LANDMARK UNIVERSITY, OMU-ARAN

LECTURE NOTE 1
COLLEGE: COLLEGE OF SCIENCE AND ENGINEERING

DEPARTMENT: MECHANICAL ENGINEERING

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Course code: MCE 211

Course title: INTRODUCTION TO MECHANICAL ENGINEERING.
Course Units: 2 UNITS.
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Course Content:–

Place of mechanical engineers in the design, developing, manufacturing, and testing energy conversion of systems. Historical survey of their efforts that have resulted in the creation of combustion engines (used in automobiles, trucks, locomotives, airplanes, factories, and utility power plants) and other forms of energy conversion equipment, such as heat pumps, air conditioners, machine tools, and appliances. Challenges faced by Mechanical Engineers in structural analysis, materials selection, manufacturing, and design. Examples of their current roles in technology in relation to building of spacecraft and power systems, artificial limbs, and textile equipment, to mention a few. Career pursuits of mechanical engineers after graduation in sales, product quality control, maintenance, patent law, or research and development. The second part of this course shall be "Car Practical". This is to introduce the students to engines in general. A car will be made available to be dismantled and the various parts distributed to the students to study and find out their design characteristics and mechanisms of working. There shall be a Seminar at the end for the students to present their findings.

BRANCHES OF ENGINEERING AND ENGINNRING TECHNOLOGY

Learning Objectives
Prospective engineering students often find it difficult to make informed choice of discipline. Often every prospective student wants to enter the so-called popular field of engineering. Unknowing to them, successful career can be pursued in quite a wide range of branches of the engineering profession.

Note: **AT THE END OF THIS CHAPTER, THE READER SHOULD UNDERSTAND.**

(a) The development of the different branches of engineering profession
(b) The different branches, areas of specialisation and career opportunities.

HISTORICAL DEVELOPMENT OF ENGINEERING DISCIPLINE.

Engineering as an act, is as old as the history of man in his endeavour to produce food, build residential houses and places of worship, live in cities, establish governments, protect the environment and transport good and services from one place to another. In the production of food and fibre, irrigation engineering dates back to about 7000 years when in Mesopotamia and Egypt, organised tillage was achieved along the valleys of the Tigris and Euphrates Rivers and the Nile River valley. Cropping was by flood and channel irrigation. This led to better crop production and was the beginning of civilization ever known to man. A dam built about 5000 years ago to store water for drinking and irrigation still exist in Egypt. Other ancient irrigation projects have been reported in China, India, Syria, Persia, Italy etc. In Africa and Asia Minor, people started to build houses about 600BC. There were also the great pyramids of Egypt notably the pyramid of Dizeh built about 2700BC. At about 300BC cities started to exist and this as marked the beginning of the building market, churches, residential houses, temples, tombs, pyramids, great walls etc. (Schwab et al 1966). At the beginning, engineering was dominated by activities centred around tillage of soil an irrigation of the tilled land for food production; the building of houses, temples, churches, roads, drainage etc and other civil activities; fabrication of instruments of military purposes. Until the recovery of the wheel, engineering as an art was mostly applied for agricultural, civil (non-military) and military purposes. At the early stage of the development of the engineering profession, there was no sharp boundaries of differentiation except in terms of whether it was applied in agriculture, military or non-military (civil) purposes. Therefore, in the beginning, there were just three engineering disciplines namely agriculture engineering, military engineering (later turned to mechanical engineering) and non-military engineering (civil) engineering. The continuing need to live in houses, develop cities, build roads, supply water cities etc facilitated the speedy development of civil engineering. Fighting of wars and the need to produce war instrument, and movement of people, goods and services hastened the development of mechanical engineering. Out of the agricultural, civil and mechanical engineering disciplines of the old, there emerged many other engineering disciplines. The field of engineering are as diversified and extensive as the activities of the engineering in food production; in the design and development of machines; in the generation, transmission and distribution of electricity; in telecommunications, road construction, water supply, material and metallurgical, petroleum, gas and mineral industries; nuclear and chemical plants; sea, land and air transport etc. Based on these activities, the following engineering discipline could be identified. **Agriculture**, Soil and Water, Civil, Highway, Environmental, Water Resources, Transportation, Public Health, **Structural;** electrical, electronic, computer, **Communication Engineering;** Mechanical, aeronautical, instrumentation, **Industrial/Production** Marine, automobile, control, mining, refrigeration and air cooling engineering, chemical, petroleum, polymer, textile engineering, material Metallurgical and ceramic engineering. However, as civilization and technology advance, and specialisation widens, formalised new engineering disciplines are bound to emerge.

Mechanical Engineering

Definition of Mechanical Engineering

Mechanical Engineering is one of the pioneer disciplines of engineering and is widely regarded as the prime mover of the engineering profession.

Mechanical Engineering as a profession, involves the sciences of human and material management in industries involving man machine environment suitability (ergonomics and bio-engineering; the science of energy, mass and heat transfer to help conserve energy or dissipate energy as may be required; the science of energy conversion and use of material to produce useful work. This may involve power generating equipments, machines that produce or consume the power, the science and act of formulation, design, development, production/manufacture, operation, testing, selection, installation and controls of machines components and systems; the technology of transportation system like automobiles, trains, marine vehicle, air craft etc the technology of refrigeration, air-conditioning, ventilation and cryogenics ie (low temperature operation for liquefying gas) e.g liquid oxygen used in medicine, liquid hydrogen used in rockets, helium, argon used in lightening; the science of tribology; friction and wear of material; the mechanics of machines/solids and strength of material.

- *Areas of specialization in mechanical engineering*

The areas of specialisation in mechanical engineering and technology includes the following.

- Industrial and Production engineering
- Refrigerator and Air-conditional engineering
- Automotive engineering
- Marine engineering
- Mining engineering
- Power plant engineering
- Design and Manufacturing engineering

The areas of Industrial and Production Engineering is concern with the planning and designs of factory production and inventory; project planning, feasibility and monitoring; industrial machine design, development, selection, installation and maintenance, factory layout and industrial process design, economics of production; cost analysis and control. The production/industrial engineer must be aware of all the activities of the business enterprise. He has sound knowledge of the technology of production process, finance and accounting. He must be conversant with the important activities of design and manufacture and also be well acquainted with the modern methods and techniques available for the efficient operation of a production/industrial engineering establishment. The engineer is specially trained in the fundamental requirements of industries and is significantly equipped to solve problems of industry some of which could have both human and social dimension

A specialist in Refrigerator and Air-conditional engineering deals with psychometric and Air system designs; selection of refrigerant design, selection and installation of refrigerator and air-conditioning equipment’s etc

The Automobile/Automotive engineer is concerned with the planning and designing of automobile workshop; selection, testing and maintenance of the automobile system, auto-systems mechanics and vehicle dynamics; design, development and testing of all classes of engines; analysis and production of fuel and lubricants.

The Marine engineer is a specialist in marine operation, naval, architecture and ship building technology; ship prolusion including ship engines and power plants; ship equipment, marine diesel engines, steam boilers, steam turbines; meteorology and navigation.

The Mining engineering is a specialist in the geology of rocks and minerals; mine surveying; mining process and system design; mine ventilation, health and safety; design, developments, selection, installation, operation and maintenance of mining plants, process control and machinery.

The Design engineer is mostly involved with the design, development, selection and installation of machines, components, systems, machine elements, etc; failure and strength analysis of machine components and systems; design optimization; kinematics, rigidity and mechanics of machines tools and components; jigs and tool designs.

- *Career Opportunities in Mechanical Engineering*

Career opportunities in mechanical engineering are so wide that its difficult to enumerate. These include private and public industries, government ministries and parastatals, educational and research institutions and self employment. In the private sector, the mechanical engineer works in many manufacturing industries such as Michelin, Dunlop, Shell, Schlumberger, Chevron, Breweries, ANNAMCO and PZ.

- **Materials and Metallurgical Engineering**

2.8.1 *Definition of Metallurgical Engineering*

Materials and metallurgical engineering deal with the manufacture, extraction and properties of metals, non-metal and alloys as engineering material. Material engineering deals with the art, science and technology of the development, selection and use of metals and non-metals like ceramics, semi-conductors, polymeric, forest products etc Metallurgical engineering is concerned with the art, science and technology of extraction, property control, shaping, selection and use of metals and alloys Materials have played vital roles in the activities of man. The nature, kind and level of usage have been the basis of classification of human development and age. Hence, the stone, bronze, golden, silver and iron ages. The most common and most important material is metal and most activities of humanity depends on materials metals and non-metals.

- *Areas of Specialization in Metallurgical Engineering*

The areas of specialisation in materials and metallurgical engineering can be grouped as follows:

(1) Material Engineering

(2) Metallurgical Engineering
(3) Ceramic Engineering
(4) Polymer Science and Engineering

The Material engineering is concerned with the science and technology of development, selection and use of metals and non-metals materials. He is concerned with the choice and design of process technology to be used; thermal treatment of materials, foundry, corrosion of metals and controls; mineral processing, extractions etc. The metallurgical engineering deals with the science and technology of the development and utilization of metals and alloys through extractions, refining and alternation of the mechanical/strength properties of metals by alloying, working etc so as to meet the designed material requirement. He is conversant with the metallurgical processes and production, atomic bonding, metallurgical etc. The ceramic engineer deals with the application of scientific principles to the fabrication of ceramic products; the mining, refining and processing of raw materials and their manufactured into finished products; the design, construction and operation of the equipments needed are all encompassed in the works of a ceramic engineer. He understands ceramics processing, process planning and design; physical and solid-state ceramics, ceramics coating of materials, glass technology, heat treatment of ceramic material etc. The polymer engineer is conversant with the synthesis, structure, physical and mechanical properties of synthetic and natural polymers. He deals with the industrial application of polymeric materials, the mechanical, rheological and chemical, properties of polymer; polymer process engineering; rubber, ceramic and glass technology; medical and industrial application of polymeric materials; plastic foams and textile technology etc.

- *Career opportunities in Metallurgical Engineering*

All industries involved in the manufacturing of metallic and non-metallic products require materials and metallurgical engineers. Companies which are prime producers of metals and alloys are in need of metallurgical engineers. A good number of these engineer could be self-employed owning their own foundries or other metal products or ceramic manufacturing industries. Consultancy, research, teaching universities, polytechnics etc. are important career and employment opportunities. Specifically, the metallurgical engineer is useful in iron and steel, car assembly plants, iron ore mines, oil companies, steel rolling mills tin smelting and processing industries etc. Also jobs for the ceramic engineer can be found in refractories, glass, enamelled and abrasive industries; cement factories, iron and steel industries, beer and soft drinks industries. Similarly, the polymer engineer is needed in the natural polymer industries e.g wool, silk, leather etc, and in the plastic, textiles, paper, packaging and chemical industries.

- **Other Engineering Discipline**

The branches of engineering listed above should not be misinterpreted to mean that there only six disciplines. However, these are the major ones with many other subsidiaries. The other disciplines include:

(1) Production Engineering

(2) Aeronautical Engineering
(3) Marine Engineering
(4) Software Engineering
(5) Bio-medical Engineering
(6) Food Engineering
(7) Environmental Engineering.

WHAT MAKES YOU A PROFESSIONAL IN ENGINEERING?

KNOWLEDGE and skill, above that of the average person, is a characteristic of the professional man. Where a workman will have specific skills in operating a particular machine, a professional person is considered to be able to apply fundamental principles that are usually beyond the range of average workman. The knowledge of these principles as well as the skills necessary to apply them distinguishes a professional man. An important concept in the minds of most is that a professional person will perform a service for people. This means that service must be considered ahead of any monetary reward that a professional man may receive. In this respect, the professional person should, by himself recognize a need for personal services and seek ways to provide a solution to these needs. Almost all Engineering is performed to fill a need in some phase of our society. It may be to develop better appliances for the household, to provide better transportation facilities, or to make possible a better life in regions of unfavorable climate. Discretion and judgment also characterize a professional person. In most situations a choice of several methods to accomplish a given task will be available. The Engineer must consider the facts available and the principles that apply and make decisions based upon these rather than upon expediency. Consideration must be given not only to the mechanical aspects of a solution but also to the effects that a particular decision will have upon the person concerned.

The *code of ethnics also serves as a guide* to the members of the profession in their conduct and relations with each other, in Engineering, the professional society is the recognized National Society of Professional Engineers and in Nigeria, the Nigeria Society of Engineers. A general code of ethics for professional engineers has been set up by the Society. Usually, professionals will band themselves together for the mutual exchange of ideas, to improve their knowledge, and to learn new skills and techniques. Meeting and discussing problems with others in the same field of endeavour afford an opportunity for the stimulations of thought to improve learning and skills. In addition to the

National Society of Professional aspect of the whole field of specialization, we have the Institute of Electrical and Electronic Engineers. In the United States. But we have the Divisions here in Nigeria e.g the Division of mechanical engineers of the Nigerian Society & Engineers. Legal status usually is a characteristic of a professional. A medical doctor, for example, has certain rights and privileges afforded by a certification, licensing, or registration. In all States, a registration law is in effect which provides for legal registration of an engineer following submission of evidence of education and technical ability. Registration confers the legal title or “engineer” to the recipient, and he may use the initials “EE”. After his name to denote his registration as “Professional Engineer”, or “Engr”. In Nigeria. Once one is registered with the council for regulation of engineering in Nigeria (COREN)

PROFESSIONALISM

Professionalism is an individual’s state of mind. It is more than developing skills and acquiring knowledge. It is a way of thinking and living. The mere acquisition of knowledge may make a person a more skilled labourer or clerk but knowledge alone does not promote a desire to serve people. In the realm of service, the engineer joins the other learned professional groups with a concept of doing always what is honest and right than what is the legal minimum. Professionalism is not inherent in a person’s nature. Like the student is still in college while the student is still in college, the meanings of professional conduct and responsibility should be learned and the beginning of a professional attitude establish. Obviously, a person will not be a professional engineer upon graduation but the fundamental concepts required should be established so that as the engineering graduate goes into employment, he can continue rather than begin his professional advancement. In college courses in engineering, some professors will promote ideas of professionalism as they teach their course. For example, in laboratory work, an honest reporting of facts and an intelligent evaluation of results is a necessary part of professional training. After graduation, opportunities for public service will present themselves. The engineer, as part of his professional responsibility, should seek and accept places of service in schools, community government, religious organizations, and charitable groups. Not only will he be able to contribute his talents to these causes,, but also he will enhance his own outlook by contacts with both professional and non-professional persons, Each individual engineer should recognize within himself the need for a professional attitude and assume the ultimate responsibility for upholding this concept. It may be argued by some that professionalism is an abstract concept and that engineers deal only in real qualities. This generalization is not completely correct, for in the creative part of engineering, the ideas always come from a realm of abstraction. For example, if a requirement arises for a source of electric power to serve a community, the need for an engineering service constitutes a problem that the engineer must solve. A power plant may need to be designed. The location, size and fuel sources constitute part of the problem about which assumption are made, engineering surveys, tests, plans, and measurements are made to define particular parts of the construction. This, of course, is in the realm of reality. However, we recognize that in the design and construction of the plant, assumptions always must be made about features or conditions that cannot be subjected to definite measurements. Thus, we see by this example that engineer must be able to operate both in the realm of abstraction and in the realm of reality.

CHARACTERISTICS AND ROLE OF THE ENGINEER

Through the ages, the engineer has been in the forefront as a maker of history. His material accomplishments have had as much impact on world history as any political, economic, or social development. His accomplishments sometimes stemmed from the pressure of need from evolving civilization; at other times, his abilities to produce and meet needs have led the way for civilizations (developments) to advance. Outstanding characteristics of engineers through the ages show willingness to work and an intellectual curiously about the behavior of things. The enquirer on why? How? With What? And at what cost? have all served to stimulate the effort to find desirable answers to many types of technological problems. Another characteristics associated with engineers is the ability to see ahead. The engineer must have a fertile imagination, must be creative, and must be ready to accept new ideas. Basically, therefore, the role of the engineer has not changed through the ages. His job is to acquire knowledge and make practical use of it. He converts scientific theory into useful application, and in so doing provides for man’s materials needs and well-being. From era to era, only the objectives that he has pursued, the techniques of solution that he has used, and the tools of analysis at his disposal have changed. Engineering has made possible the many material things that make our lives more enjoyable and provide extra time for recreation and study. The Engineer will continue to provide innovation and creation designs to ease the burden of man's physical toil and convert the materials and forces of nature to the use of all mankind. Many people find themselves groping for an answer to the question, "How would I become an engineer.

First, we must realize that one does not become an engineer by studying a few courses. Engineering education is more than the ability to know when to manipulate a set of formulae, to know where to search in an armful of reference books, or to get accurate answer from slide rule or computer; it is also a state of mind. Through experience and training the engineer must be able to formulate problem statements, conceive and design solutions that many times involve novel ideas and creative thought process. The engineer must be able to exercise judgement and restraint, design with imitative, and must be completely honest and reliable. These qualities should mature as the student engineer advances to graduate level. The public expects all engineers to be competent technically. His profession has built up a record of producing things that work. No one expects a company to produce TV tubes that spontaneously explode, or a bridge that falls down, or an irrigation ditch that has the wrong slope. In fact, the technological failures of engineering are very rare. The engineering curriculums followed in colleges are designed to instill technical competence. The grading system generally used reward acceptance solutions and penalizes inferior or unworkable solution to practical problems.

The subjects studied are not easy, and usually, students who do not accept the idea of the exactness of nature's laws will not complete a college engineering course. This discipline has paid handsome dividends. The consistency of quality in the engineering graduate over the years has given the public a confidence that cannot be destroyed. It should be realized, however, that the completion of a college or university course is not the end of study for an engineer. The pace of discovery is so rapid today that even with constant study, the engineer can barely keep abreast of technological improvements. If the engineering graduate resolves not to continue his technical study, he would be far behind in technology within ten years. The engineer, then must be capable of dealing with technological problems, not only those which he may have been trained to handle but also new and unfamiliar problems in new discoveries.

OPPORTUNITIES IN ENGINEERING

Engineering students usually ask: "What if a start out in engineering and decide to another course of study?" Let us examine the possibilities. Normally, an engineering student will follow engineering as a profession. However, many students change their mind in college or after graduation. Many authorities agree that engineering courses are excellent training for a variety of careers and records reveals that as many as 40 per cent of people on management level have engineering education. One of the basic valuable training concepts of engineering education is teaching students to think logically. This means the training and experience gained in engineering courses still will prepare a person for a wide variety of occupations.

TECHNOLOGY AND ENGINEERING FUNCTION.

The work of the Engineer

DURING the year that he (Student) is in the college, as already indicated in the previous lecture, an engineering student will study courses in many subject areas. He will study language courses to better prepare him in organizing and presenting ideas effectively; mathematic courses to learn the manipulation of symbols as an aid in problem solving; social science courses to help him better find his place in society as an informed citizen, and various technical courses. In the study of technical courses', during his training, the engineer becomes familiar with a store of factual information that will form the basis for his engineering decisions. The nature of these technical facts, in general, determines the major field of interest of the trainee. For example, he may decide to concentrate in some particular. Fields such as civil, chemical, industrial, or mechanical engineering. The college courses provide training in the learning of cats and in developing the powers of reasoning. Since it is impossible to predict what ki9nd of work a practicing engineer will do after graduation; the objective of an engineering education is to provide a broad base of facts and skills upon which the engineer can practice his profession. It is not sufficient to say that an engineer is working as a civil engineer. His work covers a wider spectrum. As a civil engineer, he may be performing researches on materials for surfacing highways, or he may be responsible for the budget preparation of a missile launch project in government service. There are many things a practicing engineer will be called upon to do which are not described in his course of study. The types of work the engineer may do, as differentiated from his field of specialization, can be called “engineering function”. Some of these functions are research, development, design, production, construction, operations, sales and management. In some engineer functions, such as the management of manufacturing plants, specialization is of lesser importance, whereas in other functions such as research in transistor theory, specialization may be extremely important. To understand more fully the activities of a practicing engineer, let us examine some of the functions.

Design.

In the modem way of life, mass production has given us cheaper products and has more articles made available than ever before in history. In the process of producing these articles, the design engineer enters the scene just before the actual manufacturing process begins. After the development engineer has assembled and tested a device desirable to produce for a mass market, a design engineer will handle the final details of making it adaptable to produce. In his role of bridging the gap between the laboratory and the production line, the design engineer is a very versatile individual. He must be well grounded in basic engineering principles and mathematics. He must not only understand the capabilities of machines, but also the temperament of the men that operate them. He also must be conscious of the relative costs of producing items, because his designs will determine how long the product will survive in the open market. Must the device or process work, it must be made in a style and at a price that will attract customers. Take example of a clock, a simple device used to indicate the time. It includes a power source, a drive train, hands and a face. Using these basic parts, engineers have designed spring driven clocks, weight driven clocks and electricity driven clocks with all variations of drive trains. The basic hands and face have been modified in some models to give a digital display. The case has been made in many shapes and perhaps in keeping with the slogan “time files”; it has even been streamlined! In the design of each modification, the design engineer has determined the physical structure of the assembly, the aesthetic features and the economies of producing. The work of the design engineer is not limited solely to perfuming engineering on mass produced items. Design engineers work on projects such as bridges or buildings in which only one of a kind is to be made. However, in such work he is still fulfilling the design process of adapting basic ideas to provide for a complete product. In this type of design the engineer must be able to use his training, almost intuitively, arrive at design solutions which will provide for adequate safety without redundancy. The more the structural material are studied the better engineers can design without additional materials for the “ignorance factor”. In the aviation industry, design engineers have attempted to use structural materials with minimum excess as a safety factor. Each part must perform without failure, and every weight must be saved. To do this fabricated parts of the design must be tested for resistance to failure on the static loads or vibratory fatiguing loads. Also, surface roughness has an importance bearing on the fatigued lives of parts, which are subjected to high stress and repeated loads. Attention must be given to surface finishes to meet certain requirements. Design work involves a production phase, so the design engineer considers cost as a factor in our competitive economy. One of the ways in which costs can be minimized in manufacturing or construction is to use standard parts, sizes and dimensions for example, if a machine were designed using non-standard bolts threads or a bridge design using non-standard steel I-beams, the design probably would be more expensive than needed to fulfill its function. Thus, the design engineer must be able to coordinate the parts of his design to function acceptably and must be produced at minimum cost. The design engineer realizes that there is more than one acceptable way to solve a design problem. Unlike an arithmetic problem with fixed numbers, which gives one answer, his problem can have many answers and many ways of obtaining a solution, and all may be acceptable. In such case, his decisions therefore are a matter of experience and sound judgments. His solutions to problems must be conscious efforts to provide the best methods considering fabrication, costs, and sales. What are the qualifications of a design engineer? He must be creative. Every design of his embodies a departure from what has been done before, though he is constrained by the reality of the physical properties of materials and economic engineering in a wide range of subjects. In addition, he must be familiar with basic principles of economics from the standpoint of employing people and using machines **AB** he progresses into supervisory and management duties, knowledge of psychology and economics becomes more crucial. design engineers will need more management courses than will research or development engineers.

Operations

In modern industrial plants, the number and complexity of machines, the equipment and building to be cared for and the planning for expansion underscore the relevance of specialized engineers. If a new manufacturing facility is to be constructed, or an addition made to an existence facility, the plant engineer will prepare the basic design, the proposed layout of space and location of equipment; he will also specify the extent of illumination, communication and air conditioning necessary. The work of construction could be contracted to outside firms but it will be the general responsibility of the plant engineer to plan it. After building, the plant engineer and his staff are responsible for the maintenance of the building, equipment, grounds, and utilities. This work varies from the routine tasks, to setting and regulating the most complex and automated machinery in the plant. The plant engineer must have a wide knowledge of several branches of engineering to perform these functions. For land acquisition and building construction, he needs the knowledge of civil engineering; for equipment and machinery, he needs mechanical training; for power, mechanical and electrical backgrounds are essential; And for specialized parts of the plant, his knowledge in such field are chemical, metallurgical, petroleum, or textile engineering will be tasked. In plants, particularly utility plants, the engineer is concerned with the operation of the plant. He sees that boilers, generators, turbines, and accessory equipment operate efficiently. He should compare costs of operating under various conditions, and set schedules for machines so that best use will be made of them. In chemical plants'' the engineer will regulate the flow and temperature at the levels to produce the greatest amount of desired product at the end of the time. In his dual role as the plant and operations engineer, he will constantly evaluate new equipment to see whether additional operating economics can be secured by retiring old ones and installing the new types, or to concentrate on refurbishing exercise. In this, he must frequently assume a salesman's role to convince management to discard the old equipment and spend money for new models when necessary. Here, the ability to combine facts of engineering economics is invaluable.

Plant engineering is closely associated with production engineering process. The production engineer will create needs foe new machines, new facilities, and new locations. The plant engineer will correlate things like the building layout, machine location, power supplies, and materials handling equipment to serve the needs of production. The general qualifications of plant and operations engineers have already been mentioned. They must have basic knowledge of a wide variety of engineering fields such as civil, chemical, electrical, and mechanical, and also posses specialized knowledge in areas peculiar to their plant and operations. In addition, the plant and operations engineers must work with men and machines to know what results to expect from them. In this part of their work, knowledge of industrial engineering principles is of great value. It is desirable to have basic understanding of economics and business law, training in detailed research procedures and abstract concepts are of lesser importance.

Integrating Science, Technology and Engineering

Adaptive Technology

Modern engineering began around the close of the World War II; Nigeria closed its own Civil War in 1970. After these periods, the pace of discovery had been so rapid that it can be regarded as a period within itself. One of the reasons for this significant development of technology at these periods is the increasing close cooperation between scientists and engineers. It is more evident that discoveries by research scientists can be used to develop new articles for commerce, while industries have realized that money spent for research and development eventually return many times its value. In the expending realm of science and technology, the engineer is a member of a three-part team of technical specialists. These specialists are engineers, scientists and technicians. Although their spheres of activity overlap, they fit into specific roles appropriate to their interests and areas of work.

The primary objective of the scientist is to discover and expand the fields of knowledge, to correlate observations and experimental data into formulation of laws, to learn new theories and explore their meanings, and to broaden the horizons of science into the unknown.

The engineer is concerned primarily with the application of discoveries to human benefit. It is his objective to design, plan, develop and construct useable devices that employ scientist principles. In this role, he must understand the laws and principles of science to be able to make practical applications of new discoveries. For example, recent discoveries by food scientists made it possible for engineers to fabricate the So *yogi* plant. The list of such co-operations in Nigeria today is numerous. It should be noted that the history of engineering in Greece had its origins in Egypt and the East. The Greeks of Athens and Sparta borrowed many of their developments. In fact, the engineers of this period were better known for the intensive development of borrowed ideas than for original creativity and invention. Their water system, for example, modeled after Egyptian irrigation systems, showed outstanding skill in the use of labour and materials. Since Nigeria had been importing various equipment and engineering systems for some decades now, it is very obvious that a lot of adaptive and copy technology should be encouraged. India is virtually crossing from the developing tag to a developed country by the use of adaptive and copy technology. This also happened in Japan.

Maintenance Technology

In modern industrial plants, the number and complexity of machines, equipment and buildings to be cared for, and the planning needed for expansion has brought about the need for specialized engineers to handle the plants. When buildings are completed and facilities installed the plant engineer and his staff is responsible for the maintenance of the building, equipment, grounds and utilities. This work varies from routine tasks, to setting up and regulating the most complex and automated machinery in the plant. For emphasis, we need to state her that the plant engineer must have a wide knowledge of several branches of engineering to perform his functions. Specifically, he needs courses in civil engineering for building construction and maintenance; for equipment, machinery as well as power he needs mechanical and electrical training, and for the specialized parts of the plant, his knowledge in such fields as chemical, metallurgical, nuclear, petroleum or textile engineering will be invaluable. (Please see section under "Operation") The lack of maintenance ability in the developing world has led to huge sums of money being used to purchase new equipment and facilities at all times. In Nigeria for example, many government agencies can just not perform because their equipment is not in good working order. They always source for money to purchase new one while the old (but maintainable) equipment is virtually wasting away. When buying new equipment, there is the need to see that the staff of the company, for better performance and long life, can maintain such. There is the constant need in a developing society like ours to have a maintenance drive. For a good maintenance programmed, there must be a source for the spare parts; hence fabrication technology is a needed to back up our maintenance drive.

Fabrication Technology

This is the field for the production and construction engineers. These engineers assist the technicians and mechanics, and help fabricate labour and production equipment. They take the design engineers' drawing and supervise the assembly of the objects as conceived and illustrated by the drawings of models. Usually, a production or construction engineer is associated with the process of estimating and bidding for competitive jobs. To do this, he employs his knowledge of engineering materials, fabrication processes, and general physical principles to estimate both time and financial cost to accomplish tasks. Here, the engineer must complete the details of the designer's plans. He must also provide the engineering for the use of special tools need for the work. He must e able, at any time, to answer questions that technicians or workmen may raise on the features of the design. He should be prepared to advise design engineers on desirable modifications that will aid the construction or fabrication processes. Preparation of schedule for production or construction is an important task of the engineer. In the case of an industrial plant, all planting for the procurement of raw materials and parts will be based on this production schedule. An assembly line in a modern automobile manufacturing plant is an example to illustrate the necessity for scheduling the arrival of parts and subassemblies at a predetermined time. In general, the production engineer must have a good understanding of the operations and must be able to visualize the parts of an operation, whether it is the fabrication of a solid-state computer circuit or the building of a concrete bridge. For developing economy, the need to simplify fabrication make it relevant and more attractive can not be overemphasized. The introduction of cottage industries where implements, equipment and facilities relative to the economy of the area can be encouraged. The fabrication of spare parts from the bedrock of a maintenance drive and culture. With the right attitude to production of spare parts and experience in aspect of copy technology whereby equipment imported are dismantled and similar. Ones fabricated-It will be easy and less expensive to invest in fabrication technology.

Research and Development Technology

Today, research is one of the more glamorous functions of engineering. In research, the engineer delves into the nature of matter, explores processes to use engineering materials, and searches for reasons for the behavior of the things that make up our world. In many instances the work of the scientists and the engineer engaged in research will overlap. The work of scientists is closely allied with research. The objective of research is to discover truths. The objective of the research engineer is directed towards the practical side of a problem, not only to discover but also to find a use for discoveries. The research engineer must be perceptive and clever. He must be able to work patiently at task never before accomplished and must be able to recognize and identify phenomena previously unnoticed. Until the last few decades, all researches were independent work by individuals. However, with the expansion of the fields of the sciences. The development engineer does not deal exclusively with new discoveries; a major part of his work involves using well-known principles and employing existing processes or machines to perform a new or unusual function. It is in this region that many patents are granted. In most instances the tasks of the research and development engineers are dictated by the immediate requirements. For example, since the export of cocoa beans was discouraged, a new type of plant was needed to process coca locally. Suppose that the development engineer does not know of any plant that could perform the task desired, should he immediately invest a device? The answer, is, 'No'. First, he should explore the file of available literature or any other sources. If no device is available, a system of existing subassemblies may be set up and joined to perform the task. For a developing nation like Nigeria, a lot of research and development programmers depends essentially on government policies. The universities, polytechnics, and research institutes can lead the way, but the relevance of their work has to be guided by specific government policies such that the research and development efforts will suit Nigerian situations. Most multi-national companies send their research and development problems to their home countries for investigation while the facilities here, are not being fully utilized and of course assisted adequately by government and the big multi-nationals a s to funding. Government, with adequate fund to execute the development projects, should supervise the work of the research centres. It is good to note that two developments have produced profound changes in our lives. These are nuclear power and the computer technology. There is still a lot of room for development in these areas, though historians of the future may well refer to our present time as the nuclear age or the computer age. The engineer of course has been a principal developer of their concepts because of the need for their capabilities.

Engineers in Management.

Recent surveys show the trend that more engineering graduates are moving into management positions, so thee is need to examine the function of an engineer in management. The basic functions of the management of a company are largely similar. For example, these involve using the capabilities of the company to produce a desirable product in a competitive economy; the use of the capabilities varies widely depending upon the enterprises involved. The executive of a company, large or small, has the equipment n the plant, the labour force, and the financial assets of the organization to use in the plant's operations. The management must make decisions involving all the three factors. In the past, it was assumed that only persons trained in business administration should aspire to management positions, however, it has been recognized that the education and the abilities which make a good engineer also provide the background to make a good management executive. The training for correlating facts and evaluating course of action in making engineering decision can be carried over to management decision on machinery, men and money. In general, the engineer is technically strong but may be native in the realm of business administration, therefore, it is in business that the engineer must work harder to develop his skills. The engineer in management is concerned more intensely with the long range effects of policy decisions where, for example, the design engineer considers first the technical phases of a project, the engineer in management considers how a particular decision will affect the men who work to produce the product and how the decision will affect the financiers of the operation. This is why the management engineer is concerned with the technical aspects of his profession just like financial, legal, and labour aspects. The growing need for engineers in management shows that the type and complexity of the machines and processes used in today's plants require a blending of technical; and business training to carry on effectively. This trend is noted in most engineering industries where majority of executive managerial positions are occupied by engineers and scientists. Of course, management positions are not executive positions, but the ability to apply engineering principles in supervising work involving large numbers of men and large amount of money is a prerequisite in management engineering.

Other Engineering Functions.

A number of engineering functions that do not fall into the categories previously described can be considered. Some of these are *testing, teaching and consulting.* As in the other functions, there are no specific curricula leading directly toward these types of work. Rather, a broad background of engineering fundamentals is the best; the work resembles design and development functions most closely. Most plants maintain a laboratory section that is responsible for engineering tests of products or for quality control of products. The *test engineer* must be qualified to follow the intricacies of a design and to build suitable test machinery to give an accelerated product. For example, in the automotive industry, not only are the completed cars tested, but also components such as engines, brakes, and tyres, are tested to provide data to improve their performance. The test engineer must be able to set up quality control procedures for production lines to ensure that production meets standard requirements. In this work, training in mathematics and statistical theory is helpful.

A career in *teaching* is rewarding for many persons. A desire to help others in their learning process; a concern for other personal problems and a thorough grounding in engineering and mathematics are desirable for those considering teaching engineering subjects. In the teaching profession, the trend today is towards the theoretical aspects of engineering, and teaching is more closely allied withy research and development functions. All colleges now require the faculty to conduct advanced degrees, so a person desiring to be and engineering teacher should consider obtaining a decorate degree in his chosen field. More and more engineers are going into *consulting* services. Employment, as an engineering consultant, can be either part time or full time. Usually a consulting engineer possesses specific skills in addition to several years of experience. He may offer his services to advices and work on engineering projects.

Frequently, two or more engineers will form an engineering consulting firm that employ other engineers, technicians, and draftsmen and will contract for full engineering services on projects. The firm may restrict engineering work to narrow categories such as the design of irrigation projects, power plants, or aerospace facilities, or a staff may be available that is capable of working on a complete spectrum of engineering problems.

On the other hand, a consulting engineer can operate alone. His firm may consist of a single individual with skills to advice and direct on an operation to tackle a given problem. For instance, he may consult for an industrial plant and the plant maybe able to economically solve a given problem, if the plant seldom needs specialization. As may be inferred, a consulting engineer must have specific skills to offer, and he may be able to use his creative ability to apply the skills to unfamiliar situation. Usually, these skills and abilities are required only after several years of practice and postgraduate studies. For a person who desires self-employment (together with its business risks but also with opportunity for financial reward), consulting work is an inviting part of the engineering profession.

Summary

As described earlier, training and skills in all function are basically the same; that is, fundamental scientific knowledge of physical principles and mathematics. However, it can be seen that research on one hand and management on the other require educational preparations.

For work in research, emphasis is on theoretical principles and creativity, with little emphasis on economic and personnel considerations. In management, attention is given to financial principles. Between these two extremes, we find emphasis on the research oriented or managerial oriented concepts.

To summarize the functions of the engineer, we can say that in all cases he is a problem solver. Whether it is a mathematical abstraction that may have an application to a nuclear process or meeting with bargaining group at a conference table, it is a problem that must be reduced to its essentials and the alternatives explored to reach a solution. The engineer then must apply his knowledge and inventiveness to select a reasonable method to achieve a result, even in the face of vague and sometimes contradictory data. In general, a long record of successful industrial management and productivity proves to accomplish this that the engineer had been able.

Much of the changes in our civilization in the past hundred years have been due to the work of the engineer. We hardly appreciate the changes that have occurred in our environment unless we attempt to picture the world of few generations ago without automobile, telephones, radio, electronics, and aircraft, automatic machine tools, electric light, television, and all the modem appliances in our homes.

Development in the field of science and engineering is progressing so rapidly at pr 8nt that within the last ten years we have acquired materials and devices that are now common place but which were unknown to our parents. Through research, development, and mass production, directly by engineers, ideas are made into realities in an amazingly short time.

In all, the engineer's role is very important and crucial. For a country like ours, development can only come through technology and practice. Structures and plant must be made to work. Funds made available for plant and equipment must be well managed, just as the present economic situation in Nigeria should put engineers in the right frame of solving problems by putting their skills and expertise to gainful use. Government must, as a deliberate policy, provide the enabling environment for innovation, skills professionalism and the technology to prosper.