ICC

ENG 101: THE ENGINEER -IN- THE SOCIETY

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Credit Unit: 2.

Assessment: Attendance – 5%; Assignments & Test – 35%; Examination – 60%

Course Outline & Lectures

- Philosophy of Science.
- History of Engineering and Technology - Introduction, career, who is an engineer, basic skills and requirements in engineering, career development in engineering, the needs of the society, developmental needs of the third world countries
- Safety in Engineering and Introduction to Risk Analysis
- The Role of Engineers in Nation Building - the engineer role in Nigerian local content initiative, the development of different branches of engineering, engineering and the different specializations, Engineering ethics and conducts, the engineers role in vision 2020, public interest and the professional, the engineers code of practice, design specifications and standards
- Invited Lectures from Professionals.

PHILOSOPHY OF SCIENCE

"Scientists discover the world that exists; engineers create the world that never was." - Theodore Von Karman. The modern scientific picture of the world seems to tell us a great deal, not just about how things are now, but how they were millions and even billions of years ago. Astrophysics tells us about the formation of the Earth, the solar system and even the universe, geophysics tells us about the development of mountains, continents and oceans, and biochemistry and evolutionary biology tell us about the development of life itself. Such scientific theories tell us more about familiar things, so, for example, we may learn where a particular river used to flow or how bees pollinate flowers. Generally, science can be defined as a body of knowledge, a way of investigating or method, and a way of thinking in the pursuit of an understanding of nature. The products of science include concepts, facts, generalizations, laws, and theories.

HISTORY OF ENGINEERING AND TECHNOLOGY

The word engineer began to appear during the Dark and Middle ages (*with the collapse of the Roman Empire in the fourth and fifth centuries A.D., what is known as Dark Ages descended on Europe*). Its root lies in the latin word *ingeniare*, "to design or devise". About A.D. 200 ingenium was used to described a battering ram, and by A.D. 1200 ingeniator was used to describe a person who operated machines of war. Thus, there is a tie-in with inventiveness and warfare in the word and background of engineering. It remained for the industrial age to blossom with the use of mathematics and Newton's laws of motion, for the engineer to combine native inventiveness with scientific theory to create the power of design and analysis available today.

The term *engineering* itself has a much more recent etymology, deriving from the wo[rd] *engineer*, which itself dates back to 1325, when an *engine'er* (literally, one who operates a[n] *engine*) originally referred to "a constructor of military engines." In this context, now obsolete, an "engine" referred to a military machine, *i. e.*, a mechanical contraption used in war (for example, a catapult). The word "engine" itself is of even older origin, ultimately deriving from the Latin *ingenium* (c. 1250), meaning "innate quality, especially mental power, hence a clever invention." Later, as the design of civilian structures such as bridges and buildings matured as a technical discipline, the term civil engineering entered the lexicon as a way to distinguish between those specializing in the construction of such non-military projects and those involved in the older discipline of military engineering (the original meaning of the word "engineering," now largely obsolete, with notable exceptions that have survived to the present day such as military engineering corps, *e. g.*, the U. S. Army Corps of Engineers).

THE ENGINEER AND THE SOCIETY

Engineers are entrusted with the highest level of responsibility protecting the public health, safety and welfare. The profession is therefore defined as a 'calling in which special knowledge and skill are used in a distinctly intellectual plane in the service of humanity (in which) there is implied the application of the highest standards of excellence…in the ethical conduct of its members.

President Herbert Hoover once noted: "It is a great profession. There is the satisfaction of watching a figment of the imagination emerge through the aid of science to a plan on paper, then it moves to realization in stone or metal or energy. Then it brings jobs and homes to men. Then it elevates the standards of living and adds to the comforts of life. That is the Engineers high privilege".

The great liability of the engineer compared to men of other professions is that his works are out in open where all can see them. His acts, step-by-step, are in hard substance. He cannot bury his mistakes in the grave like the doctors. He cannot argue them into thin air and blame the judge like the lawyers. He cannot, like the architects, cover his failures with trees and vines. He cannot, like the politicians screens his shortcomings by blaming his opponents and hope the people will forget. The engineer simply cannot deny he did it. If his works do not work, he is damned….. On the other hand, unlike the doctors, his is not a life among the weak. Unlike the soldier, destruction is not his purpose. Unlike the lawyer, quarrels are not his daily bread. To the engineer falls the job of clothing the bare bones of science with life, comfort, and hope (Fredrich 1989: 546).

With the Engineers' high privilege comes a concomitant high responsibility – protecting the public health, safety and welfare. Entrusted with the highest level of responsibility, the engineers' credibility, trust, reputation, and high ethical standards remain paramount.

Engineering generally is a profession that provides comfort for mankind. The difference between the sixties and the twenties is engineering i.e. new communication, road networks, airways e.t.c In all, the engineer has a key role to play in things that improve the quality of life - Transportation, (Roads, Railways, Airports, Marine etc), Telecommunication, Water Supply Systems; Transport Facilities. The engineer comes across as one in constant relation with the public..

Large resources are also placed at the disposal of the engineer – men, materials, machineries and money. Crowning all these is the resource of confidence which he has been generously given. How does the engineer manage these resources to the satisfaction of those who have placed confidence in him. Does the public get value for money on the resources invested?

Establishment of the Council for the Regulation of Engineering in Nigeria

There shall be established on the coming into force of this Act, a body to be known as the Council for the Regulation of Engineering in Nigeria (hereafter in this Act referred to as "the Council") which shall be a body corporate by the name aforesaid and be charged with the general duty of —

(a) determining who are engineers for the purposes of this Act;
(b) determining what standards of knowledge and skill are to be attained by persons seeking to become registered as engineers and raising those standards from time to time as circumstances may permit;
(c) securing, in accordance with the provisions of this Act, the establishment and maintenance of a register of persons entitled to practise as registered engineers and the publication from time to time of lists of those persons;
(d) regulating and controlling the practice of the engineering profession in all its aspects and ramifications;
(e) performing the other functions conferred on the Council by this Act.

[1992 No. 27]

WHO IS AN ENGINEER?

The word "engineer" is derived from the Latin verb ingeniare, which means to design, or create. Engineers are creative people who invent, develop, and manage the manufacture of their creation. Engineers are characterized by their continuous quest for knowledge and their work revolves around this quest.

The Engineering mindset is to define a problem, identify solutions to the problem, select the best solution and then implement this solution. COREN has identified four cadres in the practice of engineering in Nigeria. These are *the engineer, the technologist, the technician, and the craftsman.*

An engineer is one who acquires and uses scientific, technical and other pertinent knowl[edge] and skills to create, operate or maintain safe, efficient systems, structures, machines, pla[nts], processes or devices of practical and economic value. The work of an engineer i[s] predominantly intellectual and varied. It requires exercise of original thought and judgement concerning the development of new systems and technologies; the ability to supervise the work of others and in due time, the maturity to assume responsibility for the direction of important tasks, including the profitable management of industrial and commercial enterprises. In their work engineers have a responsibility to the society with regard to the ethical, economic and environmental impact of technical needs and changes. *By qualification, engineer shall be a person who has attained an academic standard of education in engineering science and holds a degree or equivalent qualification, following a course of studies in an approved programme of a university or recognized institution.* By this education and training, engineer shall have the ability to think in the abstract and be able to synthesize view of events which are not obviously linked together and demonstrate a sufficient degree of practical knowledge in order not to limit himself or herself to theory.

Engineering technologists require specific and detailed knowledge of the bases and practices of current technology and are concerned with maintaining and managing existing technology efficiently. By qualification, engineering technologist shall be a person who has attained a standard of education and training in engineering technology and holds a Higher National Diploma or equivalent qualification from an institution offering an approved programme of studies. His primary roles within the profession shall include the application of known and proven techniques in the execution and management of engineering works.

Engineering technicians are competent by virtue of their educational training and practical experience to apply proven techniques and procedures to the solution of practical problems with an element of personal responsibility, usually under the guidance of engineers or engineering technologists. By qualification, technician shall be a person who has attained a standard of education and training in engineering technology and holds a National Diploma, or equivalent from an institution offering an approved programme of studies. His primary role within the profession shall include the application of known and proven techniques, supervision of appropriate details of project execution, the diagnoses of faults, the day to day operation and maintenance of engineering plant, services and establishments, and the design and development of simple engineering projects.

The craftsman shall possess the skill to recognize and utilize engineering tools and materials to produce, execute and maintain engineering plant and services. His primary role within the profession shall include the responsibility for the execution of specific jobs in projects; the use of engineering tools and materials applicable to his specific vocation in the high grade production of engineering plant and services thus forming the essential support for the engineering technician where appropriate.

Responsibility of an Engineer

The engineer must be competent by virtue of his appropriate education and training:

i. To apply scientific methods and outlook to the analysis and solution of engineeri problems.

ii. To develop a thorough understanding of the special features of a branch engineering including interdisciplinary aspects, and closely and continuous following progress on a world-wide basis, assimilating such information and applyin it independently so as to be in a position to make contributions to the development c engineering science and its application.

iii. To assume personal responsibility as the occasion demands in research, design construction, manufacture, marketing, managing and in the education and training o engineers.

iv. To acquire a broad and general appreciation of engineering activity outside his own branch, together with an understanding of the public context of an engineer's work in social, organizational and economic terms and the effective and beneficial management of resources.

Registration as Engineers

(1) Subject to section 16 and to rules made under section 4 (4) of this Act, a person shall be entitled to be fully registered under this Act (COREN Acts 2004) if –

(a) he has attended a course of training approved by the Council under the next following section;

(b) the course was conducted at an institution so approved, or partly at one such institution and partly at another or others;

(c) he holds a qualification so approved; and

(d) he holds a certificate of experience issued in pursuance of section 9 of this Act; and

(e) he has completed a minimum of two years' approved post-graduate training and has passed or is exempted from professional interview; [1992 No. 27]

(f) in the case of a craftsman, he has completed a minimum of two years' working experience in his trade and submits an acceptable certificate of experience; [1992 No. 27]

(g) he has completed his second year of industrial pupilage in an approved establishment. [1992 No. 27]

(2) Subject as aforesaid, a person shall also be entitled to be fully registered under this Act if he satisfies the Councilthat he is of good character;

(a) that he holds a qualification granted outside Nigeria and for the time being accepted by the Council for the purposes of this subsection as respects the engineering profession;

CHAPTER 1

INTRODUCTION TO SCIENCE, TECHNOLOGY AND ENGINEERING

1.1 Learning Objectives

The three words - Science, Technology and Engineering are so related that most times they are used interchangeably, making it almost impossible for people to know the exact meaning of each of them. At the end of this chapter, the reader should:

(a) be able to differentiate between Science, Technology and Engineering and understand the relationships between them;
(b) understand the roles of the engineer as an artist and the roles of the engineer in the advancement of society at large;
(c) understand the engineering family by knowing the different cadres in the profession and their roles.
(d) understand the historical development of engineering and technology.

1.2 The Meaning of Science

The propensity of human beings and in fact other lower animals to probe and understand their environment is as old as creation or evolution. The Holy Bible gives a clear example of this thirst for knowledge through the story of the fall of Adam and Eve. The serpent convinced Eve to taste the forbidden fruit in the Garden of Eden. Subsequently, Eve convinced the husband Adam to do so. The motivating factor which the serpent used was that if they tasted the fruit, they would be as wise as God and know every thing that God knew. The life of a new born baby revolves around exploring his environment and this is why most babies are fascinated by sharp colours, moving objects and songs.

Sometimes, the search for knowledge produces only facts on how and not necessarily on why things happen. In general, things that cannot be explained are accepted as facts. For example it is a fact that night and day alternate every twenty four hours, rains fall during a certain period of the year, animals give birth to offsprings of their like, objects fall to the ground each time they are thrown up, the solar system maintains a certain order, fire consumes anything it comes in contact with, the human organs function in a certain manner.

It is the natural need to understand how and why these things happen in our environment that gave birth to science. In trying to understand these phenomena some quantitative and qualitative data have been generated over the years. These have led to the establishment of certain scientific laws which are generalizations of repeatedly observed phenomena. Such laws include Newtonian laws that govern motion of bodies, laws of thermodynamics, evolution principles and laws of gravity.

We can, therefore, begin to see science as a system of data and relationships covering vast areas of information derived from observation, analysis and manipulation of natural phenomenon (Pytlik, et al., 1985). It has also been defined as a systematic study of nature, and behaviour of the material and physical universe, based on observation, experimentation and measurement as well as formulation of laws to describe these facts in general terms.

The implication of the definitions above is that once a body of knowledge is regarded as science, it stands the test of time, since it is based on years of accumulated information, obtained in a systematic manner. The knowledge holds correct any where in the world with minor modifications to account for locational differences. For example, the laws of gravity holds correct any where on earth, although the gravitational constant varies slightly from one place to the other. Another good example is the law that governs the flow of electricity through wires. This law holds correct whether one is in Nigeria or in Germany.

It is this general belief on the "truth" of scientific principles and laws that made authorities in the olden days to regard scientific principles as "truth from God". With such beliefs and the fact that the state and religion were inseparable in those days, people that had contrary opinions to established scientific principles were regarded as traitors. In the days of the Roman Empire for example, radical scientists who came up with ideas that were at variance with established ones were treated as out laws. For questioning the "truth", Galileo was tried by Pope Urban VIII when he disagreed with the Copernician Theory. Another scientist,

Giodano Bruno was burnt to death under similar circumstances. In the present day scientific community, there is always resistance when a finding contrary to established laws is announced or published.

Scientific principles and laws are used to explain all aspects of human existence and the universe. This has led to the division of science into physical, social, management and biological sciences. The physical sciences deal with relationship between bodies and objects that are non-living. Such body of knowledge include principles guiding the behaviour of metals, chemicals, sand, water, air and other physical phenomena. Biological sciences deal with understanding how and why living things function the way they do. Examples include the functioning of the human body, other animals, plants and related things. The social sciences deal with laws of human behaviour which cannot be qualified physically. The body of knowledge that covers procedures for modern day management of human and material resources is referred to as Management Science.

Scientific ideas and laws are varied. In some cases, it appears that they cannot have any practical application and are referred to as Pure Science. In other situations, they have direct practical application and therefore are referred to as Applied Science. It is the application of science that gives physical meaning to knowledge resulting in technological and engineering application. For example, the law of conservation of energy which states that energy can neither be created nor destroyed but can only be converted from one form to the other became useful when the knowledge was applied in converting heat energy to kinetic energy. This led to the development of the technology of engines. But what is technology?

1.3 The Meaning of Technology

The word "Technology" has been used to mean different things to different people and circumstances. Thus different authors have defined technology from different view points. Spier (1968) stated "...technology embraces the means by which man controls or modifies his natural environment". Toffler (1970) sees technology as "that growling engine of change". Avensberg and Niehoff (1971) agree that "the technology of people is their major means of adjusting to environment". Popenoe (1971) thinks that technology is "a special kind of knowledge which is directed towards practical applications in the physical and social world". Technology has also been defined as "the information, techniques and tools with which people utilize the material resources of their environment to satisfy their various needs and desires (Lenski and Lenski, 1979). For Hanks (1979), it is the application of practical or mechanical sciences to industry or commerce. A more comprehensive definition was given by Pytlik et al (1985) as "a study of the technical means undertaken in all cultures which involves the systematic application of organised knowledge and tangibles (tools and materials) for the extension of human faculties that are restricted as a result of the evolutionary process". In another definition it was seen as the technical know-how, scientific ideas, information, knowledge, materials or goods and services capable of being systematic and sequential in its generation; communicable and adaptable to application in a given economic, political, social and cultural milieu. From these definitions, we can conclude that technology refers to the body of organised knowledge, tools and machines used by man to manipulate his environment to satisfy his basic needs.

Many writers erroneously identify technology with only the hardware of production and services. Thus when the word technology is used, there is the misconception that reference is being made to only machines or technical devices. This misunderstanding is even carried to our ivory towers where people have argued that Faculties or Universities of Technology had no business teaching courses like management and law. Such arguments are made when people understand technology to mean only the "hardware" component. But technology is much more than that because it also refers to the "software" of production and services. In general, it refers to machines (hardware) and to management practices (software) needed to achieve a production target whether goods or services. For example in a soap manufacturing company, the technology used by the firm include the machines and processes used for production as well as the management techniques used for production, storage, marketing and distribution of the products. Technology therefore extends to law, administration, banking, education, etc. In the case of law, for example, the administration of justice involves the application of certain procedures, scientific principles and rules. In this example, the software component of technology is higher

than the hardware component.

Technology is one of the major inputs which facilitate the increase in the production of goods and services. Its absence at an intermediate or advanced level has been known as a major constraint to many facets of development. No matter the primitivity of a people and their culture, there exist some level of technology which is dynamic, changing from one generation to another.

Science and Technology by themselves cannot achieve practical goals. It is only when they are matched by an appropriate engineering background that useful practical goals and services are produced.

1.4 The Meaning of Engineering

The engineering profession is one of the oldest professions in the world. Its major objective is to utilize the available resources of nature to restore the dignity of man by improving the comfort, timeliness of operations and removing the drudgery usually associated with the performance of labour intensive, time - consuming activities of mankind. It is therefore the sum-total of all actions we take to put technology to work (Adeboye et al, 1995).

One of the most comprehensive descriptions of the engineering profession is the one that describes it as the profession in which the knowledge of physical, natural, biological and management sciences, humanities and arts, gained through studying and experience is applied with good judgement to develop ways of utilising economically the materials and forces of nature for the benefit of mankind. Engineering has also been referred to as the application of science, technology, art and economics to the definition and solution of real socio-economic and ecological problems. Because of the nature of human problems, the application of the knowledge is in the area of conception, design, development, manufacture, selection, testing, adoption, operation, maintenance of machines, implements, equipments, tools, structures and systems aimed at improving the infrastructural, technological, economic and complete mechanization of the activities of humanity.

The activities of the Engineer are multifarious and as broad as one can imagine. The engineering profession is perhaps the most important profession, as the achievements and products of engineering can be easily witnessed in the construction of roads, high ways, sky scrappers, houses, churches, temples, mosques, bridges, dams, canals, docks, the design and development of motor cars, trucks, tractors, ships, aircrafts, railways, rockets, air conditioners, refrigerators, fans, radios, television, video and musical gadgets, camera, telephone, fax machines, computers, ammunition, missiles, train, satellite dish, electricity, electric motors, transformers, combine harvesters, planters, airport, nuclear power stations, and many more.

The level of engineering practice in a nation is the major index of that nation's level of development. Engineering advancement also advances technological, military, economic and infrastructural developments of a nation. The nations of the world are grouped as developed and developing or as first, second and third world countries. These classifications are based on the level of engineering sophistication and technological development. The most advanced countries in engineering and technology become the first world or the developed nations while those countries with least engineering and technological development earn the title of the "Third World" or developing nations. There is enough indication in the World today, that any nation which neglects the development of her engineering facilities and personnel is neglecting her citizens and future, technologically, economically and infrastructurally.

1.5 The Relationship Between Science, Technology and Engineering

From the above discussion it is seen that while science seeks to know why things happen, technology tells us how they happen while engineering actually makes them happen. The link between the three is so strong and close that sometimes they are used interchangeably. This link has to be recognised and nurtured for any nation to move towards the path of sustainable development. If any of the arms of the link is missing, development will be stalled. In Nigeria today, there are many missing, development will be stalled. In Nigeria today, there are many examples of this missing link. There are many processes for which we have the scientific knowledge, the technology is also available but because we lack the engineering capability, the project gets into trouble as soon as the technical partners withdraw and we are forced to go back, setting up a cycle of technological dependence. The brewery industry can be used to illustrate this. The science of brewing is understood by many Nigerians trained in the area. The hardware and software of the technology of brewing has been imported and understood by our engineers and technologists. However, the engineering capability is lacking. Thus whenever any of the sensitive machines break down, spare parts are flown in from abroad and at times technical personnel are also invited from the technical partners.

Because of this relationship between science, technology and engineering, each one is used to develop the other and vice versa. In some situations, science led to the advancement of technology and subsequently engineering practice while in others, the process is reversed. The science of crop and animal growth has greatly advanced the technology of food production to an extent that the same land can now be used to produce much more food with less labour. The need to develop machines and infrastructure to keep up with the advancement in agricultural technology has enriched and developed engineering practice in these areas. With engineering coming up with better and more complex machines, technology has further improved and hence Agricultural Sciences now have more things to study. The science of astronomy advanced the technology of navigation and because new areas were explored with improved technology, advanced knowledge of astronomy have been developed. In order to keep up with the need to construct more complicated navigation ships, crafts and instruments, the engineering practice of ship building and instruments development has advanced tremendously. Chemistry, Biology and Physics advanced the practice of Medicine. On the other hand, advances in medical technology has led to the development of more knowledge in these areas (anatomy). There was no science when the lever was invented. The study of how it functioned resulted in the development of scientific principles of lever action. This in turn has led to the development of more complicated techniques based on lever action or principles. This can be found in many engineering applications such as engines, cranes, dams, etc. On the other hand, by studying these processes and machines new areas of science have been developed.

The biggest problem facing technological development in Nigeria today is how to make this link between science, technology and engineering to be strong and effective. Science by itself is useless unless

...be translated through technology and engineering to useful ...duction and services.

Historical Development of Technology and Engineering

The historical development of technology and engineering by ...n has been more of a gradual process from primitive technology of ...nes and sticks to the present day high technology of computers and ...ace travel. It should be noted that in some societies, these two ...tremes of technologies exist side by side with a whole wide range of ...chnologies between them. The historical development was captured by ...illiam Gunston (Pytlik et al, 1985) when he wrote of man's technology ...us "... at first technology was a few bits of wood, stone and animal ...in. He learned to fashion these into useful shapes and then opened a ...ew door by mastering fire with which he not only kept warm and ...ooked food but also hardened wood and extracted and used metals. As ...e learned to build houses, farm land and domestic animals, his ...echnology advanced in parallel, until in historic times he learned to ...ansport himself in every environment on, under, above and remote ...rom the earth. Today his technology includes not only his hardware ...ade from tangible materials but also his analytical techniques, his ...athematics, his computer programs and even his thinking processes".

The stages in the development of world technology can be ...dentified to include the stone age, Bronze age, Iron Age, Middle/Dark ...ge, Industrial Revolution, Adamic Age, Space age and Computer age. ...rimitive technology was developed during the stone age which spanned ...hrough the Paleolithic and Mesolithic periods in history. Tools ...eveloped within this period were made of stones, wood, bones. These ...ools were limited in operation. As the need for better provision of the ...hree basic necessities of life (food, shelter and clothing) increased, the ...eed for better tools also increased. During the Neolithic period of ...ivilization (3500 - 1000 BC), the following metals were discovered - ...opper, bronze, iron. The use of metals was a great improvement over ...he use of stones because they could be shaped into any form and could ...bsorb larger forces. This led to the discovery of the six basic machines ...n which modern technology is based namely lever, wedge, inclined ...lane, pulley, wheel, axle and screw. The Middle/Dark Ages followed ...he metal ages with the collapse of the Roman empire. This age was

characterised by the existence of the Barbarians of Northern Africa and the emergence of Christianity as a political force. Communities were more or less self reliant within this period. Fairs were introduced in Europe at this time. This brought technologies developed elsewhere like China into Europe. Technologies introduced within this period include water wheels, wind mills, ships, ploughs, printing technology, etc.

In the 19th century, the industrial revolution occurred in Europe and North America. This was fuelled by the discovery of the steam engine by the middle of the 18th century in England. With such engines, many sophisticated machines were built and functioned together in industrial enclaves. Different technologies were developed including mining, shipping, advanced forms of transportation. As time went on, the electric motor invented in 1821 by Michael Faraday replaced the steam engine as the prime mover for many factory steam turbine invented by Charles Parsons in 1884 and internal combustion engine invented by Rudolph Diesel in 1893 replaced the steam engine as major power source for transportation. With these machines running the heavy industries, many products were developed, better processes were developed and the human mind was able to think about other things. A major break through came in chemical technology with the application of the atomic principles in the manufacture of atomic bomb. Many advanced technologies such as power generation from nuclear energy were developed during this era. With these high technology revolution came the need for precise controls and monitoring of the new complicated machines. Many electronic devices were next developed culminating in the development of the ENIAC (Electronic Numerical Integrator and Computer) by Presper Eckert Jr. and John Mauchly in the middle part of the 20th century. Since the introduction of the computer and other electronics, many technological products and services have been introduced. This has affected the society in many ways as machines aid every aspect of human existence today.

In Nigeria, the development of technology and engineering practice dates back to pre-historic times and subsequently followed the development of empires and kingdoms in pre-colonial time. The rich cultural heritage of the different tribes in Nigeria is evidence that there existed technologies through which different artifacts were made.

Modern technology and engineering came with colonization and gradually replaced what was existing. The origin of organised engineering and technology practice can be traced to the colonial administration. In order to exploit the resources of the hinterland, the colonialists, who came through the sea coasts, built roads, water ways, bridges, railways all over the country. In addition, public utilities were established including electricity, water, schools, transportation systems. In order to build and maintain these infrastructure, the then Public Works Department (PWD) was created. With these came technological ideas and materials for maintaining the required utilities. Today, there are Federal Ministries of Works and Housing, Industries, Science and Technology, Agriculture, Water Resources, Commerce, etc. all involved in the development and management of technologies and engineering related activities. To complement the activities of these, there are counterpart ministries and parastatals in the states and Local Government Areas. Engineering and Technology have also grown considerably in the private sector of the Nigerian economy over the years. In the petroleum sector, engineering and technology activities are used to mine, convey, and refine petroleum products. Some of the engineering companies involved in these include NNPC, Shell, Mobil, Total, Chevron, etc. Many roads are built today by private engineering companies including Julius Berger, RCC, MCC, Hardel and Enic, etc. The major cities in Nigeria host a large number of manufacturing industries that apply engineering and technology principles in production and distribution of goods and services. These include Lever Brothers, Plc, Patterson Zochonis (PZ), Peugeot Automobile Nigeria (PAN), ANAMCO, Michelin, Dunlop, etc. In addition to these, there are many schools, Polytechnics, colleges and Universities all over the country who are teaching the principles involved in engineering and technology practice.

1.7 The Engineer as an Artist

The pioneers of the engineering profession were more of artists than science-based engineers. This was probably why the British Institution of Civil Engineers, in 1824, defined Civil Engineering as "...the art of directing the great sources of power in nature for the use and convenience of man". In the beginning, engineering was practised as an art based on talent, skill and experience. Many of the professionals at that time were carpenters, masons, instrument makers, operators, technicians, etc.

Some examples can be given of these early engineers:

1. James Watt who was famous for making factory systems possible.
2. Brindley who developed canals.
3. Stephensons who developed the railways.
4. Macadam and Telford who showed how roads and bridges should be built.
5. Whiteworth and others who invented machines that made engineering production and manufacture viable processes.

These 19th century craftsmen did not study science before going into engineering practice. In fact modern day engineering science owes more to these great men who provided the basis for the science of engineering to be developed. They were able to achieve what they did because the whole practice of engineering is an art which can be learned or based on talent.

Even in modern day practice of engineering, we note that although the science-based engineer may have a good number of scientific formulae, principles and procedures, the end product of any engineering work is more of an art, inventiveness and creativity than science. In the logic of science, there is normally a solution to a problem, but in arts, there is no such single solution to a problem. In design and most other translation of engineering science to useful ends, the artist's procedure is followed. The actual design involves the personal touch of the designer, although he is guided by established scientific laws and principles.

Examples of the role of the engineer as an artist can be seen by observing unique buildings in Nigeria such as the National Theatre, Headquarters of the multinationals at Marina in Lagos.

1.8 The Engineering Family

In every set up where a group of people work together to achieve a common goal, there is always some kind of division of labour and hierarchy. The biological family of which every body belongs is a typical example. There is a father, mother, child, house-help, relation, etc. Each member of the family is distinct and has a specific indispensable role to play. Where any member is absent or is not performing his duties well, the overall output of the family suffers.

The group of people who carry out engineering activity in Nigeria can be classified into what Faluyi (1993) called the "Engineering Family". Just like in a family, the engineering family can only succeed if each member of the family understands and plays his role effectively. In most cases the roles are clear but sometimes they overlap.

The Council for the Regulation of Engineering in Nigeria (COREN) recognises four cadres in engineering professional practice in the country. These four cadres make up the engineering family. They are craftsman/artisan, technician, technologist and engineer.

The craftsman is at the bottom of the hierarchy but is probably the most important member of the family. He is highly skilled in one or more aspects of engineering practice to an extent that he can recognize and use engineering tools and materials for production and services in a plant or engineering work. Examples include mason, carpenter, mechanic, electrician, fitter, plumber, etc. These are the people that actually do the final phase of any engineering work. It is recommended by COREN that a craftsman should undergo a certificate vocational training in his chosen area after primary school and junior secondary school. Such training can be obtained from a trade school. However, most craftsmen in Nigeria today were trained on the job.

The next group in the ladder is the technician who is formally trained up to the technical college level in more than one specific art or engineering practice. He is usually the direct supervisor of the craftsmen and will most likely hold an Ordinary National Diploma (OND) from a college or polytechnic. Examples include, foreman in a construction site, supervisors in factories, head mechanics, etc. Whereas the craftsman in a construction site may be just a plumber, the technician will be a plumber, fitter, mason, carpenter, etc. such that he can supervise the works of the different craftsmen under him.

Technologists are higher in training than technicians, usually up to the Higher National Diploma (HND) level in their chosen disciplines. In Nigeria, they are trained at the Polytechnics and Colleges of Technology and other relevant institutions. In industry, they function partly as operatives and partly as managers. Usually, they possess most of the skills of artisans plus some level of analytical skills of the engineer. In ministries and parastatals they are sometimes called Higher Technical Officers (HTOs).

The engineer is the head of the engineering family, and is usually a holder of a Bachelor's degree in engineering and sometimes higher (Masters or Ph.D). By training, he possesses mostly analytical and managerial skills to design, analyse and manage engineering systems including men and materials. He may not necessarily be detailed or knowledgeable in the skills of the artisan but should be able to provide leadership, guidance and supervision. This is why in most establishments, engineers end up as managers, overseeing what is going on in different sections. The typical chain of command in an engineering outfit where different members of the engineering family are at work is shown in Fig. 1.1. The figure shows that in practice there are more technologists than engineers; more technicians than technologists; and more artisans than technicians. A kind of pyramidal technological structure such as shown in Fig. 1.2 is maintained giving the ratio of Engineers: Technologists: Technicians: Artisans/Craftsmen as 1:2:4:8.

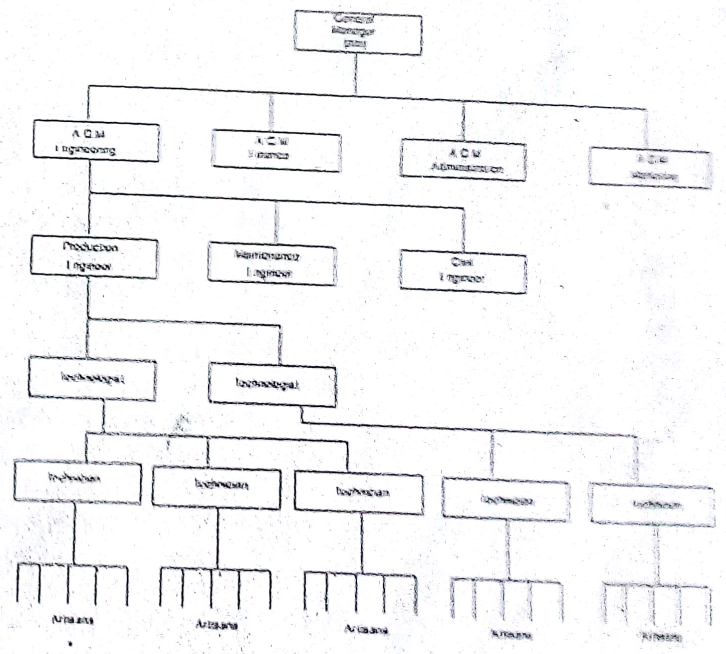

Fig. 1.1 The engineering family at work in a typical industry

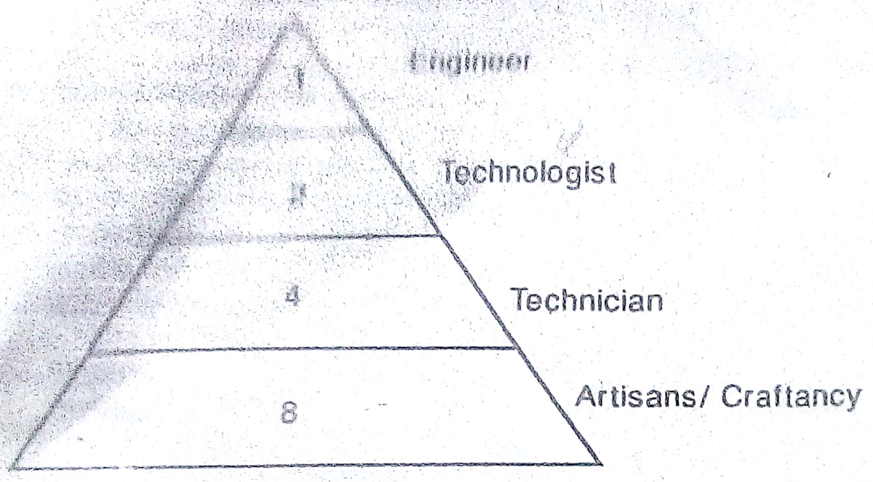

Fig. 1.2 Ratio of different cadres of engineering profession

1.9 Engineer-In-Society

The engineering profession is widely regarded as the most extensive and intensive profession covering almost all facets of human endeavour. The role of the engineer in society spans across politics, religion, technology, law, medicine, manufacturing, teaching, management, administration, defence, food production, and provision of utilities.

1.9.1 Politics

Earlier engineers abhorred politics believing that they were too busy with their tools to turn onto the rhetorics and troubles of politics and governance of man. In the beginning the pioneer professional engineers were normally busy and tired after a busy day's job of manual cutting and joining of metals, woods, etc or other products. Even when he was not planning, designing, cutting or joining metals, he would be so much occupied with the whys and hows of the numerous problems

hindering the development of [illegible] that he alienated himself from the idea of [illegible] of man and materials, believing that politics was [illegible] who had little to show from their strength [illegible] competence and practical ingenuity. Engineers were [illegible] satisfied with what they produced and the problems they solved [illegible]. They took pride in satisfying technical needs of [illegible].

They forgot that politics and the [illegible] powers of government are the pivot upon which their technical prowess and ingenuity lies. Politics is a serious game which only very serious-minded persons such as engineers must play for the greatest advantage of the people. It is widely known that politics is a process and art of power struggle, power consolidation and power [illegible]. If one has technology but has no political power, his technology will be taken away from him through the might and policies of government. If one has money and has no political power, his money can be taken away. Also if one enjoys peace without political power, his peaceful state of mind can be disturbed. When one has freedom without political power, his freedom can be violated and taken away from him in exchange for imprisonment, restriction, etc. These suggest that political power is very important to the engineer to enable him gain the right environment to practice. It will enable the engineer to participate in policy formulation necessary for the advancement of the engineering profession.

1.9.2 As a Member of the Society

The engineer is first and foremost a member of his village, town, local government area, state, country, etc. He is therefore expected to do his duties as a member of his community. He must be a good citizen, attend community gatherings/meetings and make meaningful contributions in such meetings necessary to advance ideas, knowledge and promote cordial existence between the different arms of the community. In most parts of the world, engineers are known to be the most honest professionals. The engineer must therefore try to exhibit this quality in whatever he says and does with the members of the society. In most societies, which engineers belong, they are called upon to head committees for erecting building, installing utilities, etc. The engineer should participate in these activities diligently.

Religion

The engineer-in-society needs to understand the religious beliefs f his environment and play an active part in its enhancement. He has be spiritually religious in his behaviours and actions. Religious iscipline is important in the daily co-existence of man and his eighbours. It promotes peace and tolerance. It is believed that when iod stopped creation, he handed over His tools of creation to the ngineer with the instruction to continue from where he stopped. That why the engineer has created and can create virtually anything on earth oday. It is therefore important that the engineer should think back and emember the original creator GOD, thank and ask Him for more powers create and develop these creations for the advancement of humanity.

.9.4 New Technologies

Engineers are trained to solve the technological problems of man. Wherever he may be, the engineer is widely expected to proffer solutions o most technical problems of humanity. In the midst of farmers, he hould plan, research, design and develop relevant appropriate echnology, machinery and equipment to solve the technical problems of griculture in such areas as land clearing, drying, storage, transportation, rocessing and marketing of their products.

Similarly, the engineer always seeks for the solutions for the numerous problems of the environment; transportation by air, land and sea; automobiles, telecommunications, electricity, roads, buildings, industrial constructions and maintenance.

In each of these areas, the engineer creates new technologies, both simple and complex, necessary to solve the challenging problems of the time.

1.9.5 Law

When properly enforced, laws promote peace and orderliness of human activities. A lawless society is often characterised by disorder, anarchy and confusion. The engineering profession hardly grows in a state of lawlessness. This means that the engineer requires a well-established non-oppressive law to operate. He starts with understanding

and obeying the scientific discoveries to solving the problems of nature, environment and human existence.

The engineer also needs to understand the contract laws, factory laws, etc and the general laws of his country and is duty-bound to understand and obey them with strictest discipline. To underscore the importance of understanding the law in the professional practice of the engineer, at least a course on law of practice has been incorporated in the academic programmes of most engineering disciplines in Nigerian Universities (NUC, 1989).

1.9.6 Medicine

The roles of the engineer in the development and sustenance of modern medicine is principally based on the design and manufacture of medical tools, equipment and machines. These range from the simplest tools such as syringes, needles, etc to the complex radiological laboratory and pharmaceutical machines.

Because of these machines and equipment, it is widely believed that modern medicine heavily depends on the advancement of the engineering profession in order to carry out the diagnosis of health and medical problems of mankind most efficiently. Other applications include building of hospitals, and related medical complexes as well as artificial limbs for orthopaedic requirements.

1.9.7 Military Function

The military powers of a Nation are dependent on the level of advancement of engineering and technology. The engineer designs and produces the ammunition and many military machines necessary to execute wars and maintain peace. Military engineering was one of the earliest engineering disciplines dating back to the prehistoric era when the early man first fashioned out tools to protect himself from aggressors of man and animal origins.

Total mechanization of all military operations is very vital in the prosecution of modern warfares. This is the sole duty of the engineer. The engineer is also required to construct military structures such as trenches, roads, bridges and build cars, trucks, etc to move men and materials from one location to another.

1.9.8 Administration and Management

The engineer should be fully involved in the administration and management of human and material resources in workshops and manufacturing industries. The recruitment of technical personnel, selection of production materials, machinery and equipment; performance testing of new machines/equipment; maintenance and repair of machines and equipment; costs and engineering analysis of machines, equipment, processes, controls and techniques of production, etc are all the management and administrative responsibilities of the engineer.

1.9.9 Food Production

Perhaps the most important role of the engineer in the society is in the production, processing, distribution of food. Engineers develop machines and systems that are used to produce crops and animals for food and fibre. When these are harvested, machines and structures developed by engineers are used to process and store the products, in factories, storage depots, etc.

1.9.10 Utilities

Most developed societies live in cities which require utilities such as roads, water, electricity, schools, markets, drainage systems, etc. These utilities are provided and maintained by engineers. The code of practice for engineers demands that professionals entrusted with these services should ensure that the interest of the society is placed above other interests.

1.10 Practice Questions

1.10.1 Differentiate between science and technology.
1.10.2 Using appropriate examples, differentiate between technology and engineering.
1.10.3 Outline the development of technology from prehistoric times to modern times.
1.10.4 The Engineer is at times regarded as an artist. Comment.
1.10.5 Identify and describe the different groups of professionals [illegible] engineering family.
1.10.6 What steps should be taken in an organization to avoid [illegible] conflicts between the different cadres in the Engineering fam[illegible]
1.10.7 Discuss the role of the engineer in society in general.
1.10.8 What is technology?
1.10.9 What is the linkage between the level of technology and development in a country?
1.10.10 Outline institutional framework for the developme[illegible] engineering in Nigeria.
1.10.11 Outline the different public utilities which are provided [illegible] maintained by engineers in a typical Nigerian city.
1.10.12 What is the role of engineering in military establishments.
1.10.13 How has developments in Engineering practice enhanced [illegible] practice of medicine?

CHAPTER 2

BRANCHES OF ENGINEERING AND ENGINEERING TECHNOLOGY

2.1 Learning Objectives

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

By 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 specialization and career opportunities.

2.2 Historical Development of Engineering Disciplines

Engineering as an art, 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 goods and services from one city to another.

In the production of food and fibre, irrigation engineering dates back to about 7,000 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 first civilization ever known to man. A dam built about 5000 years ago to store water for drinking and irrigation still exists in Egypt. Other ancient irrigation projects have been reported in China, India, Syria, Persia, Italy, etc.

In Africa and Asia Minor, people started the building of houses about 600 BC. There were also the great pyramids of Egypt notably the pyramid of Gizeh built about 2700BC. At about 300BC cities started to exist and this marked the beginning of the building of markets, churches, residential houses, temples, tombs, pyramids, great walls, etc. (Schwab et al, 1966).

At the beginning, engineering was dominated by activities centred around tilling of soils and irrigation of the tilled land for food production; the building of houses, churches, temples, roads, drainage, etc and other civil activities; fabrication of instruments for military purposes. Until the discovery 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 agricultural engineering, military engineering (later turned to mechanical engineering) and non-military (civil) engineering.

The continuing need to live in houses, develop cities, build roads, supply water to cities etc facilitated the speedy development of civil engineering. Fighting of wars and the need to produce war instruments, and machines for the 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 fields of engineering are as diversified and extensive as the activities of the engineer in food production; in the design and development of machines; in the generation, transmission and distribution of electricity; in telecommunications, road constructions, water supply, material and metallurgical, petroleum, gas and mineral industries; nuclear and chemical plants; sea, land and air transports etc. Based on these activities, the following engineering disciplines could be identified: Agricultural, Soil and Water; Civil, Highway, Environmental, Water Resources, Transportation, Public Health, Structural; Electrical, Electronic, Computer, and Communications Engineering; Mechanical, Aeronautical, Instrumentation, Industrial/Production, Marine, automobile, control, mining, refrigeration and air-conditioning engineering; chemical, petroleum, Polymer, textile engineering, material Metallurgical and ceramic engineering. However, as civilization and technology advance, and specialization widens, formalised new engineering disciplines are bound to emerge.

2.3 Agricultural Engineering

2.3.1 *Definition of Agricultural Engineering:*

Agricultural Engineering is the application of engineering knowledge and services in solving technical and environmental problems in agriculture. It utilizes all branches of engineering and technology in the art, science and business of crop and animal production as well as in the processing, preservation, storage, handling, manufacture, distribution or marketing of agricultural products. The primary mission of agricultural engineering is to mechanize agriculture, agro-based industries and to protect the environment of the farmer, his household and that of agro-based industries. Agricultural mechanization is defined as the application of engineering principles and technology in designing, developing, manufacturing, selecting, testing, adopting, operating and maintaining tools, implements, machines, structures and other technological systems and gadgets for improved agricultural production, storage and processing.

Modern agricultural engineering has a very recent past. There was no formalised discipline of science-based agricultural engineering until 1907. Before then, engineering in agriculture was performed by mechanical, civil and electrical engineers. As specializations widened and the application of engineering practice in agriculture became increasingly necessary, a group of engineers in the United States of America, trained as Mechanical, Civil, Electrical engineers but working in agriculture got together to form the American Society of Agricultural Engineers in 1907.

In Nigeria, there was no qualified Agricultural Engineer prior to 1960 (Odigboh, 1985). The professional body of Agricultural Engineers, Nigerian Society of Agricultural Engineers (NSAE), came into existence only in 1975.

Agricultural engineering has certain features uncommon to other engineering disciplines. The agricultural engineer deals with living plants and animal materials and therefore adds a biological dimension to his engineering training. He studies some aspects of biology, understands the principles of crop production and protection, animal production and management as well as the strength and properties of crops and animal materials.

2.3.2 *Areas of Specialization In Agricultural Engineering*

The main areas of specialization in agricultural engineering and technology are

1. Farm Power and Machinery Engineering
2. Soil and Water Engineering
3. Electric Power and Processing Engineering
4. Farm Structures and Environmental Control Engineering
5. Food Engineering
6. Wood Products Processing Engineering
7. Food Science and Technology

The agricultural engineer who specialises in Farm Power and Machinery is simply a mechanical engineer that specialises in the design, development, testing and selection of agricultural machines and equipment. Farm Power and Machinery option covers such areas as the design, development, manufacture, and maintenance of machines, implements and tools useful in agriculture. Such machines may include tractors, sprayers, water/irrigation pumps, ploughs, ridgers, harrows, planters, combine harvesters, manure spreaders,, fertilizer broadcasters, etc.

The specialist in Soil and Water Engineering option is summarily a Civil Engineer trained to handle agricultural engineering problems of soil and water conservation; design, development and installation of irrigation and drainage works and systems, rural water supply, etc.

The agricultural engineer in the Electric Power and Processing engineering option is an expert in farm/rural electrification, selection, use and installation of electric motors; application of electricity to handling, processing and storage of agricultural products; processing and storage, cleaning, sorting, grading, size reduction, heat treatment, packaging, air-conditioning and refrigeration. Such a specialist will also be involved in the conception, design, development and testing of machines for crop and animal processing.

The agricultural engineering specialist in the Farm Structures and Environmental Control Engineering concerns himself with the planning, design, of the environmental requirements of crops and animals; farmstead planning, sewage and farm waste management, planning of houses for livestock and storage of crops and animal materials; design and installation of irrigation, soil and water conservation structures.

The Food Engineer deals with food, feed, fibre and beverages/drinks manufacture; heat and mass transfers in food processing; design and installation of heat exchangers in food processing plants; hot and cold preservation of food materials; food packaging and quality control.

The Wood Products Engineering specialist is concerned with wood as a structural material in buildings, quality control of wood products; pulp and paper technology, design and development of wood seasoning and conversion machines, equipment and processes such as wood cutting, saws, cutters, saw-milling; vibration and noise in sawmills; buckling of saw blades, etc.

The specialist in the area of Food Science and Technology deals with the physical, chemical, biological and microbiological principles of food processing and preservation; food infection and poisoning; food packaging, analysis, process plant design, etc.

2.3.3 *Career Opportunities in Agricultural Engineering*

Agricultural Engineers can pursue careers in different areas of the economy. These can be classified as government, private sector, International Organization, Non-Governmental Organisations, Institutions of learning and research and self-employment.

There are many opportunities for agricultural engineers in government parastatals. These are with the Ministries of Agriculture, Water Resources and Science and Technology at the Federal, State and Local Government levels. Within these ministries and sometimes under the presidency, there are many extra-ministerial parastatals which employ agricultural engineers in large numbers. These include the National Agricultural Land Development Authority (NALDA), Crop Storage Unit (CSU), Rural Agro-Industrial Development Scheme (RAIDS), National Centre for Agricultural Mechanization (NCAM), Rural Artisan Training Support Unit (RATSU), Agricultural Mechanics and Machinery Operators Training Centres (AMMOTRAC), Directorate for Foods, Roads and Rural Infrastructure (DFRRI), Strategic Grains Reserve (SGR), National Directorate of Employment (NDE), etc.

In the private sector, opportunities exist in companies that manufacture, market or service agricultural machinery, food processing companies, and consultancy outfits. Of recent, a number of agricultural engineers have been employed in oil companies and banks. Some of the big relevant companies include Steyr, John Holt, Bewac, Scoatrac, UAC, Starch Mills, Flour Mills.

The International Organisations and NGOS include United Nations Development Programme (UNDP), United Nations Industrial Development Organization (UNIDO), Food and Agricultural Organization of the United Nations (FAO). These can employ directly or through one of their numerous projects on poverty alleviation all over the country.

In the area of self employment, agricultural engineers are involved in equipment fabrication, sales and maintenance, as well as in consultancy services.

Under educational and research institutions sector, many agricultural engineers find employment in the more than 18 agricultural research institutes in Nigeria, federal and state colleges of agriculture, polytechnics and universities.

2.4 Civil Engineering

2.4.1 *Definition of Civil Engineering*

Civil Engineering is one of the oldest engineering disciplines dating back to the time when man first sought for shelter, lived in cities and combated the problems usually associated with urbanization such as housing, waste disposal, water supply; and later problems such as transportation, harbour works, bridges, highways, airports, churches, dams, dykes, etc. Civil engineering has dominated the bulk of engineering works up to the recent past and therefore has exerted an overwhelming influence in the course of infrastructural development of nations.

Civil Engineering is concerned with the design, construction and maintenance of public services such as water supply, water ways, drainages, highways, docks, railways, roads, power stations and the creation of buildings in which people live, work and play.

2.4.2 Areas of Specialization in Civil Engineering

Many areas of specialization are identifiable within the field of Civil Engineering. Some of them include:

1. Structural Engineering
2. Water Engineering
3. Public Health Engineering
4. Highway and Transportation Engineering
5. Geotechnical/Foundations Engineering
6. Sanitary Engineering
7. Construction/Building Engineering
8. Geodetic Engineering and Photogrammetry

The Structural Engineer deals with the design and analysis of all types of structures such as buildings, bridges, storage tanks, dams, power transmission towers, etc. He understands the mechanics of structures; strength characteristics of soils and other materials; elements of architectural and construction technology required for the erection of any desired structure.

The water resources and environmental engineer is concerned with the planning, harvesting/development, transportation, storage and distribution of water and the protection of such water from adverse environmental conditions. He has good understanding of the mechanics of soils and foundations; hydraulics and hydro-geology; design and construction of hydraulic structures, water and waste water treatment plants; pollution control and water supply.

The Public Health Engineer deals with water quality management, identification and control of water diseases, design and construction of solid waste, waste water, water supply, toxic and nuclear waste treatment plants; land waste disposal system, pollution transport and control.

The Highway and Transportation engineering option deal with the movement of people and cargo from place to place by land, sea and air. This option is involved with the design, construction and, maintenance of highways and pavements; transportation planning and economics; design of traffic signals, and management [illegible] of traffic surveys on high ways etc.

The Geotechnical/Foundation Engineer is concerned [illegible] properties, stresses, bearing capacity, earth pr[illegible] settlement and shear strength of soils as engineering material. He applies his knowledge of soils to analyse the foundations of buildings.

The Sanitary Engineer deals with the problems of providing safe and adequate water supply both for domestic and industrial uses; controlling and preventing air and water pollution; disposing of all types of domestic and industrial wastes. He performs similar [illegible] as the Public Health and Environmental Engineer.

The Building/Construction engineer deals with the process of developing efficient economical methods of construction operations such as earth moving and erection procedures. He has good understanding of the properties and strength characteristics of building materials; construction techniques, building strength and stability, etc.

Geodetic Engineering and Photogrammetry deal with engineering surveying operations involving contour plans and maps; topographical surveys, etc. This option deals with the conception, design, development, testing, maintenance and application of surveying and photogrammetric instruments, equipment and machines.

2.4.3 *Career Opportunities in Civil Engineering*

The employment opportunities for civil engineers are very wide and includes the following:- building/construction industry, oil, gas, defence, transportation industries, mining, railways, agriculture, water resources development and distribution. They are also involved in teaching, research and consultancy services.

Therefore in the public sector, civil engineers work in ministries of Works, Water Resources, Defence, etc. In addition they work in those parastatals that provide public utilities such as Water Corporation, Housing Corporation, National Electric Power Authority, etc. In the private sector, every company needs a civil engineer at least for the maintenance of existing facilities. In addition, there are many construction and Civil Engineering Companies in Nigeria such as Julius Berger, Monier Construction Company (MCC), Reynolds Construction

Company (RCC), DUMEZ, and a host of others. In the area of self employment, most civil engineers are involved in construction work which is very lucrative.

2.5 Mechanical Engineering

2.5.1 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 science 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 materials to produce useful work. This may include power-generating equipment, machines that produce or consume this power; the science and art of formulation, design, development, production/manufacture, operation, testing, selection, installation and control of machine components and systems; the technology of transportation systems like automobiles, trains, marine vehicles, air crafts, etc; the technology of refrigeration, air-conditioning, ventilation and cryogenics ie (low temperature operations for liquefying gas) e.g. liquid oxygen used in medicine, liquid hydrogen used in rockets, helium, argon used in lighting; the science of tribology; friction and wear of materials; the mechanics of machines/solids and strength of materials.

2.5.2 *Areas of Specialization in Mechanical Engineering*

The areas of specialization in Mechanical Engineering and Technology include the following:-

1. Industrial and Production Engineering
2. Refrigeration and Air-conditioning Engineering
3. Automotive Engineering
4. Marine Engineering
5. Mining Engineering
6. Power Plant Engineering
7. Design and Manufacturing Engineering

The area of Industrial and Production Engineering is concerned with the planning and design of factory production and inventory, project planning, feasibility and monitoring; industrial machines 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 processes, finance and accounting. He must be conversant with the important activities of design for manufacture and also be well acquainted with the modern methods and techniques available for 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 dimensions.

A specialist in Refrigeration and Air-conditioning Engineering deals with psychrometry and air system designs; selection of refrigerants; design, development, selection and installation of refrigeration and air-conditioning equipments etc.

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

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

The Mining Engineer is a specialist in the geology of rocks and minerals; mine surveying; mining process and systems design; mine ventilation, health and safety; design, development, selection, installation, operation and maintenance of mining plants, process controls 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 machine tools and components; jigs and tool designs.

2.5.3 *Career Opportunities in Mechanical Engineering*

Career opportunities in mechanical Engineering are so wide that it is 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.

2.6 Electrical/Electronic Engineering

2.6.1 *Definition of Electrical/Electronic Engineering*

Electrical engineering emerged as a result of the discovery of electricity. Electrical/Electronic Engineering deals with the following:-

i. design and development of a vast number of electrical machines.
ii. generation, transmission and distribution of electric power.
iii. design and development of various communication components and systems such as radio, television, microwave systems, telegraphs, telephones etc.
iv. design of electronic equipment and computers.

2.6.2 *Areas of Specialization in Electrical/Electronic Engineering*

The major areas of specialization in Electrical/ Electronic Engineering are as follows:-

1. Electrical Engineering
2. Electronic Engineering
3. Computer Engineering
4. Communications Engineering
5. Power Systems Engineering
6. Instrumentation Engineering

The electrical engineer in the area of electrical engineering deals with the design, development, installation and maintenance of electro mechanical devices and machines such as electric motors, transformers etc. Electric power generations, transmissions, distribution and application of electric power measurements and instrumentation devices e.g. electric meter, rectifier, voltmeter, electrodynamometer, watt meter, electronic multimeter, digital voltmeters, oscilloscope etc; design and development of switchgears and high voltage generating and measuring equipment. He has good understanding of electrical cables, lightning phenomena and protection; amplifiers, control engineering, telecommunication engineering etc.

The electronic engineer is concerned with the design, development, installation and maintenance of electronic components and systems, power electronics and devices, computer hardware and software techniques; communication systems and devices, industrial and solid state electronics etc.

Computer is widely being regarded as the last of the technologies of man towards technological perfection. Its application knows no boundary and cuts across all known professions ranging from engineering, medicine, military, agriculture, law, management, etc. to space exploration. Computer has its own languages and helps man in decision making.

The communications engineer is concerned with the design, development, installation and maintenance of telecommunication engineering systems such as telegraph systems, codes, radio systems; terminal equipments like telephone receivers, telephone network structures, digital telephony; image and data transmission systems; optical communication systems; feed-back and control systems; planning of these systems; digital signal processing etc.

The power systems engineer deals with the planning, design, development, installation and maintenance of transformers, AC and DC machines, lighting and power installations, energy supply and distribution; selection of cables, conductors, wiring systems and accessories; illumination, earthing and testing of electrical installations; load forecasting; economics of power systems; power transmission, distribution lines etc.

The Electrical/Electronic Instrument engineer is primarily concerned with the design, development, selection, analysis and application of instruments, components, devices and machines for the general instrumentation and measurement of the flow, voltage, power etc of electricity in electrical/electronic machines, devices, installations and systems.

2.6.3 *Career Opportunities in Electrical/Electronic Engineering*

A wide range of career and employment opportunities is open to graduates of Electrical/Electronic engineering in the following areas:-

1. Telecommunication industries e.g. NITEL, P&T,
2. Power generating, transmitting, distributing and maintaining industries e.g. ~~NEPA~~. PHCN
3. Computer systems and component designing, development, sales, installation and maintenance industries, e.g. Paks, Data Sciences, IBM, Gateway, etc.
4. Automation Control units e.g Oil companies, industries.
5. Electrical services design or building services such as house wiring, lighting, systems design and selection etc.
6. Electrical/Electronic machines and equipments designing, development, installation and maintenance.
7. Electrical/Electronic/computer research industries.
8. Teaching in Universities and Polytechnics.

2.7 Chemical Engineering and Technology

2.7.1 *Definition of Chemical Engineering*

Chemical engineering is that branch of engineering which deals with the planning, designing, operating and maintaining of the various processes and operations involved in chemical, food and petrochemical industries. It is one of the newer engineering disciplines carved out of mechanical, metallurgical and agricultural engineering disciplines. It is clearly related to ceramic, petroleum and food engineering.

2.7.2 *Areas of Specialization In Chemical Engineering*

The following areas of specialization exist in Chemical Engineering and technology:-

1. Petroleum Engineering
2. Petro-chemical Technology
3. Polymer and Textile Technology
4. Nuclear Engineering
5. Chemical Reaction Engineering

The Petroleum Engineer is concerned with the exploration production, handling, refining and storage of petroleum and allied petro-chemical products. He is conversant with the design, installation and maintenance of refineries, storage tanks, reservoirs, etc. He understands drilling technology, petroleum geology, well logging, oil pollution and control; off-shore and on-shore operations; natural gas processing etc.

Petrochemical engineering is concerned with the technology of petro-chemical processes, like cracking, reforming etc; Homogenous and heterogeneous catalytic systems; quality control in petrochemical industry; chemical process evaluation and economics; oil refinery operations and products; chemical process control and instrumentation etc.

Polymer and textile engineering deals with the technology of polymerics and textile materials; the structural requirement of polymerics and textiles; technology of adhesives and elastomers; analysis and testing of polymerics and textiles; non-woven and knitting technology; modern yarn production techniques; colouration and finishing of polymerics and textiles etc.

The nuclear engineer deals with the design construction, installation, operation and maintenance of nuclear power plants. He is an expert in nuclear reactor radiation hazards and protection techniques; safety and the environmental effects and limitations of nuclear reactors; applications of nuclear power for both military and non-military purposes e.g. the use of radioisotopes in medicine and industry etc.

The Chemical Reactions Engineer is concerned with the design and installation of chemical reaction plants; analysis and design of chemical reactions; selection of reactors etc.

2.7.3 Career Opportunities in Chemical Engineering

There is abundant job opportunities for graduate chemical Engineers in the manufacture of rubber and plastics, chemicals, petroleum products, glass and ceramic, paper and boards, metals and textiles, paints. Examples include Shell, Cadbury, African Paints, etc.

They are also required in breweries, wood processing, biochemical and food processing industries, environmental control including effluent treatment, sewage disposal and water resources management; in consultancy and private employment, etc.

2.8 Materials and Metallurgical Engineering

2.8.1 *Definition of Metallurgical Engineering*

Materials and metallurgical engineering deal with the manufacture, use, extraction and properties of metals, non-metals and alloys as engineering materials.

Materials engineering deals with the art, science and technology of the development, selection and use of metals and non-metals like ceramics, semi-conductors, polymerics, 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 of materials have been the basis of classification of human development and age. Hence, the stone, bronze, golden, silver and iron ages. The commonest and most important material is metal and most activities of humanity depends on materials - metals and non-metals.

2.8.2 *Areas of Specialization in Metallurgical Engineering*

The areas of specializations in materials and metallurgical engineering can be grouped as follow :-

1. Material Engineering
2. Metallurgical Engineering
3. Ceramic Engineering
4. Polymer Science and Engineering

The Materials engineer is concerned with the science and technology of development, selection and use of metals and non-metallic materials. He is involved 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 extraction, refining and alteration 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, metallurgraphy etc.

The ceramic engineer deals with the application of scientific principles to the fabrication of ceramics products; the mining, refining and processing of raw materials and their manufacture into finished products; the design, construction and operation of the equipment needed are all encompassed in the works of the ceramic engineer. He understands ceramic processing, process planning and design; physical and solid-state ceramics; ceramic coating of materials, glass technology, heat treatment of ceramic materials etc. The polymer engineer is conversant with the synthesis, structure, physical and mechanical properties of synthetic and natural polymers. He deals with the industrial applications of polymeric materials; the mechanical, rheological and chemical properties of polymers; polymer process engineering; rubber, ceramic and glass technology; medical and industrial applications of polymeric materials; plastic foams and textile technology etc.

2.8.3 *Career Opportunities in Metallurgical Engineering*

All industries engaged in the manufacture of metallic and non-metallic products require materials and metallurgical engineers. Companies which are prime producers of metals and alloys are in need of metallurgists and metallurgical engineers. A good number of these engineers could be self-employed owning their own foundries or other metal products or ceramic manufacturing industries. Consultancy, research, teaching in 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 drink industries.

Similarly, the polymer engineer is needed in the natural polymer industries (e.g. wool, silk, leather etc. and in the plastics, textiles, paper packaging and chemical industries.

2.9 Other Engineering Disciplines

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

- Production Engineering
- Aeronautical Engineering
- Marine Engineering
- Software Engineering
- Biomedical Engineering
- Food Engineering
- Environmental Engineering

2.10 Practice Questions

2.10.1 *What is Agricultural Engineering?*

2.10.2 *Describe the different areas of Agricultural Engineering?*

2.10.3 *What is the role of Agricultural Engineering in National Development?*

2.10.4 *Answer the above questions for the other disciplines of engineering*

CHAPTER 3

ENGINEERING EDUCATION AND TRAINING IN NIGERIA

3.1 Learning Objectives

Education and training are very important aspects of engineering practice because the future of the profession depends on how well educated, trained and skilled the younger generation of engineers are. The education of members of the engineering family vary according to the cadre. By the end of this chapter, the reader should understand the processes involved in training of artisans/craftsmen, technicians, technologists and engineers.

3.2 Education and Training of Artisans/Craftsmen

As pointed out earlier, the craftsman must be trained to recognize and use engineering tools (both hand and machine tools) and materials for the production, operation and maintenance of engineering facilities, products and services. The training of craftsmen involves both theoretical and practical education as opposed to the general notion that they should be trained in only practical jobs.

To formally qualify as a craftsman, the candidate must attend an approved vocational training school or centre. These are usually the technical schools scattered all over the country in addition to some government owned trade centres. The training at these centres are supported by practical experiences in industries and industrial development centres. At the end of the programme which usually lasts for about three years, a certificate is usually awarded. Examples include Trade Test Certificates. To be admitted to such schools and training centres, one has to go through primary and junior secondary schools.

It should be noted, however, that most craftsmen in Nigeria, and those in small private establishment and those on their own, do not have any formal education. Most of them (e.g. mechanics, carpenters, masons, plumbers) acquired their skill through informal training as apprentices to more experienced ones. Such apprenticeship schemes last from 5 to 10 years depending on the age of the candidate at the beginning of the training. Such training procedures are not good for

(1) E.N.G 101

ENGINEERING ETHICS AND CONDUCTS

In engineering ethics and conducts, we are primarily concerned with the ethical context and professional issues that arise in the practice of engineering and on the response of the engineering body to such issues. Although most engineers will never face situations associated with disaster, all will encounter situations requiring ethical reflections and decision making.* The study of professional ethics as part of engineering education is vital and will make engineers better professionals. Our central focus is on 'professional ethics' and not 'personal ethics'. The two cannot of course be totally separated. In one respect it is appropriate to say that personal ethics is a foundation for professional ethics: one's desire to be an ethical engineer is part of one's desire to be an ethical person. However, there exist some major differences.
The most obvious difference is that professional ethics deals with the ethical standards adopted by a professional body. On becoming a professional, one joins a body of other professionals. This body has standards. One of the most obvious places to look for these is in the codes of ethics of professional societies. Engineering societies, for instance, have adopted principles of ethical conducts for their members. Engineers must perform under a standard of professional behaviour that requires adherence to the highest principles of ethical conduct.

OBJECTIVES OF PROFESSIONAL ETHICS

Engineering ethics has two dimensions. First, engineers must think ahead to anticipate possible consequences of their actions as professionals, especially those that may have an important ethical dimension. Second, engineers must think effectively about those consequences and decide what is ethically and professionally right. In line with these established facts, engineering ethics is aimed at:

- Stimulating the engineers' moral imagination necessary in anticipating the consequences of their actions as professionals, and in proffering solutions to ethical problems encountered in professional life.
- Helping engineers properly utilize their technical and analytical skills essential to good engineering practice with some caution in analyzing moral issues.
- Enabling the engineer to maintain and improve the honour and dignity of engineering profession.
- Guiding the engineer to uphold honesty and impartiality in his service to his employer, clients and the public.
- Making the engineer advance the competence and prestige of his profession.
- Reminding the engineer of his professional calling for effective utilization of his knowledge and skill to advance human welfare.

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FUNDAMENTAL CANONS:

These have to do with the basic rules or principles that must guide the practice of engineering as a profession. According to the National Society of Professional Engineers (a body overseeing the affairs of all registered professional engineers in the USA), engineers, in the fulfilment of their professional duties, shall:

- ✓ Hold paramount the safety, health, and welfare of the public.
- ✓ Perform services only in their areas of competence.
- ✓ Issue public statements only in an objective and truthful manner.
- ✓ Act for each employer or client as faithful agents or trustees.
- ✓ Avoid deceptive acts.
- ✓ Conduct themselves honourably, responsibly, ethically, and lawfully so as to enhance the honour, reputation, and usefulness of the profession.

ENGINEERS' CODES OF ETHICAL CONDUCT

Code of Ethics simply put is a system of moral principles. There are several engineering branches with their respective professional societies but we shall concern ourselves primarily with the ethical code of the Council for Regulation of Engineering in Nigeria (COREN). In several respects, the COREN is unlike the bodies representing the major branches of engineering, such as the Nigerian Institute for Mechanical Engineers (NImechE), Nigerian Institute for Agricultural Engineers (NIAE), Nigerian Institute of Electrical and Electronics Engineers (NIEEE), etc. While these bodies are concerned primarily with the pursuit and dissemination of technical knowledge in their respective areas of engineering, the COREN is primarily concerned with non-technical matters involving the engineering profession. It is concerned rather with issues such as licensing, professional development, avoiding conflicts of interest, encouraging engineers not to encroach on the practice of other engineers, and other issues in the area of professional practice.

WHY DO WE USE COREN CODE?

- ❖ COREN is a professional society that every engineer must register with irrespective of their specialty.
- ❖ The COREN code is the code used by the Investigating Panel and Disciplinary Tribunal in determining cases referred to them.

These codes, as a matter of fact, should be impressed firmly into the minds of engineering students in their professional training and later guide them in their professional engineering practice. The codes simply state these ideals formally:

COREN Code of Ethics

- ❖ A registered engineer may be engaged in:
  - ✓ Research, production, supervision, construction, management, e.t.c.
  - ✓ May be retained as a Consultant for professional advice.
- ❖ A registered engineer when trusted with the finances of his Client or Employer must let his honesty of purpose be above suspicion.

- He must be fully conscious that he has moral responsibility for his associates and subordinates.
- Fully conscious that the profession carries with it, great responsibility to the public.
- He must act in professional manners to avoid conflicts of interest.

Responsibility of a Registered Engineer to the Profession

- Shall not knowingly take part in a competition involving the submission of proposals for engineering work unless an assessor who shall be an engineer of repute has been appointed whose responsibility is to provide professional judgment on such proposals.
- A registered engineering personnel should only deal with legitimate enterprises
- Registered engineering personnel shall not be engaged in the practice of making preliminary studies and estimates of cost without adequate compensation.
- Registered engineering personnel shall not advertise engineering services in manners derogatory to the dignity of engineering as a profession.
- Shall not offer to make payment by way of commission or otherwise in order to secure employment and/or contract.
- It is the duty of every registered engineering personnel to report to Council the violation of this Code of Conduct.

Relation among Registered Engineering Personnel

- A registered engineer shall not act to injure the reputation of another registered engineer.
- A registered engineer should not be involved in any job that has already been entrusted to another registered engineer.
- A registered engineer shall not review or take over work of another registered engineer until he has obtained a written notification from the client that the former engineer has been disengaged and has been completely settled.
- It is improper for a registered engineer to secure an engagement by reducing his fees.
- It is the duty of the registered engineer to ensure that credit for work and ideas are attributed to the real authors.

Relation of a Registered Engineer with Employer or Client

- A registered engineer shall not place orders on his own behalf in respect of a project in which he is engaged but shall only do so explicitly on behalf of his client.
- A registered engineer shall not be the medium of payments made on his client's behalf. He shall only issue certificates of payment.
- Unless authorised, a registered engineer shall not receive directly or indirectly any royalty, gratuity or commission in connection with the work he is employed.
- He shall accept remuneration only from his employer or client.

Responsibility of Engineering Person as an Employer

- A registered engineer, as an employer, must ensure that only registered engineers hold engineering posts.
- He shall ensure that trainee engineers working under him to qualify for registration are given good technical exposures/experience to enable them earn satisfactory certificates and endeavour to issue such certificates promptly.

4P

Responsibility of Engineering Personnel to the Public

- Must maintain dignified interest in the welfare of the community.
- Must challenge untrue, unfair and exaggerated statements on technical issues.
- Must enforce technical regulations.
- A registered engineer who shall be convicted by a competent tribunal of a criminal offence will be unfit to practice.

Responsibility of the Registered Engineers with regards to Contracts

- Must ensure that public interests are incorporated in any contract to be executed.
- Must ensure that fairness and honour shall govern the use of every bid over which he is to adjudicate.
- Must not compromise the professional standard for lower bidder.
- Shall not call for full estimates from bidders on tentative projects.

CASE ANALYSES:

CASE 1:

Ben Frank, a registered engineer, is President/CEO of an engineering firm which has done overseas assignments in various parts of the world. The firm is negotiating for a contract in a foreign country in which it has not worked previously. Ben is advised by a high-ranking government official of that country that it is established practice for those awarded contracts to make personal gifts to the government officials who are authorized to award the contracts, and that such practice is legal in that country. Frank is further advised that while the condition is not to be included in the contract, his failure to make the gifts will result in no further work being awarded to the firm and to expect poor cooperation in performing the first contract. He is further told that other firms have adhered to the local practice in regard to such gifts.

Would it be ethical for Frank to accept the contract and make the gifts as described?

CASE 2:

Daniel is designing a new chemical plant. One of his responsibilities is to specify the valves to be used in a certain portion of the plant. Before he makes his final decision, a salesman for one of the firms that manufactures valves invites him to a golf game at the local country club. Should Daniel accept the offer?

CASE 3:

Fred discovers that his plant is discharging into the river a substance that is not regulated by the government. He decides to do some reading about the substance and finds that some of the studies suggest that it is a carcinogen. As an engineer, he believes he has an obligation to protect the public, but he also wants to be a loyal employee. The substance will probably be very expensive to remove and his boss says, "Forget about it until the government makes us do something. Then all the other plants will have to spend money too, and we will not be at a competitive disadvantage." What should Fred do?

CASE 4:
Jim's company has an in-house tool and die department that would like to bid on a contract that has been submitted to outside vendors. The department manager of the in-house tool and die department asks Jim for the quotes from the other vendors, so he can underbid them. "After all," the department manager argues, "we are both on the same team. It's better to keep the money inside if we can. You don't have to tell the outsiders what you have done." What should, Jim do?

CASE 5:
A: Noble Nice, a Professor on the engineering faculty at a University of Technology, headed a research project three years ago where he selected Jack Jones, an undergraduate as his research assistant. At first Jack was enthusiastic about the project, and certainly felt honored that Professor Nice selected him as his undergraduate assistant. However, in the course of time Jack grew impatient with the laboratory work and write-ups, leaving Professor Nice to do more and more of the work himself. Eventually, Jack left the project before the work was completed.
One year later Jack, then a graduate student at another University, wrote to Professor Nice requesting a copy of the final report of the work they had done together. Jack explained that he had matured considerably since his undergraduate days and was now working in a related area. "Now," he said, "I think I'm ready for more serious work. It would help me a lot if I could see how things finally worked out in the project."
Should Professor Nice send the report to Jack?

B: Professor Nice was not anxious to share the report with anyone. Disappointed with the results of the research, he had turned his attention elsewhere. As far as he was concerned, the project was dead. He also had to admit that he was still unhappy with Jack's performance. Nevertheless, he was impressed with Jack's acknowledgment of his earlier immaturity and his apparent desire to do serious work. So, he sent the report, pointing out to Jack that, although the research was now complete, it had not turned out as he had hoped, and that he had no plans to do further work in the area. He wished Jack well in his graduate work and hoped that this report might be of some help in giving him new ideas.
Several years later Professor Nice discovered that Jack used the report as his master's thesis, adding only a couple of introductory paragraphs, a concluding section, and an updated bibliography. No reference to Professor Noble Nice appeared anywhere in the thesis!
What, if anything, should Professor Nice now do about this? Is there anything he could have done earlier that might have prevented this from happening? What might he do in the future to decrease the chances of this sort of thing happening again?

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History of Engineering

Main article: History of engineering

The history of engineering can be roughly divided into four overlapping phases, each marked by a revolution:

- Pre-scientific revolution: The prehistory of modern engineering features ancient master builders and Renaissance engineers such as Leonardo da Vinci.
- Industrial revolution: From the eighteenth through early nineteenth century, civil and mechanical engineers changed from practical artists to scientific professionals.
- Second industrial revolution: In the century before World War II, chemical, electrical, and other science-based engineering branches developed electricity, telecommunications, cars, airplanes, and mass production.
- Information revolution: As engineering science matured after the war, microelectronics, computers, and telecommunications jointly produced information technology.

Engineering in the Pre-scientific Revolution

The forerunners of engineers, practical artists and craftsmen, proceeded mainly by trial and error. Yet tinkering combined with imagination produced many marvelous devices. Many ancient monuments cannot fail to incite admiration. The admiration is embodied in the name "engineer" itself. It originated in the eleventh century from the Latin ingeniator, meaning one with ingenium, the ingenious one. The name, used for builders of ingenious fortifications or makers of ingenious devices, was closely related to the notion of ingenuity, which was captured in the old meaning of "engine" until the word was taken over by steam engines and its like. Leonardo da Vinci bore the official title of Ingegnere Generale. His notebooks reveal that some Renaissance engineers began to ask systematically what works and why.

Later, as the design of civilian structures such as bridges and buildings matured as a technical discipline, the term civil engineering entered the sphere as well as a way to isolate themselves from those who builds the military equipments then. In other words, mechanical and civil engineering as the earliest practices of the earth.

Some instances of this phase are the pyramids in Egypt, the Hanging Gardens of Babylon, the Acropolis and the Parthenon in Greece, the Roman aqueducts, and the tombs of India.

Engineering in the Industrial Revolution

The first phase of modern engineering emerged in the Scientific Revolution. Galileo's Two New Sciences, which seeks systematic explanations and adopts a scientific approach to practical problems, is a landmark regarded by many engineer historians as the beginning of structural

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analysis, the mathematical representation and design of building structures. This phase of engineering lasted through the First Industrial Revolution, when machines, increasingly powered by steam engines, started to replace muscles in most production. While pulling off the revolution, traditional artisans transformed themselves to modern professionals. The French, more rationalistic oriented, spearheaded civil engineering with emphasis on mathematics and developed university engineering education under the sponsorship of their government. The British, more empirically oriented, pioneered mechanical engineering and autonomous professional societies under the laissez-faire attitude of their government. Gradually, practical thinking became scientific in addition to intuitive, as engineers developed mathematical analysis and controlled experiments. Technical training shifted from apprenticeship to university education. Information flowed more quickly in organized meetings and journal publications as professional societies emerged.

In Mechanical Engineering, The inventions of Thomas Savery and James Watt(the Scottish engineer) gave rise to modern practices in mechanical engineering. The development of specialized machines and their maintenance tools during the industrial revolution led to the rapid growth of Mechanical Engineering globally.

Similar technological revolutions occurred in virtually all other fields of human activities.

Engineering in the second industrial revolution

The second industrial revolution, symbolized by the advent of electricity and mass production, was driven by many branches of engineering. Chemical and electrical engineering developed in close collaboration with chemistry and physics and played vital roles in the rise of chemical, electrical, and telecommunication industries. Marine engineers tamed the peril of ocean exploration. Aeronautic engineers turned the ancient dream of flight into a travel convenience for ordinary people. Control engineers accelerated the pace of automation. Industrial engineers designed and managed mass production and distribution systems. College engineering curricula were well established and graduate schools appeared. Workshops turned into to laboratories, tinkering became industrial research, and individual inventions were organized into systematic innovations:

Engineering in the information age

Research and development boomed in all fields of science and technology after World War II, partly because of the Cold War and the Sputnik effect. The explosion of engineering research, which used to lagged behind natural science, was especially impressive, as can be seen from the relative expansion of graduate education. Engineering was also stimulated by new technologies, notably aerospace, microelectronics, computers, novel means of telecommunications from the

Internet to cell phones. In 1990, with the rise of computer technology came up, the idea of carrying out analysis came into existence by the advent of the first computer. Just like the first search engine was built by computer engineer Alan Emtage.

Computer and Robotics took the world into a new life of easiness in computation and project execution. Today, control engineering involves production of electrically operated mechanical devices and using them in manufacturing , production firms to harness quick production and at low cost. This is otherwise known to be mechatronics engineering.

Turbojet and rocket engines propelled aeronautic engineering into unprecedented height and spawned astronautic engineering. Utilization of atomic and nuclear power brought nuclear engineering. Advanced materials with performance hitherto undreamed of poured out from the laboratories of materials science and engineering. Above all, microelectronics, telecommunications, and computer engineering joined force to precipitate the information revolution in which intellectual chores are increasingly alleviated by machines.

Engineering developed extensive theories of its own and firmly established itself as a science of creating, explaining, and utilizing manmade systems. This period also saw the maturation of graduate engineering education and the rise of large-scale research and development organized on the national level.

So far the physical sciences – physics and chemistry – have contributed most to technology. They will continue to contribute, for instance in the emerging nanotechnology that will take over the torch of the microelectronics revolution. Increasingly, they are joined by biology, which has been transformed by the spectacular success of molecular and genetic biology. Biotechnology is a multidisciplinary field, drawing knowledge from biology, biochemistry, physics, information processing and various engineering expertise. The cooperation and convergence of traditional intellectual disciplines in the development of new technology is the trend of the future.

**************** END OF LECTURE *******************

Lecture Note 5

Objectives & Mandate

- Provide students with Accident Prevention Methods
- Keep students informed on changes to legislation that effects them
- Provide information, resources and training to help students meet the legislated responsibilities
- Provide a comprehensive safety program

1

Objectives

- Basic safety philosophy
- Overview of safety management
- Elements of a safety program
- Creation of your company safety manual
- Implementation guideline

2

Basic Safety Philosophy

- All injuries can be prevented
- Management is responsible for preventing injuries
- All operating exposures can be prevented
- Training employees to work safely is essential

3

SAFETY

Is a state of mind by which a person is constantly aware of the possibility of an incident or accident occurring at any time

4

Safety Management

Human Costs

Financial Costs

"A systematic, organized process to reducing the human and financial costs of workplace incidents"

- Moral obligation
- Financial benefits
- Legal requirements

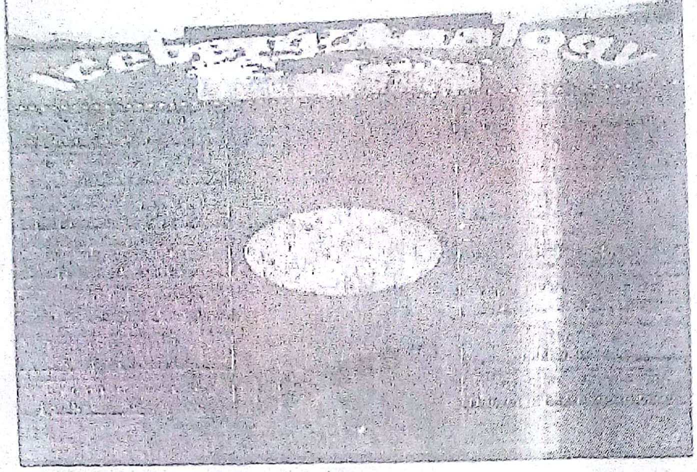
5

Moral Obligation

- Quality of life
- Protection of those you employ from illness or injury
- Good conscience

6

Financial Benefits #1



Legal Requirements

- Workers Compensation Act
- Highway Traffic Act
- Building Codes
- Fire Codes
- Criminal Code
- Workplace Safety and Health Act

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Legal Duties of Employers

- *Workplace Safety And Health Act*
  - USA- code W210
  - Nigerian safety Acts

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The Mines Department discharges the responsibilities under the ambit of various decree, laws, acts and regulations guiding its establishment and operations

These Acts and Regulations are as follows

The Mineral Act of 1990
The Coal Corporation Ordinance of 1990
The explosive Acts of 1990
The explosive regulations of 1990
The quarries Act of 1990
The Nigeria Mining Corporation Act of 1990
The Gold Trading Act
The Diamond Trading Act

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Responsibilities of Employers

Due Diligence

- Establish a written safety and health program (20+ employees)
- Share "Required Information" that
  - May affect the safety of other persons
  - Is necessary to identify and control hazards at a workplace

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Due Diligence

- Only form of defense allowable to an employer
- Employer must PROVE that they did everything "reasonably practicable" to prevent the incident

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Elements of a Safety Program

14. Manitobe Supplement

1. Safety Policy
2. Hazard Assessment
3. Safe Work Practices
4. Safe Work Procedures
5. Company Safety Rules
6. Personal Protective Equipment
7. Preventative Maintenance
8. Training & Communication
9. Inspections
10. Investigations & Reporting
11. Emergency Preparedness
12. Stats & Records
13. Legislation

13

Management Commitment

- Essential to successful implementation and maintenance of your safety program
- Leadership and safety start at the top

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Management Commitment

- Management must be convinced that safety is:
  - Manageable
  - Ongoing
  - Profitable
  - Equal to other business considerations
    - ➢ Cost, production, quality, employee relations
- Management requires:
  - Time
  - Effort
  - Money
  - Personal Example

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Section 1 Company Safety Policy

- Company safety philosophy
- Management's commitment to safety
- Objectives of the safety program
- Assignment of responsibility for safety
- Signed and dated by the CEO
- Reviewed annually by management

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Safety Responsibilities

Review Sample Policies

- All personnel are responsible for their own personal safety and for those who report to them
- Assignment of responsibilities is restricted only to safety
- Ensure all levels of your company have written responsibilities

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Section 2 Hazard Assessment

- Necessary to ensure:
  - Workers Legal Right to Know
  - Due diligence
  - Corrective measures are completed
    - › Reduce risk
    - › Reduce injuries/property damage
    - › Improve productivity
    - › Improve employee morale

Review Sample Responsibilities.

Hazard Assessment

Hazard: Any circumstance or condition which poses the risk of an accident or injury

Hazard Assessment: A thorough examination of an operation to identify the actual and potential hazards prior to work commencing and whenever the work or work environment changes

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Hazard Assessment

- Unsafe condition
- Unsafe act
  - People
  - Environment
  - Materials
  - Equipment and Tools

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Conducting a Hazard Assessment

- People, Environment, Material and Tools
- Ask yourself "What If?"
- Use a checklist
- Rank hazards according to severity and probability

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Hazard Assessment

Prioritizing hazard assessments

- Any job that has produced fatalities/ serious injuries
- Any job that is associated with frequent incidents
- Any job that has the potential for serious injuries
- New (or recently changed) jobs
- Jobs that are seldom performed

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Hazard Ranking Exercise

Severity	Probability
1. Imminent Danger	A. Probable
2. Serious	B. Reasonably Probable
3. Minor	C. Remote
4. O.K.	D. Extremely Remote
5. Not Applicable	

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Control of Hazards

- To try and reduce or control the hazard

Path to the Worker

- Elimination
- Substitution
- Engineering Process
- Administrative Controls
- Personal Protective Equipment

Follow – Up

24

Contractor Evaluation/Monitoring

Review Sample Checklists

Employers must develop:

- A criteria for evaluating and selecting employers and self-employed persons
- Procedures for regularly monitoring employers and self-employed persons

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Section 3 Safe Work Practices

- Means of controlling hazards
  - Doing jobs with a minimum of risk to people and property
- General accepted safe working practices of what you should or should not do that are specific to your company:

  Ie: Hand Tools
  Ladder Safety
  Material Handling

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Safe Work Practices

- Management to show commitment by ensuring:
  - They are in writing
  - Necessary equipment and support are available
  - Supervisors ensure safe work practices are followed
  - Employees understand and apply

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ACCEPTED PRACTICE BECOMES THE EXPECTED STANDARD

28

Section 4 Safe Work Procedures

- Means of controlling hazards
  - Doing jobs with a minimum of risk to people and property
- Specific written description of how to do a job from start to finish

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Safe Work Procedures (SWP)

- SWP are required by law:
  - All tasks in which hazards have been identified
- Conduct JHA or JSA
  - Select job to be analyzed
  - Break job down into sequence of steps
  - Identify potential hazards
  - Determine control methods

  JHA Job hazard analysis
  or
  JSA Job safety analysis
- Write safe work procedure

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Section 5
General Safety Rules

- "Thou shall" and "Thou shall not" statements that leave no room for discretion
- KISS principle Keep it simple, stupid -Navy 1960
- Management and supervisors must lead by example
- Clearly defined disciplinary action

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Section 6 Personal Protective Equipment

Review Sample Rules

Last Line of Defence

- Used only when engineering controls and administrative controls are ineffective or insufficient

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Personal Protective Equipment

- Basic PPE
  - Should be worn at all times
  - Hard hats, eye protection, safety footwear, appropriate clothing
- Specialized PPE
  - Worn for specific jobs or for protection from specific hazards
  - Gloves, welders goggles, respirators, fall arresting equipment

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Personal Protective Equipment

- Selection of PPE
  - Regulations
  - MSDS
  - Manufacturer Specifications
  - Injury reports
  - Experience of management and workers

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Section 7
Preventative Maintenance

- Reduce the risk of injuries, damage or lost production
- Comply with Legislation
- Comply with Manufacturers Specification

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Maintenance

- Ensure that Tools, Equipment and Vehicles are properly:
  - Inspected
  - Maintained
  - In good repair

Sign Off

Maintenance Policy

- Inventory of Equipment
- Maintenance Schedule
- Qualified personnel
- Documentation / Records
- Monitoring
  - Operators
  - Management

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Section 8
Training and Communication

- Essential to the success of your Safety Program
- All Training is Safety Training
- Minimum 3 training components:
  - New Hire Orientation
  - Job Specific Training
  - Safety Meetings

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New Hire Orientation

- Mandatory requirement
- Standardized and based on a written plan or checklist
- Review of company policies, procedures and rules

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Job Specific Training

- Required procedures to complete a task safely
- Formal or Informal
- Written or performance test
- Document
- Involvement of the S & H committee or Safety Rep

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Safety Meetings

- Toolbox or Tailgate Meetings
- Legislated Responsibility
  - 5 or more workers
  - 30 minutes every two weeks
- Document topics and those in attendance

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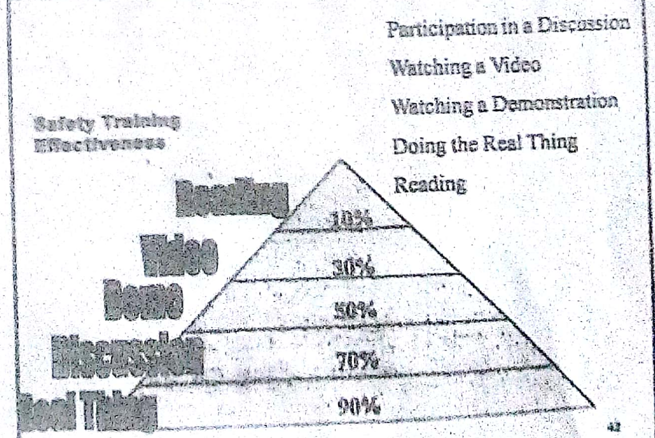

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Section 9
Inspections

- Identify and control hazards
  - Ongoing (informal) inspections
  - Planned (formal) inspections
- Inspection policy
  - Objectives clearly stated
  - Direction and responsibility clearly stated

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Inspection Purposes

- Identify existing and potential hazard and safety violations
- Determine causes of hazards
- Monitor hazard controls
- Determine corrective action
- Reinforce & promote safe practices
- **Comply with legislation**

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Section 10
Investigation & Reporting

- Incident: Any unplanned and unwanted event which results in or "could have" resulted in damage or injury
- Incident Investigation: Determination and analysis of the facts of the incident to establish the causes and the corrective measures required

Prevent Repetition

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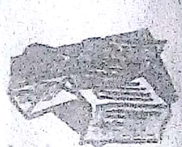
Investigation Policy



- Objectives of investigations
- Type of incidents to be investigated
- Procedures to follow
- Responsibilities

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Section 11
Emergency Preparedness

Be Prepared

Proactive

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Emergency Preparedness

- Plan or contingency to deal with potential emergency situations
- At Minimum:
  - Provide first aid to the injured
  - Provide transportation to medical aid
  - Conduct initial attack on fire
  - Promptly contact outside agencies for help
- Pre-job planning and/or hazard assessment may identify other potential emergency situations

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Section 12
Statistics & Records

Due Diligence

- Prevention
- Measurement

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Section 13
Legislation

Minimum Standards

- Joint Workplace
- Workers Rights
  - Right to Refuse
  - Right to Know
  - Right to Participate

Legislation

- Familiarization with Legal Duties and Responsibilities for:

• Employers	Section 4(1) - 4(6)
• Supervisors	Section 4.1
• Workers	Section 5
• Self-Employed Persons	Section 6

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Legislation

• Prime Contractors	Section 7(1) - 7(3)
• Contractors	Section 7.1
• Owners	Section 7.2
• Suppliers	Section 7.3

Section 14
Manitoba Supplement

- Required on all construction sites
  - Joint Safety & Health Committee

    AND/OR
  - Safety & Health Representative
- Effective vehicle for communication amongst all levels of the company

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S & H Committee Duties

- Receipt, consideration and disposition of concerns and complaints respecting the safety and health of workers
- Identification of risks to safety and health of workers and others
- Develop and promote protective measures, programs, education and information concerning safety & health in the workplace

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Further Duties of Committee

- Co-operate with OSH Officers
- Develop and promote and make recommendation concerning safety and health education
- Inspections of the workplace
- Participate in investigations
- Other duties specified in the Act

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Manitoba Supplement

- Hearing Conservation Program
  - Testing
  - Monitoring
  - Employee training
- Lock-Out/Tag-out
  - Written Procedure
  - Employee training

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Manitoba Supplement

Musculoskeletal Injuries:

- Identify/Communicate/Control

Harassment/Violence:

- Policy
- Training

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Manitoba Supplement

- Working Alone
  - Written Procedure
  - Employee training
- WHMIS
  - Labels
  - MSDS
  - Employee training

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Javid

Manitoba Supplement

- Prime Contractor
  - Responsibilities
  - Responsibilities of Sub-Contractor
- Operator training/certification
  - Competent person
  - Certification required
    - Forklifts
    - Cranes

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Questions

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