase, multidimensional flow in porous media and the mathematical procedures required for their solution. Differencing Schemes for the partial differential equations. Numerical methods for the solution of behaviour equations; recent developments, Treatment of reservoir history matching techniques.

Drilling Optimization (3 Units)
This course stresses the principles of minimum cost drilling. The course gives explanation and application of established procedures for selecting mud properties, for optimizing hydraulics for optimizing bit weight and rotary speed, and for bit selection. Lectures will be supplemented with current literature on optimized drilling.

Optimization Methods (2 Units)
Well Planning data for optimized drilling Cost per foot. Bit selection. Time value of money. Expected Value Method etc

Rig Hydraulics (2 Units)
Review of drilling fluid properties, field application of drilling fluid technology, solving mud problems, Slip velocity, friction loss, jet bit hydraulics, surge and swab pressure analysis, Guide to optimum hydraulics, Hole Cleaning

Bit selection (2 Units)
Types of bits, classification, dull bit grading and wear evaluation, down hole motors and steerable systems. Current bit technology. Rock failure models, optimal weight on bit rotary speeds. Bit Weight and Rotary speed
Effects of bit weight, rotary speed and tooth wear on penetration rate, Estimation of model equations

Drill Hole Geomechanics (2 Units)
Pressures, Formation pressure prediction, Fracture gradient prediction, selecting casing depths, Stresses around a drilled hole.

Formation Evaluation I (2 Units)
Current state of the art and importance to optimized drilling

Emerging Drilling Technologies (2 units)
Directional drilling, horizontal drilling, Multilateral drilling, coiled tubing drilling, under balanced drilling. Effects on Optimized drilling. Drill string analysis and effects on optimized drilling

Alternative Hydrocarbon Sources (Oil Shale, Coal Tar Sands) (3 Units)
Nature and properties of fossil fuels in relation to use; preparation of fuels; by-products; fuel analysis. Critical assessment of technological aspects of national and global energy consumption, fuel resources, and technically feasible methods of energy conversion.

Coal Conversion Processes (3 Units)
Analysis of the reactions processes and conditions for conversion of coal to synthetic natural gas, low BTU gas, liquid fuels and chemicals, solvent refined coal, and other products; coal pyrolysis and hydrogeneration; chemical character of coal products; fundamental engineering challenges.

Risk Analysis in Petroleum Ventures (3 Units)
Practical application of risk analysis techniques to oil and gas ventures. Topics covered include the risk adjusted value, exploration economics, risk aversion and its management, controlling risk by sharing, capital budgeting and project selection, and search area analysis. Participants will get practice in the determination and selection of oil and gas business strategies and tactics.

LNG Processing (3 Units)
Processing of natural gas for liquefaction. Thermodynamics cryogenics, liquid recovery. Plant design. LNG storage, transportation, regasification, feasibility studies.

Artificial Lift Methods (2 Units)
Design and comparison of artificial lift systems including sucker rod pumping, gas lift, electrical submersible pumping, hydraulic pumping, jet pumping, plunger lift and other methods.

Improved Recovery Methods (2 Units)
Transport of mass and heat through porous media. Specific applications to misciple displacement of oil, flow of non-Newtonian fluids surfactants, inert gas injection, and other modern fluid injection methods.

Thermal Recovery Methods (2 Units)
Applicability of thermal recovery methods to oil recovery. Theory of displacement mechanisms, thermodynamics of steam, heat transfer calculations, design of steam floods, comparison with other improved recovery methods. In situ and wet combustion techniques.

Rock Mechanics (3 Units)
Application of theories in mechanics and properties of rock to problems of rock failure, solutions of equations of rock mechanics. Application to mining and drilling. Rock mechanics in Oil and Gas exploration and production. Definition of rocks, rock properties and rock classification, density, specific gravity ,porosity, permeability, stress: forces, stresses and their effects, rock, strength and failure criteria, deformation of rocks, crater formation, plastic and pseudo plastic characteristics of rocks load rate mechanism, static and impact loading; tooth penetration as a function of differential pressure on drilling rate, rock-bit interaction, well bore stability, application of rock mechanics to well completion, well stimulation, reservoir engineering, safety and environment Use of rock mechanics soft wares

Graduate Seminar in Petroleum Engineering (1 Unit)
This is a required course for all graduate students. A series of seminars will be delivered

by students following extensive literature review on topics of current research interest in Petroleum Engineering. Presentation and communication skills in will be emphasized. Use of modern computer language for presentations is a prerequisite for this course. Soft skills in the work place, team building skills and entrepreneurial skills. Stress management

Graduate Seminar in Economics (1 Unit)

This is a required course for all graduate students in the Petroleum Economics option. A series of seminars will be delivered by students following extensive literature review on topic of current interest in Petroleum Economics. Presentation and communication skills will be emphasized. Use of modern computer language for presentations is a prerequisite for this course. Soft skills in the work place, team building skills and entrepreneurial skills. Stress management

M.Eng Thesis (6 units)

Directed research on some problems within an approved area. Examination and written thesis are required.

Micro Economics (2 units)

The aim of this course is to provide a thorough grounding in the techniques and practical application of micro economic analysis. The course will cover allocation of resources, the theory of price, theories of consumer behaviour, supply and the theory of costs, the theory of the firm, and the need for government intervention.

Macro Economics (2 units)

This course is intended to give students an appreciation for the working of an economic system. Such economic problems as unemployment, inflation, economic instability and the role of government in these issues are analyzed. Macro economic models as applied in the areas of agriculture and industry will be emphasized. Similarly, the role of the Federal and the State Governments in the Nigerian economy will receive emphasis. The topics to be covered will include, but will not be limited to the following: Macro Economic Concepts and Measurement, National Income, National Product, Domestic Product, Macro Economic Models, Consumption, Capital and investment, Money supply, Demand for money, Inflation, Economic Growth, Monetary and Fiscal Policy, Income Distribution.

Production Management (2 units)

The objective of this course is to introduce to the students the scope and capabilities of manufacturing and servicing systems and to provide him/her with knowledge through which he/she can improve the operation and efficiency of each system.

8.7 CHEMICAL ENGINEERING

8.7.1 Postgraduate Diploma Programme

a. Candidates having a Higher National Diploma (HND) with at least an upper Units or its equivalent in Chemical Engineering from any recognized Polytechnic.
b. Candidates having a Bachelor's degree with at least a 3rd Class division in Chemical Engineering of any recognized University.
c. Candidates having Bachelor's degree with at least a 2nd Class Lower division in Chemistry from a recognized University.

Graduation Requirements

To obtain a PGD in Chemical Engineering a candidate must satisfy the examiners with a minimum of 64 Units, made up as follows:

a. 51 Units of the Core Courses
b. 4 Units of the Elective Courses
c. 3 Units of the Design Project
d. 6 Units of the Research Project

Course Outline

Year One Courses

Course Title	Unit (s)
Engineer-in-Society	1
Material Science	2
Engineering Mathematics I	3
Engineering Mathematics II	3
Chemical Engineering Thermodynamics I	3
Chemical Engineering Thermodynamics II	3
Transport Phenomena I	3
Transport Phenomena II	3
Chemical Engineering Kinetics	3
Chemical Reaction Engineering	3
Chemical Engineering Laboratory I	2
Chemical Engineering Laboratory II	2
Chemical Engineering Process Analysis	3
Unit Operations I	3
Engineering Drawing	2
Numerical Analysis and Computer Programming	2

Year Two Courses

Course Title	Unit (s)
Unit Operations II	3
Unit Operations III	2
Process Design and Economics	2
Design Project	3
Research Project I	3
Research Project II	3

Chemical Process Dynamics & Control	3
Process Optimization	2
Process Modeling and Simulations	2
Management and Law	2
Basic Biotechnology	3

Electives

Course Title	**Unit (s)**
Analytical Chemistry	2
Organic Chemistry	2
Applied Electricity	2
Strength of Materials	2
Natural Gas Processing	2
Coal Production Technology	2
Cement Technology	2
Battery Technology	2
Brewing Technology	2
Loss Prevention in Process Industries	2
Polymer Science and Technology	2
Corrosion Engineering	2
Engineering Costing and Evaluation	2
Electrochemical Technology	2
Pulp and Paper Technology	2
Sugar Technology	2
Introduction to Petroleum Engineering	2
Petroleum Refining Technology	2
Petrochemical Processing	2
Biochemical Engineering	2
Environmental Pollution Control	2

Year One: First Semester

Compulsory Courses

Course Title	**L TP**	**Units**
Engineer-in-Society	1 0 0	1
Engineering Mathematics I	2 2 0	3
Chemical Engineering Thermodynamics I	1 2 0	2
Transport Phenomena I	1 2 0	2
Chemical Engineering Kinetics	2 2 0	3
Chemical Engineering Lab.I	0 0 3	1
Chemical Engineering Process Analysis	2 2 0	3
Engineering Drawing	1 0 3	2
Total Units		17

Second Semester
Compulsory Course

Course Title	L TP	Units
Materials Science	1 0 0	1
Engineering Mathematics II	2 2 0	3
Chemical Engineering Thermo II	1 2 0	2
Transport Phenomena II	1 2 0	2
Chemical Reaction Engineering	1 2 0	2
Chemical Engineering Lab. II	0 0 3	1
Unit Operations I	2 2 0	3
Numerical Analysis and Computer Programming	2 0 0	2
Total Units		**16**

Year Two: First Semester
Compulsory Course

Course Title	Unit	L T P
Unit Operations II	2 2 0	3
Process Design and Economics	2 2 0	3
Research Project I	0 0 9	3
Process Dynamics and Control	1 2 0	2
Process Modeling and Simulations	1 2 0	2
Basic Biotechnology	2 0 0	2
First Elective	1 0 3	2
Technical Report Writing	1 0 3	2
Total Units		**17**

Year Two: Second Semester
Compulsory Course

Course Title	Unit	L T P
Unit Operations III	2 0 0	2
Design Project	2 2 0	3
Research Project	2 2 0	3
Process Optimization	2 0 0	2
Management and Law	2 0 0	2
Second Elective	2 0 0	2
Third Elective	2 0 0	2
Total Units		**16**

ELECTIVES

SEMESTER 3	SEMESTER 4
Analytical Chemistry*	Natural Gas Processing
Organic Chemistry*	Coal Production Technology
Applied Electricity**	Cement Technology
Strength of Materials **	Battery Technology
	Brewing Technology
	Loss Prevention in Process Industries

	Polymer Science and Technology
	Corrosion Engineering
	Engineering Costing and Evaluation
	Electrochemical Technology
	Pulp and Paper Technology
	Sugar Technology
	Introduction to Petroleum Engineering
	Petroleum Refining Technology
	Petrochemical Processes
	Biochemical Engineering
	Environmental Pollution Control

* Compulsory for candidates with Chemical Engineering background

** Compulsory for candidates with Chemistry/Industrial Chemistry/Biochemistry background

COURSE DESCRIPTIONS

Material Science (2 Units)

Simple stress and strain; Theory of Torsion, Range and classification of engineering materials, Process for shaping materials, formation and growth of microcracks, effect of alloying, hardening, Plastic deformation of crystalline materials, Alloy hardening, Testing, Recovery, crystallization and grain growth, Elements of creepage, fatigue. Structure and properties of engineering/minerals, Selection of materials for construction.

Chemical Engineering Thermodynamics I (3 Units)

Generalized P-V-T Relations: P-V-T behaviour of pure substances. Equation of state for gases. The principle of corresponding state. Compressibility relations, reduced pressure, volume and temperature. Pseudocritical constants. P-V-T approximation for gaseous mixture, ideal gas mixture. Dalton's Law of additive volume, pseudocritical point method. Kay's rule, Gilliand's methods. Heat effects: heat capacities as a function of temperature. Heat capacities of solids and liquids, heat effects, accompanying phase change. Clausious – Clapeyron equation. Standard heats of reaction, formation and combustion. Effect of temperature on heat of reaction. Heats of mixing and solution. Enthalpy – concentration diagrams for H2SO4 – H2O etc. Partial enthalpies; single and multiple effect evaporators with regards to heat effects. Power cycles and Refrigeration cycles.

Chemical Engineering Thermodynamics II (3 units)

The Euler equations, Gibbs-Duhem equation, Phase equilibria, Partial molar quantities, Gaseous and Liquid non-reactive multicomponent system, fugacity, fugacity coefficient, activity coefficient, Marqules and Van Laar equations, Chemical equilibria-multicomponent multiphase systems. Phase transition.

Transport Phenomena I **(3 units)**

Units and dimension. Properties of fluid-momentum and Energy equations. Votex motion in liquids. Friction, types of flow, flow in open channels, Dimensional Analysis, flow measurement devices. Pumps Compressors, Valves and Pipings.

Transport Phenomena II **(3 units)**

Compressible flow: Normal short waves, flow in pipes and nozzles.
Coding Tower designs psychometric charts, estimation of tower.
Drying: Drying mechanisms, estimation of drying periods, description and function on industrial drying.
Conduction: The Fourrier equation and application to composites, cylinders spheres, Analytical and numerical solutions of steady and unsteady state conduction equations.
Mass Transfer: Fick's law, diffusion in stationary media, additivity of resistances, diffusion of Vapours.
Convection: Principles of free and forced convection. Determination of film transfer coefficients, Heat exchanger design. General diffusion and convection equation-Navier-Stoke's equation, problems formulation and solution.
Radiation: Mechanism of radioactive heat transfer, shape factors, heat exchange between radiating networks.

Chemical Engineering Kinetics **(3 units)**

Classification of reactions, definition and reaction rates, variables affecting reaction rates; homogeneous reactions (elementary and non-elementary reactions), molecularity and reaction order, rate constant, temperature dependency theories, activation energy, constant-volume batch rector (irreversible reaction of zero 1^{st}, end and nth order); series and parallel reactions, overall order from half-life data; reversible reactions of 1^{st} and 2^{nd} order); analysis of total-pressure data (homogeneous and autocatalytic reactions). Homogeneous Catalysis, Chain reactions, Photochemistry, Adsorption of gases on solids, Kinetics of heterogeneous and catalytic reaction. Principle of surface chemistry, Application of gas chromatography detergency, emulsion, settings, froth, floatation of materials, Lyopphilic and Lyophobic colloids.

Chemical Reaction Engineering **(3 units)**

Classification and types of reaction, Methods of operation and design equations. Temperature stability, Optimisation of yield, Departures from plug-flow, mixing and RTF, Fluid-solid reactors, Mass transfer and reaction in porous solids, Fixed and fluidized reactor design, Catalyst deactivation.

Chemical Engineering Laboratory I **(2 units)**

Experiments illustrating fluid flow properties; heat transfer by conduction and combined conduction and radiation; the use of overall heat transfer coefficients; mass transfer; simultaneous heat and mass transfer.

Chemical Engineering Laboratory II **(2 units)**

Selected pilot plant experiments will be carried out. These are designed to enable verification of the unit operations theory and empirical relationships covered during the

unit operations course lectures. Also selected experiments in Chemical Reaction Engineering, Biochemical Engineering, Process Dynamics and Control.

Chemical Engineering Process Analysis (3 units)

Introduction to Chemical Engineering unit operations and auxiliary facilities. Units and Conversion of Units. The basic equations of process industries. Industrial stoichiometry. The principle of conservation of energy and matter to industrial processes. Chemical Engineering process flow charts and process symbols.

Unit Operations I (3 units)

Vector approach to static; friction; kinematics; dynamics

Particulate – fluid mechanics Motion of single particles and drops in fluid; terminal fluid velocities' flow past sphere assemblies, effect of particles concentration on sonic rate, thickener concentration.

Centrifugal characteristics of a rotating fluid; principle of sedimentation and centrifuging, types of centrifuges.

Flow of single fluid through packed beds; calculation of pressure drop, counter-current and co-current flow of fluid through packed columns, flooding and loading rates.

Filtration; constant rate and constant-pressure filtration, washing and drying of cakes, selection of equipment. Fluidization: types of fluidization, calculation, factors influencing fluidization characteristics, behaviours of bubbles, heat and energy transfer and chemical reactions in fluidized beds. Conveying: principles of pneumatic and hydraulic conveyance, flow of non-Newtonian suspensions. Size reduction: Law of communication, particle size distribution and size analysis, selection of equipment, atomization of liquid, size enlargement. Mixing of fluids and solids.

Engineering Drawing (2 units)

Use of drawing instruments; lines, letting and dimensioning: paper sizes scales and drawing layout. Engineering graphics Geometrical figures, conics, etc. Development; Intersection of Curves and Solids. Projections; autographic, auxiliary and isometric projections. Simple examples; Threaded fasteners. Pictorial/Freehand sketching. Conventional codes and presentation. Technological scheme. Presentation of chemico-technological system.

Numerical Analysis & Computer Programme (2 units)

Relevance of Computer to Chemical Engineering practice. Review of computer programming and their application to Chemical engineering problems. Introduction to technical computation software (i.e. Matcad, Mathematical, Matlab etc). Using matlab to formulate structure codes and the exploration of the relevant tool boxes of Matlab as applicable to Chemical Engineering problems. Use of Microsoft excel to implement numerical computations, solutions of linear and non linear equations, regression analysis and graphing.

Unit Operation II (3 units)

Stroke's and Newton's laws, flow in particle beds. Characteristics of packed columns. Estimation of fluidisation point and bed expansion. Regions of fluidisation. Pressure

drop, Heat and Mass transfer in fluidized beds, Sedimentation, Flocculation, Filtration, particle properties. Screening and Classification, Grinding, Centrifuging and Electrostatic precipitation.

Unit Operations III **(2 units)**

Physical properties of importance to separation processes. Stage-wise exchange and equilibrium stages. Leaching and extraction with immiscible solvents. Binary distillation. Continuous contact columns, NYU and HTU.

Application to isothermal gas absorption, packed and plate columns, hydrodynamic limitation and performance data.

Process Design And Economics **(3 units)**

Presentation and discussion of real process design problems; Sources of design data; Process and engineering flow diagram; process outline charts in-corporating method studied and critical examination; mechanical design of process vessels and piping; Cost, optimization in design. Environmental considerations; site considerations; process services. A design. Environmental considerations, site considerations; process services. A design project will be submitted and orally defended at the end of the course. It shall be 40 percent of the overall grade of 100 percent.

Design Project **(3 units)**

A design project involving the study of a process, preparation of flow-sheets, heat and mass balances, and detailed design of some plant items will be submitted and orally defended at the end of the course. Economics and safety considerations must be stressed.

Research Project I **(3 units)**

Individual research project under the supervision of an academic staff. Project should focus on national and state industrial problems.

Research Project II **(3 units)**

Individual research project under the supervision of an academic staff.

Process Dynamics And Control **(3 units)**

Review of Mathematical concepts (Laplace transform), Process Dynamics (Linear lumped and distributed parameter systems, non-linear systems). Frequency response analysis, Feedback control and higher level control systems, multi-variable control and experimental case studies. Introduction to computer control.

Process Optimization **(2 units)**

A Chemical Engineering treatment of the popular forms of the calculus of variation, maximum principles, dynamics programming. Optimization of staged systems, Stationary Optimization, Optimum seeking methods, Network analysis and queuing theory.

Process Modeling And Simulation **(3 units)**

Formulation of simple and complex chemical engineering problems and their solutions. Application to chemical engineering stage processes including rectification,

multicomponent distillation, staged absorbers, all types of reactors and heat exchangers. Development of solution approaches through the usage of computer programming and software (like Matlab, Aspen etc.) However a computer-based term paper is required in this course.

Introduction to Biotechnology (2 units)

Definition and scope of biochemical engineering. Introduction to microbiology and biochemistry Enzyme kinetics, production purification and applications. Classifications and growth characteristics of micro-organism. Isolation and enumeration of micro-organisms Metabolic pathways. Characteristics of viruses. Introduction to recombination DNA technology. Cloning of gene libraries. Vector systems. Joining of DNA molecules. Transfer of DNA into bacterial host cells. Screening clones. The use of restriction enzymes in Genetic Engineering.

Analytical Chemistry (2 units)

Treatment of analytical data. Gravimetric and volumetric analyses; acid-base and oxidation-reduction titration; precipitation and compexometric titration; fundamentals of spectrochemical and electrometric methods; ion exchange chromatography and solvent extraction.

Applied Electricity (2 units)

Circuit Elements: D.C. circuit: A.C. Circuit: Field theory Analogue Electronics; Principle of Electronic Amplifiers; D. C. Machines; A.C. Machines.

Loss Prevention in Process Industries (2 units)

Hazards in chemical process industries; safety in plants; causes of accidents in process plants; prevention of accidents; HAZO, etc; Maintenance of plants to minimize losses; waste disposal and effluent treatment; pollution control; legal implications of various losses.

Battery Technology (2 units)

Chemical current source (CCS), General knowledge and Terminology; properties of CCS, Active Chemical and Active Mass, Electrolytes and
Separation, Electrical Properties of Accumulator, Specific characteristic of electrode in CCS processes, Primary CCS e.g. Le-Clanche dry cell etc Primary CCS in non aqueous electrolytes accumulations.

Polymer Science and Technology (2 units)

Basic definitions; Classification of Polymers, Polymerization mechanisms; Structure and property of Polymers, Solution properties of Polymers; Rheology and mechanical properties of Polymers; Unit operations in Polymer processing – Extrusion, injection molding, blow moulding, structural foam molding, calendaring fiber spinning, Casting.

Electrochemical Technology (2 units)

Basic elements of electrochemical systems, Electrodes, Diaphragm, Electrolytes. Anode, cathode, solutions, voltage balance and electromotive force – Nerst equation – calculation

involving Nerst formula, - method of minimizing voltage and electromotive force – current density and industrial electrolyses.

Pulp and Paper Technology (2 units)

Cellulose and Hermicellulose-structures and characteristics. Lignin, Pulp woods-types and properties. Types of pulping processes-sulphate, alkaline, mechanical semichemical etc. Bleaching fibre preparation, nature of fibre bounding. Sheet formation. Water usage and disposal in pulp and paper industries. Microbiology. Internal surface sizing. Wet strength. Colouring. Properties of paper. Pigment coating, printing, laminating and comigating. Saturation of paper and paper plastics.

Sugar Technology (2 units)

Description of equipments and consideration of the operations involved in the manufacture of refined sugar from sugar cane.

Petroleum Production and Refining (2 units)

Origin of oil and gas. Oil exploration, drilling and production. Chemistry and Physics of petroleum. Crude oil and gas processing. Catalytic processes. Heavy oil processing. Oil blowing chemical feed stocks.

Petrochemical Processes (2 units)

The oil industry and its relevance to the petrochemical industry. The non-oil fossil fuels and their relevance to the petrochemical industry. Petrochemical precursors, socio-economics, socio-political and geographical implication of the petrochemical industry. Planning petrochemical industry for a developing country.

Biochemical Engineering (2 units)

Theory of batch, semi-continuous and continuous cultures mass and energy balances in microbial cultures. Oxygen transfer in microbial culture. Design of fermentors, Air filtration. Instrumentation and control of fermentation systems. Introduction to brewing technology, antibiotic production, and lactic acid production. Biological waste treatment. Biomass conversion and utilization of waste.

Environmental Pollution and Control (2 units)

Introduction to environmental engineering, bio-geochemical cycles and pollution problems (green-house effect, ozone depletion, toxicity, bioaccumulation). Effects of toxic materials. Relationship between effect and dosage, lifetime of pollutants and removal processes, mobile and stationary sources of air pollutant, air pollution control-desulphurisation, pre-and post-combustion, other combustion related pollutants and their abatement. Industrial waste water-undesirable characteristics of industrial waste water, technology for control of emission of heavy metals (prescipitation, ion exchange), volatile organic compounds (VOCs) and toxic organic compounds (adsorption, steam stripping, solvent extraction, chemical oxidation), oxidation and oxygen demand, biological growth and bio-logical oxidation, characterization of industrial wastes (COD, BOD, ETC), waste minimization.

8.7.2 M.SC/M.ENG. AND PH.D PROGRAMMES

Compulsory Courses

List of Courses	Units
Advanced Chemical Engineering Analysis	3
Advanced Transport Phenomena	3
Advanced Thermodynamics	3
Advanced Separation Processes	3
Advanced Chemical reaction Engineering	3
Research Seminar	
Total	

Courses

Optional Courses

List of Courses	Unit
Numerical Methods Applied to Chemical Engineering	3
Radiative Transfer	3
Fluid and Particulate Mechanics	3
Separation Processes for Biochemical Products	3
Systems Engineering	3
Fundamentals of Advanced Energy Conversion	3
Advanced Bio-chemical Engineering	3
Advanced Reservoir Analysis	3
Polymer Engineering	3
Corrosion Science and Engineering	3
Advanced Corrosion	3
Engineering Risk-Benefit Analysis	3
Total	

Electives may be sourced from Petroleum Engineering, Chemistry and Environmental Engineering

COURSE DESCRIPTION

Advanced Chemical Engineering Analysis (3 Units)

Matrix formulation of Chemical Engineering problems. Numerical methods variation methods. Statistical methods, parameter estimation. Residence time distribution theory. Operational research. Applications of commercial software such as MATLAB, HYSYS and ASPEN.

Advanced Transport Phenomena (3 Units)

Derivation and application of Navier Stokes equation: velocity profiles in laminar and turbulent flows. Universal velocity profile. Macromolecular hydrodynamics and non-Newtonian fluids. Thermal and concentration boundary layers. Differential equations

for transfers processes and their applications. Diffusion, mass transfer with chemical reaction, interfacial phenomena. Phase transformation, solar energy.

Advanced Thermodynamics (3 Units)
Application of thermodynamic principles to selected topics, including equations of state, thermodynamics of non-reacting systems, complex chemical equilibrium, phase stability and immiscibility. Energy analysis, pinch technology.

Advanced Separation Process (3 Units)
Uses and characteristics of separation processes. Binary separation processes. Multi-component, multistage separations. Extractive and azeotropic distillation. Capacity and efficiency of contacting devices. Energy requirements, selection and optimal design operation for separation process. Selected recent topics in separation techniques.

Advanced chemical Reaction Engineering (3 Units)
Survey of kinetic principles and factors which influence reaction rates. Kinetics of complex, homogeneous and heterogeneous reactions. Correlations in homogeneous and heterogeneous catalysis. Consideration of several topics in catalysis, cracking, reforming, hydrogenation; hydration, oxidation. Analysis of chemical kinetics and transport phenomena in the design and operation of industrial reactors. Optimization of chemical reactors.

Numerical Methods Applied to Chemical Engineering (3 Units)
This course focuses on the use of modern computational and mathematical techniques in chemical engineering. Starting from a discussion of linear systems as the basic computational unit in scientific computing, methods for solving sets of nonlinear algebraic equations, ordinary differential equations, and differential-algebraic (DAE) systems are presented. Probability theory and its use in physical modeling is covered, as is the statistical analysis of data and parameter estimation. The finite difference and finite element techniques are presented for converting the partial differential equations obtained from transport phenomena to DAE systems. The use of these techniques will be demonstrated throughout the course in the MATLAB® computing environment.

Radiative Transfer (3 Units)
This course investigates the principles of thermal radiation and their applications to engineering heat and photon transfer problems. Topics include quantum and classical models of radiative properties of materials, electromagnetic wave theory for thermal radiation, radiative transfer in absorbing, emitting, and scattering media, and coherent laser radiation. Applications cover laser-material interactions, imaging, infrared instrumentation, global warming, semiconductor manufacturing, combustion, furnaces, and high temperature processing.

Separation Processes for Biochemical Products (3 Units)
This course serves as an introduction to the fundamental principles of separation operations for the recovery of products from biological processes, membrane filtration, chromatography, centrifugation, cell disruption, extraction, and process design.

Fundamentals of Advanced Energy Conversion (3 Units)

This course covers fundamentals of thermodynamics, chemistry, flow and transport processes as applied to energy systems. Topics include analysis of energy conversion in thermomechanical, thermochemical, electrochemical, and photoelectric processes in existing and future power and transportation systems, with emphasis on efficiency, environmental impact and performance. Systems utilizing fossil fuels, hydrogen, nuclear and renewable resources, over a range of sizes and scales are discussed. Applications include fuel reforming, hydrogen and synthetic fuel production, fuel cells and batteries, combustion, hybrids, catalysis, supercritical and combined cycles, photovoltaics, etc. The course also deals with different forms of energy storage and transmission, and optimal source utilization and fuel-life cycle analysis.

Advanced Reservoir Analysis (3 Units)

Mathematical development and calculations of reservoir behaviour and flow of oil, gas and water. Treatment of performance calculations, for depletion gas cap, water, gravity and combination drives water recharge theory. Development and use of fluid displacement equations.

Advanced Corrosion (3 Units)

Emphasis on corrosion damage and its underlying principles. The thermodynamics and kinetics of electrochemical corrosion of metals and alloys. Different forms of corrosion-uniform attack, galvanic corrosion, pitting, intergranular, selective leaching, erosion corrosion and stress corrosion are discussed extensively, together with their prevention techniques. Corrosion prevention, control and Monitoring. Materials selection for use in corrosive environments. Treatment of environmental degradation of non-metals (Ceramics, silicate glasses, concrete, etc) and polymers.

Engineering Risk-Benefit Analysis (3 Units)

ERBA emphasizes three methodologies - reliability and probabilistic risk assessment (RPRA), decision analysis (DA), and cost-benefit analysis (CBA). In this class, the issues of interest are: the risks associated with large engineering projects such as nuclear power reactors, the International Space Station, and critical infrastructures; the development of new products; the design of processes and operations with environmental externalities; and infrastructure renewal projects.

Fluid and Particulate Mechanics (3 Units)

A review of the rheological properties of fluids. Application of equations from macroscopic energy mass and momentum balances; compressible flow. Navier-stokes equation and its application. Turbulent flow. Non-Newtonian fluids; the concept of "slip". Fluid Particle Systems; Stokes Law. Motion of fluid particles: Fluidization; heat and mass transfer in fluidized system. Transport of multiphase systems. Two-phase gas liquid flow; flow patterns and consideration of energy requirements; critical two phase flow. Boiling heat transfer in two-energy requirements; critical two phase flow. Boiling heat transfer in two-phase flow; burnout in nuclear reactors. Solid-liquid systems; hydraulic and pneumatic transport; Durand's equation; deposition of solids from slurries. Applications of hydraulic transport.

Systems Engineering **(3 Units)**

System analysis, dynamics, and control. General time and periodic processes. Stability of linear and non linear systems. Optimal Control Theory. Static Optimisation including numerical Optimisation. Dynamic Optimisation for continuous and discrete processes. Multi-level Optimisation Operations Research.

Advanced Biochemical Engineering **(3 Units)**

Growth and non-growth associated fermentation systems. Kinetics in Chemostat (steady-state) and in other fermentor configurations. Development of cellulosic and hydrocarbon based materials by microbes (moulds, yeast, algal and bacteria) Biochemical Reactor Design. Product Isolation and recovery Modeling of fermentation systems.

Polymer Engineering **(3 Units)**

Polymerization mechanisms, structure and properties of polymers including polymer modification, Polymer reaction engineering, polymer viscoelisticity, mechanical properties of polymers, unit operation in polymer processing.

8.8 AGRICULTURAL ENGINEERING

8.8.1 Postgraduate Diploma

Graduation Requirement

To qualify for the award of Postgraduate Diploma, a candidate must have been unitized with at least 64 Units of compulsory courses which include the project report.

Core Courses Year One

First Semester		
	Course Description	**Units**
1.	Engineering Mathematics I	3
2.	Machine Design and Drawing	3
3.	Fluid Mechanics	2
4.	Statistical Method for Engineers	2
5.	Engineer-in-Society	2
6.	Mechanics of Machine	3
TOTAL		**15**

Electives

Engineering Drawing	3
Engineering Survey and Photogrammetry	3
Strength of Materials	2

Year One

Second Semester		
	Course Description	Units
1.	Engineering Mathematics II	2
2.	Heat and Mass Transfer	3
3.	Energy Application in Agriculture	3
4.	Introduction to Engineering Materials	2
5.	Surface and Ground Water Hydrology	3
6.	Numerical Methods and Computer Programming	3
TOTAL		**16**

Electives

Handling and Storage of Agricultural Products	3
Drainage	2
Engineering Properties of Structural Materials	2

Year Two

First Semester		
	Course Description	Units
1.	Farm Power	3
2.	Farm Structures Design	2
3.	Technical Report Writing and Presentation	2
4.	Management Law and Entrepreneurship	3

5.	Farm Tractor and Equipment Maintenance	2
6.	Food Processing and Plant Design	3
	TOTAL	**15**

Electives

Farm Electrification	2
Irrigation	2
Engineering Properties of Biomaterials	3

Year Two

Second Semester		
	Course Description	Units
1.	Farm Machinery	2
2.	Land Clearing and Development	2
3.	Rural Water |Supply and Sanitation	2
4.	Farmstead Planning and Control	2
5.	Project	6
	TOTAL	**14**

Electives

Environmental and Waste Management Engineering	2
Crop Processing Techniques	3
Theory of Cultivation Practices	2

COURSE DESCRIPTION

Environmental and Agricultural Waste Management (2 Units)

Sources, characteristics and Types of Agricultural wastes. Control, treatment and disposal of solid wastes. Control, treatment and disposal of liquid waste and slurry. Conversion and utilization of agricultural waste. Environmental impact assessment of agricultural processes and operations. Pollution of water, air and land by agric process and bio-waste and control.

Surface and Groundwater Hydrology (3 Units)

The hydrologic cycle. Agro-climates and temperature/moisture limits to the growing season. The precipitation process and rainfall types. Precipitation measurement. Point rainfall analysis. Depth and depth-area-duration analysis. Evapo transpiration and methods of its estimation. Runoff process. Stream gauging. Stream flow hydrographs, floods routing. Groundwater hydraulics. Quality control in hydrologic data analysis. Frequency analysis. Types and principles of groundwater production methods. Types, designs, construction, installation, operation, maintenance and retrieval of groundwater production equipment. Rigs, Pumps casting, screws and maters.

Farmstead Planning and Control (2 Units)

Definition of farmstead. Farmstead planning and layout. Family housing. Livestock housing. Structures for farmstead products and food storage etc. Environmental control. Structural requirement of crops and live stocks.

Farm Structures Design (2 Units)

Introduction to Agricultural Structures. Selection of material in relation to use wood, concrete and masonry. Types of structural frames. Introduction to structural design-Philosophy of design, elastic and plastic design concepts. Reinforced concrete design. Design of beams, slabs etc.

NOTE: For all designs, wood, steel and concrete are to be considered.

Engineering Properties of Biomaterials (3 Units)

Physical, mechanical, rheological and thermal properties of agricultural materials. Newtonian and non-Newtonian fluids. Fluid types and viscometry.

Energy Application in Agriculture (3 Units)

Energy needs for farming (field and Farmstead uses), Processing of agricultural corps and village communities. Human labour: energy and power consumptions and outputs of various work activities, work rates and rest, human work assessment. Draught animal power: Characteristics and capabilities of various species for transport draught operations in the field and use with animal power. Gears: Characteristics and selected for various agricultural purposes; alternative fuels and alternative types of engine; power transmission by belt driven. Electrical Power Installations: motor characteristics and selection, control gear, systems of waving, safety; applications (case study/design); diesel generation. Other energy sources. Solar energy; collectors; cells; stores, energy converters, costs, wind energy, wind characteristics; type of turbines, applications, cists, biomass and derivatives. Energy strategy, assessment of needs and availability for typical agricultural, processing and domestic purposes; balanced use strategy.

Machine drawing and design (3 Units)

Part assembly, detail drawing of machine components. Sketching and use of standards: design, features, symbols, screws, fasteners, couplings clutches, gears, machine component design. Presentation of design portfolio.

Mechanics of Machines (3 Units)

Force and motion relationships in constrained mechanisms. Analysis of cam, gear, linkage belt drive and chain drive systems for motion and power transmission, vehicular mechanics; break and clutch systems. Kinetics of rotating and reciprocating masses. Elements of vibratory systems.

Fluid Mechanics (3 Units)

Elements of fluid statics; pressure, surface tension, viscosity, compressibility, etc. Hydrostatic forces on submerged surfaces due to incompressible fluid. Introduction to fluid dynamics, conservation laws; introduction to viscous flow. Fluid properties. Fluid statics. Fluid motion: continuity Bernoulli, energy, momentum equations. Reynolds number. Dimensional analysis.

Introduction to Engineering Materials (2 Units)
Characteristics and manufacturing methods of construction materials. Cement, sand, lime, bricks, tiles, mortar, concrete, timber, steel, G.I. sheet, A.C. sheet; use of modern engineering materials and materials for special purposes.

Farm Electrification (3 Units)
Electrical codes, tariffs and regulations. Generation and Transmission of electricity, farmstead distribution systems. Testing procedure. Power factor correction. Selection and use of electric motors. Transformers. Energy conversion. Application of electricity to processing and storage of agricultural products. Basic electronic application to farm electrical processes.

Land Clearing and Development (3 Units)
Land resources and land use Acts in relation to Nigerian agriculture. Objectives, methods and equipment for land clearing and development. Machinery selection, mechanics of operation and vegetation types land reclamation. Earthmoving machinery and earth moving mechanics.

Crop Processing Techniques (3 Units)
Clearing, sorting, grading and separation principles, techniques and machine. Particle size analysis and size reduction. Fed grinding and mixing. Processing systems for seeds, grains fruits, vegetables, poultry, meat, milk, forage process conditions, observations and controls. Process analysis and plant design.

Engineering properties of structural material (2 Units)
Types of structural materials. Wood, concrete, structural steel e.t.c. properties of structural materials: Concrete: compressive strength, composite materials, aggregate size, water cement ratio, ultimate strength, design of concrete mixers, fineness modulus, consistency, curing and testing method, compression, stress-drain diagram, modulus of elasticity, tensile strength, yield point. Steel: grade, designation, sizes, diameters. Wood: Classification of wood, cellular make up, moisture content and shrinkage, stress grades and design values, bending, tension, parallel to grain, modulus of elasticity, moisture content factor, duration of load factor, timber drying and storage, wood fasteners.

Food Processing and Plant Design (3 Units)
Theology of slurries and pumping of non-Newtonian materials as homogenous and heterogeneous suspension. Characteristics and selection of pumps. Mixing theory and determination of degree of mixing. Mixing machine characteristics applied fluids, powders and pasts. Process modeling of mixers by dimensional analysis. Separation techniques of solid/liquid regimes including filtration, sedimentation, centrifuging. Milling of grains, comminution and fracture mechanism, characteristics of selected seeds cleaning machines. Design and fabrication of food process equipment.

Farm Tractor and Equipment Maintenance (2 Units)
Importance of maintenance. Basic Theory of reliability. Reliability of tractors and automobiles. Routine Services, repairs and maintenance schedule, machine diagnosis. Preventive maintenance of lubrication systems, cooling system, ignition system, electrical

system, hydraulic system, power transmission and chassis. Theory of interchangeability. Technology of repair of basic elements of farm equipment.

Theory of Cultivation Practice (2 Units)

Cultivation in agriculture and irrigated agriculture. Soil types and properties. Bulk shear strength, inter face sliding resistance; Soil strength Soil consistence variations. Implement-Soil interaction. Implement resistance on Soil. Draught resistance safety devices on implement during cultivation. Ideal soil conditions for performing basic cultivation. Selection of equipment for various farm operations based upon operating soil and other related conditions.

Rural Water Supply and Sanitation (2 Units)

Water requirements. Water quality standards. Water borne diseases. Biochemical oxygen demands. Potable water impurities. Sources and Treatment methods of water for rural homes. Water lifting devices. Transportation and distribution systems. Pipe sizes. Waste disposal in rural communities. Collection, conveyance, treatment and disposal of sewage from rural homes. Septic tanks, digestion ponds and family privies.

Irrigation (2 Units)

Design of open channels. Water flow measurements. Pumping power requirements. Design of irrigation systems: Border, sprinkler, drip, e.t.c, choice of method field management, irrigation scheduling, salinity and quality of irrigation water. Reclamation of saline and alkaline soils. Seepage from canal lining. Systems control methods: Continuous supply; rotation; on-demand and systems automation. Irrigation agronomy experiments. Irrigation water management.

Strength of Materials (2 Units)

i. Force equilibrium – Free-body diagrams
ii. Concept of stress, strain: Tensile tests. Young's modulus and other strength factors.
iii. Axially loaded bars, composite bars, temperature stresses and simple indeterminate problems. Hoop stress, cylinders, rings.
iv. Bending moments, shear force and axial force diagrams for simple cases. Simple torsion and application.

Drainage (2 Units)

Surface drainage. Sub-surface drainage. Design of drainage systems. Envelope, materials and their design. Loads on conducts. Drainage pumping. Construction and installation of drains, maintenance of drains.

Engineering Drawing (3 Units)

Introduction to Engineering drawing. Engineering graphics. Development and intersection of curves and solids. Projections: Lines, planes and simple solids. First and third angle projections; orthographic, auxiliary and isometric projections. Simple examples. Threads, fasteners, etc. Pictorial/Free-hand sketches.

Handling and Storage of Agricultural Products (3 Units)

Review of handling techniques. Design and selection of conveying systems including beld, chain, bunker, vibratory, pneumatic and screw conveyors. Grain handling systems, forage and hay handling systems. Fruits and vegetables handling systems. Mechanical damage to agric. Products during harvesting, transportation and processing. Economics of material handling. Rural storage systems in Nigeria. Design of storage bins and silos. Pests, rodent, fungi, and diseases that attack crops in storage methods of control: Fumigants, insecticides, etc. storage systems for various crop including refrigeration and frozen storage systems. Containerization of Agric. Products. Deterioration of products in storage. Environmental control in storage.

Farm power (3 Units)

Farm Power sources. Force analysis and power measurement on tillage tools, types, classification and operating principles of internal combustion engines, types of engine cycles. Efficiencies of engine cycles. Engine combustion processes. Engine operation systems: the fuel system, cooling systems, ignition systems, lubrication systems, turbo-charging.

Engineering Survey and Photogrammetry (3 Units)

Definitions. Measurements of distances. Use of minor instruments. Random error. Chain surveying. Bearing of lines. Leveling, Topographic surveys. Traversing. Theodolite traversing. Plane table surveying. Triangulation. Land shaping and earth work. Photogrammetry. Aerial photography.

Farm Machinery (2 Units)

Tractors use in farming. Constructional features of tractor. Tillage: objectives and principles of Tillage. Primary and secondary tillage equipment. Ploughs: components and operations. Principal type: implement for seedbed preparation. Equipment for sowing and planting. Equipment for Distributing and treating manures. Equipment for crop protection. Silage making and feeding. Forage harvesting: Cutting and swath treatment combine harvester. Root harvesting machinery. Seed clearing and feed preparation. Equipment for livestock husbandry. Equipment for milk production.

Heat and Mass Transfer (3 Units)

Heat transfer by conduction: One-dimensional heat conduction problems and solution. Fourier's equation using energy conservation approach, steady and unsteady state 2 – D heat conduction (Laplace equation, Poisson's equation). Dimensionless variables of heat conduction. Heat transfer by convection: Basic equations of heat convection. Free and forced convections. Dimensionless numbers and similarity. (Reynold, Pronate, Grashof, Rayleigh, Station, Nusselt, Frouds Pedet and Greetz numbers). State Head transfer by radiation: Electromagnetic Spectrum, thermal radiation spectrum emissivity, transmisivity, emissive power. Real and ideal surfaces. Total and monochromatic radiation. State Kirehoffs law, wien's displacement, Stephen – Bolzman's law. Direct exchange between black and gey surface, exchange in enclosures with non-participating medium. Heat exchangers: Functions of heat exchangers. Basic types of heat exchangers. Analysis of heat exchanger using the Logarithmic Mean Temperature

Difference (LMTD) and number of transfer Units (NTU) methods. Mass transfer: Definition of momentum transfer. Navier stoke's equation analysis of boundary layer theory, boundary layer thickness, drag, boundary layer control. Flow through conduits and over submerged bodies (flat plates, cylinders and spheres) 30h (T); 45h (P)

8.8.2 M.SC./M.ENG. AND PH.D PROGRAMMES

Common Courses

List of Course	Units
Statistics and Experimental Techniques	2
Environmental Impact Analysis	1
Statistics	3
Numerical Analysis	3
Agric. Engineering Seminar	1
Instrumentation and measurements in Engineering Systems	2
Total	11

Core Courses by Options
Farm Power and Machinery

List of Courses	Unit
Advanced Farm Equipment Design and Evaluation	3
Traction and Trafficability of farm	3
Advanced Farm Power and Machinery Management	3
Principles and Application of ergonomics	3
Advanced Soil Mechanics and Soil Conservation	3
Thesis	6
Total	21

Soil and Water Engineering Option

List of Courses	Unit
Irrigation Systems Development	3
Agricultural Land Drainage	3
Open Channel Hydraulics	2
Soil and Water Conservation	2
Advanced Groundwater Hydrology	3
Advanced Surface Water Hydrology	3
Thesis	6
Total	21

Agricultural Products Processing and Storage Option

List of Courses	Unit
Agricultural Processing unit operations	3
Agricultural materials handling system	3
Analysis and selection of Agricultural processing	2

Equipment	
Theory and Techniques of farm products storage	2
Design of storage structures	2
Crop Drying Systems	3
Thesis	6
Total	21

Farm Structures & Environmental Control

List of Courses	Units
Farm Estate Planning and Design	3
Structural Analysis and Design of farm Buildings.	3
Agricultural Waste Treatment and System Design.	3
Solar energy utilization in Agricultural	3
Environmental control in farm building and structures	3
Thesis	6
Total	24

Optional Courses

List of Courses	Unit
Agric. Mechanization Strategies and System	2
Metrology in Engineering properties of biomaterials.	2
Special problems in Agric. Engineering	2
Crop Protection machinery	3
Harvesting machinery	3
Advanced soil Physics	3
Advanced Soil Water and Plant Relationship	3
Water Resources development for Agric. purposes	3
Dam Design and Reservoir Operations	3
Entrepreneurial skills and Management	2
Total	26

Ph.D Degree Programmes

Common Courses	**Units**
Ph.D Thesis	12
Special Problems in Agric. Engineering	2
Environmental Impact Analysis	1
Computer modeling of Agricultural Systems	3
Experimental Design	2
Seminar (1unit per Semester)	2
Total	22

Core Courses by area of Specialization
Farm Power And Machinery:

List of Courses	**Units**
Tractors and other Farm Power Systems	2
Tillage machines & machinery	2

Earth moving machines and machinery	2
Planting and Fertilizer Application machinery	2
Total	8

Soil and Water Option:

List of Courses	**Units**
Sediment transport Hydraulics and earthen channel Design	2
Applied Hydrology	2
Water Resources Development for Agric. Purposes	2
Advanced Soil Physics	2
Total	8

Agricultural Products Processing and Storage

List of Courses	**Units**
Industrial Food Processing and Storage	2
Design of Storage Structures	2
Experimental Stress Analysis	2
Bio-Process Engineering	2
Total	8

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Farm Structures and Environment

List of Courses	**Units**
Metrology in engineering Properties of	2
Biomaterials	2
Building Science	1
Environmental Health engineering	1
Computational Methods	2
Stability of Structures	2
Total	8

Agricultural Engineering Department ffers courses at M.Eng and PhD in Water Resources and Environmental Engineering.Some of the overlapping course have been defined under the Civil Engineering department.

COURSE DESCRIPTION

Statistics and Experimental Techniques (3 Units)

Statistical concepts; measure of central tendencies and dispersion; tests of significance; correlation and regression; statistical quality control; principles of experimental designs; Experimental layout; analysis of data and interpretation of results commonly used; designs: completely randomized, randomized complete block, factorial experiment, split plot, strip plot. Probability as a function of sample space, laws of probability, conditional probability; Baye's rule. Random variables. Mathematical expectation. Computation of mean and variance of common probability mass functions using the methods of

expectation and methods probability distributions of discrete and continuous random variables. Chebyshebis inequality, bivariate, marginal and conditional distributions and moments.

Advanced Soil Mechanics & Soil Cultivation (3 Units)

The place of cultivations in agriculture, soil physical conditions required for optimum plant growth, soil and water conservation and efficient mechanization; role of cultivations in providing these conditions and the basic cultivation operations required. Soil strength parameters: nature of cohesion, adhesion and friction clod and bulk shear strength, interface, sliding resistance. Change in strength with changes in soil consistence. Critical state concept with changes in soil consistence. Soil conditions under basic cultivation operations can be performed. Soil failure: Mohr-coulomb failure critical; soil failure by wide narrow and very narrow times, effect of rake angle and curvature on failure patterns and direction and magnitude of forces, estimation of forces on times factors affecting and methods of reducing draught, theory and nature of scouring. Implement design: application of soil mechanics principles to implement design for basic cultivation operation, role of current equipment in satisfying design requirements. Implement selection: Selection of equipment for minimum cultivation operations required.

Numerical Analysis (3 Units)

Accuracy in numerical calculations, errors, significant figures, calculation of sine, cos, and exponential series by Taylor's expansion. Interpolation; Newton's forward, backward and central difference formulae. Numerical differentiation and integration; Trapezoidal and Simpson rules, automatic selection of interval size, Newton – cotes formulae. Solutions of algebraic and transcendental equations; graphical, bisection interaction. Newton, Raphson solution of simultaneous equations (Gauss and Gauss-siedel); Eingenvalues and Eingenvectors; Numerical solution of ordinary differential equations. Methods of Euler, picard, Taylor's and runge-Kuta Predictor-corrector. Method for solving ordinary differential equations, Introduction to partial differentiation.

Agricultural Engineering Seminars (2 Units)

Agricultural Engineering seminar reports on research/special topic/development in Agricultural Engineering, written and presented as a seminar to staff and students of the Department. Training in technical report writing.

Instrumentation and Measurements in Engineering Systems (2 Units)

Motion, force, torque, and shaft power, pressure and sound flux; humidity measurement; application of primary sensing element; data manipulation, computing and compensating devices; data transmission and recording.

Advanced Farm Equipment Design and Evaluation (2 Units)

General approach to problem formulation and solution; Farm machine systems and design of machine elements; synthesis of unit; reliability criteria; research reviews on design and analysis of farm equipment, test type and evaluation; integrated system approach to machinery evaluation.

Traction and Trafficability on Farm (2 Units)
Tractor transport mechanisms; evaluation of soil values related to traction; soil-vehicle modes and prediction of traction performance; compaction due to machine traffic; design of traction and transport devices; research review.

Advanced Farm Power and Machinery Management (3 Units)
System approach in farm machinery management; application of programming techniques to problems of equipment selection; maintenance and scheduling of operations; equipment replacement criteria and inventory control for spares.

Principles and Applications of Ergonomics (3 Units)
Human factors in system development; energy liberation and transfer; mechanical efficiency of human body; Anthropometric limitations in equipment design; biomechanics of motion.

Irrigation Systems Development (3 Units)
Detailed study of the design of farm irrigation systems. Land classification and preparation. Theory and empirical methods of estimating consumptive use, hydraulics and economics of irrigation design, feasibility studies; problems of irrigation.

Agricultural Land Drainage Engineering (2 Units)
Drainage requirements of crops; theory of land drainage; Drainage of homogenous, stratified soils; Drainage analogues and models; Design and installation of drainage systems; salinity control.

Open Channel Hydraulics (2 Units)
Theory and application of flow in open channels; dimensional analysis; energy-momentum principles' kinematics and dynamics wave approximations; gradually varied flow; spill ways, routing, model studies.

Soil And Water Conservation (3 Units)
Review of the principles of soil erosion by water and wind; Review of the control of water and wind erosion; rainfall simulation; soil conservation structures; Design of earth embankments.

Advanced Groundwater Hydrology (3 Units)
Groundwater occurrence and mapping procedures; theory of groundwater flow; analysis of pumping tests; requirements and procedures for well construction and techniques of groundwater prospecting.

Advanced Surface Water Hydrology (3 Units)
Overland flow and numerical floods routing; linear approaches to hydrograph; linear reservoirs; frequency; regression and correlation techniques; stream flow simulation techniques; hydrology of agricultural lands.

Agricultural Processing Unit Operations (3 Units)
Scientific foundations of major unit operations in agricultural engineering processing systems; fluid statics; fluid flow phenomena. Non-Newtonian fluid characteristics. Agitation, mixing and blending in food processing; Heat and mass transfer; separation operations; comminution operations. Handling of particulate solids.

Agricultural Materials Handling System (3 Units)
Factor influencing selection of materials handling equipment; treatment of specific handling equipments as links in a total process; economics and cost analysis; design and development of handling equipment.

Analysis and Selection of Agricultural Processing Equipment (2 Units)
Developments in cleaning and sorting systems; Effects of grain crop characteristics on selection of cleaning equipment; Theory, design, capacity and efficiency of plain sieves, cylindrical sieves; magnetic and aerodynamic methods.

Theory and Techniques of Farm Products Storage (2 Units)
Mechanisms of deterioration; Biochemical and enzymental changes and effects; storage techniques. Thermodynamics and energy changes; cold storage; storage of processed foods; warehousing and materials handling in storage.

Design of Storage Structures (2 Units)
Traditional storage structures. Design of modern storage structures; Lateral loads; theories of failure in non-fluid masses; fibrous materials; Design of container walls for combined loading; Hopper bottom bins; flow properties of bulk materials.

Crop Drying Systems (3 Units)
Theoretical foundations; Analysis of crop drying systems; Determination of drying constants for local food crops; Energy sources for crop drying; solar energy utilization; simulation of drying systems.

Farm Estate Planning and Design (3 Units)
Planning of farm estate; Design of infrastructural facilities; Farmstead planning; location of service entrance and source of water supply. Design of electricity and water supply distribution (network); Design of farmstead roads and road network; location and design of facilities and equipment for farm waste disposal.

Structural Analysis & Design of Farm Buildings (2 Units)
Deformation and stress analysis for steel, wood and concrete structures. Deflection under stress; indeterminate frames; depth of embedment for lateral stability and uplift resistance; Design for lateral and combined loading.

Agricultural Waste Treatment and System Designs (3 Units)
Characteristics of agricultural waste; environmental impact; physical, chemical and biological treatment; solid waste treatment; Design of waste treatment facilities and system; legal aspects.

Solar Energy Utilization in Agriculture (2 Units)
Solar radiation measurement; flat plate collector design and performance testing; Design of other collectors; solar heating system; solar cooling systems; economics of solar thermal systems.

Agricultural Waste Utilization (3 Units)
Processing and utilization of animal wastes for animal feeds, organic fertilizer, fish production, single cell protein, algae and insect production. Processing and utilization of crop residues and food processing wastes; Energy generation from agricultural wastes; Land application of agricultural wastes; industrial uses of crop residues.

Environmental Control in Farm Buildings and Structures (3 Units)
Environmental control for animals, plants and farm produce; Psychometric: application to design problems on comfort, air conditioning and heat and mass transfer problems; Design procedure for energy balance systems.

Agricultural Mechanization Strategies and Systems (2 Units)
Selection and utilization of agricultural equipment for various types of farms; methods of optimization of tractor-implement combination; strategies for food processing and industrial raw materials handling systems; Economics of farm transportation.

Metrology in Engineering Properties of Bio-Materials (2 Units)
Measurement, evaluation and analysis of physical, mechanical, rheological, thermal, electrical and optical properties of bio-materials. Force-deformation tests; Hertz theory and Boussinesq theory; measures of mechanical parameters of food texture.

Special Problems in Agricultural Engineering (2 Units)
Analysis of a specified engineering problem in general area of interest related to the area of research work conducted by a postgraduate student but different from the specific research topic.

Crop Protection Machinery (2 Units)
Theory and design of selected types of nozzles, pressure valves and agitators; Field and laboratory testing of spraying and dusting equipment; Design, development and testing of cultivation equipment.

Harvesting Machinery (3 Units)
Methods of mechanical harvesting; force analysis and design consideration of grain combines, corn pickers, forage harvesters; Balers and binders, root harvesters; Testing of harvesting machinery.

Advanced Soil Physics (3 Units)
Water entry and distribution in uniform and layered soils; heat flow in soils; solute transport; break through curves; hydrodynamic dispersion; models of water and solute uptake by roots and stems; numerical methods.

Advanced Soil Water and Plant Relationship (3 Units)

Soil water content; soil water potential; soil water movement; soil-plant-atmosphere relations; plant water potential; water transport in soil-plant systems.

Water Resources Development for Agricultural Purposes (3 Units)

Water impounding reservoirs, design criteria, spill way capacity, sitting and management; water diversion, conveyance and distribution systems; energy dissipaters. Irrigation water quality and Management.

Dam Design and Reservoir Operations (2 Units)

- As in Water Resources and Environmental Engineering.

Environmental Impact Analysis (1 Units)

- As in Water Resources and Environmental Engineering

Computer Modeling of Agricultural Systems (3 Units)

Integration of Engineering and Biological principles with efficient modeling techniques to solve complex problems in Agricultural operations. Topics include the mathematical formulation and modeling of agricultural processes: processes and equipment simulation: optimization and control using digital computer techniques. Use of "canied programme", development of individual programmes, programme solutions

8.9 FOOD SCIENCE AND TECHNOLOGY

Introduction

Food Science and Technology as professional and academic disciplines involve the application of Physical, Biological and Engineering Sciences and Technology to address problems of food analysis, quality, processing, preservation, storage, distribution, the development of novel and improved food products and the creation of industrial systems that make these activities possible.

Postgraduate Studies in Food Science and Technology aim at training candidates for positions in research, high level teaching and higher scientific and technical positions in industry, government and international agencies.
Postgraduate training in Food Science and Technology are conceived at three levels, namely: The Postgraduate Diploma, the Masters/M.Phil Degree
Levels and the Ph.D Degree Level.

Philosophy and Objectives

The objective of postgraduate programmes in Food Science and Technology is to provide academic and professional training beyond the Bachelor's degree level in food processing, food chemistry, food microbiology, toxicology, food biotechnology and quality control. Together, these fields encompass a broad range of complex problems in food research, the food industries, food regulation and control that can only be solved through high powered scientific and technological insights made possible by education and training at the cutting edge of science and technology.

Facilities Required

i. Advanced Laboratories in Food Chemistry, Food Analysis, Food Microbiology and Quality Assessment.
ii. A Food Processing Pilot Plant furnished with the primary unit operations equipment for raw material preparation, heating, cooling, canning, freezing, drying, freeze- drying, filtration, centrifugation, distillation, crystallization, evaporation, etc. for food.
iii. Fermentation and Biotechnology Laboratory
iv. Applied Biochemistry and Nutrition Laboratory

8.9.1 Postgraduate Programmes

Admission Requirements

i. HND in Food Science and Technology or other disciplines of Science with at least a lower Credit pass;
ii. B.Sc. or B.Tech in Food Science and Technology with a third class honours degree; or
iii. B.Sc. or B.Tech in any related science discipline with at least a second class (lower) honours degree.

Graduation Requirements

To qualify for the award of a postgraduate diploma in Food Science and Technology, a candidate shall satisfy a minimum of 64 Units Units as follows:

i. 48 Units of compulsory or core courses
ii. 10 Units of elective courses
iii. 6 Units of project work.

Outline of Course Programme
Postgraduate Diploma (4-Semesters) in Food Science and Technology

A. **Core/Compulsory Course**			
Year One		**Year Two**	
Introductory Food Science and Technology	2	Seminar	2
Food Chemistry	3	Project Work	6
Food Microbiology	3	Methods of Food Analysis	3
Quantitative methods in Food Science and Technology-I	3	Applied Biochemistry and Human Nutrition	3
Computer Applications in Food Science and Technology	3	Unit Operations in Food processing-III	2
Unit Operations in Food processing-I	2	Unit Operations in Food processing-IV	2
Unit Operations in Food processing-II	2	Quantitative methods in Food Sc. & Tech.-II	3
Processing & Preservation of Foods of Plant Origin-I	2	Methods of Product Development in the Food Industries	3
Processing & Preservation of Foods of Animal Origin-I	2	Processing & Preservation of Foods of Plant Origin-2	2
Food Physics and Packaging	2	Processing & Preservation of Foods of Animal Origin-2	2
Quality Control in Food Industries	3		
Technical Report Writing	2		
Total	**29**		**28**
B. **Elective Courses**			
Fermented Foods	3	Food Toxicology	3
Food Storage and Distribution		Food Security and Policy Issues	2
Techniques in the Food Industries	2	Special problems in Food Science and Technology	2
Food Laws & Standards	2		
Environmental Problems of Food Processing	2		

Course Description (Postgraduate Diploma in Food Science and Technology)
Seminar (2 Units)
Student shall prepare and present a proposal seminar on a project chosen for investigation and shall present another terminal seminar at the end of the investigation.

Project Work
Guided/Supervised investigation of a food science or food technology problem selected and conducted by student. Project shall challenge the creativity of student and shall culminate in a long essay to be examined by a panel of examiners.

Technical Report Writing **(2 Units)**

Principle of communications. Preparation and writing of technical reports. Oral presentation of reports. Use of visual aids and other communication equipment in technical and research presentations. Use of power point presentations for professional effectiveness.

Introduction to Food Science and Technology **(2 Units)**

Foods as a source of nutrients for man and as raw materials for the food industries. Food, chemistry and the main components of foods. microbiology, biochemistry and nutrition. The Food industries and treatments used for food processing. Causes of food deterioration and methods of food preservation. Food a manufacturing methods. Food quality, nutritional value and the effects of food processing.

Food Chemistry **(3 Units)**

Carbohydrates. Lipids. Proteins. Vitamins. Minerals. Water. Enzymes. Pigments and colours. Flavour. The properties of foods.

Food Microbiology **(3 Units)**

Nature and types of micro-organisms. Microbial contamination and spoilage of different kinds of foods. Food poisoning. Sanitation, control and inspection in food handling. Microbiology of water.

Methods of Food Analysis **(3 Units)**

Principles and practices of food analysis. Sampling and sample preparation. Techniques of proximate analysis. Chromatography including HPLC. Spectrophotometry Polarimetry. Flame Photometry. Electrophoresis. Isoelectric focusing. Viscometry and Rheometry. Membrane filtration. Contamination analysis and identification of indicators of food spoilage.

Applied Biochemistry and Human Nutrition **(3 Units)**

Physiologic and Metabolic nature and reactions of food macromolecules. Carbohydrates– mono, di, tri and polysaccharides; proteins, amino acids, peptides; vitamins; minerals; lipids; enzymes. Biochemical energetics. Use of enzymes in food processing.

Food Toxicology **(2 Units)**

Appraisal of hazardous food components. Toxic factors native to food raw materials and ingredients. Toxic factors induced by processing. Relationship of chemical structure, activity and metabolism of teratogenesis and cereinogenesis. Use of experimental animals in toxicological studies. Analytical aspects. Detoxification mechanisms. Methods of toxin removal from food.

Unit Operations in Food Processing-I **(2 Units)**

Mass and Energy Balances. Fluid Mechanics. Thermodynamics. Food Rheology.

Unit Operations in Food Processing-II **(2 Units)**

Heat Transfer. Mass Transfer. Contact Equilibrium Separation Processes. Heat Exchangers.

Unit Operations in Food Processing-III (2 Units)

Preliminary and Preparative Operations in Food Processing. Ancillary Operations: size reduction, sieving and sifting, centrifugation, filtration, mixing, emulsification and molding. Water and waste water treatment. Solid waste disposal. Steam boilers. Materials Handling.

Unit Operations in Food Processing-IV (2 Units)

Evaporation. Concentration. Dehydration. Refrigeration and Freezing. Thermobacteriology.

Fermented Foods (3 Units)

Methods of food fermentation from traditional to modern times. Bioreactor systems and their operation. The technology of fermented food commodities: beverages, cereals, roots and tubers, fruits and vegetables, oil seeds, meat, fish, eggs and dairy products.

Quality Control in Food Industries (2 Units)

Laboratory and commercial procedures for evaluating the sensory properties and market quality of foods. Analysis and reporting of Taste Panel data. Evaluation of changes in foods as a result of processing, packaging and storage. Microbiological quality factors of raw materials, processed and preserved foods. Methods of routine investigation, Special Methods of data evaluation.

Food Storage and Distribution Techniques in the Food Industries (2 Units)

Environmental factors, their influence in food storages systems and management practices applied to control them. Food commodity characteristics in storage. Transportation systems. Bulk storage and retail storage systems. Unit operations and their application in storage system cost analysis.

Food Laws and Standards (2 Units)

Food law, its philosophy and development. Food standards, codes of practice and statutory regulatory aspects. Food export regulations. Legislation on food additives. Toxic substances in food addictives. Legislation on pesticide residues in food raw materials. Legislation on labeling. Detoxification of food and avoidance of contamination.

Environmental Problems in Food Processing (2 Units)

Water supply and water quality for food processing. Waste water treatment and water recycling. Solid waste treatment and by-product utilization. Pollution control and management in the food industries.

Food Security and Policy Issues (2 Units)

World food problem. National, regional and international food security. The imbalance between demand and supply of food. The population question. Strategic reserves and their management within the context of food security. Interphases of food, nutrition, agriculture, health and biotechnology as they relate to food security. The role of food processing in the management of food security. Concepts of food self-sufficiency, food self-reliance and autarky.

Special Problems in Food Science and Technology (2 Units)
Course shall be undertaken by guided self-study of student involving any combination of literature survey, laboratory and/or fieldwork, data analysis, report writing and seminar presentation. It shall focus on identified problems of interest in Food Science and Technology. This course shall be conducted in modules of 2-Units Units at a time up to a maximum of 4-Units Units in the course of a single diploma programme.

Processing and Preservation of Foods of Plant Origin-I (2 Units)
Cereals, Legumes, Oil seeds, Pulses, Sugar Cane. The chemistry and technology of commodities. Conversion of raw materials into a sequence of finished commercial products. Baked and confectionary goods. Edible oils. Sugar and syrups. Fermented beverages from cereals and adjuncts.

Processing and Preservation of Foods of Plant Origin-II (2 Units)
Fruits, Vegetables, Roots, Tubers, Coffee, Tea, Cocoa. Harvesting system. Postharvest physiology. The chemistry and technology of commodities. Storage systems. Conversion operations by which raw materials are converted to food products of commerce. Coffee, tea and cocoa beverages. Cocoa butter and chocolate manufacturing. Wines from fruits and vegetables.

Processing and Preservation of Foods of Flesh Origin-I (2 Units)
Dairy, Eggs and Poultry. The chemistry, microbiology and technology of milk, ice cream, yogurts, cheese and butter. Poultry and Egg processing.

Processing and Preservation of Foods of Flesh Origin-II (2 Units)
Meat, Fish and Wild Life. Slaughter of meat animals and dressing. The chemistry, microbiology and technology of conversion into sausages, bacons, corn beef, ground beef, etc. Fish cleaning and dressing. Conversion into sardines, fish protein concentrate, fish meal. Cray fish and oyster smoking, freezing drying, salting and fermentation. Wild life domestication their characteristics and processing into marketable products.

Quantitative Methods in Food Science and Technology-I (3 Units)
Dependent and independent variables. Functions (graphical representation, trigonometric, exponential, logarithmic and inverse functions). Inequalities. Differential calculus. Integration. Functions of many variables. Partial differentiation. Vectors. Series. Complex numbers. Orthogonal functions. Fourier Series. Determinants and matrix algebra. Differential equations. Partial differential equations. Introduction to numerical methods.

Quantitative Methods in Food Science and Technology-II (3 Units)
Data as ratios, rates and percentages. Tabular and graphic representation of data. Measures of central tendency. Dispersion, skew and kurtosis. Statistical Models. Samples, sampling and variability. Distribution and parameter estimation. Tests of significance and reliability. Regression and correlation analysis. Planning of experiments and associated analysis of variance. Statistical quality control.

Computer Application in Food Science and Technology (3 Units)

Course is designed to provide students with hands-on experience in using computers for planning experiments, collecting the resulting data, analyzing and interpreting such data and presenting the outcome with high professional lucidity. Course shall be taught by guiding students through a process of self learning-by-doing in which they are exposed to popular computer softwares used in science, engineering and technology disciplines. The focus shall be on three groups of such softwares used as follows:

(a) Problem-solving spreadsheet programmes such as Lotus-123 and Microsoft-Excel.

(b) Computer Softwares for planning experiments, collecting data, analyzing and interpreting such data. Examples are:
- Minitab Statistical Package
- SPSS Data Analysis Package
- Statgraphics (Statistical Graphics System)

(c) Mathematical Softwares such as: • Mathcad and • Slidewrite

8.9.2 M.SC. OR M.TECH PROGRAMMES

Admission Requirement

i. B.Sc. or B.Tech Degree in Food Science and Technology or any related science discipline with a minimum of second class (lower) honours.

ii. PGD in Food Science and technology at a minimum of Upper Units pass.

(a) **M.Phil Degree Programme in Food Science and Technology**

Candidates who complete their postgraduate degree programme with a CGPA of less than 3.00 on a 5-point scale or the equivalent of 55% in the M.Sc. or M.Tech degree in Food Science and Technology may be admitted into the M.Phil programme. Such candidates shall be required to complete a minimum course work of eighteen (18) Units Units made up of six (6) Units of relevant core courses and nine (9) Units of elective courses. On successful attainment of a minimum CGPA of 3.50 on a 5-point scale OR 60% minimum at the end of the course work, such candidates shall be deemed to be qualified to transfer to the Ph.D. programme.

(b) **Ph.D Degree Programme in Food Science and Technology**

Normally, only candidates who hold the M.Sc. or M.Tech degree or equivalent qualification in Food Science and Technology may be admitted into the Ph.D. degree programme. Such candidates shall normally possess a minimum CGPA of 3.50 on a 5-point scale or 60% minimum.

Graduation Requirements

(a) **M.Sc./M.Tech Degree Programme in Food Science and Technology**

The course requirements for graduation at this level sum up to minimum total of 36 Units Units that shall be satisfied as follows:

(i) 20 Units of compulsory or core course

(ii) 10 Units of Elective courses

(iii) 6 Units of Project work.

(b) **M.Phil Degree Programme in Food Science and Technology**: Candidates who wish to obtain a terminal M.Phil degree in Food Science and Technology shall satisfy a minimum course load of 36 Units as follows:

i. 18 Units selected from M.Sc./M.Tech degree course list
ii. 18 Units of research work.

(c) **Ph.D Degree Programme in Food Science and Technology**: Course work requirements at this level sum up to a minimum total of 45 Units as follows:

i. 21 Units of advanced course work.
ii. 24 Units of research work.

M.Sc/M.Tech, M.Phil. and Ph.D in Food Science and Technology

Areas of Specialization

At the Masters, M.Phil. and Ph.D. levels a candidate enrolled for a degree may specialize in any one of the following areas:

i. **Food Science:**
- Food Chemistry and Analysis
- Food Microbiology
- Food Safety and Toxicology
- Food Processing
- Food Biotechnology
- Food Quality Assurance

ii. **Food Technology**
- Food Processing
- Quality Assurance
- Product Development
- Food Fermentation
- Technology of Specific Commodities of Food.

i. Core/Compulsory Courses	**Units**
M. Sc/M.Tech Seminar	1
M.Phil Seminar	1
Ph. D. Seminar	1
M.Sc./M.Tech. Research Project	6
M.Phil Research Project	18
Ph.D. Research Project	24
Design and Analysis of Experiment in Food Processing	3
Advanced Food Chemistry	3
Advanced Food Biotechnology	3
Advanced Food Microbiology	3
Advanced Analysis and Instrumentation in Food Science	3

Quality Control in Food Industries	3
ii. **Food Technology Elective**	
Product Development Strategies in Food Industries	2
Advanced Technology of Processing, Storage and Distribution of Food Commodities of Plant Origin	2
Advanced Technology of Processing, Storage and Distribution of Food Commodities of Animal Origin	2
Selected Unit Operations in Food Processing	2
Global and National Food Security and Policy Issues	2
Advanced Food Thermobacteriology and Canning Technology	2
Advanced in Food Packaging	2
Enzymes in the Food Processing Industries	2
Special Problems in Food Technology	2
iii. **Food Science and Nutrition Electives**	
Food Safety and Toxicology	2
Risk Analysis in Foods and Ingredients	2
Special Topics in Food Science	2
Advanced Topics in Nutrition	2
Special Problems in Human Nutrition	2
	10
iv. **Elective Courses from Cognate Disciplines in Science and Computer Science**	
Higher (300/400) Level Undergraduate and Postgraduate Course(s) in:	
Chemistry/Biochemistry/Microbiology	
Approved Courses in Statistical Methods for Experimental Planning and Analysis	
Approved Courses in Computer Application in Food Science and Technology	
Approved Higher Level Undergraduate and Postgraduate Courses in Agriculture	
Approved Higher Level Undergraduate and Postgraduate Courses in Food Engineering or Agricultural Engineering	

Course Description (Masters, M.Phil or Ph.D in Food Science and Technology)

Seminar **(1 Unit)**

The Seminar for any postgraduate degree encompasses the preparation of two research reports accompanied by formal presentations made by the candidate. The first research report (or proposal) is presented at the commencement of the research programme. The

second report comes at the end of data collection and analysis and leads to the completion of the dissertation or thesis as the case maybe.

Research Project (Masters: 6 Units; M.Phil: 18 Units; Ph.D (24 Units)
For any of the Masters, M.Phil and Ph.D. degrees, each candidate shall conduct a research on an approved topic and write a dissertation (Masters/M.Phil or Ph.D.) as the case may be under staff supervision. In the case of the Ph.D. degree the research and thesis must be of sufficient depth and scope as to break new ground in the discipline of Food Science and/or Technology.

Design and Analysis of Experiments in Food Processing (3 Units)
Survey of strategies of experimentation using statistical techniques. Comparative experiments and inferences. Analysis of Variance in experiments with single and multiple factors. Randomized blocks, Latin squares and related designs. Factorial designs. Fitting regression models. Response surface methods and designs. Nested and split-plot designs.

Advanced Food Chemistry (2 Units)
Advanced treatment of the following topics with specific examples from the literature: Formation of flavour substances in foods, analytical techniques in flavour research, structure of starch, ripening of fruits. Products of microbial metabolism: (a) Enzymes, (b) Primary metabolites and (c) Secondary metabolites. The chemistry of food addictives. Browining reaction and their control.

Advanced Food Biochemistry (3 Units)
Protein, lipid, carbohydrate chemistry and biochemistry in natural and processed foods and their changes during storage. The fundamental roles of pectin, vitamins, pigments and minerals. Texture, flavour and colour as affected by chemical/ biochemical interactions of food macromolecules. Enzymes and enzymic reactions and their effects.

Advanced Food Microbiology (3 Units)
Relationship of environment to the occurrence, growth and survival of microorganisms in foods. Methods of evaluation. Mechanisms to control species of importance. Control of food borne pathogens and toxins. Enumeration and identification of microbs in foods. Products of microbial metabolism (a) Enzymes, (b) Primary metabolites and (c) Secondary metabolites.

Advanced Food Biotechnology (3 Units)
Advances in biotechnology and their applications in food safety (biosensors) and quality. Methods of genetic engineering of animal and plant cells and tissues and their applications in food processing. Ethical concerns in food biotechnology.

Advanced Analysis and Instrumentation in Food Science (3 Units)
Application of modern instrumental methods of analysis to the examination of food products. Atomic absorption spectrometer (AAS). High Performance Liquid Chromatography (HPLC). Gas Chromatography (GC). Mass Spectrometer (MS). Near Infra-red Reflectance Spectroscopy (Near-IR), IR, Ultraviolet-visible spectroscopy (UV-VIS). Applications in the food industry.

Quality Control in the Food Industries (3 Units)
Laboratory and commercial procedures for evaluating the sensory properties and market quality of foods. Analysis and reporting of Taste Panel data. Evaluation of changes in foods as a result of processing, packaging and storage. Microbiological quality factors of raw materials, processed and preserved foods. Methods of routine investigation, Special Methods of data evaluation. Food plant organization and management. Statistical methods in quality control and introduction to operations research in the food industry. Food laws development and enforcement. Modern techniques in qualitative measurements in Food Science will be considered. Quality control in some selected food commodities.

Product Development Strategies in the Food Industries (2 Units)
Product Development starting from searches, screening and selection of product ideas. The integration of chemistry, analysis, microbiology and processing to design, produce and evaluate product candidates. Acceptance-testing procedures. Market-testing procedures. Cost analysis. Manufacturing for the market. The interphase of interdisciplinary experts in this process. The role of management in the process. The challenge of leadership in the product development process. Criteria of assessing success.

Advanced Science and Technology of Processing, Storage and Distribution of Selected Food Commodities of Plant Origin (2 Units)
Course is offered in modules of 2-Units at a time up to a possible maximum of 4-Units for any one student in the course of a single degree. Each module is designed to selectively cover advanced techniques for processing, storage and distribution of one cluster of related food commodities of plant origin of interest to the students registered such as fruits and vegetables, roots and tubers, fats and oils, cereals and legumes, coffee, tea, cocoa, and their derivative products of food manufacture.

Advanced Science and Technology of Processing, Storage and Distribution of Selected Food Commodities of Animal Origin (2 Units)
Course is offered in modules of 2-Units at a time up to a possible maximum of 4-Units only for any one student in the course of one degree. Each module is designed to selectively cover advanced techniques for processing, storage and distribution of one cluster of related food commodities of animal/flesh origin of interest such as dairy and analogous products, meat, poultry, fish, eggs and wildlife and their derivative products of food manufacture.

Global and National Food Security and Policy Issues (2 Units)
This course shall be presented through symposia, seminar presentation, class discussions and submission of a long essay of at least five thousand words on any topic of interest. Specifically the course shall examine issues relating to: Global food situation; Production and demand for cereal, pulses, legumes, roots and tubers. Food and Nutrition Security. Famine and poverty alleviation strategies. Potentials of technology to meet world food needs. Global and regional meat demand and supply prospects. World food situation in relation to processing and storage. Strategies for accelerated food production to meet rising demand in the food processing industries. Food self-sufficiency, food self-reliance

and autarky as approaches to food security. The role of food processing in the management of food security.

Advances in Food Thermobacteriology and Canning Technology (2 Units)
Review of advances in conventional concepts of thermal process calculations. Consideration of quality optimization strategies. Computer-
aided thermal process calculations. Aseptic processing techniques and calculations. Case study applications in evolving aspects of canning.

Unit Operations in Food Processing (2 Units)
Principles, techniques and application of unit operations in the transformation of raw materials into high quality food products. Examples are preparative operations such as cleaning, washing; conversion operations such as size reduction, centrifugation, filtration, screening; thermal processing such as heating, cooling, freezing; dehydration, evaporation, canning, etc.

Advanced Food Packaging (2 Units)
Food structure and packaging. Food rheology and packaging. Mechanical behaviour of packaged foods. Thermal and electromagnetic properties of packaged foods. Food packaging materials and their properties. Shelf-life prediction and testing. Micro-and-macro environmental considerations in food packaging.

Enzymes in Food Processing Industries (2 Units)
The production and purification of enzymes for food processing. The technological application of enzymes in foods.

Food Safety and Toxicology (2 Units)
Natural food toxins, polyphenolic compounds, saponins, flavonoids, lectins, anti-vitamins cyanogens, favism, oestrogens, and goistrogens. Occurrence, nature and composition. Effects on nutritional and aesthetic quality of foods. Biochemical and physiological functions in food materials. Interactions of polyphenols with food nutrients. Removal of toxins. Incidence and presence of toxic microorganisms and their products in foods. Biological, serological and biochemical methods for detecting toxins. Means for control of these toxins in foods and for prevention of food borne public health hazards.

Risk Analysis in Foods and Ingredients (2 Units)
The concept of risks and its assessment using modern methods including HACCP. Review of microbiological and chemical agents of risk and toxicity. Residues in food products. Methods of evaluating potential toxicity of chemicals to living systems. Regulatory toxicology. Environmental toxicology. Handling of toxic substances.

Advanced Topics in Nutrition (2 Units)
The nutritional aspects of metabolism of carbohydrates, fats, proteins, vitamins, and minerals are considered in detail. Pathology of nutrient deficiencies. Imbalance and toxicity are discussed. Mechanics of regulation and behavioral aspects of food and fluid intake are examined. The effects of nutritional status on organs including the gastro-

intestinal tract, liver, muscles, kidney and bones are discussed. Inter-retardation is covered.

Special Problems in Food Technology (2 Units)
Course will be offered by guided self-study of student who will carry out any combination of literature search, laboratory and/or field work, analysis of data and report presentation on selected topics of interest in food technology that impinge on student's larger thesis research interest. Course shall be taken in modules of 2-Units Units up to a possible maximum 4-Units Units in the course of any one postgraduate degree.

Special Topics in Human Nutrition (2 Units)
The impact of food processing on nutrition and health. Nutrition and mega-vitaminization. Nutrition in diseases and ageing. Nutritional basis of infant food formulation and processing. Fortification of processed foods. Dietary fibres. Micro-nutrient nutrition.

Further Elective courses from Cognate Disciplines of Agriculture, Science and Engineering
Candidates are encouraged to take higher level undergraduate and postgraduate courses in cognate disciplines of Agriculture (Crop Science and Animal Science); Science (Chemistry, Microbiology, Computer Science); and Engineering (Food and Agricultural).

8.10 FOOD ENGINEERING

Introduction

Food Engineers plan, design, construct, implement, operate, manage and conduct research-and-development on food processes and food machinery-and-equipment systems for the food industries. The food engineer combines in the same person for the diverse purposes of serving the food-and-allied industries, the range of skills and expertise necessary for the creative planning, design, development and implementation of functional processes as well as equipment-and-machinery systems for the manufacture, storage and distribution of foods and allied ingredients.

The postgraduate programme in Food Engineering provides students with opportunities to acquire and deepen diverse intellectual, quantitative and practical skills that equip them to apply rigorous techniques of engineering analysis in finding solutions for complex problems which arise in the conception, design, development and implementation of processes as well as equipment-and-machine systems in the manufacture, storage and distribution of commercial food and allied ingredients.

Philosophy and Objectives

Food Engineering is a new discipline of engineering which seeks to play the same indispensable role in the development of the food-and-allied Industries that other engineering fields of various disciplinary domains do in their cognate fields of professional specialization. As a hybrid discipline of study and research, Food Engineering underscores unique points of view which necessarily combine the objectives of a number of different but convergent domains which integrate engineering analysis with bio-systems as they specifically apply to understanding and configuring the complexity of food systems. The thrust of Food Engineering embraces the following emblematic objectives:

- A focus on food system inputs into food processing as derived from agriculture, forestry and fishery as fundamentally bio-resources which function and are handled as biological entities.

- Focus on the maximization of value-addition to enhance convenience, nutritional and aesthetic quality, taste, texture, flavour safety and storability of food and agricultural raw materials through diversified processing, preservation and marketing.

- Focus on concerted search for increased insights into basic physical, chemical and biological phenomena, which cause changes in food quality so that design of food processes and food machinery can be anchored increasingly on sound scientific and technological foundations of understanding of mechanisms rather than on costly empiricism based on trial-and-error.

- Focus on a systematic search for objective instruments to measure and monitor quality, mechanisms and phenomena relating them to readily controllable process and machine variables and their associated modes of control.

- Search for optimization processes, equipment choices and operational specializations which bring into one convergent focus, conditions of safety, quality assurance, system and cost efficiencies.

- Search for machine design systems which are structurally and electronically sound and compatible with quality factors inherent in food systems of interest.

- Competent understanding of energy, mass and momentum balances, transfer and rate processes, thermodynamics and the range of physicochemical inter-relationships responsible for transformations that take place during food processing, food storage and food distribution.

- An increasing understanding of the environment and its effects on food systems design and operation.

Facilities Required

i. Advanced Laboratory for Food and Ingredients Analysis
ii. Advanced Instrumentation Laboratory for Engineering Properties and the Packaging of Foods and Ingredients
iii. A well equipped and versatile Pilot Plant with control instrumentation for Food Processing Containing the Primary Unit Operations Equipment for Food Processing, Storage and Distribution.
iv. Advanced Laboratory for Food Microbiology, Fermentation and Biotechnology.
v. Fabrication Workshop to Support in-house Food Machinery-and-Equipment Design Efforts.

8.10.1 Postgraduate Programmes

Admission Requirements

i. Higher National Diploma (HND), in Food Engineering or any other cognate Engineering discipline with at least a lower Units.
ii. B.Sc., B.Eng., B.Tech Degree in Food Engineering or any other cognate Engineering discipline with a minimum of second class (lower) honours.
iii. B.Eng./B.Tech in Food Engineering with third class honours.
iv. B.Sc. or B.Tech in Food Science and Technology or any related discipline of applied science or technology with at least a second class (lower) honours degree.

Graduation Requirements

To qualify for the award of a Postgraduate Diploma in Food Engineering, a candidate shall have satisfactorily completed a minimum of 64 Units Units of course work made up as follows:

i. 48 Units of compulsory or core courses
ii. 10 Units of elective courses
iii. 6 Units of project work

Postgraduate Diploma (4-Semesters) in Food Engineering

i. **Core/Compulsory Course**

Title	Units	Title	Units
Engineering Mathematics I	3	Food Microbiology and	
Engineering Mathematics II	3	Biotechnology	3
Statistical Methods, Experimental	3	Engineering properties of Food	
Design and Analysis	3	Law, Management and	
Numerical Methods and Computer		Entrepreneurship	2
Programming	3	The Engineer in Society	
Food Chemistry, Biochemistry and		Food Engineering-2	2
Food Analysis	3	Food Equipment and Machinery	
Food Engineering- I	3	Design	3
Food Plant Layout and Process		Unit Operations in Food	
Design	3	Processing- II	3
Unit Operations in Food		Food Packaging	2
Processing-I	3	Seminar	2
Food Quality Assessment	2	Project Work in Food Engineering	6
Technical Report writing	2		
Total Units	28	Total Units	29

ii. **Elective Courses**			
Technology of Foods of Plant Origin	3	Technology of Food of Flesh	
Selected Topics in Food Processing	2	Origin	3
Selected Topics in Food Engineering	2	Selected Topics in Food Storage	2
		Selected Topics in Food	
		Distribution	2

Course Description (Postgraduate Diploma in Food Engineering)

Seminar **(2 Units)**

Student shall prepare and present a proposal seminar of the project chosen for investigation and shall present another terminal seminar at the end of the investigation.

Project Work **(3 Units)**

Guided/Supervised investigation of a food engineering problem selected and conducted by student. Project shall challenge the creativity of student and shall culminate in a long essay to be examined by a panel of examiners.

Technical Report Writing **(2 Units)**

Principle of communications. Preparation and writing of technical reports. Oral presentation of reports. Use of visual aids and other communication equipment in technical and research presentations. Use of power point presentations for professional effectiveness.

Engineering Mathematics-I **(3 Units)**

Review of matrix operation including inversion. Eigen values, Eigen vectors and canonical transformations and applications. Three dimensional vector representation. Vector calculus. Gradient, divergence and curl line. Surface and volume integrals. Laplacian operations. Green's, Stoke's and Divergence theorems and applications. Ordinary and partial differential equations. Applications to physical problems. Complex variables. Numerical analysis. Special functions and integrals, problem formulation and simple methods of solution.

Engineering Mathematics-II (2 Units)

Complex variables: function, deviation and language. Series, Taylor series, Cauchy theorem, Cauchy formula, Cauchy integrals. Analytic functions, singular points, residual problems, Conformal problems and mapping. Special functions: Gamma, Delta, Beta and Error functions. Fourier integrals, Fourier transforms for solving partial differential equations.

Numerical Methods and Computer Programming (3 Units)

Gaussian elimination. Gauss-Seidel methods and Newton-Raphson-Heraton methods of solving linear equations. Forward and backward difference tables. Central difference formula. Finite difference Solution to partial differential equations. Solutions of ordinary differential equations (1st and 2nd order) using Runge- Kutta method. Flow charting. Algorithms. Inputs and outputs. BASIC, FORTRAN and Modern Languages. Computer software analysis. Applications in heat, mass and momentum transfer and ICT.

Statistical Methods (2 Units)

Descriptive Statistics: Central tendencies and dispersion. Elementary probability theory and, conditional probability. Baye's theorem. Probability distributions and applications. Elementary theories of sampling and estimation. Test of hypothesis and significance. Curve fitting, Linear and Multiple regression analysis. Linear correlation. Analysis of variance. Time series analysis. Statistical quality control for mean, standard deviation, range, number of defects etc., sampling techniques, average sampling number. Stochastic processes.

Engineer in Society (2 Units)

Philosophy of science, History of engineering and technology. Safety in engineering and introduction to risk analysis. The role of engineers in nation building. Invited Lectures from Professionals.

Law, Management and Entrepreneurship (3 Units)

Principles of Management. Industrial group and organizational behaviour. Motivation. Industrial Law, legislation on wages, trademarks and patents, Laws of contract and sales of goods. Liability for industrial injuries. Industrial relations. trade unions, employer associations, wages bargaining and the role of the state. Relevant topics on entrepreneurship designed by the National Universities Commission for Nigerian Universities.

Food Chemistry, Biochemistry and Analysis (3 Units)

Composition of Food and interactive changes that occur during processing with special reference to water, carbohydrates, lipids, proteins, vitamins and minerals. The biochemistry of food enzymes, pigments, colours, flavours and related metabolism. Methods of food analysis with emphasis on proximate determinations, and the application of flourimetry, chromatography, electrophoresis in the analysis of food constituents and toxicants.

Food Microbiology and Biotechnology (3 Units)
Detection and enumeration of micro-organisms of importance in food and food processing. Sampling and preparatory treatments of food samples for microbiological analysis. Microbiology in quality control and food standards. Food and beverage fermentation. Food enzymes and their applications in food processing. Bioreactor operation and design. Genetic manipulation of industrial microorganisms. Plant cell tissue culture biotechnology applications. Biosensors. Environmental biotechnology.

Food Engineering – I (3 Units)
Fluid mechanics. Food rheology. Heat, mass and momentum transfer considerations in food processing.

Food Engineering – II (3 Units)
Physical and engineering properties of foods. Thermodynamics of food systems. Psychrometry. Thermal process calculations. Kinetics of chemical reactions in food systems.

Unit Operations in Food Processing –I (3 Units)
Preparatory operations. Size reduction of solid and liquid foods. Mixing and forming. Separation processes. Contact equilibrium separation processes.

Unit Operations in food processing – II (3 Units)
Blanching. Canning. Evaporation. Distillation. Dehydration. Frying. Refrigeration and Freezing. Material handing. Extraction. Filtration. Crystallization.

Food Quality Assessment (3 Units)
Food standards and the laws empowering them. Food quality grades. Methods of quality assessment. Statistical quality control including the application of quality charts. Methods of sensory evaluation. Plant sanitation and hygiene as factors of food quality. Sampling, verification and consumer acceptance testing.

Principles of Food Packaging (3 Units)
Types and properties of food packaging materials. Food packaging equipment. Food packages and their interaction with food. Transfer processes in the package micro-and-macro environments. Package testing and safety considerations. Design of packages. Recycling of packages. Irradiation of packages.

Technology of Foods of Plant Origin (3 Units)
Processing technology involving unit operations, Unit processes and selection of equipment systems employed in the conversion of cereals, legumes, oilseeds, nuts, sugar cane, fruits and vegetables, roots and tubers into industrial food products. Quality

considerations for raw material sourcing and finished goods. Cost analysis associated with conversion operations.

Technology of Food of Flesh Origin (3 Units)
Processing technology involving unit operations, unit processes and selection of equipment systems employed in the conversion of milk into assorted dairy products; meat, fish, poultry and egg processing into commercial products. Quality considerations for raw material sourcing and finished goods. Cost analysis of conversion operations.

Food Plant Layout and Process Design (3 Units)
Background to food process design. Uniqueness of the nature of food processes as contrasted from other processes such as chemical and biochemical processes. Flow sheet construction and flow sheet symbols. Process strategy planning. Process optimization. Instrumentation of process systems. Feed-forward and feed-back control systems. Sizing and selection of process equipment. Plant layout planning and methods. Plant cost analysis. Process design problem as a project.

Food Equipment and Machinery Systems Design (3 Units)
Review of machine design procedures and methods. Engineering materials and their properties. The engineering team approach to design. Fabrication methods. Fits and tolerances. Stresses, deflection and buckling. Couplings, keys, splines, bolts and screws. Drives using belts and gears. Vibrations and springs. Bearings and lubrication. Design problem as a project.

Selected Topics in Food Engineering (3 Units)
Course shall be undertaken by guided self-study of student involving any combination of literature survey, laboratory and/or fieldwork, data analysis, report writing and seminar presentation. It shall focus on specific topics of interest in food engineering such as energy analysis in food processing, boilers and their application in food processing, water supply systems, waste management systems, extrusion cooking of foods, freeze concentration and freeze drying, novel processing of pulsed electric fields, high hydrostatic pressure, dielectric, ohmic and infrared heating of foods and osmotic dehydration.

Selected Topics in Food Processing (2 Units)
Course shall be undertaken by guided self-study of student involving any combination of literature survey, laboratory and/or fieldwork, data analysis, report writing and seminar presentation. It shall focus on identified problems of interest in food processing such as the application of enzymes, flavour technology, fermentation processes, biotechnological innovations in ingredient production, microwave food processing; the chemistry, microbiology and technology of specific food commodities.

Selected Topics in Food Storage (2 Units)
Course shall be undertaken by guided self-study of student involving any combination of literature survey, laboratory and/or fieldwork, data analysis, report writing and seminar presentation. It shall focus on specific topics of current local and international interest in food storage and food storage systems for selected food commodities or food ingredients.

It shall address the chemistry, biochemistry, microbiology of the storage system and their effect on quality. It shall address the design of storage systems, their operations and the associated cost analysis.

Selected Topics in Food Distribution (2 Units)

Course shall be undertaken by guided self-study of student involving any combination of literature survey, laboratory and/or fieldwork, data analysis, report writing and seminar presentation. It shall focus on specific aspects of the transportation and distribution of food commodities to and from food factories and storage. It shall address problems of packaging, containers and containerization, refrigeration contamination, labour and cost, deteriorative agents and processes involved in distribution.

8.10.2 M.ENG./M.TECH./M.SC. AND M.PHIL./PH.D PROGRAMMES

Admission Requirements

a. **M.Eng. or M.Tech Degree Programme in Food Engineering**

i. B.Eng. or B.Tech. Degree in Food Engineering or any other cognate Engineering discipline with a minimum of second class (lower) honours.

ii. PGD in Food Engineering with a minimum of Upper Units Pass.

b. **M.Phil Degree Programme in Food Engineering**

Candidates who complete their postgraduate degree programme with CGPA of not less than 3.00 on a 5-point scale or the equivalent of 55% in their M. Tech or M.Eng. Degree in Food Engineering may be admitted to undertake the M.Phil degree programme. Such candidates shall be required to complete a minimum course work of eighteen (18) Units Units made up of six (6) Units Units of core courses and twelve (12) Units Units of elective courses. On successful attainment of a CGPA of not less than 3.50 on a 5-point scale OR 60% minimum at the end of the course work, such candidates shall be deemed to be qualified to transfer to the Ph.D. programme.

c. **Ph.D Degree Programme in Food Engineering**

Normally, only candidates who hold the degree of M.Eng. or M.Tech or an equivalent qualification in Food Engineering may register for the Ph.D degree programme in Food Engineering. Such candidates shall normally possess a CGPA of not less than 3.50 on a 5-point scale OR 60% minimum.

Graduation Requirements

a. **M.Eng./M.Tech. Degree Programme in Food Engineering**

Course work requirements for graduation sum up to a total of 36-Units Units as follows:

(i) 20 Units of compulsory courses
(ii) 10 Units of Electives Courses
(iii) 6 Units of project

b. **M.Phil Degree Programme in Food Engineering**

Candidates who wish to obtain a terminal M.Phil Degree in Food Engineering shall satisfactorily complete a course workload of 36 Units Units as follows:

(i) 18 Units selected from M.Eng./M.Tech degree course list
(ii) 18 Units of research work.

c. **Ph.D Degree Programme in Food Engineering**
Course work requirements for the Ph.D in Food Engineering sum up to a total of 45 Units Units as follows:
(i) 21 Units of Advanced Course t; and
(ii) 24 Units of research work.

Outline of Courses

M.Eng/M.Tech, M.Phil and Ph.D in Food Engineering Areas of Specialization

At the Masters and Ph.D degree levels, a candidate enrolled for a degree may specialize in any one of three areas as follows:
a. Food Process Design and Development and related problems;
b. Food Machinery-and-Equipment systems Design and Development and related problems; and
c. Food Storage, Distribution, Environmental Analysis and related problems.

i. Core/Compulsory Course	**Units**
M.Eng/M.Tech Seminar	1
M.Phil Seminar	1
Ph. D. Degree Seminar	1
M.Eng./M.Tech. Research Project	6
M.Phil Research Project	18
Ph.D. Research Project	24
Design and Analysis of Experiments in Food Processing	3
Instrumentation and Control in Food Processing	2
Mathematical Modeling, Process Optimization and Computer Applications in Food Engineering	3
Advanced Food process and Plant Design in Food Engineering	3
Advanced Food Machinery and Equipment Design	3
Reaction Engineering in Processing, Storage and Distribution Systems for Food and Ingredients	2
Transport Phenomena in Food processing	2
Quality Control in the Food Industries	3
Advanced Food Thermobacteriology and Canning Technology	2
Advance Physico-chemical and Engineering Properties of Foods and Ingredients	2
Advanced Bio-engineering and Biotechnology Applications in Food processing	2
Environmental Engineering in Food processing	-
Special Topics in Advanced Food Engineering	-
ii. **Elective Courses**	
Advanced the Technology of Processing, Storage and Distribution of	2

Food Commodities of Plant Origin	
Advanced Technology of processing, Storage and Distribution of food Commodities of Animal (Flesh) Origin	2
Product Development Strategies in the Food Industries	2
Global and National Food Security and Policy Issues	2
Special Topics in Food Science and Technology	2
iii. **Further Elective Courses from Science and Base Engineering Disciplines**	
Agricultural Engineering	
Mechanical Engineering	
Chemical Engineering	
Computer Science	
Mathematics/Statistics	

COURSE DESCRIPTION

Seminar (1 Unit)

The Seminar for any postgraduate degree encompasses the preparation of two research reports accompanied by formal presentations made by the candidate. The first research report (or proposal) is presented at the commencement of the research programme. The second report comes at the end of data collection and analysis and leads to the completion of the dissertation or thesis as the case may be.

Research Project (Masters: 6 Units; M.Phil: 18 Units and Ph.D Thesis: 24 Units)

For any Masters, M.Phil or Ph.D. degree, each candidate shall conduct a research on an approved topic and write a dissertation (Masters/M.Phil) or thesis (Ph.D.) as the case may be under staff supervision. In the case of the Ph.D. degree the research and thesis must be of sufficient and scope to break new ground in Food Engineering.

Design and Analysis of Experiments in Food Processing (3 Units)

Survey of strategies of experimentation using statistical techniques. Comparative experiments and inferences. Analysis of Variance in experiments with single and multiple factors. Randomized blocks. Latin squares and related designs. Factorial designs. Fitting regression models. Response surface methods and designs. Nested and split-plot designs.

Instrumentation and Control in Food Processing (2 Units)

Measurement and control of flow, pressure, temperature, viscosity, humidity, etc as fundamental parameters of food processing operation. Sensors and signal conditioning. Telemetry. Feed forward and feedback control systems. The transfer function. System stability and optimization. Computer-aided control system applications in Food Processing.

Mathematical Modeling, Process Optimization and Computer Applications in Food Processing (3 Units)

Principles of modeling using fundamental approaches. Principles of modeling using empirical approaches. Process simulation modes and process flow sheet optimization. Applications in food processing systems using dedicated computer softwares.

Advanced Food Process and Plant Design in Food Engineering (3 Units)

The food process as a sequence of physico-chemical and biological transformations/conversions of food biomaterials. Advances in mass and energy balances around individual and integrated unit operations. Flow sheet synthesis and planning. Design and choice of processing equipment. Instrumentation and control in food processing. Plant layout planning. Cost analysis. Project evaluation. Case study applications. Process design project.

Advanced Food Machinery and Equipment Design (3 Units)

Review of physical and engineering properties of food biomaterials. Review of advances in machine component design procedures. The properties of engineering materials. Compatibility considerations between food and machine parts. Application of CAD/CAM in food machine design using dedicated softwares. Concepts of hygiene and sanitary design. Case study applications in typical machine systems in food processing. Machine design project.

Reaction Engineering in Processing, Storage and Distribution systems for food and Ingredients (2 Units)

Theory of reaction rates. Types and order of reactions. Simple and complex kinetics of reactions. Enzymatic reaction kinetics. Temperature dependence of reaction rates. pH dependence of reaction rates. Computer-aided reaction kinetic calculations. Case study applications in processing, storage and distribution chains for foods and ingredients.

Advanced Food Thermobacteriology and Canning Technology (2 Units)

Review of progress in conventional concepts of thermal process calculations. Consideration of quality optimization strategies. Computer-aided thermal process calculations. Aseptic processing techniques and calculations. Case study applications in evolving aspects of canning.

Advanced Biochemical Engineering and Biotechnology Applications in Food Processing (2 Units)

Elements of genetics and concepts of recombinant DNA biotechnology (Genetic Engineering). Advanced concepts and practices in bioreactor design and operation. Single cell protein and enzyme biotechnology. Food and beverages biotechnology applications in fermentation processes. In vitro cultivation of plant and animal cells and tissues. Case study applications in food processing.

Transport Phenomena in Food Processing (2 Units)

Heat, mass and momentum transfer theory and applications in food processing. Computer-aided approaches shall be applied.

Quality Control in the Food Industries (3 Units)

Laboratory and commercial procedures for evaluating the sensory properties and market quality of foods. Analysis and reporting of Taste Panel data. Evaluation of changes in foods as a result of processing, packaging and storage. Microbiological quality factors of raw materials, processed and preserved foods. Methods of routine investigation, special methods of data evaluation. Food plant organization and management. Statistical methods in quality control and introduction of operations research in the food industry. Food laws development and enforcement. Modern techniques in qualitative measurements in Food Science will be considered. Quality control in some selected food commodities.

Advanced Technology of Processing, Storage and Distribution of Selected Food Commodities of Plant Origin (2 Units)

Course is offered in modules of 2-Units at a time up to a possible maximum of 4-Units for any one student in the course of a single degree. Each module is designed to selectively cover advanced techniques for processing, storage and distribution of one cluster of related food commodities of plant origin of interest to students registered such as fruits and vegetables, roots and tubers, fats and oils, cereal and legume, baked goods, sugar confectionery and syrups.

Advanced Technology of Processing, Storage and Distribution of Selected Food Commodities of Animal Origin (2 Units)

Course is offered in modules of 2-Units at a time up to a possible maximum of 4-Units only for any one student in the course of one degree. Each module is designed to selectively cover advanced techniques for processing, storage and distribution of one cluster of related food commodities of animal/flesh origin of interest such as dairy and analogous products, meat, poultry, fish, eggs and wildlife.

Global and National Food Security and Policy Issues (2 Units)

This course shall be presented through symposia, seminar presentation, class discussions and submission of a long essay of at least five thousand words on any topic of interest. Specifically the course shall examine issues relating to: Global food situation: Production and demand for cereal, pulses, legumes, roots and tuber; Food and Nutrition security; Famine and Poverty eradication strategies; Potential of technology to meet world food needs; Global and regional meat demand and supply prospects. World food situation in relation to processing and storage. Strategies for accelerated food production to meet rising demand from the food processing industries. Other issues relating to contemporary World food situation.

Product Development Strategies in the Food Industries (2 Units)

The product development method. Food eating habits. Factors to be considered in the development of nutritious foods, raw materials selection and quality. Setting up of linear programming model. Development of the model for computer solution. Use of linear programming models to design and develop new food products for laboratory

development, consumer surveys and acceptability of developed food products. Legal aspects of food product development.

Environmental Engineering in Food Processing (2 Units)
Environmental Impact Assessment (EIA) strategies and approaches in the siting and management of food processing plants. Sanitary and hygienic considerations in food plant design and construction. Cleaning strategies and requirements. Water supply. Solid and liquid waste assessment, their management and utilization.

Special Topics in Advanced Food Engineering (2 Units)
Course is offered in modules of 2-Units at a time up to a maximum total of Units for any one student in the course of one degree. Each module shall be focused on an identified problem in Food Engineering. Course shall be executed by guided self-study of student involving any combination of the following: survey of significant sources, laboratory and/or field work, analysis of data, report preparation and seminar presentation.

Advanced Physico-chemical and Engineering Properties of Foods and Ingredients (3 Units)
Food rheology. Food texture. Surface properties. Thermodynamic and thermal properties. Electrical properties. Mass Transfer properties. Study shall encompass critical review of procedures and instrumental methods of measuring and estimation of these properties and their relevance to quality assurance and the design of food processes and food machinery.

Fabricated Foods (2 Units)
Novel sources of proteins, fats and carbohydrates. Hydrolyzed vegetable proteins. Synthetic flavours. Separation, purification and texturization of new protein foods.

Elective courses in Science or Food Science and Technology
To further strengthen the scientific foundations of the food engineering programme at the Masters/M.Phil/Ph.D. levels, it is desirable and recommended that up to 4-Units Units of relevant elective courses shall be selected in any cognate science discipline and/or in Food Science and Technology. Such courses shall be at the senior undergraduate and postgraduate levels only.

Elective Courses from related Engineering and Computer Science Departments
To strengthen the foundations of the postgraduate programme in Food Engineering at the Masters/M.Phil/Ph.D. levels, it is desirable and strongly recommended that 6-Units of relevant elective courses be selected from the base-engineering fields (Civil, Mechanical, Chemical and Agricultural and from Computer Science). Such courses shall be at the senior-undergraduate (400 and 500-levels) and post-graduate levels. In civil engineering choice should be restricted to environmental and structure related courses that can be applied in physical development of food factories. In mechanical engineering and agricultural engineering, choice of course(s) should be restricted to machine design and energy resources. In chemical engineering, choice should be on process design, optimization and control that can be applied in food process and plant design. In

computer science, choice of course(s) should be on computer applications for the solution of food Engineering problems.

8.11 FOOD BIOTECHNOLOGY

Fundamentals of food Biotechnology.

M.Sc Food Biotechnology

M.Sc. Students Seminar (2 Units)

Discussion of selected topics in food Engineering.

Advanced Food Properties and Analysis (3 Units)

Physical and hemical properties of foods, colloids with emphasis on emulsion, gels, and sols, Viscoelastic modeling of biological solide, colloids and fluids. Methods of evaluation of texture, viscosity/consistency, colours flavour, and aesthetics in foods. Interrelations between sensory qualities and physical/chemical attributes of quality. Selected problems associated with modern food analysis including the detection and quantification of toxicants, food additives, vitamins, amino acids and flavour.

Methods of Data Analysis (3 Units)

Experimental statistical methods in respect of planning and analysis of data from controlled experiments. Interpretation of experimental data. Mathematical formulation of typical biophysical problems in food processing and preservation. Solution of resulting differential equations. Matric, Selected numerical methods.

Optimization Bioprocess and Methods (3 Units)

Experimental design, date analysis, model building, reactor dynamics and computer control for optimization. Mathematical and experimental techniques for optimizing processes.

Momentum, Heat and Mass Transfer (3 Units)

Prediction of velocity, temperature, and concentration profiles for flowing fluids; unifying concepts and analogies in momentum, heat and mass transport; streamline flow and turbulence, molecular and eddy conduction and diffusion, boundary layers, smooth and rough conduits and other boundaries.

Unit operations in food Technology (Food Engineering) (3 Units)

Advanced treatment of selected unit operations including food dehydration, refrigerated and frozen storage, thermal process calculations and canning, food concentration, separation processes. The underlying scientific principles will be emphasized and factors of equipment choice and operations considered.

Food Process, Plant design and Machinery (3 Units)

Integrated design of complete food process. Process Engineering. Instrumentation, Layout, Project economics, flow sheets. Energy and mass balance. Capital investment.

Biotechnology (2 Units)

Fermented foods of tropical and temperate countries. Oriental fermented foods. Production of vitamins, amino acids, polysaccharides, polyhydroxy alcohols by fermentation. Microbial protein enrichment of carbohydrate foods. Single cell proteins.

There shall be emphasis on the theoretical or fundamental reactions involved and conditions affecting fermentative efficiency. (2 Units)

Food Physics and Packaging (Engineering Properties) (3 Units)
Food structure, Food rheology, Mechanical behaviour of foods. Electromagnetic properties, Thermal properties, Physio-chemical, Microbiological and economic problems related to the use of metal, glass, paper, flexible films and other packaging materials in the food industry.

Special topics in Food Science and Technology (2 Units)
Topics shall be selected from broad based contemporary topics in Food Science and Technology.

Dissertation (12 Units)

ELECTIVES
Relevant electives should be selected as opportunity to a maximum Units Units of 4.

8.12 SYSTEMS ENGINEERING PROGRAMMES

The Postgraduate Programmes in Systems Engineering have been grouped into five designated areas of specialization as listed below:

a. M.Sc (Systems Engineering) with specialization in Engineering Analysis
b. M.Sc (Systems Engineering) with specialization in Modeling and Simulation
c. M.Sc (Systems Engineering) with specialization in Artificial Intelligence
d. M.Sc (Systems Engineering) with specialization in Information Technology
e. M.Sc (Systems Engineering) with specialization in Engineering Systems Management.

Admission Requirements:

i. Candidates with a Bachelor's degree in Engineering or Physical Sciences (Physics, Mathematics; Computer Science etc.) discipline with at least a second class lower.

Degree Requirements

To satisfy the requirements for the award of the M.Sc. Systems Engineering degree, in any area of specialization, a candidate must:-

a. Offer and pass all core courses in his chosen area of specialization.
b. Offer and pass some specified elective courses as is required to bring the total of 800-level course Units (including core courses but excluding project) to at least 18 Units.
c. Offer and pass 6 Units of project and
d. Satisfy all other conditions stipulated earlier for the award of the degree.

8.12.1 M.Phil PROGRAMME

The M. Phil. Programme consists of courses of formal instruction, research seminar(s) and a dissertation. A candidate may specialize in one of the areas of specializations listed above, for the Master of Science degree programme.

Admission Requirements:

To be eligible for admission into the M. Phil programme, a candidate must:

a. Hold either a Master Degree of at least a CGPA of 3.0/5.0 or 50% in any of the designated specialties of Systems Engineering.

8.12.2 Ph.D PROGRAMME

In this programme, the emphasis is on original research, candidates may undertake their research in one of the areas of specialization listed for the M.Sc. (Systems Engineering) Degree programme.

Admission Requirements

To be eligible for admission into the Ph.D programme, a candidate is required to:-

i. Be a holder of an M.Phil, degree or equivalent in System Engineering awarded by any recognized university
ii. Be a holder of an M.Sc degree of equivalent with a minimum CGPA of 3.5/5.0 or 60%in Systems Engineering awarded by any recognised University.
iii.

PROGRAMME STRUCTURE

i. **M.Sc/M.Phil Courses**

COMPULSORY COURSES

Course Title	**Units**
Numerical Methods in Engineering	3
Methods of Applied Mathematics I	3
Linear and Non-Linear System Analysis	3
Knowledge-Based Systems & Artificial Intelligence	3

ii. M.Sc (Systems Engineering) with specialization in Engineering Analysis

a. Compulsory Courses

Course Title	**Units**
Methods of Applied Mathematics II	3

b. Two Elective courses from the following:

ELECTIVES

Course Title	**Units**
Mechanics of Continua	3
Mathematical Theory of Elasticity	3
Functions Space Methods	3
Continuum Mechanics and Thermodynamics of Solids	3
Electromagnetic Wave Interactions	3
Continuum Electromagnetics	3

i. **M.Sc (Systems Engineering) with specialization in Modeling and Simulation**

a. Compulsory Courses

Course Title	**Units**
Systems Identification, Optimization and Control	3

b. Two Elective courses from the following:

ELECTIVES

Course Title	**Units**
Mathematical Programming	3
Modeling and Simulation	3

i. **M.Sc. (Systems Engineering) with specialization in Artificial Intelligence**

a. Compulsory Courses

Course Title	Units
Expert Systems with Applications to Engineering Problems	3
Introduction to Neural Networks and applications	3

b. One elective course from the following:

ELECTVES

Course Title	Units
Robotic Application	3
Expert Systems in Manufacturing & Engineering	3
Knowledge Based Systems and Web Agent	3

i. **M.Sc (Systems Engineering) with specialization in Information Technology**

a. Compulsory Courses

Course Title	Units
Computer Communications and Networks	3
Fault-Tolerant Digital Systems	3

b. One elective course from the department, Faculty of Engineering or any other faculty within the University as may be appropriate for the designated area of specialization as listed below or as approved by the department.

Course Title	Units
Data Base Systems	3
Computer Communication networks & Distributed Processing	3
Database Managements System Design	3

i. **M.Sc (Systems Engineering) with specialization in Engineering Systems Management**

a. Compulsory Courses

Course Title	Unit
Theory of Reliability of Engineering Systems	3
Crisis Management in Engineering Systems	3

b. One elective course from within the department, Faculty of Engineering or any other faculty within the University as may be appropriate for the designated area of specialization as listed below or as approved by the department.

Course Title	Unit
Hazardous Material Management I	3

Advanced Industrial Management I	3
Occupational Safety Engineering II	3
Systems Methodology	3
Management Information Systems	3
Management and Methods in Reliability	3
Safety Engineering Management	3
Utility System Reliability	3
Knowledge Based System and Web Agents	3
Environmental Impact Assessment	3
Advanced Engineering Management Science	3

DESCRIPTION OF COURSES

Numerical Methods in Engineering (3Units)
Methods for obtaining numerical solutions to problems arising in Engineering. Linear and non-linear mechanical systems. Ordinary and partial differential equations, initial-value problems, and extreme.; Calculus of variation. Function-space methods. Applications to vibrations, diffusion, heat transfer, wave propagation, membranes, plates, fluid flow and celestial mechanics. Simulation of dynamical system. Analog computation.

Methods of Applied Mathematics I (3Units)
Ordinary differential equations; series; orthogonal functions and SturmLiouville theory; functions of several real variables, vector field and integral theorems; matrices; partial differential equations.; Emphasis is on application and techniques of solution, wherever possible.

Methods of Applied Mathematics II (3Units)
Continuation of partial differential equations; Green's function; Fourier and Laplace transforms; complex variables; calculus of variations; tensor analysis.

Mechanics of Continua (3 Units)
Introduction to the mechanics of continuous media. Cartesian tensors; kinematics of deformable media; stress, stress, balance laws; constitutive relations for selected solids and fluids. Further theory of kinematics of deformable media; thermodynamics and balance laws of continua; general theory of constitutive equation and typical examples; selected topics such as multipolar continuum theories, non-linear elasticity, variation principle for continuous fields, mixture theory, coupling of mechanical and electromagnetic fields.

Mathematical Theory of Elasticity (3 Units)
Development in tensor form of the basic equations of large-deformation elasticity; solution of certain large-deformation problems. Linearization to infinitesimal elasticity. Boussineq-Papkovich potentials and their application to three-dimensional problem; contact problems; plane stress by method of Muskhelishvili; application of conformal mapping; Cauchy integral techniques in elasticity; torsion problems.

Functions Space Methods (3 Units)
Function spaces in Engineering inner products; Linear Operations; The Method of Moment.; basic functions.; point matching.; Galerkin and Ritz procedures.; Approximate and Extended operators.; The numerical reduction of Engineering field problems.; System Matrices and Eigenfunction procedures.

Continuum Mechanics and Thermodynamics of Solids (3 Units)
Theory of nonlinear elasticity and Thermoelasticity; universal solutions, wave propagation, stability theory. Nonlinear viscoelasticity and introduction to more general theories of solids.

Electronmagnetic Wave Interactions (3 Units)
Maxwell's Equations. Duality and Uniqueness. Image Theory, the Equivalence principle the Induction Theorem. Reciprocity. Green's Functions. Integral Equations. Plan, Cylindrical and Spherical waves. Radiation. Electromagnetic scattering. Aperture interactions. Perturbational and Network Permutations. Variational Techniques.

Continuum Electromagnetics (3 Units)
Static and quasi-stationary electromagnetic field equations. Field transformation in moving coordinate systems. Boundary conditions and constitutive relations for moving media. Magnetic diffusion and charge relaxation. The Maxwell Stress tensor. Electromagnetics of elastic solids and Newtonian fluids. Electromahnetic engineering hydrodynamics. Magnetic pumps, the linear conduction motor and magnetic levitation.

Mathematical Programmeing (3 Units)
Techniques for modeling decision-making problems using appropriate mathematical models of linear, integer, combinatorial, or non-linear programming. Modeling techniques will be illustrated with examples, A comprehensive treatment of applicable algorithms to solve wide varieties of mathematical programming models will be provided.

Linear and Non-linear System Analysis (3 Units)
Numerical linear Algebra: Direct and Iterative Methods; Generalized Elgenproblem.' Linear, multiple and quasi linear regression analysis.' Analysis of variance/covariance and design of orthogonal experiments. Unification of real differential systems, real difference systems and modular sequential systems. Application to critical path methods (CPM), PERT, network Analysis, production/inventory nmodels and decision analysis. Introductory cybernetics and systems simulations. Digital filters, transfer functions, realizability, canonical forms, stability and minimal realizations.; properties of, and stability in, nonlinear network and systems.

System Identification, Optimization and Control (3 Units)
Numerical techniques for estimation/identification in static and dynamic models.; empirical dynamic models for linear sampled data systems with stochastic inputs. The Kalman Filter, its extensions and stochastic approximations. Classical and modal optimization methods. Mathematical programming search techniques: Linear, nonlinear

and Dynamic models. Optimal control for discrete and continuous time systems with equality and inequality constraints.

Modeling and Simulation (3 Units)
A study of the construction of models, which simulate real systems. The methodology of solution should include probability and distribution theory, statistical estimation and inference, the use of random varieties and validation procedures. A simulation language should be used for the solution of typical problems.

Knowledge-Based Systems & Artificial Intelligence (3 Units)
Basic concepts: Artificial intelligence; Intelligent machines and expert systems; symbolic representation of knowledge; symbolic processing with Prolog; Data dependency as an alternative paradigm to imperative programming; Rule-based problem solver and knowledge representation techniques implemented in Prolog; Examples based on use of grammars, production rule driven system and semantic nets, Machine intelligence.; Neural nets as an alternative to rule-based systems; The single-layer perceptron and the back-propagation algorithm; Heuristic Search and Inference; Forward and Backward chaining; Data Driven Reasoning; Goal-Driven Reasoning; Heuristic Search: Domain-specific search; Min-max methods and strategies: pruning.

Expert Systems with Applications to Engineering Problems (3 Units)
Application of expert Systems to engineering problems using Prolog as the programming language. Engineering problems considered will be process control, systems and control. Applications will include electric utility systems, distillation columns and other process control problems.

Introduction to Neural Networks & Application (3 Units)
Introduction to artificial neural network architectures, adaline, madaline, back propagation, BAM, and Hopfield memory, counter-propagation networks, self organizing maps, adaptive resonance theory, are the topics covered. Students experiment with the use of artificial neural networks in engineering through semester projects.

Robotic Applications II (3 Units)
History, development of the work environment for robots, their application and implementation. Concepts of control and sensory feedback in robots are covered.

Expert Systems in Manufacturing & Engineering (3 Units)
Intelligent engineering system design using knowledge bases problem solving symbolic models, knowledge representation, inferencing are the topics covered. Students develop these skills through semester projects based on a specific engineering application using an expert system shell of their choice.

Knowledge Based Systems and Web Agents (3 Units)
Introduction to knowledge based systems as a technique for problem solving in systems engineering. Knowledge representation, knowledge acquisition, search, logic and reasoning about uncertainty, analyses of the use of knowledge based systems for

engineering design problems. Emphasis on the interface between operations research and artificial intelligence techniques for problem solving.

Data Base Systems (3 Units)
Fundamental concepts of database including a history of development, definition of terms, functional requirements of complex data structures, data base administrator functions, privacy-confidentiality issues, and future directions. Case studies are coordinated with a detailed examination of several commercially available systems.

Computer Communications and Networks (3 Units)
Network architecture model including physical protocols for data transmission and error detection/correction, data link concepts, LAN protocols, internetworking, reliable end-to-end service, security, and application services. Students will implement course concepts on an actual computer network.

Fault-Tolerant Digital Systems (3 Units)
Design and analysis of fault-tolerant digital systems. Fault models, hardware redundancy, information redundancy, evaluation techniques, system design procedures.

Computer Communication Networks and Distributed Processing (3 Units)
A study of networks of interacting computers. The problems, rationales and possible solutions for both distributed processing and distributed databases are to be examined. Major national and international protocols including SNA, X..21 and X.25 are to be presented. Network Topologies.

Database Management System Design (3 Units)
Database concepts: data independence; relationships, logical and physical organizations schema and subschema. Data models; hierarchical, network and relational. Data normalization. Data description languages. Query facilities. File organization. Index organization. File security. Data integrity and reliability.

Hazardous Material Management I (2 Units)
All aspects from generation to final disposal will be studies, including: identifying hazardous materials, chemical safety, storing and shipping chemicals, and treatment and disposal of hazardous wastes.

Advanced Industrial management I (3 Units)
Contemporary management philosophies and their impact on engineers and engineering managers. Topic include: total quality management, re-engineering, advanced quality initiatives, leadership and strategic planning.

Occupational Safety Engineering II (3 Units)
An overview of factors affecting safety in organizations, emphasizing analysis techniques and design strategies. Topics include occupational safety. Accidents, fire protection, industrial hygiene, hazardous waste, toxicology, radiation safety, product liability and

federal standards. A project involving a hazard analysis and the design of a solution for a field location is required.

Systems Methodology (3 Units)
This course introduces students to the basic processes for system design and engineering and examines the management of systems engineering projects. We first discuss the systems viewpoint and the systems engineering process. Next we examine issues relating to requirements specification and problem formulation. We highlight different methods for systems modeling and forecasting and for choosing among different system alternatives. The course also provides specific examples of systems engineering taken from the fields of telecommunications, manufacturing, environment/resources systems and transportation.

Management Information Systems (3 Units)
Study of the operational and managerial information needs of an organization. Emphasis is on the information needed throughout an organization and on information systems to meet those needs.

Management and Methods in Reliability (3 Units)
Study of basic concepts in reliability as they apply to the efficient operation of industrial systems.

Safety Engineering Management (3 Units)
Principles of safety engineering applied to industrial situations; job safety analysis and specifications of solutions; reduction of accident rates, frequency and costs; protective equipment, jugs, fixtures and standards; rules regulations and law.

Utility System Reliability (3 Units)
Reliability definition and measures. Probability concepts and Markov chains. Failure models and availability models. Utility system reliability. Loss of load probability method. Evaluation of transmission network reliability. Analysis of the electric power, water and telephone system reliability.

Theory of Reliability of Engineering Systems (3 Units)
Reliability Models; failure distributions, reliabilities, physical models, reliability design. Analysis of failure data; empirical methods, reliability testing, identifying distributions. Applications; examples of analysis of failure/repair data from the manufacturing , industrial and service sectors.

Knowledge Based Systems and Web Agents (3 Units)
Introduction to knowledge based systems as a technique for problem solving in systems engineering, knowledge representation, knowledge acquisition, search, logic and reasoning about uncertainty, analyses of the use of knowledge based systems for engineering design problems. Emphasis on the interface between operations research and artificial intelligence techniques for problem solving.

Environmental Impact Assessment (2 Units)
Introduction to environmental process, and technical, policy and legal implications. Emphasis will be placed on identification and evaluation of impacts, and attaining a sustainable future.

Crisis Management in Engineering Systems (3 Units)
Definition of Crisis (architecture and scale): 4-D Modeling of Crisis, Impact of Crisis on System; 1st and 2nd Order Effects; System Tools/features and role in crisis management; Monitoring and Surveillance, Forecast and Prediction Models; Contingency Plan; Disaster Mitigation and Relief Measures; Communication Networks; Decision Support Tools; Disaster Recovery Plans etc;

Uses of Case Studies: Analysis of recent cases of Oils Spills, Gas Pipeline Vandalism/Explosion, Dam Failure, Armoury Explosion etc.

Advanced Engineering Management Science
Solving of managerial problems utilizing management science techniques Problems are analysed, modeled and solved using such techniques as linear, goal, dynamic, programming, simulation, statistical analysis or other non-linear methods. Solutions will involve the use of personal or mainframe computers. A study of the current literature in management science will also be conducted.

M.Sc. Project (6 Units)
The student will be expected to carry out a significant piece of work either closely related to the requirements of the public or organized private sectors or at the leading edge of research.

M.Phil/Ph.D. COURSES

Seminar In Systems Engineering (3 Units)
The student will be expected to attend the weekly departmental seminar and participate actively, The student will be expected to Present a Seminar in any area of Systems Engineering that may relate to his/her research area.

Methods of Applied Mathematics III (3 Units)
Application of advanced mathematical techniques to engineering problems. Conformal mapping; complex integral calculus; Green's function; integral transforms; asymptotics, including steepest descent and stationary phase; Wiener-Hopf technique; general theory of characteristics; perturbation methods; singular perturbations including PLK method and boundary layers Problems drawn from vibrations and acoustics, fluid mechanics and elasticity, heat transfer and electromagnetics.

Methods of Applied Mathematics IV (3 Units)
More extensive treatment for Part III of series. Topics include: method of matched asymptotic expansions; WKB approximation; Hibert-Schmidt and Fredholm theories of

integral equations; singular integral equations; Wiener-hopf equations with application to finite interval; Carleman equation and its generalization, effective approximations; further methods in partial differential equations: slot problems.

Theory of Plasticity (3 Units)

Theory of inelastic behavior of materials. Plastic stress-strain laws, yield criteria, and flow laws. Flexure and torsion of bars; thick-walled cylinders; metal forming and extrusion; stress analysis in metals and soil Limit analysis of beams, plates, and shells, Shake-down. Selected topics in dynamic plasticity.

Special Topics in Engineering Analysis (3 Units)

Selected topics in modeling and simulation will be discussed in as much detail as possible.

Numerical Methods for Closed Systems I (2 Units)

- Introduction; Conservation laws and different formulations and representations
- Navier Stokes Equation
- Closed Systems; Stability Patterns and Waves

Numerical Methods for Closed Systems II (3 Units)

Numerical approximation of Conservation Systems

- Finite Difference
- Finite Element
- Finite Volume
- Conservation Element/Solution Element (CE/SE) Method problems drawn from vibrations and acoustics, fluid mechanics and elasticity, transport processes and electromagnetics

Special Topics in Artificial Intelligence in Engineering (3 Units)

Selected topics in artificial intelligence will be discusses in as much detail as possible.

Applied Fuzzy Set Theory I (3 Units)

The emphasis will be on application aspects. Topics covered are elementary fuzzy set theory, fuzzy measure, possibility theory, fuzzy linear programming and other fuzzy optimization techniques, fuzzy linguistics and expert systems, fuzzy production and inventory control, and fuzzy operations research models.

Design and Analysis of Robust System Controls (3 Units)

General nature of engineering control systems. Time and frequency domain treatment of control systems design. State Space representation of univariate and linear multivariate systems. The concept of state estimation, measurability, observability, controllability, sensitivity, and stability in Liapunov's sense. Optimal control systems design, objective functions and use of quadratic performance index. Performance and robustness of multivariate feedback system design; based on Nyquist like techniques, linear quadratic gain (LQG) method, etc. Tracking system design, using output feedback . Observers and tracker synthesis using entire eigenstructure assignment.

Advanced Manufacturing Through Neural Networks (3 Units)
Intelligent system architectures, advanced neural networks paradigms; ARTMAP, CMAC, fuzzy logic, associative hierarchical networks, radial bais function, adaptive heuristic critic for solving product design, process planning and control, scheduling, feature identification and assembly problems in building autonomous manufacturing systems.

Special Topics in Information Technology (3 Units)
Selected topics in information technology (II) will be discussed in as much detail as possible.

Special Topics in Engineering Systems Management (3 Units)
Selected topics in engineering Systems Management will be discussed in as much detail as possible.

Research Seminar I (3 Units)
The course is designed for M. Phil candidates who will be required to make two seminar presentations. Emphasis here will be placed on literature review as well as the derivation and/or development of relevant mathematical models and procedures. A written report as well as an oral presentation are essential aspects of the course.

Research Seminar II for PhD Students (3 Units)
This course is designed as a sequel to Research Seminar I. In addition to the requirement and procedure of SSG 951 emphasis here shifts to originality of research work and the contribution to knowledge resulting from the research.

Research Seminar III (3 Units)
Course content and format designed as a terminal presentation of research findings for Ph.D candidates.