INTRODUCTION TO ENGINEERING DISCIPLINES

(ABE 206 VOLUME II Second Edition)

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PREFACE

An introduction to engineering disciplines is one of the general engineering courses in both the Nigeria University Commission (NUC) and Council for Regulation of Engineering (COREN) programme Benchmark Minimum Academic Standards (BMAS). The engineering curriculum being operated at the University of Ilorin is structured from 200 Level which is the first contact year of engineering to the students. Thus, engineering students of University of Ilorin actually begin their training in 200 Level for all courses. It is therefore appropriate that all the students are introduced to all disciplines being offered at university of Ilorin and the profession of engineering especially for the practice and prospects. The contents of the booklet is aimed at sensitizing the engineering students ~~; the would be engineers~~ to understand the subject contents, the ethics of the professional practice and engineering career portfolio.

Seasoned and experienced lecturers from each of the engineering disciplines were assembled to offer the course. In our opinion, these students shall be motivated early enough to realize the reasons of being in the faculty and strategize how to accompany their academic aims and scholarship aspirations. The course is domesticated in the Department of Agricultural and Biosystems Engineering with course code ABE 206 and consequently coordinated by a lecturer in person of Dr. M.O. Sunmonu.

This booklet is to serve as a reading material to facilitate students learning and understanding and prepare them for the Engineer in Society course at the final stages of their training while on the University campus. The pictorial display of the relevant products or tools to facilitate each discipline were included as well as a chapter on the relevance of the discipline in the advancement of humanity.

Professor D. S. Ogunniyi
Dean, Faculty of Engineering and Technology

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Dr. M. O. Sunmonu
ABE 206 Course Coordinator

NOTE ON THE SECOND EDITION

It has been nearly four (4) years since the first edition of ***Introduction to Engineering Disciplines (ABE 206)*** was published. The first edition has enjoyed faculty wide use as introductory aspects for curriculum in engineering discipline. This positive, favorable and encouraging response has encouraged all the authors to improve but follow the same format, objectives and philosophy of the previous edition. The main goal is to provide the students with the solid introductory foundation in engineering which will subsequently help them in their careers as engineers-to-be. It is noted that this book is widely used as a basic reference in many universities in Nigeria.

Engineers are change agents in the society. Few professions have such a direct and positive impact on people's lives as engineers do. Through research and innovative solutions to real-world problems, engineers constantly re-invent the machines, processes, structures and gadgets that improve individual's lives daily. By applying science in new ways, engineers use initiative imagination to turn ideas into realities that help meet the needs of the society. During the delivery of this course-introduction to engineering disciplines, readers will learn what engineers really do and the tools they use in virtually in all as aspects of engineering disciplines. It is a compulsory and required status for all 200 Level Engineering Students. The purpose is to allow students get a glimpse of engineering from the beginning of their study at the University.

The students are also informed of a discipline's scope and preparatory steps necessary for effective advancement in their training.

The second edition has been substantially updated and expanded in line with the current trend and advancement in technology.

Dr. M. O. Sunmonu
Course coordinator

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PHILOSOPHY OF THE COURSE

The Introduction to engineering disciplines is an emerging course that considers what engineering is, options in engineering discipline, what engineers do and how their work impacts on the society. It is a course that prepares the students mind on how to become professionally qualified Engineers as well as providing the students with fundamental engineering knowledge in their respective choice of career. Engineering is the profession aimed at modifying the natural environment, therefore the philosophy of engineering is the consideration of philosophical issues as they apply to engineering. Such issues might include the objectivity of experiments as well as the ethics of engineering activity in the workplace and in society.

The general philosophy behind Engineering is that Engineers work to fulfill the needs of society (water, electricity, air quality, technological improvements etc.), and as such Engineers are expected to act ethically towards the society. This course will use online resources extensively and help develop research and communication skills of students, whilst providing an overview of the historical significance of Engineers in society, and what it takes ~~means~~ to be an Engineer.

OBJECTIVES OF THE COURSE

The specific objectives of this course are to:

1. expose and familiarize the students to the various options available in their respective departments,

2. enlighten the students on various job opportunities available in their respective disciplines, and

3. impact on the students the theoretical and practical understanding of engineering and technology.

DEPARTMENTAL OPTIONS

(a) Agricultural and Biosystems Engineering

1. Aquacultural Engineering
2. Power and Machinery Engineering
3. Processing and Storage Engineering
4. Soil and Water Engineering
5. Structure and Environmental Engineering

(b) Biomedical Engineering

1. Biomedical Instrumentation and Micro/Nano Systems
2. Cell and Tissue Engineering
3. Computational Bioengineering

(c) Chemical Engineering

1. Processes Engineering
2. Biotechnology/Biomedical Engineering
3. Petroleum Engineering
4. Environmental Engineering
5. Process Control and Modelling
6. Reaction Engineering
7. Polymer Engineering
8. Thermodynamics, Energy and Exergy Analysis

(d) Computer Engineering

1. Embedded Systems and Automation
2. Computer Communications and Networks
3. Computer System Architecture
4. Cryptography and Information Security
5. Mobile Computing and Distributed Systems
6. Software Engineering
7. Computational Science Engineering
8. Computer Vision and Robotics
9. Digital Signal Processing

(e) Civil Engineering

1. Geotechnical Engineering
2. Structural Engineering
3. Transportation Engineering
4. Water Resources Engineering
5. Materials Engineering
6. Construction Engineering and Management
7. Environmental Engineering

(f) Electrical and Electronics Engineering

1. Electronics and Telecommunications Engineering
2. Computer and Control Systems Engineering
3. Power and Machines Engineering

(g) Food Engineering

1. Food Machinery/Equipment/Systems Design
2. Food Process Design and Development
3. Bioproduct Processing and Engineering Option
4. Food Storage, Distribution, Environmental Analysis

(h) Materials and Metallurgical Engineering

1. Wear and Corrosion
2. Advanced Materials Engineering
3. Metallurgical Engineering
4. Mineral Processing and Extractive Metallurgical Engineering
5. Material Engineering
6. Material production Engineering

(i) Mechanical Engineering

1. Automobile/Vehicle System Engineering
2. Combustion and Environment Engineering
3. Heat Transfer, Thermodynamics and Energy Systems Engineering
4. Manufacturing Engineering
5. Mechanical Design and Mechanics Engineering
6. System Dynamics and Control Engineering
7. Mechatronics Engineering
8. Materials and Metallurgy, and Processing Engineering
9. Fluid Mechanics/Environmental Fluid Mechanics Engineering
10. Machine Design and Solid Mechanics Engineering
11. Welding and Joining
12. Automation and Control Engineering
13. Biomedical and Fluid Mechanics Engineering

(j) Water Resources and Environmental Engineering

1. Water Resources Engineering
2. Environmental Engineering

(k) Introduction to Engineers in Society

COURSE CODE, TITLE AND CREDIT UNITS:

ABE 206: INTRODUCTION TO ENGINEERING DISCIPLINES (2 CREDITS)

COURSE SYNOPSIS:

Introduction to engineering disciplines; Definition of agricultural, biomedical, chemical, computer, civil, electrical, food, mechanical , material and metallurgical, and water resources and environmental engineering; Specialization/Options in various departments in engineering; Use of various implements and equipment in engineering for various operations/processes; Prospects and job opportunities in various disciplines in engineering; Relevant regulatory bodies in engineering; and The role of engineers in advancement of humanity.

CHAPTER 1

AGRICULTURAL AND BIOSYSTEMS ENGINEERING DISCIPLINE

J. O. Olaoye and T. A. Ishola

COURSE SYNOPSIS

Agricultural and Biosystems Engineering

Introduction to agricultural and biosystems engineering profession; Definition of agricultural and biosystems engineering. Specializations/Options in agricultural and biosystems engineering, Use of various implements and equipment in agricultural and biosystems engineering for different operations/processes. Prospects and job opportunities in agricultural and biosystems engineering as a profession; Relevant regulatory bodies and societies in agricultural and biosystems engineering. The role of agricultural and biosystems engineers in advancement of humanity.

1.1 INTRODUCTION TO AGRICUTURAL AND BIOSYSTEMS ENGINEERING DISCIPLINE

1.2 DEFINITION

Engineering – This is the profession in which knowledge of the mathematical, physical and biological sciences gained by study, experience and practice is applied in the efficient use of materials and forces of nature for the benefit of man and the environment.

Agriculture – Encompasses the art, science and industry of managing the growth of plants and animals for the benefit of man. It includes the production of crops and rearing of livestock including fishes; their processing to varied degrees and products; and marketing of their end products.

Agricultural and Biosystems Engineering – This is the application of engineering and technology at the interface of physical and biological sciences to solve agricultural production problems. It requires the application of knowledge from other branches of engineering to the extent that such knowledge may be used in solving engineering problems of agriculture in all ramifications and in rural living.

The principal objective of Agricultural and Biosystems Engineering is to provide appropriate modern equipment, technology and conducive environment for agricultural production, processing and storage. This ensures improved productivity, profitability and sustainability of the enterprise. Agricultural and Biosystems engineers are uniquely qualified to use their knowledge of mathematics, biological and physical sciences, and engineering principles to solve problems relating to the production, handling and processing of biological materials for food, feed, fiber and fuel; the preservation of natural resources and environment quality; and the design and production of machine systems. Through Agricultural and Biosystems engineering, the following are achieved:

(a) Reduction in the hazards of farming operations,

(b) Reduction of drudgery in agricultural productions,

(c) Moderation of seasonality of agricultural produce availability by development of systems that protect production from vagaries of weather,

(d) Continuous development and improvement of equipment and technologies for production, processing and storage,

(e) Enhancement of quality of life and financial security for farming families and enterprises,

(f) National self-sufficiency in food supply and raw materials for agro-based industries,

(g) Sustainability of the environment for agricultural production systems,

(h) Development of innovative green products and industries,

(i) Conversion of bio-based resources to food, fuel and other renewable products,

(j) Design of new generations of devices or systems for biological systems,

(k) Control of biological systems for natural resource protection, waste remediation and ecosystem restoration, and

(l) Development of sensors, control systems and computer models to monitor and control biological processes occurring in industry or the environment.

Agricultural and Biosystems engineer design systems and solve problems requiring mathematics and the application of physical, biological, and engineering sciences involving biological systems. Agricultural and Biosystems engineers address society's grand challenges in food, energy, and water. A good Agricultural and Biosystems engineer must be knowledgeable to an appropriate level, in most aspects of engineering disciplines and have interest in working in rural, semi-urban and peri-urban settings.

1.3 SPECIALIZATION / OPTIONS IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING

Agricultural and Biosystems Engineering profession worldwide focuses its attention on six (6) main areas, namely:

1.3.1 Aquacultural Engineering

Aquaculture engineering is the branch of Agricultural and Biosystems engineering that studies cultured aquatic species and the production systems used in their culture. Study, research and development in this area ranges from low intensity man-made pond systems to highly intensive recirculation systems involving natural lakes. Species cultured in these systems could range from warm to cold water fish and from fresh to sea water. This is an important aspect of agriculture in fishery. In modern day fishery, either in ponds, rivers, or the oceans, a variety of machines is used

for raising, catching and processing fish. Aquacultural Engineering deals with the structures and machines required for various fishery operations.

1.3.2 Processing and Storage Engineering

Agricultural processing and storage is another branch of Agricultural and Biosystems Engineering. In this course, the two categories are: Agricultural Processing and Storage of Agricultural Products. Agricultural processing can further be divided into crop processing and food processing. Crop processing is any procedure or treatment that prepares farm products for utilization or preservation. Food processing, however, is the process of physically or chemically converting the crops into a form that could easily be cooked or eaten. Storage can be defined as the art and science of keeping of crops in good condition in a safe place until usage time or consumption time.

1.3.3 Power and Machinery Engineering

This branch of Agricultural and Biosystems Engineering deals with the area of farm mechanization. Farm mechanization is the application of engineering principles and technology in agricultural production, processing and storage. Agricultural mechanization is a wider term used when these activities extend beyond the boundaries of the farm unit. Farm mechanization is not only tractorization but a process of improving farming operations and farm structures.

The major role of power units in the farm is to operate farm equipment for land clearing and development, cultivation, harvesting, processing, handling, transporting, loading, unloading, pumping and any other farm operations. The use of farm machinery in Nigerian agriculture is gaining popularity because of the increasing awareness to large- scale farming.

1.3.4 Structures and Environment Engineering

This branch of Agricultural and Biosystems Engineering deals with the planning, design and construction of farmstead and controlled environments for production, storage and processing. Farmstead structures include animal housing units, farm dwellings and produce structures. Examples of closed controlled-environment systems are silos, rhumbus and green houses.

1.3.5 Soil and Water Engineering

Soil and water engineering is that branch of Agricultural and Biosystems engineering where engineering principles are applied in solving problems associated with managing soil and water resources. The aim of soil conservation is to protect the soil from degradation which may result from the effect of water, wind and improper land use practices. Soil and water conservation may involve modified tillage and crop management practices. It could include mulching using artificial and natural materials, contouring and terracing. Conservation of soil water may also involve engineered systems for improving soil profile water storage.

Drainage is an aspect of soil and water engineering dealing with the removal of excess water from surface and subsurface of the field. Irrigation is also an aspect of soil and water engineering dealing with the application of water to the field so that crop production is not hampered by water stress. It is required when precipitation is either not available or is insufficient to meet crop water requirement.

Water conveyance systems may also consist of pipelines and canals. Field water application systems vary in levels of sophistication. They include wild flooding, engineered surface and overhead application system.

1.4 USES OF VARIOUS IMPLEMENTS AND EQUIPMENT IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING FOR VARIOUS OPERATIONS

The following are some of the implements and equipment used for various operations in Agricultural and Biosystems Engineering (Table 1.1):

Table 1.1: Equipment, implements and Instruments Used for Various Operations in Agricultural and Biosystems Engineering

S/No.	Name of Equipment	Picture	Uses
1	Weighing Scale		An instrument used to measure the weight of an item
2	Testometric Universal Testing Machine (TUTM		A tool for determining the mechanical properties of agricultural and biomaterials .
3	Kartar 4000 (41") Multicrop Combine Harvester		A machine that harvest grain crops.
4.	Injector Pump Calibration Machine		Capable of accurately testing and calibrating diesel fuel injection pumps.
5.	Gunson digital exhaust gas analyzer (Model-G4125).		Applications of Exhaust gas analyzer include combustion and emission sources in burners, engines, generators. The analyzer is used for

			the testing and setting of all carburettors (petrol - leaded or unleaded) and petrol injection systems on any vehicle. It is necessary for emissions reporting requirements.
6.	Q600 SDT Simultaneous Differential Scanning Calorimetry and Thermogravimetary Accessories		An analysis instrument for performing both differential scanning calorimetry (dsc) and thermogravimetric analysis (tga)
7.	Waterproof digital theodolite topcon dt-207/dt.		An instrument for the measurement of horizontal and vertical angles. Theodolites also determine the relative location, and are extremely useful in navigation and meteorology.
8.	Infiltrometers.		A device used to measure the rate of water infiltration into soil or other porous media.
9.	Water pump and suction hoses		Instruments that lift and conduct the water from the source (lake, river, pond, etc.) to the pump.

10.	Portable Leaf Area Meter Model CL 202L		Equipment for measurement of leaf area parameters
11.	Centrifuge		The Centrifuge is used to separate fluids of different densities. This is achieved with a rapidly rotating container that applies centrifugal force to its contents.
12.	Digital UV VIS Spectrophometer		A spectrophotometer i s a specialized instrument that can be used to measure and quantify the reflectance and transmittance properties of a sample material.
13.	IRRAA25591 DDM 2911 Automatic Density Meter		The Equipment measures the density, specific gravity and other related parameters of the liquid in different forms.
16.	Particle Size and Shape Analyzers (MODEL 1180)		The equipment uses the principle of Dry Jet Dispersion Technology (DJD) which is the latest development in particle size analysis. Dry Jet Dispersion guarantees that particles will not break apart during dispersion.
17.	Massey Ferguson 3070		A universal machine that supplies the tractive force, pull and push for diverse operation in the farm. It is furnished with PTO, hitching points,

			draw bar pull, hydraulics systems and other auxiliary features.
18.	H-4320.4F Ro-Tap Motorized Sieve Shaker With 6 Sieves + Pan		Equipment for material sample analysis
19.	TESTO 645 Temperature and Humidity Measurement Data Lodger with Probe and Cables.		This equipment is used for the measurement of temperature and humidity.
20.	Automatic Rainfall Recorder		Equipment for measurement of rainfall data.
21.	Soil Bin Track		Soil Bin Track for Laboratory Investigation of Effect of Tillage Tool on Simulated Soil Conditions
22.	H-4967 2000G Speedy Moisture Tester		Equipment for soil moisture measurement
23.	Boom Sprayer		Ancillary equipment for crop protection

1.5 PROSPECTS AND JOB OPPORTUNITIES IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING

The prospects of Agricultural Engineer upon completion of studies are very wide. The broad Agricultural and Biosystems Engineering Curriculum makes an Agricultural Engineers A "***Jack of all trades and almost a master of all".*** So employment opportunities in Agricultural and Biosystems Engineering cut across many areas. Such areas are stated below:

Human Resources Development
To keep the Agricultural and Biosystems Engineering profession alive, a younger generation of Agricultural Engineers must be trained to replace the old ones. These objectives can be achieved by establishing educational and research institutions such as Universities, Polytechnics, Colleges of Agriculture and Education, Research Institutes; and by recruiting the already trained and experienced Agricultural Engineers and other relevant professionals.

Private Firms
An Agricultural Engineer can work in private establishments dealing with plant leasing or hiring service, consultancy services and sales and services of farm machinery**.**

Industries
Few examples of industries that employ the services of Agricultural Engineers are:

1. Agro- industrial set up such as sugar company,
2. Paper production factories,
3. Oil palm production companies,
4. Vegetable oil production companies,
5. Farm equipment manufacturing industries (design, supervision and fabrication of various farm equipment)
6. Feed processing industries (Agricultural Engineers advice on purchase, installation and maintenance of agro-processing equipment).

Private Farm Establishments
Agricultural Engineers are useful in the development of machinery maintenance procedure for private crop production farms. They can also serve in the management team of the establishment.

Financial Institution
The Agricultural Engineer is, in most cases, an inventory officer or investment officer in Agricultural Credit and Loan Section in institution such as banks and insurance firms.

Field Practice
An Agricultural Engineer may be deployed to the field to investigate the problems confronting the farmers, analyze such findings, in collaboration with other engineers and non-engineers find solutions to such problems and train farmers on how such solutions can be implemented.

Government Agencies Dealing with Agricultural Production
Such agencies are Ministries of Agriculture, River Basin Development Authorities, Agricultural Development Cooperation, Agricultural Mechanization Development, Boards or Cooperation or Company, World Bank Assisted Agricultural Development Programme.

Self-Employment
An Agricultural Engineer can set up a private professional practice such as workshops that can take care of the maintenance and development of farm machinery and processing equipment.

Miscellaneous

An Agricultural and Biosystems Engineer is very versatile because of his broad background. His academic training makes him fit for some civil and mechanical jobs. He can be an Environmental Engineer, Waste Management Engineer, Quality Control Engineer and Project Engineer. Environmental consulting firms and government agencies hire Agricultural and Biosystems engineers, particularly to work in areas of ecosystems protection and water quality. The bioenergy industry is a rapidly growing sector, and Agricultural and Biosystems engineers are employed both by small firms that design and build custom bioenergy systems and by major energy corporations. In the biomedical field, Agricultural and Biosystems engineers are typically employed by pharmaceutical companies and companies that produce other health and medical related products. He can pursue higher degrees in these other engineering branches and he can be easily trained to face series of challenges in these disciplines.

1.6 RELEVANT PROFESSIONAL BODIES IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING

A Professional Regulatory Body is a body established by a decree or an act of the legislative arm of Government and its primary function is to regulate the training of members of the profession and the professional practice. Such regulatory body for the Agricultural and Biosystems Engineering and other Engineering professions in Nigeria is the Council for the Regulation of Engineering in Nigeria (COREN). A practicing agricultural engineer must be registered by the Council for the Regulation of Engineering in Nigeria (COREN). A professional Society is an association formed by members of the profession with the primary objectives of providing a forum where members of the profession can interact to share ideas. Such professional societies are Nigerian Society of Engineers (NSE), Nigerian Institution of Agricultural Engineers (NIAE), West African Society of Agricultural Engineers (WASAE), Pan African Society of Agricultural Engineers (PASAE) and American Society of Agricultural and Biological Engineers (ASABE). The Nigerian Society of Engineers is the umbrella association for all engineering disciplines in Nigeria and it provides a bigger forum where, apart from interacting with themselves, Agricultural Engineers can interact with other engineering professionals.

1.7 THE ROLES OF AGRICULTURAL AND BIOSYSTEMS ENGINEERS IN ADVANCEMENT OF HUMANITY

Agricultural and Biosystems Engineers can contribute to the development of our nation through agricultural development in the following ways:

1. Development and production of appropriate agricultural machinery,
2. Development and production of storage and processing facilities for the farm produce,
3. Development of appropriate Irrigation and Water Conservation methods that can be readily practiced by the farmers,
4. Formulation of, and research into, mechanization system that will be relevant to a particular vegetation and soil types,
5. Standardization of equipment being imported into the country,
6. Conduction of research into human factors in the use of machinery,

7. Formulation of appropriate standard agricultural mechanization management systems that will be peculiar to Nigeria though may be adaptable to other countries in the areas of maintenance,
8. Research into fundamental problems affecting operations of the machines e.g. soil dynamics,
9. Investigation into material properties of crops to determine the appropriate storage facilities to be provided,
10. Crop Production,
11. Animal and Fish Production,
12. Management, Distribution and Transportation,
13. Development of systems that convert biological waste products into energy and other valuable products,
14. Design and management of manufacturing processes to ensure that the food is free from foodborne pathogens,
15. Working to improve methods for rapid detection of pathogens and disease diagnostics.

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CHAPTER 2

BIOMEDICAL ENGINEERING DISCIPLINE

M. O. Ibitoye , I. O. Muniru, L. J. Jilantikiri, Y. K. Ahmed and T. M. Ajibola

COURSE SYNOPSIS

Biomedical Engineering

Introduction to biomedical engineering profession; Definition of biomedical engineering. Specializations/Options in biomedical engineering, Use of various equipment in biomedical engineering for different operations/processes. Prospects and job opportunities in biomedical engineering as a profession; Relevant regulatory bodies and societies in biomedical engineering. The role of biomedical engineers in advancement of humanity.

2.1 INTRODUCTION TO BIOMEDICAL ENGINEERING DISCIPLINE

2.2 DEFINITION

Biomedical Engineering is an innovative and hybrid engineering discipline which applies the engineering problem-solving principles of design and analysis in combination with basic knowledge of medical sciences to solve biological, medical and clinical problems for improved healthcare delivery. According to the World Health Organization, Biomedical Engineers are trained to design, evaluate, regulate, maintain and manage healthcare facilities globally. Biomedical Engineers are able to solve problems due to their acquired knowledge which could be transformed to designing and creating instruments and equipment needed to facilitate seamless healthcare delivery. This wide knowledge enables the Biomedical Engineering Graduates to specialize in various areas of interest which allows them to collaborate with investigators (researchers) in related fields thus promoting their career prospects. Biomedical Engineers work with health caregivers or medical practitioners and other stakeholders to understand the nature of the challenges in core areas of medicine and allied disciplines and act as key players in medical revolution. Among other notable areas of place of work and occupation of Biomedical Engineers are academia, hospitals, industries, research institutes, international agencies, non-governmental agencies and government ministries and parastatals. Higher degrees, Master's and Doctoral, in Biomedical Engineering may be needed for wider opportunities in research institutes.

2.3 SPECIALIZATION/OPTIONS IN BIOMEDICAL ENGINEERING

The Department of Biomedical Engineering currently has three sub-specializations including:

2.3.1 Biomedical Instrumentation and Micro/Nano Systems

This option emphasizes the fundamental and advanced knowledge of the design and fabrication of biomedical sensors, bioelectronics and instrumentation with biosignals processing procedures involved in innovative medical instrumentation, equipment and systems design. Students in this option are normally interested in research studies leading to the design and development of cost-effective and efficient medical sensor and equipment particularly for diagnosis, drug delivery and therapy for use in clinical settings. Technological innovations from this option may also include

design principles of Nanomaterials and Biomedical Micro-Electro-Mechanical Systems (BioMEMS) and their drug delivery applications.

2.3.2 Cell and Tissue Engineering

This option applies engineering principles to study the characteristics and responses of cell and tissue for medical applications. Fundamental concepts in tissue engineering such as communication mode between tissue cells are few among important topics to be covered in this option. Cell and tissue engineering field has a continuum of cellular responses to cell and tissue culture for disease treatment. Stem cell technology for tissue regeneration is one area of important research interest of this option. This includes identification and isolation of stem cells from tissues. Major example of breakthrough in stem cell therapy is in the repair or replacement of human tissue and organs.

2.3.3 Computational Bioengineering

This option explores the computer modelling applications in Biomedical Engineering and Medicine. The application areas of computation bioengineering include bioinformatics, biophysics, molecular genomics, synthetic biology, modelling dynamics of biological systems, and computational simulation. Research studies in these areas could facilitate prognostics and diagnostics of diseases using evidence based on clinical data profiling, with the added advantages of allowing patients various options of evidence-based therapies.

Other major sub-specializations in biomedical engineering are:

2.3.4 Medical Imaging and Nuclear Physics

This specialization aims to introduce students to the application of ionization and non-ionization radiations for image formation and reconstruction procedure, and application of radiation for therapies. This specialization is meant to thoroughly discuss the instrumentation and principle of operation of various imaging modalities, their strengths and weaknesses and areas of current and potential applications. Topics to cover under this specialization are medical diagnosis and therapy applications of medical imaging modalities.

2.3.5 Biomechanics and Medical Robotics

Biomechanics involves the study of motion and the effects of forces and fluids on biological organs and systems. Biomechanical study of human skeletal and muscular systems may be performed at a macro level where effects of joint articulation is observed, or at a molecular level where the biomechanics of muscles and tissues for example, are examined. This is mostly applied in the clinical study of human normal and pathological movements including joint movements and human gait. Biomechatronics and medical robotics for human physical function promotions are the recent advances of biomechanics.

2.3.6 Rehabilitation Engineering and Assistive Technology

This field of Biomedical Engineering is concerned with the creation of treatment methods and technology to restore or augment lost or failing systems or functions. Individuals with spinal cord injury, stroke and brain disorders through trauma or disease could experience a

reduction/incomplete or complete loss of either motor, sensory or both functions. Clinical manifestation of which could lead to reduced or complete loss of physical ability in the victims. Rehabilitation engineers are responsible for providing solutions to improve the quality of lives of these individuals through the development of innovative technologies to restore or support these functions.

2.3.7 Telemedicine

Telemedicine typically applies information and communication technologies to process medical data and information to facilitate tele-consultancy and seamless healthcare access for use in rural communities of developed worlds and in limited resources settings. With this technology, caregivers can diagnose and treat patients remotely.

2.3.8 Biomedical Signal Processing

This option emphasizes the procedure of measuring, analyzing, and processing biomedical/physiological signals including image, speech and video signals. This option extracts useful information from the signals for diagnostics or therapeutics applications.

2.3.9 Biomaterials

This sub-specialization studies engineering materials that have undergone modification to facilitate their interaction with living tissue without posing any danger or threat to the system in which they are to be used. Biomaterials could be devices or implants e.g. artificial joints, or materials that could be used to target drug delivery to a certain body part.

These are the major and traditional sub-specialization in biomedical Engineering. However, there are other emerging, innovative and often hybrid options including genomics, medical virtual reality, neural engineering, artificial intelligence and nanomedicine.

2.4 USES OF VARIOUS EQUIPMENT IN BIOMEDICAL ENGINEERING FOR DIFFERENT OPERATIONS

Shown on Table 2.1 are some of the equipment used for various operations in Biomedical Engineering:

Table 2.1: Equipment, implements and Instruments Used for Various Operations in Biomedical Engineering

S/No.	Name of Equipment	Picture	Uses
1.	Anaesthesia machine		Provides an appropriate and constant supply of medical gases, combined with an accurate concentration of anaesthetic vapour i.e. isoflurane, to be delivered to unconscious patient at a safe pressure and flow.

2.	Aspiration/Suction Pump		This is used to remove unwanted fluids from body orifices, through a tube into a chamber emptied by a piston.
3.	Autoclave / Sterilizer		It is a pressure chamber that uses elevated temperature and pressure to destroy bacteria, spores and germs on medical devices.
4.	Blood Chemistry analyzer		It is used for identification and determination of the concentration of electrolytes, metabolites, proteins, and/or drugs in body fluids samples i.e. serum, plasma, urine, cerebrospinal fluid.
5.	Centrifuge		A motor-driven medical equipment which spins fluid samples at high speed, subjecting it to centripetal force, in order to separate its constituents.
6.	Coagulation analyzer		This device allows the measurement of blood platelet levels in a fast and simple process and it is used primarily to detect clotting deficiencies in the blood.
7.	Defibrillator		This is used to perform cardiac resuscitation, by applying a high energy electric shock to the heart through the chest wall.
8.	Diagnostic Ultrasound with probes		It uses the application of ultrasound to view the images of internal body organs such as muscles and blood vessels.
9.	Electrocardiogram (ECG) Machine		It uses electrodes affixed to specific locations on the body to collect and record the heart's electrical activity.

10.	Electrosurgical Unit		The device is used to ablate, resect, and coagulate soft tissues and for blood vessels' haemostasis during surgery.
11.	Endoscopy system – scope, insufflator, light source.		It is a nonsurgical procedure to observe some organs in the human body, with an endoscope, an elastic tube with a light and camera attached its head.
12.	Fetal Doppler		This uses the principle of ultrasound to measure and record the heart rate of a fetus in the mother's womb.
13.	Hospital bed		A special bed which is designed for hospitalized patients.
14.	Infant Incubator		It is a controlled enclosure in which a premature baby is placed for continuous observation and care.
15.	Infant Warmer		This equipment supplies heat to infants at modulated rate to keep them warm.
16.	Nebulizer		This is a device used in administering vaporized medicine or pill for direct inhalation into the lungs.
17.	Oxygen Concentrator		It helps to extract pure oxygen gas from atmospheric air by selectively removing nitrogen and other gases.

18.	Portable Glucose Monitor		It is used to measure the amount of the glucose in a blood sample.
19.	Pulse Oximeter		It noninvasively measures oxygen saturation level in the blood through an infrared transceiver clipped to the finger.
20.	Sphygmomanometer – with Stethoscope		To measure blood pressure as well as the heart sound.
21.	Spirometer		This is used in breathing test to determine the air capacity of the lungs.
22.	Surgical Lamp – ceiling mounted		It provides a shadow-less illumination in the operation theatre during surgical operation.
23.	Digital thermometer		A digital thermometer to measure the body temperature.
24.	Ventilator		This is an artificial breathing machine which provides oxygen to patients when they are unable to breathe on their own.
25.	Vital Sign Monitor		It is used to measure vital signs to monitor clinical conditions.
26.	Wheelchair		This is used for moving patients that have difficulties due to illness, injury, or disability.

27.	X-Ray system		An imaging system that uses x-rays (a form of electromagnetic radiation) to generate body parts images in different shades of black and white.
28.	Computed Tomography Machine		It is advanced x-ray system, which produces 3-dimensional images of body parts.
29.	Magnetic Resonance Imaging machine		This uses non-ionizing strong magnetic fields and radio waves to produce images of body organs.
30.	Linear Accelerator		The LINAC uses external beam of high-energy x-rays or electrons to destroy cancerous tumours treatments in patients undergoing radiotherapy.
31.	Surgical Robot		This is a robotic system used to provide support in surgical procedures.
32.	Electro stimulator		This is used to generate and send electrical impulses to the nerves or muscle in the body usually to elicit muscle contraction for therapeutic purposes.
33.	Medical Equipment Safety Analyzers		The devices are used to ensure the performance and safety of medical equipment.

34.	Bioreactor		This is a vessel in which biological reactions and cell culture are carried out.

2.5 PROSPECTS AND JOB OPPORTUNITIES IN BIOMEDICAL ENGINEERING

Engineering and healthcare providers are two areas of study that are consistently acknowledged for providing the best career prospects, however, biomedical engineering being a fusion of these two areas offers much greater prospects. The nature of job opportunities that are open to Biomedical Engineers are so vast and varied, as the many health-related challenges in the world. Biomedical Engineers work in hospitals, research facilities/centres, manufacturing industries, pharmaceutical companies, universities among others. Some of the common professions in biomedical engineering include:

1. **Manufacturing/Biomedical Design Engineer:** develops and designs medical devices and products with strict compliance to prevailing regulatory policies.
2. **Quality Engineer:** trained to enforce and ensure that medical products meet certain standards and specifications. They offer suggestions for modifications when necessary and may be responsible for coming up with in-depth revisions themselves.
3. **Software Engineer in Biomedical Engineering:** trained to design and develop computer programs for various medical applications. These programs typically allow medical personnel to display and manipulate data recorded by other medical devices.
4. **Researchers:** primarily seek information to aid with the proper design of medical products and to ensure that they pose no threat or risk to the users. Many researchers also conduct research studies and teach at the university and research institutes.
5. **Clinical Engineer:** works in the hospital to advise on and install, monitor and maintain biomedical products in the facility.
6. **Tissue Engineer:** uses advanced engineering techniques and equipment to repair and regenerate damaged body tissues and organs.
7. **Trainer:** trains medical practitioner and allied professional the safe and effective use of medical equipment.

According to a report by the Health Technology Assessment division of the World Health Organization (WHO), BME is estimated to have a job growth of seventy-two percent (72%) between 2008 - 2018 as shown in Figure 2.1.

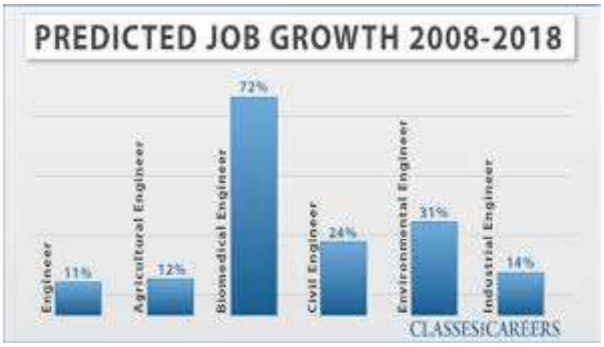


Figure 1.1: Predicted Job Growth 2008- 2018

Similarly, according to a paper presented at the University of Southampton, biomedical engineers are in high demand globally, with future job growth expected worldwide as a result of increasing technology, the need for efficient and effective medical devices, combined with aging population. This growth is estimated to be at twenty-three percent (23%) from 2014 through 2024 as reported by the US Bureau of Labor Statistics (www.bls.gov).

2.6 RELEVANT PROFESSIONAL BODIES IN BIOMEDICAL ENGINEERING

1. Council for the Regulation of Engineering in Nigeria (COREN)
2. Nigerian Society of Engineers (NSE)
3. Association of Medical Devices Engineers (AMDE)
4. Nigerian Institute for Biomedical Engineering (NIBE)
5. Association of Biomedical Engineers and Technologists of Nigeria
6. American Institute for Medical and Biological Engineering
7. American Society of Biomechanics
8. American Society for Engineering Education, Biomedical Engineering Division (ASEE BME)
9. American Society of Mechanical Engineers, Bioengineering Division
10. Association for the Advancement of Medical Instrumentation
11. Biomedical Engineering Society (BMES)
12. European Society for Biomaterials (ESB)
13. European Society of Biomechanics (ESB)
14. IEEE Engineering in Medicine and Biology Society (EMBS)
15. Institute of Biological Engineering (IBE)

16. Institute of Physics and Engineering in Medicine (IPEM)
17. International Federation for Medical and Biological Engineering (IFBME)
18. International Society of Biomechanics (ISB)
19. International Society for Prosthetics and Orthotics (ISPO)
20. International Union for Physical and Engineering Sciences in Medicine (IUPESM)
21. Society for Biomaterials

2.7 THE ROLES OF BIOMEDICAL ENGINEERS IN ADVANCEMENT OF HUMANITY

Humans continuously strive towards improving their living experiences through perpetual improvisation of techniques for meeting the necessities of life (food, shelter and healthcare). However, engineering has always played vital roles in the eventual realization of these necessities. Advances in healthcare over the last century have helped man to devise means of improved understanding of his body systems both in healthy and diseased conditions. At the core of these advances is biomedical engineering discipline; from the stethoscope that detects heart sounds (vibration and waves) to the electrosurgical unit that is used for cutting soft tissues (using heat energy) to radiotherapy equipment that uses photon energy to destroy cancer cells.

In pursuance of effective and efficient healthcare provision, biomedical engineering has immensely helped to improve accuracy in medical diagnosis with the development of sophisticated imaging modalities like the Computed Tomography, Ultrasound, and Magnetic Resonance Imaging, this is in addition to the advancement in body fluid analyses using plate readers and other automation technologies.

Currently, there are efforts in the healthcare ecosystem towards genomic and personalized medicine (GPM); whose foundation is based on the understanding of the DNA (the genetic code of life). Biomedical Engineers and technologists have worked to build devices and algorithms that are expanding these possibilities. One of such possibilities is gene therapy; a procedure which can be used to correct genetic disorders and reverse some devastating illnesses such as sickle cell anemia and Parkinson's disease, is gaining wide acceptance in medicine. Another fascinating advancement in biomedical engineering is neural stem cell regeneration therapies, the new hope for individuals with spinal cord injury, stroke and those with brain disorders.

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