

**UNIVERSITY OF NIGERIA, NSUKKA  
FACULTY OF ENGINEERING**

**DEPARTMENT OF  
AGRICULTURAL AND BIORESOURCES  
ENGINEERING**

**M.Eng & Ph.D DEGREE PROGRAMMES**

**REVISED 2015**

## **1. Philosophy of the Programmes**

The world's population is expected to grow from about 7 billion today to at least 8 billion by the year 2025. Most of this growth will take place in the developing world including Africa. It is therefore clear that expanding agricultural and Bioresources production in a sustainable manner will be crucial in responding to these trends. Complex problems ranging from the development of sustainable systems for the production of food, fiber and renewable energy, to the scale-up of products of new discoveries in biology and biotechnology will require engineering solutions. These solutions must be developed in the context of globalization and the prevailing role of Information and Communications Technology (ICT), while at the same time ensuring local relevance and the protection of the environment. The programmes are, therefore, aimed at producing 21<sup>st</sup> century engineers that are well equipped to tackle these challenges in the context of the philosophy, "think globally, act locally".

The aim of the M.Eng and Ph.D programmes is to train productive and technological human resources to execute the production phase of agriculture; the production of field and research equipment and systems suitable for local applications; the conduct of pure and applied research required for accelerating the growth of the agricultural and bioresources sector; and to participate in the training of agricultural/bioengineers for other universities, colleges of technology and schools of agriculture.

## **2. Objectives**

The specific objectives of the programmes are, through the requisite training of needed engineers:

- (i) To increase and sustain agricultural and bioresources production;
- (ii) To manage the natural resources such that a high level of production can be sustainably achieved without damage to the environment;
- (iii) To maintain or change the natural characteristics of food and biomaterials for desired purposes;
- (iv) To remove or reduce the physical drudgery in production operations;
- (v) To provide desirable amenities for communities of producers, usually rural; and,
- (vi) To increase efficiency and precision of production through automation and ICT applications.

## **3. Scope of the Programmes**

The M.Eng and Ph.D degree programmes of the Department of Agricultural and Bioresources Engineering are guided by the awareness that the achievement of self-reliance in national agricultural and rural development depends largely on the effective development of the indigenous technological human resources. The postgraduate programmes of the Department are, therefore, a conscious attempt to discharge its educational and professional responsibility to the nation in its efforts to develop the agricultural and bioresources sector. The programmes are to fulfill this role by

furthering the effective application of appropriate engineering principles and technology.

The postgraduate courses cover all specialization areas of Agricultural and Bioresources Engineering, namely: power systems, machinery and mechatronic engineering; soil and water resources engineering; food and bioprocess engineering; structures and environmental control engineering; biomass and renewable energy engineering; aquacultural engineering; forest engineering; and ecological engineering.

The study for the M.Eng degree in Agricultural and Bioresources Engineering is done by course work with research work to be presented in a project report. The study for the Ph.D degree is by a combination of course work and comprehensive research to be embodied in a thesis. The M.Eng and Ph.D students may specialize in any of the areas listed above.

#### **4. Entry Requirements**

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

Applicants must possess B.Sc or B.Eng degree with at least second class honours of minimum GPA of 2.5 on a 5-point scale, or an equivalent qualification, in Agricultural and Bioresources Engineering or a related field of Engineering to qualify for admission into the M.Eng programme.

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

Candidates must possess M.Sc or M.Eng degree with a GPA not less than 3.5 on a 5-point scale from the University of Nigeria, Nsukka. Applicants who already possess a masters degree at the same level of pass from recognized institutions may be considered for entry to the Ph.D programme.

#### **5. Mode of Study**

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

The M.Eng programme is by course work to be examined in written papers together with research work to be presented in a project report, where course work predominates over research and constitutes not less than two thirds of the total credit hours. Students are required to take prescribed compulsory and core courses in their chosen area of specialization.

The minimum credit load for the Master of Engineering degree programme in Agricultural and Bioresources Engineering Department is 39 units which must consist of 3 units of one faculty course, 3 units of two seminar presentations, 6 units of M.Eng thesis plus the core courses in the candidate's chosen area of specialization. Pass mark for a postgraduate course is 50%

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

The Ph.D degree programme is usually prosecuted by a combination of course work and comprehensive research to be embodied in a thesis. PhD candidates are expected to take a minimum credit load of 30 units comprising 3 units of a faculty course, 6 units of two seminar presentations, 12 units of PhD thesis and 12 units of Departmental course work.

Candidates are required to pass all prescribed course work in the first year of their study with a sum average of 60% before proceeding to the research component of their study after a general and comprehensive examination by their PhD Guidance Committees and a successful seminar presentation on the proposed research work by the candidates. A candidate who meets the average score of 60% but fails to score at least 50% in one or more courses may proceed to the research component of the programme but will be required to retake the failed courses. Where a candidate fails to meet the average score of 60%, he/she will be required to repeat the entire course work in the second year of the programme, and failure to meet this requirement for the second time, the candidate will be advised to withdraw from the programme by the Departmental PG Committee.

## **6. Duration**

### **M.Eng programme**

Full Time: A minimum of 4 semesters

Part Time: A minimum of 6 semesters

### **Ph.D programme**

Full Time: A minimum of 6 semesters

Part Time: A minimum of 8 semesters

## **7. Areas of Specialization**

The Department of Agricultural and Bioresources Engineering offersthe following eight areas of specialization for the Master of Engineering (M.Eng) and Doctor of Philosophy (Ph.D) degrees:

- (i) Power Systems, Machinery and Mechatronic Engineering
- (ii) Soil and Water Resources Engineering
- (iii) Food and Bioprocess Engineering
- (iv) Structures and Environmental Control Engineering
- (v) Biomass and Renewable Energy Engineering
- (vi) Aquacultural Engineering
- (vii) Forest Engineering
- (viii) Ecological Engineering

## 8. Stress Areas

General	0
Power Systems, Machinery and Mechatronic Engineering	1
Soil and Water Resources Engineering	2
Food and Bioprocess Engineering	3
Structures and Environmental Control Engineering	4
Biomass and Renewable Energy Engineering	5
Aquacultural Engineering	6
Forest Engineering	7
Ecological Engineering	8
Project/Thesis	9

## 9. List of Approved Supervisors and Areas of Research Interest

### Professors (Available for Masters and PhD Degrees supervision)

- a. C.C. Mbajiorgu, B.Sc.(Ife), M.Eng.(ABU), Ph.D(TUNS, Canada)  
Research Areas: Soil and Water Resources Engineering; Ecological Engineering; Aquacultural Engineering
- b. W.I. Okonkwo, B.Eng.(Makurdi), M.Eng.(Nig.), Ph.D(Nig.)  
Research Areas: Food and Bioprocess Engineering; Structures and Environmental Control Engineering; Biomass and Renewable Energy Engineering

### Senior Lecturers (Available for Masters and PhD Degrees supervision)

- c. B.O. Ugwuishiwu, B.Sc.(Nig.), M.Eng.(Nig.), Ph.D(Nig.)  
Research Areas: Structures and Environmental Control Engineering; Biomass and Renewable Energy Engineering

### Senior Lecturers (Available for Masters Degree supervision)

- d. E.A. Echiegu, B.Sc.(Ife), M.Eng.(Nig.), Ph.D(TUNS, Canada)  
Research Areas: Structures and Environmental Control Engineering; Biomass and Renewable Energy Engineering; Ecological Engineering
- e. A.O. Ani, B.Sc.(Ilorin), M.Eng.(Nig.), Ph.D(Harbin, China)  
Research Areas: Power Systems, Machinery and Mechatronic Engineering; Food and Bioprocess Engineering; Forest Engineering
- f. C.N. Anyanwu, M.Sc.(Sofia, Bulgaria), Ph.D(Nig.)  
Research Areas: Food and Bioprocess Engineering; Biomass and Renewable Energy Engineering
- g. S.L. Ezeoha, B.Sc.(Nig.), M.Eng.(Nig.), Ph.D(Nig.)  
Research Area: Food and Bioprocess Engineering
- h. C.C. Anyadike, B.Eng.(Makurdi), M.Eng.(Nig.), Ph.D(Nig.)  
Research Areas: Aquacultural Engineering; Soil and Water Resources Engineering
- i. J.N. Nwakaire, B.Sc.(Nig.), M.Eng.(Nig.), Ph.D(Nig.)  
Research Areas: Power Systems, Machinery and Mechatronic Engineering; Biomass and Renewable Energy Engineering

## 10. Course Outline

### First Semester - M.Eng Programme

#### **(A) COMPULSORY/GENERAL COURSES**

<u>Course No</u>	<u>Title</u>	<u>Units</u>
PGC 601	Analytical Tools and ICT for Research in Engineering	3
ABE 601	Special Problems in Agric. and Bio Engineering	3
CSC 611	Design of Experiments	3

#### **(B) CORE COURSES BY AREA OF SPECIALIZATION**

##### **1. Power Systems, Machinery and Mechatronic Engineering**

ABE 611	Tractors and other Farm Power Systems	3
ABE 613	Planting and Fertilizer Application Machinery	3
ABE 615	Mechatronics and Robotics Technology Applications	3

##### **2. Soil and Water Resources Engineering**

ABE 621	Irrigation Systems Development and Evaluation	3
ABE 623	Land Drainage Engineering	3
ABE 625	Applied Hydrology	3

##### **3. Food and Bioprocess Engineering**

ABE 631	Agricultural Processing Unit Operations	3
ABE 633	Industrial Food Processing and Storage	3
ABE 635	Agricultural Materials Handling Systems	3

##### **4. Structures and Environmental Control Engineering**

ABE 641	Farm Estate Planning and Design	3
ABE 643	Structural Analysis and Design of Farm Buildings	3
ABE 645	Agricultural Waste Treatment and System Design	3

##### **5. Biomass and Renewable Energy Engineering**

ABE 651	Biomass Processing Engineering	3
ABE 653	Solar Thermal Engineering	3
ABE 655	Wind, Geothermal and Small Hydro-power Engineering	3

##### **6. Aquacultural Engineering**

ABE 661	Aquacultural Systems	3
ABE 663	Aquacultural Environmental Requirements	3
ABE 665	Design of Aquacultural Systems	3

##### **7. Forest Engineering**

ABE	671	Forest Stand Establishment and Maintenance	3
ABE	673	Forest Power and Machinery Design	3
ABE	675	Tree Felling and Log Processing	3

### **8. Ecological Engineering**

ABE	681	Catchment Hydrology and Management	3
ABE	683	Wetlands and Environmental Water Quality Management	3
ABE	685	Ecosystems Climate Change Impacts and Adaptation Mechanisms	3

### **(C) ELECTIVE COURSES**

ABE	605	Applications of Finite Elements Method in Agric. & Bio Engineering	3
ABE	607	Applied Expert Systems	3
ABE	609	Simulation Modeling and Optimization Techniques	3
ABE	617	Agricultural Mechanization Strategies and Systems	2
ABE	619	Tillage Mechanics and Machinery	3
ABE	627	Sediment Transport Hydraulics and Earthen Channel Design	3
ABE	647	Rural Infrastructure Engineering	3

## **Second Semester – M.Eng Programme**

### **(A) COMPULSORY/GENERAL COURSES**

<u>Course No</u>	<u>Title</u>	<u>Units</u>
ABE 602	Agric. and Bio Engineering Seminars	3
ABE 604	Directed Studies	3

### **(A) CORE COURSES BY AREA OF SPECIALIZATION**

#### **1. Power Systems, Machinery and Mechatronic Engineering**

ABE	612	Crop Protection Machinery	3
ABE	614	Harvesting Machinery	3
ABE	616	Mechatronics Design	3
ABE	690	M.Eng Project Report	6

#### **2. Soil and Water Resources Engineering**

ABE	622	Soil Erosion Prediction and Control Technology	3
ABE	624	Irrigation Water Quality and Management	3
ABE	626	Water Resources Development for Agric. Purposes	3
ABE	690	M.Eng Project Report	6

#### **3. Food and Bioprocess Engineering**

ABE	632	Crop Drying Systems	3
ABE	634	Analysis and Selection of Cleaning and Sorting Equipment	3
ABE	636	Theory and Techniques of Farm Products Storage	3

ABE	690	M.Eng Project Report	6
<b>4. Structures and Environmental Control Engineering</b>			
ABE	642	Environmental Control in Farm Building and Structures	3
ABE	644	Farm Structures Management	3
ABE	646	Agricultural Waste Utilization	3
ABE	690	M.Eng Project Report	6
<b>5. Biomass and Renewable Energy Engineering</b>			
ABE	652	Solar Photovoltaic Engineering	3
ABE	654	Biofuels and Bioenergy Engineering	3
ABE	656	Renewable Energy Policy and Management	3
ABE	690	M.Eng Project Report	6
<b>6. Aquacultural Engineering</b>			
ABE	662	Materials for Aquacultural Facilities	3
ABE	664	Aquacultural Equipment and Controls	3
ABE	666	Aquacultural Waste Management Systems	3
ABE	690	M.Eng Project Report	6
<b>7. Forest Engineering</b>			
ABE	672	Timber Transportation	3
ABE	674	Special Logging Techniques	3
ABE	676	Operational, Security and Safety Issues in Forest Engineering	3
ABE	690	M.Eng Project Report	6
<b>8. Ecological Engineering</b>			
ABE	682	Ecosystem Analysis and Assessment	3
ABE	684	Non-point Source Pollution Assessment and Control	3
ABE	686	Restoration and Bioremediation Engineering	3
ABE	690	M.Eng Project Report	6
<b>(C) ELECTIVE COURSES</b>			
ABE	606	Metrology in Engineering Properties of Bio-materials	3
ABE	618	Earthmoving Mechanics and Machinery	3
ABE	628	Ground Water Hydrology and Development	3
ABE	638	Design of Storage Structures	3
ABE	648	Solar Energy Utilization in Agriculture	3
ABE	658	Integration of Renewable Energy into Energy Grid System	3
ABE	688	Advanced Waste Disposal and Pollution Management Systems	3

**First Semester - Ph.D Programme**



**(A) GENERAL/COMPULSORY COURSES**

PGC	701	Synopsis and Research Grant Writing in Engineering	3
ABE	701	Special Problems in Agric. and Bio Engineering	3
ABE	703	Instrumentation and Measurements in Agric. and Bio Engineering Research	3
ABE	705	Agric. and Bioresources Engineering Seminar I	3

**(B) ELECTIVE COURSES**

ABE	605	Applications of Finite Elements Method in Agric. Engineering	3
ABE	607	Applied Expert Systems	3
ABE	609	Simulation Modeling and Optimization Techniques	3
ABE	617	Agric. Mechanization Strategies and Systems	3
ABE	619	Tillage Mechanics and Machinery	3
ABE	627	Sediment Transport Hydraulics and Earthen Channel Design	3
ABE	647	Rural Infrastructure Engineering	3
CSC	611	Design of Experiments	3

**Second Semester – Ph.D Programme****(A) COMPULSORY COURSES**

ABE	702	Agric. and Bio Engineering Seminar II	3
ABE	704	Directed Studies	3
ABE	790	Ph.D Thesis	12

**(B) ELECTIVE COURSES**

ABE	604	Metrology in Engineering Properties of Bio-materials	3
ABE	618	Earthmoving Mechanics and Machinery	3
ABE	628	Ground Water Hydrology and Development	3
ABE	638	Design of Storage Structures	3
ABE	648	Solar Energy Utilization in Agriculture	3
ABE	658	Integration of Renewable Energy into Energy Grid System	3
ABE	688	Advanced Waste Disposal and Pollution Management Systems	3

**11. Courses Description****11.1 M.Eng Courses Description****PGC 601: Analytical Tools and ICT for Research in Engineering**

Use of advanced analytical tools like MATLAB/SIMULINK, SCILAB/XCOS, etc for solution of engineering problems and their applications (Application of these softwares depends on the various problems formulated in different departments). Information literacy, information sources (media, publishers, and aggregators); validity of information, plagiarism and legal aspects. Information search – search engines, journal repositories,

academic (social) networks, search strategies, personal contacts, tools for managing references. Integrating information literacy in research; cloud computing, audiovisual tools, e.g. powerpoint presentations. Literature review; reading and summarizing relevant articles, critical analysis and evaluation of research, identification of themes and comparators, writing review documents and identification of research (or knowledge) gaps. Scientific method and nature of evidence: Experimental methods and design methods (as may be applicable in individual departments and research areas), data collection and management of quantitative data. Human participants – expert reviews, focus groups, questionnaires and interviews. Project management and report writing; project planning, report structure and style, general report writing techniques.

(3 Units)

#### **ABE 601: Special Problems in Agric. & Bio Engineering**

Analysis of a specified engineering problem, specific to a student and in his/her area of specialization, and submitted in a written report as term paper.

(3 Units)

#### **ABE 602: Agric. and Bio Engineering Seminars**

Student is required to present a minimum of two seminars in the course of the programme. The first at the proposal stage of research work based on the special problems course (ABE 601), and the second at the completion stage of the project report (ABE 690). The two seminars are to be assessed 50%-50% for the course grade.

(3 Units)

#### **ABE 604: Directed Studies**

This is a course to be written outside the candidate's chosen area of specialization to be submitted in the form of a term paper.

(3 Unit)

#### **ABE 605: Applications of Finite Elements Method in Agric. & Bio Engineering**

Matrix algebra and its application in the implementation of the finite element method (FEM). Development of a finite element model governing equations, problems idealization, constitutive relationships, boundary conditions, geometric and material non-linearities, computer implementation. Specific agricultural engineering problems will be solved using existing FEM. These include problems in tillage, soil compaction, design of frames of agricultural machines, stress analysis of soils and other storage structures, stress distribution in bio-material under load.

(3 Units)

#### **ABE 606: Metrology in Engineering Properties of Bio-materials**

Techniques for the measurement, evaluation and analysis of the physical characteristics, mechanical, rheological, thermal, electrical and optical properties of bio-materials in relation to handling, storage, processing and quality control of agricultural and food materials, Force-deformation tests and analysis, Hertz theory and Boussine theory; bulk compression test, parallel shear tests, stress relaxation tests, creep apparatus; triaxial tests, rheological models, viscometry, (Stormer viscometer, MacMichael Viscometer, etc.); angle internal friction/angle of repose measurements; strength and flow ability of

unconsolidated materials; measurements of suspension/terminal velocity; techniques for measuring volume, density, porosity, specific surface, and permeability of granular materials. Thermal conductivity apparatus for agricultural/food materials. Measures of mechanical parameters of food texture. Measurement and analysis of particle size distribution. (3 Units)

#### **ABE 607: Applied Expert Systems**

Introduction to expert systems and artificial intelligence. Heuristic search, production systems, structural objects and predicate logic. Tools for building expert systems. Induction, knowledge acquisition and representation. Plausible reasoning. Explaining expert system behaviour. Specific expert system case studies. Applications evaluation. VP-Expert as a case study of an expert system shell. Practical exercise in the construction of an expert system using VP-Expert. (3 Units)

#### **ABE 609: Simulation Modeling and Optimization Techniques**

The nature of simulation; systems, models and simulation; discrete-event simulation; continuous simulation; combined discrete continuous simulation; Monte Carlo simulation; modeling complex systems; simulation languages and their comparison with general purpose languages; simulation outputs data analysis for a single system; calibration and validation of simulation models; variance reduction techniques; optimization techniques – genetic algorithm (GA), particle swarm optimization (PSO), Rosenbrock's technique (RNB), Shuffled complex evolution–University of Arizona (SCE-UA), Simplex Search (SIM), and simulated annealing (SA). (3 Units)

#### **ABE 611: Tractors and Other Farm Power Systems**

Practical tests on the various types of tractors and internal combustion engines. Gasoline and diesel tractors. Tractor hydraulics and hydraulic equipment. Tractor stability. Power measurement methods. Power efficiency in farm tractors. Tractor breakdown, maintenance and management. Electric power. Other farm power sources. (3 Units)

#### **ABE 612: Crop Protection Machinery**

Research and development in crop protection methods and equipment. 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 (mechanical weeders and cultivators). (3 Units)

#### **ABE 613: Tillage Mechanics and Machinery**

Conventional, minimum and optimum tillage concepts. Research and development in tillage mechanics and machinery. Advanced mechanics of soil-machine interactions. Force analysis and design considerations of mouldboard, disc and rotary tillers. Field testing and evaluation of tillage machinery. (3 Units)

#### **ABE 614: Harvesting Machinery**

Research and development in harvesting machinery. Methods of mechanical harvesting. Force analysis and design consideration of grain combines, com pickers, cotton pickers, forage harvesters. Balers and binders, root harvesters. Testing of harvesting machinery.

(3 Units)

#### **ABE 615: Mechatronics and Robotic Technology Applications**

Automation and control; Position and navigation; Autonomous vehicles; Basic structure of robotics; Classification and structure of robotic systems; Drives and control systems; Co-ordinate transformation and kinematic analysis; Trajectory planning and control; Programming; Intelligent robotic systems; Robotic applications and installations; Brief history of robotics, definitions and standard configurations; Design of robot manipulators including controller architectures: Kinematics and dynamics of manipulators arms, Trajectory control, on-line and off-line programming methods, modeling and simulation, Sensor controlled robots - vision systems, tactile and force sensing, Application of robots in agriculture and other fields, Task planning, work-cell integration and communication, safety and legislation issues, Introduction to the design and configuration of mobile robots, controller architectures and applications, Kinematics and trajectory control of mobile robots, including modeling and simulation, Sensor control of mobile robots for localization, navigation and obstacle avoidance.

(3 Units)

#### **ABE 616: Mechatronics Design**

Introduction to the philosophy and methodology of mechatronics, including the design and manufacture of mechatronic products; Review of mechatronic machine systems, control, programming and computational requirements; Embedded processor design and interfacing, including ADC, DAC, serial/parallel communication protocols; PIC programming using assembler and C; Real-time computational requirements including effects of quantization and aliasing, discrete position and velocity control algorithms; Application and selection of sensors, review of signal conditioning techniques and analogue/digital electronics; Motion control systems and control architectures. Multi-axis control systems, i.e .electronic gearbox; Design and development of a fully functional mechatronic system; Case studies of intelligent systems such as automated handling; CNC machine tools and CMMs; agricultural and consumer mechatronic products.

(3 Units)

#### **ABE 617: Agricultural Mechanization Strategies and Systems**

Development of strategies for integrated agricultural mechanization concepts and principles. Selection and utilization of agricultural equipment for various types of farms. Methods of optimization of tractor-implement combination. Selection and classification of irrigable land. The economics of erosion control. Strategies for food processing and industrial raw materials handling systems. Economics of farm transportation. (3 Units)

#### **ABE 618: Earthmoving Mechanics and Machinery**

Methods of clearing the various types of lands. Evaluation of the different types of earth-moving equipments theory, design, capacities, efficiencies and power

requirements. Cost analysis and selection of land clearing and earth-moving equipment. Earth-moving mechanics. (3 Units)

**ABE 619: Planting and Fertilizer Application Machinery**

Research and development in planting and fertilizing equipment. Theory and design of feed, mechanisms for different types of solid and liquid fertilizers, manure spreaders, seeds and tubers. Testing of planting and fertilizing equipment. (3 Units)

**ABE 621: Irrigation Systems Development and Evaluation**

Total and supplemental irrigation in Nigeria. Selection and classification of irrigable lands. Irrigation water requirements of principal crops. Irrigation system evaluation and improvement 0 sprinkler, furrow, border strip. Advance recession and soil intake functions. Hydraulics sprinkler systems. Economic, social and environmental implications of irrigation system development. (3 Units)

**ABE 622: Soil Erosion Prediction and Control Technology**

Rainfall excess calculations. Runoff coefficients for overland flow, rills, and interrill areas. Overland flow routing. Soil properties affecting erosion. Random roughness, ridge height, bulk density and soil water content. Soil detachment by raindrops and concentrated flow. Governing equations for sediment continuity, detachment, deposition, shear stress in rills, and transport capacity. Generalized models of interrill and nil erosion. Interrill erodibility, nil erodibility and critical shear of cropland soils. Temporal modification of erodibility parameters as influenced by above and below ground residue, plant canopy, tillage and soil consolidation. Downslope spatial variability. WEPP model application in soil conservation planning and design of conservation systems. (3 Units)

**ABE 623: Land Drainage Engineering**

Introduction to groundwater hydraulics and water in the soil moisture. Dynamics of water in the soil, saturated Rows, continuity equation, boundary conditions, and solution techniques. Steady and non- steady state drainage problems. Stratification and anisotropy. Permeability and hydraulic conductivity. Rainfall-runoff relations for surface drainage. Salinity problems in soil water. Drainage criteria in relation to soils and crops. Design and maintenance of field systems for subsurface and surface drainage, for salinity control, and erosion control. Design and maintenance of drainage systems. Drainage materials. Procedures in drainage projects. Application of computer models in land drainage, reclamation and improvement. (3 Units)

**ABE 624: Irrigation Water Quality and Management**

Quality of surface waters; ground water quality; quality of impounded waters. Soil and water classifications and crop tolerance. Management of saline and alkali soils in irrigated areas, and water quality requirements for their reclamation. (3 Units)

**ABE 625: Applied Hydrology**

Introduction to agro-meteorology. Temperature, pressure, wind, sunshine, radiation and humidity. Clouds, condensation and precipitation. Rain interception. Evaporation and transpiration. Infiltration and subsurface flow processes, saturated and unsaturated. Surface runoff, runoff hydrography, and flow fouling. Statistical and frequency analysis of hydrologic data. Hydrologic design. Reservoir design, sedimentation and useful life. Hydrologic models and modeling of agricultural watersheds.

(3 Units)

**ABE 626: Water Resources Development for Agricultural Purposes**

Principles of irrigation water measurement. Water impounding reservoirs design criteria, spill way capacity, siting and management. Water diversion, conveyance and distribution systems. Energy dissipators. Trends in water resources development in Nigeria. (3 Units)

**ABE 627: Sediment Transport Hydraulics and Earthen Channel Design**

Introduction to fluvial hydraulics. Origin and properties of sediments, Threshold of particle transport. Sediment movement, bed load, suspended load and total load transport. Roughness of channel, vegetated and cultivated land surfaces Velocity distribution in alluvial channels Stable channel design, empirical and tractive force methods. Comparison of regime and tractive force methods. Ripples, dunes and anti-dunes. Watercourse geometry. Scour below hydraulic structures. (3 Units)

**ABE 628: Ground Water Hydrology and Development**

Ground water occurrence and movement. Well hydraulics. Well development drilling techniques, screens. Well tests. Ground water levels and fluctuations. Ground water quality. Surface and sub surface investigations. Artificial recharge. Basin-wide ground water development. (3 Units)

**ABE 631: Agricultural Processing Unit Operations**

Unit operations as links in the chain of all agricultural engineering processing systems. Scientific foundations of major unit operations in agricultural engineering processing systems. Fluid statics and its applications; fluid flow phenomena; compressible and incompressible fluids in conduits; Non-Newtonian fluid characteristics, Hydro-transport and metering of fluids. Agitation, mixing and blending in food processing. Heat and mass transfer applications; Evaporation, concentration extraction and crystallization. Separation operations. Comminuting operations. Handling of particulate solids. Extraction and pelletization. (3 Units)

**ABE 632: Crop Drying Systems**

Introduction: Theoretical foundations; conservation concept, thermodynamics of irreversible processes, driving potentials. Analysis of crop drying systems; deep bed, fixed, through flow and fluidized bed systems. Determination of drying constants for local food crops. Comparative study of air distribution systems and structures. Energy sources for crop drying. Solar energy utilization. Simulation of drying systems. (3 Units)

**ABE 633: Industrial Food Processing and Storage**

Engineering principles of food crop preservation and storage. Thermal processes in food engineering. Food quality evaluation. Consumer acceptance and food prices. Design and development of machines for primary/secondary processing of local crops. Feasibility studies for agro Enterprises development in agribusiness. (3 Units)

**ABE 634: Analysis and Selection of Cleaning and Sorting Equipment**

Developments in cleaning and sorting systems Effects of grain crop characteristics on selection of cleaning equipment. Theory, design, capacity and effici of plain sieves, cylindrical sieves, Magnetic methods and aerodynamic methods used in cleaning and sorting equipment. (3 Units)

**ABE 635: Agricultural Materials Handling Systems**

Design applications of engineering principles involved in handling bio-materials. Factors influencing selection of materials handling equipment. Farm transport. Treatment of specific handling q as links in a total process. Materials handling as a processing activity; economics and cost analysis. Design and development of handling equipment relevant to Nigerian agricultural industry. (3 Units)

**ABE 636: Theory and Techniques of Farm Products Storage**

Mechanisms of deterioration; methods of quantification and analysis. Biochemical and enzymal changes and effects. Storage techniques; Underground pit storage, evaporative cooled storage irradiation techniques. Ambient storage of primary products: Thermodynamics and energy exchanges, time temperature effects and shelf life, optimum storage conditions and management control strategies. Example applications and local crops. Cold storage: Freezing rate effects of frozen product quality, ice crystal formation and ice crystal damage, freezing injury and entopic energy and effects on physiological stability. Cold storage transport. Storage of processed foods: environmental factors and container permeability. Warehousing and materials handling in storage. (3 Units)

**ABE 638: Design of Storage Structures**

Study and evaluation of traditional storage structures, design and construction (barns, cribs, clamps, underground structures). Structural design of modem storage structures (bins, tanks, silos, etc.). Lateral loads L theories of failure in non-fluid masses: granular

materials (yams, cassava, palm-fruits, waters, etc): fibrous materials: Image, hay, etc. Design of container walls for combined loading. Hopper bottom bins; flow properties of bulk materials; theories of flow, criteria of flow, predicting stress distribution in hopper bottom bins. (3 Units)

#### **ABE 641: Farm Estate Planning and Design**

The farm estate and farmstead concepts, farm estate enterprises. The planning of the farm estate; general layout and location of farmstead, infrastructures, services and conveniences (health clinics, schools, markets, postal agency, central workshop and fuel depot, etc). Design of infrastructural facilities, farm estate roads and road network development, farm electrification, water supply, etc. Farmstead planning: layout and location of buildings and facilities (farm house, livestock buildings, storage facilities, workshop, etc). 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.

(3 Units)

#### **ABE 642: Environmental Control in Farm Building and Structures**

The environment; Interaction of the natural, biological and human systems; physiological factors, thermal interchanges, environmental indices, health and comfort. Environmental control for animals, plants and farm produce; types of control; physical, mechanical and chemical; control measures and devices to achieve suitable quality of the environment; functional requirements for housing animals and crops; analysis of factors affecting energy and mass exchanges with the environment; systems approach to environmental control. Psychometrics: application to design problems on comfort, air-conditioning and to problems involving heat and mass transfer. Design procedure for energy balance systems, heat loss studies insulation materials and design, water vapour barrier materials and design.

(3 Units)

#### **ABE 643: Structural Analysis and Design of Farm Buildings**

Light weight frames low profile buildings. Deformation and stress analysis for steel, wood and concrete structures. Deflection under stress. Solution of indeterminate frames. Predicting stress distribution. Analysis of specific structural frames: Two hinged arches, three-hinged arches, rigid frames, combined systems Pole buildings. Depth of embedment for lateral stability and uplift resistance, rigid pillar design load distribution in a multiple bent, Load bearing panels for low profile buildings. Diaphragms and stressed skin panels; design for lateral loading, design for combined loading, fabrication techniques. Sandwich panels: theory of the structural sandwich, predicting stress and deformation, materials and methods of fabrication.

(3 Units)

#### **ABE 644: Farm Structures Management**

Engineering Economy (interest, depreciation, economic comparison of farm buildings); Farm Building Costs (Investment cost/bill of engineering measurements and Annual running costs); economic rate of return and optimum investment in buildings; farm



building project implementation processes, farm building project management (organizational forms); tendering, contracts; project supervision and post construction management.

#### **ABE 645: Agricultural Waste Treatment and System Design**

Sources of Agricultural Wastes. Characteristics of Agricultural waste as related to handling and treatment processes. Environmental impact of Agricultural waste. Agricultural waste collection. Physical, chemical and biological treatment of Agricultural waste: Screening, sedimentation, floatation, disinfection, chemical precipitation, aerobic ponds, ditches and lagoons activated sludge processes, RI3C, trickling filter, aerobic and anaerobic digestion. Solid waste treatment. Composting. Land treatment. Non point source pollution control. Design of waste treatment facilities and systems including computer application. Legal aspects of agricultural waste management. (3 Units)

#### **ABE 646: Agricultural Waste Utilization**

Physical, chemical and biological characteristics of livestock and poultry manure, crop residues and wood Processing wastes. 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: Thermochemical processing: combustion, gasification and pyrolysis. Biological processes: aerobic and anaerobic digestion. Characteristics and utilization biogas and digestion by-products. Land application of agricultural wastes. Industrial uses of crop residues. (3 Units)

#### **ABE 647: Rural Infrastructure Engineering**

The design, construction and maintenance of rural infrastructure; rural road selection, inventorization, design, construction, routine and maintenance; design of rural water supply scheme including spring water, hand pump and motorized borehole and rainwater schemes; rural electrification schemes; procurement processes and supervision of rural infrastructure. (3 Units)

#### **ABE 648: Solar Energy Utilization in Agriculture**

Solar radiation measurement. Computer estimation of available solar radiation. Review of Heat transfer. Flat plate collector design and performance testing. Design of other collectors. Analysis of sensible and latent heat for thermal energy storage. Solar heating systems: Solar crop dryers, green houses, solar stills, solar livestock housing. Solar cooling systems; solar refrigerators. Solar enhanced evaporative coolers. Solar heating and cooling system design procedures including computer simulation. Economics of solar thermal systems. (3 Units)

#### **ABE 651: Biomass Processing and Systems**

Processes and technologies for sustainable use of biomass in producing energy and chemical products. Basic biomass processes and chemistry; analysis of biomass direct combustion and co-firing in power plants; fixed bed, fluidized bed and dust combustion; heat transfer and basic phenomenon in burning; current theories and thermodynamic; reaction kinetics; plant design and optimization; emissions, ash deposition and corrosion control; slagging and fouling problems; emission and combustion characteristics of various fuels; burner, boiler and combined heat pump technologies. Gasification processes and the main types of gasifier design. production of synthesis gas (i.e. CO, H<sub>2</sub>, H<sub>2</sub>O, CO<sub>2</sub>, tar vapour and ash particles) for subsequent conversion to hydrogen and transport fuels; gas cleaning technologies for biomass. Biochemical conversion of syngas to liquid biofuels. Fast pyrolysis technology for the production of liquid bio-oils or pyrolysis oil from biomass, refined to produce a range of fuels, chemicals and fertilizers; biorefineries. Biomass demulsification and densification machine design. (3 Units)

### **ABE 652: Solar Photovoltaic Engineering**

Generation of solar electricity for rural power supply and farm electrification. Solar cell technology, introduction to solar Photovoltaic (PV) technology, principles and workings of photovoltaic engineering, design of PV systems, PV arrays, PV components sizing (inverters), PV solar energy storage batteries, PV water pumping and the design, determination of power requirement of PV systems and performance evaluation of PV systems. Current research issues and advances. (3 Units)

### **ABE 653: Solar Thermal Engineering**

Introduction to solar thermal technologies. Solar energy radiation and measurement, solar energy collection and storage, active and passive solar systems, greenhouse effect, design of solar systems (flat plate solar collector and concentrating solar collector), heat and mass transfer processes, low temperature grade applications in agriculture, solar livestock housing, solar crop drying, solar water heating, desalination technology, solar heating and cooling processes. Current research trends and advances. (3 Units)

### **ABE 654: Biofuels and Bioenergy Engineering**

Sources and characteristics of biodiesel feedstock. Conversion of feedstock into biodiesel (transesterification); components and operation biodiesel processing system; safety issues in biodiesel production and usage. Production of ethanol by yeast and bacteria. Substrate range in ethanol tolerance; flocculence in yeast; yield of ethanol production from sugars. Production of butanol. production of hydrogen from photosynthesis, and from fermentative bacteria; production of hydrogen from wastewater; standards for biodiesel quality; Anaerobic processes (hydrolysis or liquefaction, acidogenesis and methanogenesis). Digester operation parameters; Anaerobic reactor systems (CSTR, plug flow reactors, two-phase reactors, anaerobic contact process, UASB, No-mix Reactors, anaerobic filters, SPAG reactors, DSFF and fluidized bed and expanded bed reactors. kinetics of anaerobic fermentation; collection, cleaning and utilization of biogas; integration of biomass technologies (generation of methane and hydrogen) with fuel cells. (3 Units)

### **ABE 655: Wind, Geothermal and Small Hydro Power Engineering**

Theoretical, technological and economic aspects of wind energy systems. Types of wind turbines, estimation of power output of specific wind energy devices and systems, structural suitability of wind towers and on-shore (urban) and off-shore wind energy systems. Planning, construction, implementation, operation, and maintenance geothermal and small hydropower systems; Economic evaluation, risk, and cost aspects. (3 Units)

#### **ABE 656: Renewable Energy Policy and Management**

Renewable energy Policy in Nigeria. Tariff systems for electricity supply (feed-in tariff etc) in Nigeria and other countries. Renewable energy pricing and cost competitiveness. Levelized cost of electricity (LCOE). Business models, financing structures and risk assessment for renewable energy projects. Payback time of renewable energy projects. Life cycle cost and other methods of analysis. Carbon financing (credit) of renewable energy projects. Analysis of both current and future national and international regulations and directives on biofuels and bioenergy; evaluation of different production alternatives for bioenergy; competitiveness of bioenergy alternatives in agriculture compared to other energy sources; cost effective production and use of feedstock; technical and economically competitive use of biofuel for transportation; Barriers removal in the marketing of biofuels. Invited seminars by renewable energy entrepreneurs. (3 Units)

#### **ABE 658: Integration of Renewable Energy into Energy Grid System**

Fundamentals of electricity markets and CO<sub>2</sub> emissions trading; Basics of electricity grids; Future role and responsibilities of transmission grids; Grid integration of renewables and the concept of smart grids; Market integration of renewables and storages; Direct marketing of green electricity; Examples for integrating renewable energy sources into the grid; Market overviews on renewable energy. (3 Units)

#### **ABE 661: Aquacultural Systems**

Introduction to aquacultural systems; System types; ponds; raceways; net pens; cages; Tanks; Recirculating Aquacultural Systems (RAS). Evaluation and comparison of aquacultural systems. (3 Units)

#### **ABE 662: Materials for Aquacultural Systems**

Considerations in materials selection for aquaculture; weight of water; corrosion; biofouling; ozone as a constraint in material selection; system components and materials selection for tanks; raceways; waterproof lining; screen mesh; nets; ozone units; advantages and disadvantages of various materials – masonry, metal, plastics, rubber, woods, and other materials. (3 Units)

#### **ABE 663: Aquacultural Environmental Requirements**

Primary constraints in aquacultural systems; Properties of water; Oxygen as a constraint; other constraints; Environmental needs of aquatic organisms. Optimization of environmental factors for aquacultural production. Water quality requirements for aquaculture. (3 Units)

**ABE 664: Aquacultural Equipment and Controls**

Feeding equipment; harvesting equipment; monitoring equipment; water management equipment; monitoring and control systems for aquacultural production. (3 Units)

**ABE 665: Design of Aquacultural Systems**

Constraints and techniques used for the design of various systems – ponds, raceways, net pens, tanks, recirculating systems. Systems design for optimal and sustainable aquacultural production in the tropical environment. (3 Units)

**ABE 666: Aquacultural Waste Management Systems**

Materials to remove from aquacultural systems; methods to remove ammonia, solids; methods to dispose of solids; methods to remove dissolved and colloidal matter; methods to remove carbon dioxide; effluent regulations. (3 Units)

**ABE 671: Forest Stand Establishment and Maintenance**

Site preparation; planting; cleaning and thinning of young stands; pruning; fertilization; fire protection; soil restoration; forest roads; forest regulations. (3 units)

**ABE 672: Timber Transportation**

Special vehicular and traction requirements for timber transportation. Log extraction; skidding; winch skidding; grapple skidding; forwarding; locomotion. Equipment and procedures for timber transportation. Safety considerations. (3 Units)

**ABE 673: Forest Power and Machinery Design**

Special needs and considerations for design of forest power and machinery. Design of multifunction heads and crane booms; measuring and working devices; forest tractors and excavators; power saws and tools. (3 Units)

**ABE 674: Special Logging Techniques**

Occasions and situations warranting special logging. Equipment and procedures for special logging. Semiaerial systems; aerial or off-the-ground systems; water transportation. (3 Units)

**ABE 675: Tree Felling and Log Processing**

Tree harvesting; the felling process; felling tools; mechanical tool fellers; ergonomics of tree felling; log processing techniques; delimiting; topping and bucking; debarking and slashing; wood comminution. (3 Units)

**ABE 676: Operational Security and Safety Issues in Forest Engineering**

Tree felling organization; felling angles; felling patterns; operational, security and safety considerations in use of forest machinery – power saws; tools; forest machines, etc; operations in hazardous conditions; safety and security rules and regulations. (3 Units)

**ABE 681: Catchment Hydrology and Management**

The hydrological cycle; rainfall-runoff relationships at the catchment scale. Catchment analysis and data management systems; GIS; DEM; GPS and remote sensing applications; hydrological catchment models and modeling; best practices in catchment management; the catchment approach to natural resources and ecosystems management; reservoir sedimentation control and prediction of useful life of reservoirs; forest management and the water cycle. (3 Units)

**ABE 682: Ecosystem Analysis and Assessment**

Ecosystems productivity, goods and services; production and decomposition in nature; homeostasis of ecosystems; food chains, food webs and trophic levels; ecosystem energetics; biogeochemical cycles and recycle pathways; nutrient cycling in the tropics; assessment of ecosystem condition and health. (3 Units)

**ABE 683: Wetlands and Environmental Water Quality Management**

Classification of wetlands and their national inventory; characterization of wetlands; wetland resources and their conservation; hydrology of wetlands; soils of wetlands; vegetation of wetlands; wetlands creation; restoration of impaired wetlands; design and operation of constructed wetlands; wetland ecology and management. Sources of water in nature; characteristics of water in the natural environment; environmental water quality requirements for aquatic and terrestrial life and other ecosystems; natural purification of water in rivers, soils, wetlands, forests and other ecosystems. Watershed management for environmental water quality; Tropic states; biological, chemical and physical contaminants; water quality modeling; water treatment practices and methods. (3 Units)

**ABE 684: Non-point Source Pollution Assessment and Control**

Concept of non-point source pollution; characteristics of non-point source pollution; types of non-point source pollution and their sources; human activities in the drainage basin as sources of non-point source pollutants; measurement and modeling of non-point source pollution; non-point source pollution control measures; selection, development, and implementation of a nonpoint source pollution control programme. (3 Units)

**ABE 685: Ecosystems Climate Change Impacts and Adaptation Mechanisms**

Current climate change and variability in the tropics and globally; future climate change predictions; risks and impacts on agriculture, water resources and ecosystems' life and productivity; reducing risks and vulnerability of ecosystems; resilience building strategies and mechanisms; climate change adaptation benefits of the natural environments; ecosystem-based natural resources management, fisheries resources management, and biodiversity conservation. (3 Units)

**ABE686: Restoration and Bioremediation Engineering**

Contaminant characteristics and partitioning; soil vapour extraction; in-situ air sparging; in-situ bioremediation; vacuum enhanced recovery; in-situ reactive walls; in-situ reactive zones; hydraulic and pneumatic fracturing; phytoremediation mechanisms; pump and treat systems; stabilization and solidification. (3 units)

**ABE 688: Advanced Waste Disposal and Pollution Management Systems**

Natural attenuation and ground contamination; control and management of pollution plumes; soil composition and transmission properties; soil-water systems and interactions; partitioning and mobility of heavy metals; interaction between organic contaminants in soil-water systems; biological transformation of contaminants; biodegradation of organics and biotransformation of metals, non-metals and radionuclides; field applications, performance assessment and future directions. (3 units)

**ABE 690: M.Eng Project Report**

A project report shall embody an original investigation or design, undertaken in the immediate supervision of one or more members of the academic staff of the Department. The report shall not have been, in part or in full submitted for any other diploma or degree of this University or of another educational institution. (6 Units)

**11.2 PhD Courses Description**

**PGC 701: Synopsis and Research Grant Writing in Engineering**

Choice of broad research area with consideration of interdisciplinary topics; Identification of research/knowledge gaps and research objectives. 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 appendices, function of figures, equation editors, tables and illustrations. Literature search, references (citations and listings). Nature of recommendations and conclusions. Guide for writing memoranda, business letters. Oral presentation of technical reports and thesis. Synopsis writing. Developing long-term research plan. Identification of potential funding agencies and their requirements. Research objectives in relation to interests of the funding agencies. Estimating research timelines. Budget preparation, manpower requirements and availability, research facilities, legal issues, etc. (3 Units)

**ABE 701: Special Problems in Agric. & Bio Engineering**

Analysis of a specified engineering problem, specific to a student and in his/her area of specialization, and submitted in a written report as term paper. (3 Units)

**ABE 702: Agric. and Bio Engineering Seminar II**

This is the second seminar presentation to be made by the PhD candidate at the completion stage of the thesis (ABE 790). (3 Units)

**ABE 703: Instrumentation and Measurements in Agric. and Bioresources Engineering Research**

Methods and Instrumentation for field and laboratory measurements on agricultural machines, Data transformation and evaluation of measurement results, Dimensional analysis. Computational techniques. Instrumentation for measurement of passive electrical properties of biomaterials. Electrodes interface and polarization. Physical models of biological systems and equivalent electrical circuits. Instrumentation for, quality evaluation of foods, microcomputer based data acquisition and control systems. (3 Units)

**ABE 704: Directed Studies**

This is a course to be written outside the candidate's chosen area of specialization to be submitted in the form of a term paper. (3 Units)

**ABE 705: Agric. and Bio Engineering Seminar I**

This is the first seminar presentation to be made by the PhD candidate at the proposal stage of research work based on the Special Problems course (ABE 701). (3 Units)

**ABE 790: Ph.D Thesis**

A thesis shall embody original scholarship and independent research which must make a distinct contribution to knowledge in an area of agricultural and bioresources engineering. The thesis must be submitted in an approved format and defended in an oral examination. (12 Units)