COURSE CODE: *AGE 405*
COURSE TITLE: *Farm Electrification*
NUMBER OF UNITS: *3 Units*
COURSE DURATION: *Three hours per week*

COURSE DETAILS:

Course Coordinator: **Dr. Olayanju T.M. Adeniyi,** B.Sc., M.Sc. Ph.D
Email: olayanjutma@unaab.edu.ng
Office Location: **Room G003, CVE Building, COLENG**
Other Lecturers: **None**

COURSE CONTENT:

Electricity as a power source on the farm lighting, farm production and processing. Planning the farm stead distribution system:- demand load for farm buildings and workshops, central metering and distribution, capacity of main service. Selecting feeder conductors. Electric central and circuit protection. Electric motor selection. Care and maintenance of electrical farm installations and machines – hatcheries, milking machines, feed mills, etc. Stand-by power units; purpose and importance, stand-by power generator types, selection, maintenance and operation.

COURSE REQUIREMENTS:

This is a compulsory course for all students in the Department of Agricultural Engineering. In view of this, Students are expected to participate in all the course activities and have minimum of 75% attendance to be able to write the final examination.

READING LIST:

1. A text book of Electrical technology by B.L Tereja and A.K. Tereja Volume I – Basic Electrical Engineering. S.Chand and Company Ltd. 2005
2. Rural Electrification. Mijinyawa et al 2000.

LECTURE NOTES

AGE 405: RURAL ELECTRIFICATION (3 Units)

COURSE BASICS

Safety Rules : Never underrate the danger of electricity in any form even from a battery

- Avoid working on live/hot wire appliances. Disconnect or pull fuses before any operation
- Ground all electric motor and frames of portable and mobile machines
- Do not probe into any appliance with just any screw driver, use the approved type
- Do not touch electrical appliances, switches etc tucked in water
- Avoid touching/holding electric fence
- Check all wires to ensure the connections are well made

Generation and flow of electricity using the atomic theory

Atoms are made of electrons moving and arranged on shells in an orderly manner with 2 in the first shell, 8 in the second…… This is similar to the solar system arrangement as explained by Rutherford theory. The metallic elements mostly have one electrons on the outer shell which makes them loose i.e. Weak binding/attractive force to the protons in the nucleus (have equal positive charges to the negatively charged electrons). When there is an external force these electrons are easily attracted by the force and lost or knocked off their orbit (resulting in inbalance in the +ve and –ve). This result in the atom becoming positively charged (ion). The electrons move in space towards the force and this drift of electron is what is known as flow of electricity. Current is measured in terms of the number of electrons moving through a point at a particular time as defined by Coloumb.

Conductivity and resistance to electricity

The electrons when flowing may collide with each other or with the atoms depending on the concentration of the electrons and the ions. The collisions results in the reduction of the number of electrons passing through a particular point at a time. The extent of the reduction in the flow is what is used a s a measure of resistance to flow and vice versa for conductivity

Fluid flow phenomenon

In a fluid flow, the pressure to convey water up to a higher level is often provided by a pump, or down a slope by gravity from a storage tank. This results in a flow rate through the pipe, the rate is also determined by the extent of the roughness or smoothness of the pipe which determines the resistance to flow i.e friction

Electricity flow is analogous to this as the VOLTAGE is the pressure produced from a storage device e.g. battery or a generator (pump). These constitute the force attracting or pulling the charges as explained in (a). The rate of flow of the electrons escaping from the charged ions (CURRENT) is analogous to the flow rate of water in the pipe. The friction is the resistance to flow as explained in (b)

Heavy machineries

Drawing of very high current in heavy machineries at the detriment of other equipment can be prevent by the use of capacitor. Capacitors have two conductive plates separated by dielectric materials which are insulators that doesn't allow the passage of electricity. As shown below when the circuit is off, because the circuit to the capacitor is still closed, the charges are however not able to pass through the insulator but are deposited on the plates as positive and negative charges. This continues until the main circuit is on. During this period, current will flow to the machine from the battery of the main supply. In addition the charges stored are also released to compliment the current drawn from the main circuit to start the equipment.

1.0 Electricity

I INTRODUCTION

Electricity, all the phenomena that result from the interaction of electrical charges. Electric and magnetic effects are caused by the relative positions and movements of charged particles of matter. When a charge is stationary (static), it produces electrostatic forces on charged objects, and when it is in motion it produces additional magnetic effects. So far as electrical effects are concerned, objects can be electrically neutral, positively charged, or negatively charged. Positively charged particles, such as the protons that are found in the nucleus of atoms, repel one another. Negatively charged particles, such as the electrons that are found in the outer parts of atoms, also repel one another (*see* Atom). Negative and positive particles, however, attract each other. This behaviour may be summed up as: like charges repel, and unlike charges attract.

II ELECTROSTATICS

The electric charge on a body is measured in coulombs (*see* Electrical Units; International System of Units). The force between particles bearing charges q_1 and q_2 can be calculated by Coulomb's law,

$$F_{elec} = \frac{q_1 q_2}{4\pi\varepsilon r^2}$$

This equation states that the force is proportional to the product of the charges, divided by the square of the distance that separates them. The charges exert equal forces on one another. This is an instance of the law that every force produces an equal and opposite reaction. (*see* Mechanics: *Newton's Three Laws of Motion*.) The term π is the Greek letter pi, standing for the number 3.1415..., which crops up repeatedly in geometry. The term ε is the Greek letter epsilon, standing for a quantity called the absolute permittivity, which depends on the medium surrounding the charges. This law is named after the French physicist Charles Augustin de Coulomb, who developed the equation.

Every electrically charged particle is surrounded by a field of force. This field may be represented by lines of force showing the direction of the electrical forces that would be experienced by an imaginary positive test charge within the field. To move a charged particle from one point in the field to another requires that work be done or, equivalently, that energy be transferred to the particle. The amount of energy needed for a particle bearing a unit charge is known as the potential difference between these two points. The potential difference is usually measured in volts (symbol V). The Earth, a large conductor that may be assumed to be substantially uniform electrically, is commonly used as the zero reference level for potential energy. Thus the potential of a positively charged body is said to be a certain number of volts above the potential of the Earth, and the potential of a negatively charged body is said to be a certain number of volts below it.

A Electrical Properties of Solids

The first artificial electrical phenomenon to be observed was the property displayed by certain resinous substances such as amber, which become negatively charged when rubbed with a piece of fur or woollen cloth and then attract small objects. Such a body has an excess of electrons. A glass rod rubbed with silk has a similar power; however, the glass has a positive charge, owing to a deficiency of electrons. The charged amber and glass even attract uncharged bodies (*see* Electric Charges *below*).

Protons lie at the heart of the atom and are effectively fixed in position in solids. When charge moves in a solid, it is carried by the negatively charged electrons. Electrons are easily liberated in some materials, which are known as conductors. Metals, particularly copper and silver, are good conductors. *see* Conductor, Electrical.

Materials in which the electrons are tightly bound to the atoms are known as insulators, non-conductors, or dielectrics. Glass, rubber, and dry wood are examples of these materials.

A third kind of material is called a semiconductor, because it generally has a higher resistance to the flow of current than a conductor such as copper, but a lower resistance than an insulator such as glass. In one kind of semiconductor, most of the current is carried by electrons, and the semiconductor is called n-type. In an n-type semiconductor, a relatively small number of electrons can be freed from their atoms in such a manner as to leave a "hole" where each electron had been. The hole, representing the absence of a negative electron, is a positively charged ion (incomplete atom). An electric field will cause the negative electrons to flow through the material while the positive holes remain fixed. In a second type of semiconductor, the holes move, while electrons hardly move at all. When most of the current is carried by the positive holes, the semiconductor is said to be p-type.

If a material were a perfect conductor, a charge would pass through it without resistance, while a perfect insulator would allow no charge to be forced through it. No substance of either type is known to exist at room temperature. The best conductors at room temperature offer a low (but non-zero) resistance to the flow of current. The best insulators offer a high (but not infinite) resistance at room temperature. Most metals, however, lose all their resistance at temperatures near absolute zero; this phenomenon is called superconductivity.

B Electric Charges

One quantitative tool used to demonstrate the presence of electric charges is the electroscope. This device also indicates whether the charge is negative or positive and detects the presence of radiation. The device, in the form first used by the British physicist and chemist Michael Faraday, is shown in Figure 1. The electroscope consists of two leaves of thin metal foil (*a,a*_) suspended from a metal support (*b*) inside a glass or other non-conducting container (*c*). A knob (*d*) collects the electric charges, either positive or negative, and these are conducted along the metal support and travel to both leaves. The like charges repel one another and the leaves fly apart, the distance between them depending roughly on the quantity of charge.

Three methods may be used to charge an object electrically: (1) by contact with another object of a different material (for example, touching amber to fur), followed by separation; (2) by contact with another charged body; and (3) by induction.

Electrical induction is shown in Figure 2. A negatively charged body, *A,* is placed between a neutral conductor, *B,* and a neutral non-conductor, *C.* The free electrons in the conductor are repelled to the side of the conductor away from *A*, leaving a net positive charge at the nearer side. The entire body *B* is attracted towards *A,* because the attraction of the unlike charges that are close together is greater than the repulsion of the like charges that are farther apart. As stated above, the forces between electrical charges vary inversely according to the square of the distance between the charges. In the non-conductor, *C,* the electrons are not free to move, but the atoms or molecules of the non-conductor are stretched and reoriented so that their constituent electrons are as far as possible from *A;* the non-conductor is therefore also attracted to *A*, but to a lesser extent than the conductor.

The movement of electrons in the conductor *B* of Figure 2 and the reconfiguration of the atoms of the non-conductor *C* give these bodies positive charges on the sides nearest *A* and negative charges on the sides away from *A.* Charges produced in this manner are called induced charges and the process of producing them is called induction.

III ELECTRICAL MEASUREMENTS

The flow of charge in a wire is called current. It is expressed in terms of the number of coulombs per second going past a given point on a wire. One coulomb/sec equals 1 ampere (symbol A), a unit of electric current named after the French physicist André Marie Ampère. *See* Current Electricity *below*.

When 1 coulomb of charge travels across a potential difference of 1 volt, the work done equals 1 joule, a unit named after the English physicist James Prescott Joule. This definition facilitates transitions from mechanical to electrical quantities.

A widely used unit of energy in atomic physics is the electronvolt (eV). This is the amount of energy gained by an electron that is accelerated by a potential difference of 1 volt. This is a small unit and is frequently multiplied by 1 million or 1 billion, the result being abbreviated to 1 MeV or 1 GeV, respectively.

IV CURRENT ELECTRICITY

If two equally and oppositely charged bodies are connected by a metallic conductor such as a wire, the charges neutralize each other. This neutralization is accomplished by means of a flow of electrons through the conductor from the negatively charged body to the positively charged one. (Electric current is often conventionally assumed to flow in the opposite direction—that is, from positive to negative; nevertheless, a current in a wire consists only of moving negatively charged electrons.) In any continuous system of conductors, electrons will flow from the point of lowest potential to the point of highest potential. A system of this kind is called an electric circuit. The current flowing in a circuit is described as direct current (DC) if it flows continuously in one direction, and as alternating current (AC) if it flows alternately in each direction.

Three interdependent quantities characterize direct current. The first is the potential difference in the circuit, which is sometimes called the electromotive force (emf) or voltage. The second is the rate of current flow. This quantity is usually given in terms of the ampere, which corresponds to a flow of about 6.24×10^{18} electrons per second past any point of the circuit. The third quantity is the resistance of the circuit. Under ordinary conditions all substances, conductors as well as non-conductors, offer some opposition to the flow of an electric current, and this resistance necessarily limits the current. The unit used for expressing the quantity of resistance is the ohm, which is defined as the amount of resistance that will limit the flow of current to 1 ampere in a circuit with a potential difference of 1 volt. The symbol for the ohm is the Greek letter Ω, omega. The relationship may be stated in the form of the algebraic equation $E = I \times R$, in which E is the electromotive force in volts, I is the current in amperes, and R is the resistance in ohms. From this equation any of the three quantities for a given circuit can be calculated if the other two quantities are known. Another formulation is $I = E/R$. *see* Electric Circuit; Electric Meters.

Ohm's law is the generalization that for many materials over a wide range of circumstances, R is constant. It is named after the German physicist Georg Simon Ohm, who discovered the law in 1827.

When an electric current flows through a wire, two important effects can be observed: the temperature of the wire is raised, and a magnet or a compass needle placed near the wire will be deflected, tending to point in a direction perpendicular to the wire. As the current flows, the electrons making up the current collide with the atoms of the conductor and give up energy, which appears in the form of heat. The amount of energy expended in an electric circuit is expressed in terms of the joule. Power is expressed in terms of the watt, which is equal to 1 J/sec. The power expended in a given circuit can be calculated from the equation $P = E \times I$ or $P = I^2 \times R$. Power may also be expended in doing mechanical work, in producing electromagnetic radiation such as light or radio waves, and in chemical decomposition.

V ELECTROMAGNETISM

The movement of a compass needle near a conductor through which a current is flowing indicates the presence of a magnetic field (*see* Magnetism) around the conductor. When currents flow through two parallel conductors in the same direction, the magnetic fields cause the conductors to attract each other; when the flows are in opposite directions, they repel each other. The magnetic field caused by the current in a single loop or wire is such that the loop will behave like a magnet or compass needle and swing until it is perpendicular to a line running from the north magnetic pole to the south.

The magnetic field about a current-carrying conductor can be visualized as encircling the conductor. The direction of the magnetic lines of force in the field is anticlockwise when observed in the direction in which the electrons are moving. The field is stationary so long as the current is flowing steadily through the conductor.

When a moving conductor cuts the lines of force of a magnetic field, the field acts on the free electrons in the conductor, displacing them and causing a potential difference and a flow of current in the conductor. The same effect occurs whether the magnetic field is stationary and the wire moves, or the field moves and the wire is stationary.

When a current increases in strength, the field increases in strength, and the circular lines of force may be imagined to expand from the conductor. These expanding lines of force cut the conductor itself and induce a current in it in the direction opposite to the original flow. With a conductor such as a straight piece of wire this effect is very slight, but if the wire is wound into a helical coil the effect is much increased, because the fields from the individual turns of the coil cut the neighbouring turns and induce a current in them as well. The result is that such a coil, when connected to a source of potential difference, will impede the flow of current when the potential difference is first applied.

Similarly, when the source of potential difference is removed the magnetic field "collapses", and again the moving lines of force cut the turns of the coil. The current induced under these circumstances is in the same direction as the original current, and the coil tends to maintain the flow of current. Because of these properties, a coil resists any change in the flow of current and is said to possess electrical inertia, or inductance. This inertia has little importance in DC circuits, because it is not observed when current is flowing steadily, but it has great importance in AC circuits. *See* Alternating Currents *below*.

VI CONDUCTION IN LIQUIDS AND GASES

When an electric current flows in a metallic conductor, the flow of particles is in one direction only, because the current is carried entirely by electrons. In liquids and gases, however, a two-directional flow is made possible by the process of ionization (*see* Electrochemistry). In a liquid solution, the positive ions move from higher potential to lower; the negative ions move in the opposite direction. Similarly, in gases that have been ionized by radioactivity, by the ultraviolet rays of sunlight, by electromagnetic waves, or by a strong electric field, a two-way drift of ions takes place to produce an electric current through the gas. *see* Electric Arc; Electric Lighting.

VII SOURCES OF ELECTROMOTIVE FORCE

To produce a flow of current in any electrical circuit, a source of electromotive force or potential difference is necessary. The available sources are: (1) electrostatic machines such as the Van de Graaff generator, which operate on the principle of inducing electric charges by mechanical means ; (2) electromagnetic machines, which generate current by mechanically moving conductors through a magnetic field or a number of fields (*see* Electric Motors and Generators); (3) batteries, which produce an electromotive force through electrochemical action; (4) devices that produce electromotive force through the action of heat (*see* Crystal: Other Crystal Properties; Thermoelectricity); (5) devices that produce electromotive force by the photoelectric effect, the action of light; and (6) devices that produce electromotive force by means of physical pressure—the piezoelectric effect.

VIII ALTERNATING CURRENTS

When a conductor is moved back and forth in a magnetic field, the flow of current in the conductor will change direction as often as the physical motion of the conductor changes direction. Several electricity-generating devices operate on this principle, and the oscillating current produced is called alternating current. Alternating current has several valuable characteristics, as compared to direct current, and is generally used as a source of electric power, both for industrial installations and in the home. The most important practical characteristic of alternating current is that the voltage or the current may be changed to almost any value desired by means of a simple electromagnetic device called a transformer. When an alternating current passes through a coil of wire, the magnetic field about the coil first expands and then collapses, then expands with its direction reversed, and again collapses. If another conductor, such as a coil of wire, is placed in this field, but not in direct electric connection with the coil, the changes of the field induce an alternating current in the second conductor. If the second conductor is a coil with a larger number of turns than the first, the voltage induced in the second coil will be larger than the voltage in the first, because the field is acting on a greater number of individual conductors. Conversely, if the number of turns in the second coil is smaller, the secondary, or induced, voltage will be smaller than the primary voltage.

The action of a transformer makes possible the economical transmission of current over long distances in electric power systems (*see* Electricity Supply). If 200,000 watts of power is supplied to a power line, it may be equally well supplied by a potential of 200,000 volts and a current of 1 ampere or by a potential of 2,000 volts and a current of 100 amperes, because power is equal to the product of voltage and current. However, the power lost in the line through heating is equal to the square of the current times the resistance. Thus, if the resistance of the line is 10 ohms, the loss on the 200,000-volt line will be 10 watts, whereas the loss on the 2,000-volt line will be 100,000 watts, or half the available power.

The magnetic field surrounding a coil in an AC circuit is constantly changing, and constantly impedes the flow of current in the circuit because of the phenomenon of inductance mentioned above. The relationship between the voltage impressed on an ideal coil (that is, a coil having no resistance) and the current flowing in it is such that the current is zero when the voltage is at a maximum, and the current is at a maximum when the voltage is zero. Furthermore, the changing magnetic field induces a potential difference in the coil, called a back emf, that is equal in magnitude and opposite in direction to the impressed potential difference. So the net potential difference across an ideal coil is always zero, as it must necessarily be in any circuit element with zero resistance.

If a capacitor (or condenser), a charge-storage device, is placed in an AC circuit, the current is proportional to its capacitance and to the rate of change of the voltage across the capacitor. Therefore, twice as much current will flow through a 2-farad capacitor as through a 1-farad capacitor. In an ideal capacitor the voltage is exactly out of phase with the current. No current flows when the voltage is at its maximum because then the rate of change of voltage is zero. The current is at its maximum when the voltage is zero, because then the rate of change of voltage is maximal. Current may be regarded as flowing through a capacitor even if there is no direct electrical connection between its plates; the voltage on one plate induces an opposite charge on the other, so, when electrons flow into one plate, an equal number always flow out of the other. From the point of view of the external circuit, it is precisely as if electrons had flowed straight through the capacitor.

It follows from the above effects that if an alternating voltage were applied to an ideal inductance or capacitance, no power would be expended over a complete cycle. In all practical cases, however, AC circuits contain resistance as well as inductance and capacitance, and power is actually expended. The amount of power depends on the relative amounts of the three quantities present in the circuits.

IX HISTORY

The fact that amber acquires the power to attract light objects when rubbed may have been known to the Greek philosopher Thales of Miletus, who lived about 600 BC. Another Greek philosopher, Theophrastus, in a treatise written about three centuries later, stated that this power is possessed by other substances. The first scientific study of electrical and magnetic phenomena, however, did not appear until AD 1600, when the researches of the English doctor William Gilbert were published. Gilbert was the first to apply the term electric (Greek *elektron*, “amber”) to the force that such substances exert after rubbing. He also distinguished between magnetic and electric action.

The first machine for producing an electric charge was described in 1672 by the German physicist Otto von Guericke. It consisted of a sulphur sphere turned by a crank on which a charge was induced when the hand was held against it. The French scientist Charles François de Cisternay Du Fay was the first to make clear the two different types of electric charge: positive and negative. The earliest form of condenser, the Leyden jar, was developed in 1745. It consisted of a glass bottle with separate coatings of tinfoil on the inside and outside. If either tinfoil coating was charged from an electrostatic machine, a violent shock could be obtained by touching both foil coatings at the same time.

Benjamin Franklin spent much time in electrical research. His famous kite experiment proved that the atmospheric electricity that causes the phenomena of lightning and thunder is identical with the electrostatic charge on a Leyden jar. Franklin developed a theory that electricity is a single "fluid" existing in all matter, and that its effects can be explained by excesses and shortages of this fluid.

The law that the force between electric charges varies inversely with the square of the distance between the charges was proved experimentally by the British chemist Joseph Priestley about 1766. Priestley also demonstrated that an electric charge distributes itself uniformly over the surface of a hollow metal sphere, and that no charge and no electric field of force exists within such a sphere. Coulomb invented a torsion balance to measure accurately the force exerted by electrical charges. With this apparatus he confirmed Priestley's observations and showed that the force between two charges is also proportional to the product of the individual charges. Faraday, who made many contributions to the study of electricity in the early 19th century, was also responsible for the theory of lines of electrical force.

The Italian physicists Luigi Galvani and Alessandro Volta conducted the first important experiments in electrical currents. Galvani produced muscle contraction in the legs of frogs by applying an electric current to them. In 1800 Volta demonstrated the first electric battery. The fact that a magnetic field exists around an electric current was demonstrated by the Danish scientist Hans Christian Oersted in 1819, and in 1831 Faraday proved that a current flowing in a coil of wire can induce electromagnetically a current in a nearby coil. About 1840 James Prescott Joule and the German scientist Hermann von Helmholtz demonstrated that electric circuits obey the law of conservation of energy and that electricity is a form of energy.

An important contribution to the study of electricity in the 19th century was the work of the British mathematical physicist James Clerk Maxwell, who proposed the idea of electromagnetic radiation and developed the theory that light consists of such radiation. His work paved the way for the German physicist Heinrich Hertz, who produced and detected electromagnetic waves in 1886, and for the Italian engineer Guglielmo Marconi, who in 1896 harnessed these waves to produce the first practical radio signalling system.

The electron theory, which is the basis of modern electrical theory, was first advanced by the Dutch physicist Hendrik Antoon Lorentz in 1892. The charge on the electron was first accurately measured by the American physicist Robert Andrews Millikan in 1909. The widespread use of electricity as a source of power is largely due to the work of such pioneering American engineers and inventors as Thomas Alva Edison, Nikola Tesla, and Charles Proteus Steinmetz. *See also* Electronics.

2.0 Electricity Generation

I INTRODUCTION

Electricity Generation, is the process of converting energy stored in fuels or drawn from the environment into electrical energy. It embraces numerous complex technologies.

Energy appears in nature in two forms, disordered and ordered (*see* Physics: *The Second Law of Thermodynamics*). The disordered form, of which heat is a prime example, can be converted into other forms, such as mechanical energy, through a heat engine. Typical heat engines are piston engines, as used in cars, or gas turbines, as used in jet aircraft. The efficiency of practical heat engines is rather low—in general, less than 40 per cent. This means that less than 40 per cent of the energy output from the engine is in a useful form.

The ordered form of energy, of which mechanical and electrical energy are prime examples, is "high-grade" energy, as one type can be converted to other types at nearly 100 per cent efficiency. For example, electrical energy can be converted into mechanical energy in a motor at an efficiency of over 90 per cent.

II THE ADVANTAGES OF ELECTRICITY

The reasons why electricity is universally employed as a medium of energy transfer and use are that: (1) It can be efficiently transported from generators to the point of use in the consumer's premises through a simple-to-install network of wires. (2) It can be converted at high efficiency into heat, mechanical, and chemical energy. It powers electronic devices. It provides light. (3) It is instantly controllable at the point of use—it takes only a flick of a switch to turn an electrical device on or off.

III GENERATING STATIONS

Traditionally electrical energy has been produced in power stations using fossil or nuclear fuels.

In a typical coal-fired power station the coal is ground to fine powder in a mill, mixed with pre-heated air and blown into a furnace, where it burns like a gas. The furnace, or boiler, is the largest structure in a power station, as its walls are lined with several kilometres of water pipes which are designed to extract as much heat as possible from the burning fuel. The hot gases boil the water in the pipes and convert it into high-pressure, high-temperature steam. Afterwards, the low-temperature gases are forced through dust extractors to collect as much of the ash as possible. In modern stations they pass through specialized equipment to extract the environmentally harmful sulphur products of combustion. Finally, the flue gases are forced up a tall chimney stack and discharged into the atmosphere.

The steam generated by the boiler is supplied to a turbine, in which its heat energy is converted into mechanical energy by making a shaft rotate. It is here that the inefficiency of heat engines takes its toll. The low-temperature, low-pressure steam at the output of the turbine has to be condensed into water and pumped back into the boiler to close the cycle. Large quantities of cooling water are needed for this task—perhaps 230,000 cubic metres (50.6 million gallons) per hour for a 2,000 MW station (1 MW equals 1 megawatt). If the power station is built on a river estuary, the river can supply the water; otherwise, the cooling water has to be recycled. Cooling towers enable this to be done by getting rid of the waste heat into the atmosphere. Only relatively small amounts of make-up water are required to replace the water lost through evaporation.

Stations fired with oil or gas operate in essentially the same way as a coal-fired station. In a nuclear power station, however, heat is generated in the core of the reactor through the breakdown of a fissionable material such as uranium. The heat is carried away by a coolant liquid or gas, which is then used to raise steam in the manner already described. There are a large number of reactor designs, using different coolants and reactor structures. The rate of reaction is controlled by a set of rods made of a material that absorbs neutrons. These rods can quickly be lowered into the core to shut the reactor down in emergencies. A “biological shield”, consisting of concrete several metres thick, surrounds the reactor to protect operators from the core, which is intensely radioactive. (*See* Nuclear Energy.)

Recently a new type of gas-fired power station, known as the combined-cycle gas turbine (CCGT) station, has been very popular with electricity companies. It uses two stages of energy extraction from the fuel, allowing overall efficiencies to approach 55 per cent. The gas is first burnt in a gas turbine to generate electricity. The exhaust gases from the turbine are then used as in a conventional power station to raise steam for further electricity generation.

A turbine driven by steam or gas is coupled to the rotor of an electrical generator, which consists of a solid steel cylinder with a winding that carries direct current and spins at 3,000 revolutions per minute. Because of the current flowing through it, the rotor becomes a strong electromagnet. The stationary part of the electrical generator, the stator, carries three windings. The rotating magnetic flux induces alternating voltages in these “three-phase” windings. These alternating voltages have a frequency of 50 Hz (hertz, cycles per second). The electrical power produced in an external circuit is proportional to the product of voltage and current. Thus the mechanical power input from the turbine is converted into electrical power output at the generator. The conversion efficiency here is nearly 100 per cent.

IV PROBLEMS OF ELECTRICAL GENERATION

Electrical energy is the lifeblood of all industrialized societies, central to the maintenance of their standards of living, and it is essential to developing countries if they are to escape from poverty. The problem is that in the long term all fossil and nuclear fuels have a limited availability. Predictions range from 40 to 60 years for gas and oil to 200 years for coal at the current rate of consumption (*see* Energy Supply, World). A more pressing problem at present is that the burning of coal, oil, and gas is producing a number of by-products that are harmful to the environment. The accumulation of carbon dioxide, the most important greenhouse gas, over the last few decades is believed to be responsible for increasing the Earth's surface temperature. The majority of scientists specializing in this area believe that if we continue on our present path severe climatic changes may occur in a few decades.

V SOURCES OF ELECTRICAL ENERGY

If the use of fossil fuels is to be curbed, the only alternatives available are nuclear energy and renewable energy. After the Chernobyl accident, some scientists believe that the risks involved in nuclear power may not be acceptable. The creation of radioactive waste that will have to be contained for many centuries is also felt to be an unfair legacy to our descendants. Other scientists believe that to prevent climatic changes we will have to put up with these risks. In contrast, renewable energy is environmentally very clean, though not problem-free.

The total amount of energy received by the Earth in light from the Sun is immense—more in fifteen minutes than humanity consumes in one whole year. Only a fraction of this is usable, but this fraction could provide a hundred times our energy needs. At present the most promising renewable sources are those from wind, Sun, water, and biofuels. The principal disadvantage of many renewables is aesthetic. This is simply because those renewable energies are so “dilute” that very large or numerous installations are needed to collect the energy. This is particularly true of solar and wind energy.

A wind farm is a group of wind turbines that converts part of the kinetic energy of the wind into electricity. The wind slows down as it passes through the rotating blades of the turbines, and the energy it loses (about 40 per cent) is converted by the turbine into mechanical and then electrical energy, which is fed into the electricity grid.

In photovoltaic devices, sunlight falls on special semiconductor material, which converts about 15 per cent of the sunlight energy directly into DC electricity (direct, or one-way, current). This has to be converted into AC (alternating current) before it is fed into the mains.

In water-driven systems the kinetic energy of falling water is first converted into the mechanical energy of turbines and then into electrical energy (*see* Hydro-Power). The process is reversed in pumped-storage schemes, in which water is pumped into reservoirs electrically at times when demand for electrical power is at a minimum. The water is allowed to flow out of the reservoir at peak times, driving generators and supplementing the electrical supply. This enables the power station to keep running at a more uniform level, which is especially important in the case of nuclear energy plants.

In some power stations, heat is produced by burning rubbish or the methane gas produced by the decomposition of waste in tips. Others use “biofuels”: waste matter from agricultural processes, or wood from the regular coppicing of purpose-grown plantations.

If the development of renewable energy is seriously pursued, it is likely that power systems of the future will consist of a diversity of small generating units using these varied technologies, rather than the cathedral-like power stations of today. *See also*Energy Conservation: *Electricity Generation*.

3.0 Electricity Supply

I INTRODUCTION

Electricity Supply is delivery of electrical energy from generating stations to consumers.

The supply system must provide the electrical energy to consumers at fixed voltage, with minimum transport cost, and with high reliability.

After gradual development over the last hundred years, the complex electricity supply systems of today are capable of satisfying these requirements most of the time.

II CHOICE OF VOLTAGE

The electrical power delivered by a transmission line is proportional to the product of its voltage relative to earth and the current. The power loss in the line is given by the product of the line resistance and the current squared, $W = I^2R$. It follows that to transport a given amount of electrical energy over long distances as efficiently as possible it is necessary to do it at the lowest possible current and the highest possible voltage. However, the higher the voltage adopted, the further the transmission line must be kept from people and from the ground, the taller must be the pylons that carry the line, and the broader the right of way that the line occupies. This increases the capital cost of the line. Hence, as in all engineering problems, a compromise has to be sought between the rising capital costs as the voltage is increased and the rising running costs as the voltage is decreased. For a given power level there is a specific voltage that results in a minimum overall cost.

In the United Kingdom a range of specific voltages have been adopted to cover adequately various levels of power transmission. These include 11 kV, 33 kV, 66 kV, 132 kV, 275 kV, and 400 kV (1 kV, or kilovolt, is 1,000 volts).

At generating stations electricity is produced at a voltage in the range 20 to 30 kV. For long-distance transport this voltage is transformed up to 275 kV or 400 kV. In other countries, with very long transmission distances, the voltage may be raised to 1,000 kV. The power system component that steps up the voltage is a transformer, one of the most fundamental electromagnetic devices.

The remote end of the long-distance “supergrid” line terminates in a bulk-power sub-station some distance from the periphery of a large load centre, such as a city. At the sub-station the voltage is stepped down to a “sub-transmission” level of 132 kV (in the UK) and through multiple overhead lines is distributed over rural areas to a number of strategic points on the outskirts of the city. There the voltage is reduced further to the primary distribution level of 33 kV or 11 kV, and eventually to the secondary distribution level of 415 V for use by consumers. In Britain the distribution is through underground cables, freeing towns and cities of the pylons that are often seen on the Continent and in the United States. Industrial consumers, depending on their size, may be supplied at the 11 kV or 33 kV level.

III ALTERNATING CURRENT

Electricity is generated, transmitted, and used in the form of three-phase alternating current (AC). The current strength of AC electricity oscillates sinusoidally at 50 Hz (1 Hz, or hertz, is 1 cycle per second) in most countries but at 60 Hz in the United States. Generators provide three such varying voltage outputs, delayed by one third of a cycle with respect to each other. The reason for this complexity is that generators, transmission lines, and motors can be designed to operate most efficiently when working with this three-phase AC. Additionally, and most importantly, transformers work only with AC. Householders are supplied from one of the phases of the three-phase system. Its voltage is nominally 230 V to ground.

IV FREQUENCY STABILITY

The frequency of the mains supply is maintained at 50 Hz with great precision. The frequency is a sensitive indicator of the balance between input and output power in the network. A drop in frequency indicates that the demand is greater than the supply. This indicates to the generating stations that they should connect more generating units to the system to supply the increasing demand. A rise in frequency indicates that the demand is dropping and generating units are shut down to preserve the balance. This "commitment" of units on and off the system is one of the important functions of the generating companies. Because of the delays involved in commitment, the companies attempt to predict the demand variations through load-forecasting.

V VOLTAGE STABILITY

One important task of the supply system is to provide consumers with electricity at constant voltage. All industrial and household electric appliances are designed to operate at a constant voltage. For example, a light bulb is designed to consume, say, 100 W (watts) at 240 V. If the voltage is increased, by even a small margin, the coiled filament will overheat and melt. Conversely, if the voltage drops below the nominal value the lamp will not provide its intended light output. Electricity companies have a variety of means of maintaining the voltage supplied to consumers within statutory limits.

VI RELIABILITY OF SUPPLY

Reliability is ensured through a complex protection system built into the transmission network. A typical malfunction of a network is the collapse of a pylon, owing to the weight of snow combined with the forces exerted by very high winds. The physical contact of the transmission lines, a "short circuit", causes large currents to flow in the system, which, unless checked, would damage other equipment, such as transformers and generators.

The protection system has numerous detectors dispersed throughout the system. It trips faulty components by means of switches, known as circuit-breakers, which are located at strategic points throughout the network.

Circuit-breakers are often used to protect household circuits, too, but the cheapest and most reliable protection device is the fuse, which "blows" (burns out) if the current passing through the fuse to an appliance exceeds the fuse rating, thus protecting the wiring network.

4.0 DOMESTIC ELECTRICITY

Domestic electricity is that electricity which is supplied to homes under specific conditions of current and voltage. Voltage, measured in volts (V), causes electric current, measured in amperes (A), to flow in a conducting material such as copper wire. For practical and commercial reasons a "harmonized" 230-V system is used in homes in member countries of the European Union. In the United States, domestic voltage is 120 V. Various sizes of cable are used, depending on the circuit requirements. Typically these are: 6 A for lighting; 16 A for water heaters; 32 A for sockets (the "ring main"); 40 A for ovens; 63 A for showers.

Electric current flows when a circuit is continuous and unbroken—for example, when a switch is closed to the "on" position, enabling an electrical appliance to be operated. Because conductors carry electric current, they must be insulated in order to prevent potentially fatal contact with them. The usual insulating material is PVC (polyvinylchloride), a plastic that is flexible and mechanically strong, and can be made thick enough to prevent a short-circuit between the conductor and any adjacent metal parts.

For identification purposes, insulation is colour-coded. In the permanent "hidden" house wiring, "live" cables are coloured red and are used for the supply to the appliance. Neutral cables are coloured black and are used to complete the circuit from the appliance back to the supply. A third cable, identified by green and yellow stripes, is used to connect the exposed metallic parts of the appliance to earth, so that if a fault develops in the appliance, any small fault current will flow to earth, and the exposed parts will remain at earth potential. If there is a more serious fault, the current flowing to earth will operate a protective device. The three cables are grouped together and further insulated by a grey PVC outer covering. Flexible cables running from an appliance to its plug are also colour-coded. The live cable is brown, the neutral one is blue, and the earth is again green and yellow.

Electric current can cause fires in property, and electric shock to human beings and animals. Fires are caused by overloading circuits—attempting to take more current from the circuit than it is designed to support. Electric shock is experienced when current passes through a living body. The result is, at best, an unpleasant experience; or burns (which can be both external and internal), or death.

While a current of a few amperes is sufficient to cause a fire, voltages in excess of 50 V and current in excess of 50 mA (1 mA, or milliampere, is one-thousandth of an ampere) can prove fatal to human beings. (A 25-V shock for domestic pets can be fatal.)

Consequently, the electrical installations in homes require some form of protection to safeguard property and lives. This is the function of the consumer unit, which is used to divide the incoming electrical current between circuits, each carrying an appropriate current, and to provide protection in each individual circuit against the hazards of shock and fire. Protection devices are designed to sense the development of a dangerous situation and operate to cut off the electrical supply to that circuit before the danger reaches an unacceptable level.

Such protective devices include miniature circuit-breakers (MCBs), which prevent circuits from being overloaded; and residual-current devices (RCDs), which protect against earth faults, which can cause an electric shock. An earth fault is a condition in which current flows to earth through a conducting pathway, which could be a human body.

Consumer units with these protective devices have superseded outdated fuseboards, although many older properties still have fuseboards (*see* Fuse).

Some appliances do not include an earth wire. This is because the appliances are double-insulated to prevent accidental contact with the live parts inside. It is a legal requirement in the United Kingdom for appliances to be supplied with a 13 A plug connected. These plugs have rectangular pins and are fitted with a fuse in order to protect the appliance from damage. It is essential that the correct rating of fuse is used.

The power used by an appliance (the rate at which it consumes energy) is measured in watts (W). The amount of power used by a particular appliance must be shown on it. Appliances rated up to 720 W must be protected by a 3-A fuse; between 720 W and 1,200 W by a 5-A fuse; and from 1,200 W to 3,000 W by a 13-A fuse.

EXAMPLES

Electrical consumption

Determine the cost of using the following appliances for the period indicated. Use PHCN domestic rate

i. 2000W water heater for 3 hours
ii. Sixty 60W bulbs in a poultry from 7pm till 7am for a month.
iii. An hammer mill with 2000W electric motor in a feedmill. It is normally operated non-stop only during official government working hours for 22 days in a month.

Solution

- 2000x3 = 6000WHr = 6KW Hr @ ₦4.00 per KW-Hr = ₦ 24.00
- 60 x 12Hrs x 30 days = 21600 WHr ; 21.6 x 4 KW-Hr = ₦ 86.40
- 2000W x 8 Hrs x 22 days = 352000 WHr; 352 x 4 KW-Hr = ₦ 14,808.00

Work that can be done with 1KWhr of electricity

Types of work possible with 1kW-Hr electricity

(i.) Pumping 20 Litres or 500 gallons of water
(ii) Milking 20 cows
(iii) Cooling 40 Litres of water or milk for one day
(iv) Shelling corn of 778.69 kg at a moisture content of 13% wet basis
(v) Heating 16 Litres of water
(vi) Running a tool grinder for 3 hours

Examples

1. Wire guage No 10 on the American Wire Guage has a current carrying capacity of 30A and a resistance of 0.9998 Ohm per 330 m. Calculate the voltage drop and the power loss if the wire is used to transmit power from a poultry house to the feed store which is about 0.33km away.

The current carrying capacity is over 330 m which is also = 0.33Km
Voltage drop = IR = 30A x 0.998Ω = 29.94 V
Power loss = I^2R = $(30)^2$ x 0.998 = 892W

2. During the operations in a feedmill, the meter disk makes 8.5 rev in 30 seconds. The meter K = 0.6 Watt/rev. What is the energy consumption? Calculate the monthly cost of operating the feedmill if the production capacity is an average of 3 bags/minute for a requirement of 1360 bags per day. The PHCN Industrial tariff rate is ₦8.00 per KWhr.

Speed of rotation = 8.5rev/30 sec,
meter constant, K = 0.6W/rev
Energy = Power x time (hr)
Speed of rotation (rev per Hr) = 8.5 x 3600/30 = 1020rev/hr

Energy consumption = K (W/rev) x Speed (Rev/hr) = 0.6 x 1020 = 612 W/hr
Rate = 3 bags/min
Daily production = 1350 bags/day
Daily operation time = 1350/3
= 450 min/day = 450/60 = 7.5 hr/day
Daily power consumption = 7.5 hr x 0.612Kw = 4.59KWhr
Monthly consumption = 4.59 x 30 = 137.7KWhr
Tariff = N 8.00 per KWhr
Total cost = 137.7 x 8.00 = ₦1,101.60 per month

3. In a farm settlement, there are 5 pepper grinders using 2kW electric motor; 20 households (each with 12, 60W light bulbs; 5, 13A sockets; 2, 15A sockets; 2, 5A, sockets; 3, electric ceiling fans 20W); two saw mills each consuming 5kW; a feedmill (20kW), a livestock farm (20kW), palm oil processing mill (50kW), 2 cassava processing centres (15Kw each), Village market/recreation centre and hall (100kW).
   i. Calculate the amount the PHCN will be realising from the settlement on a monthly basis assuming an average 8 operating hours for all the users. (PHCN TARRIF = ₦4.00 per kW-Hr)
   ii. As the only Agricultural Engineer in your states Rural Electrification Board, justify the reason why you are recommending that the 300kVA transformer in use should be changed.
   iii. Recommend and appropriate transformer to the Board.

P = IV

S/No	Description	No	Current	Voltage	Power (kW)	No of household	Total power (kW)
1	Grinder	5			2		10
2	Light bulbs	12			0.06	20	14.4
3	Socket	5	13	240	3.12	20	312
4	Socket	2	15	240	3.6	20	144
5	Socket	2	5	240	1.2	20	48
6	Fan	3			0.02		0.06
7	Saw mill	2			5		10
8	Feed mill	1			20		20
9	Livestock farm	1			20		20
10	Palm oil mill	1			50		50
11	Cassava Processing Centre	2			15		30
12	Village Centre	1			100		100
						TOTAL	**758.46**

i. Power consumption is calculated in kW-Hr = Total Power x time of use
Daily Power consumption = 758.46 x 8 = 6064kW-Hr
Monthly PC = 6064 x 30 =181,920
At ₦ 4.00 per kW-Hr, total monthly earning = 181,920 x 4 = ₦727,680.00

ii. With a power consumption of 758.46 kW, the 300kVA 300kW is grossly inadequate at peak load

iii. A transformer of 1000KVA is recommended for immediate installation while plan should be on the pipeline for one with a higher capacity to take care of development

4. a. Differentiate between the terms "Total Connected Load (TCL)" and "Probable Maximum Load (PML)".

Total Connected Load (TCL) - is the load rating of an appliance or a system which it carries/supplies when operated throughout the day. This is the load consumed by the appliance during operations. etc

Probable Maximum Load (PML) – is the resulting load consumed when an appliance is operated only when needed i.e. effective period of service. etc

b. Design the interior lighting system using "LUMEN method" for the fertilizer store with a floor dimension of 8m x 15m using Tungsten Lamp. Take E = 50 lux, Hm = 3, Coeff of utilization (C) for RI of 1.74 for medium surface = 0.55, Maintenance factor (M) = 0.7

Minimum service value of illumination for fertilizer store, E = 50 lux
Area (A) = 8 x 15 = 120m^2

Using Tungsten lamp of 200W
From Table 10, Hm = 3.0

Room Index = 8 x 15 / (3.0(8 + 15)) = 1.74

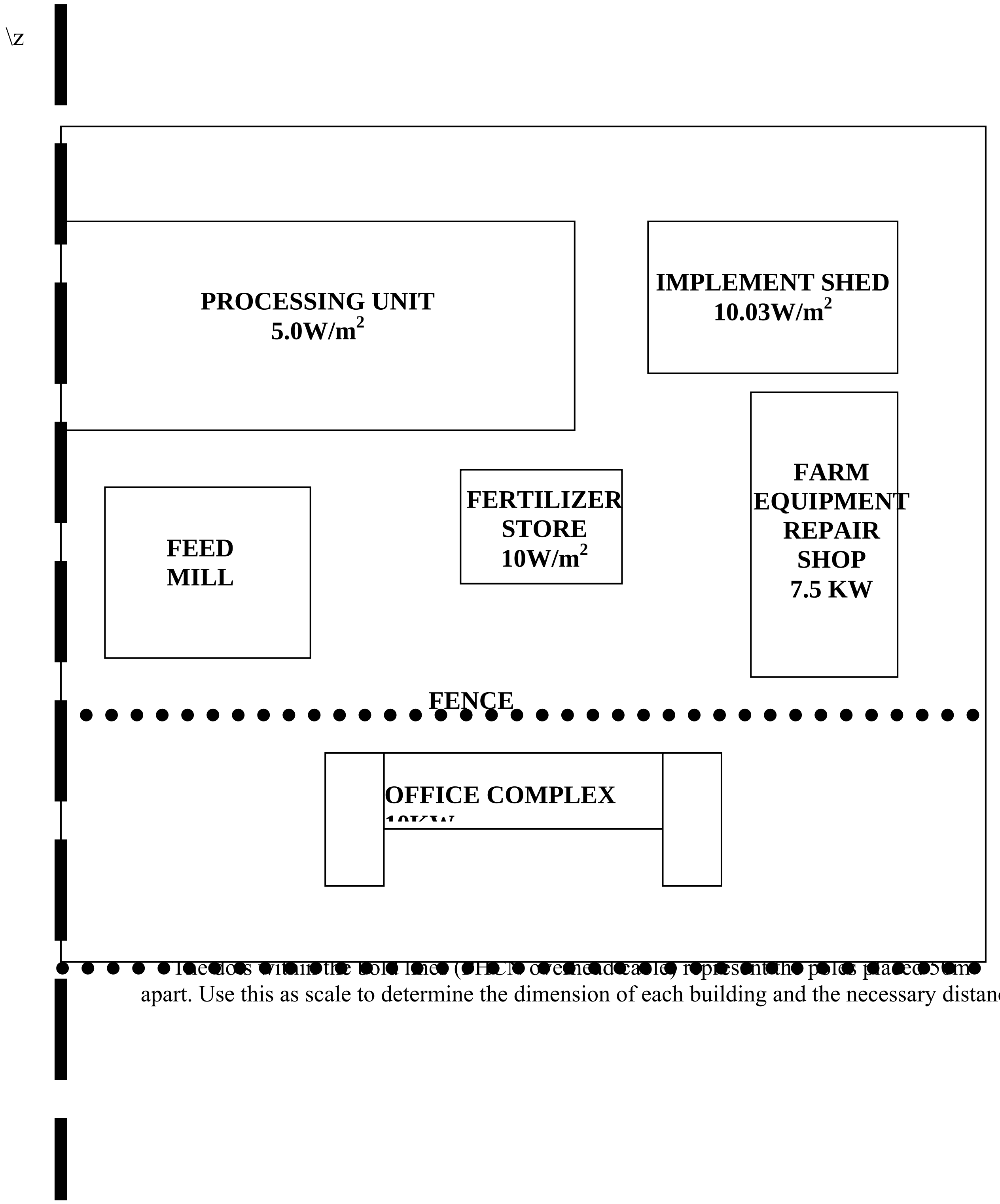
Using dispersive reflections for the lamp
From Table 11, Coeff of utilization (C) for RI of 1.74 for medium surface = 0.55 by interpolation on the table

From Table 9
Cleaning at average frequency for average surface, maintenance factor (M) = 0.7
Installed flux therefore = EA/CM = 50 x 120/(0.55x0.7)
= 15584 lumens
Maximum spacing is given as 3/2 (Hm) = 1.5 x 3 = 4.5
Arrangement using this spacing gives ????? = 2 across, 3 along
Checking the selected lumen
No of bulbs = no bulbs along x no of bulbs across = 6
Lumens per bulb = Installed flux ÷ no of bulbs = 15584 ÷6 = 2597
Is this equal, less or greater than the lumen for the 200W Yes this is equivalent for 200W (with 2720lumens).

If less then OK or select the appropriate bulb with the lumen and calculate the new arrangement if higher select the appropriate bulb with the lumen and calculate the new arrangement

You are at liberty to select other types of lamp with justification hence all the our answers may not necessarily be the same. The arrangement is also dependent on the selection made.

a. The Farmstead layout shown in Figure 1 with the total connected loads for each unit indicated is the layout design developed by the UNAAB AGENG Consultancy Unit for an integrated farm for production and processing of selected arable crops for export. This is to be sited in all the states of the federation.



The dots within the bold lines (OHCT overhead cable) represent the poles placed 50m apart. Use this as scale to determine the dimension of each building and the necessary distances.

a. Steps to take in designing for the main service switch

(i) List the full load (Current/Wattage) for each building or service point
(ii) Obtain the TCL and convert to PML using the approved/recommended %
(iii) Single out the largest load from (ii)
(iv) Add the other PML and divide by 2 i.e half the sum of the remaining PML
(v) Add (iii) and (iv) to obtain PML for the entire farmstead
(vi) Choosse the appropriate wire size for this load having known the length of run

Select a service switch equal to a step higher

b. If the length of run to the Service entrance meter (M) is 180m from any of the main PHCN overhead cable, calculate the wire size required for supply to the service meter. Measure the length of the path of run from the meter to each building and the feeder wire size required for each of the building. Assume 90% of the TCL is the PML in each of the building and the local service voltage supply is 240V.

Probable meter location

From the figure, X and Y being the coordinates of each structure are read and the TCL calculated for each as follows

TCL (W) = TCL (W/m^2) x Area (m^2)

Unit	Length of run measured (2 marks)		TCL (KW) (1 mark)	Current (A) TCL/240 (2 marks)	PML (90% TCL) (2 marks)
Office	150		10	41.6	9.00
Feedmill	100		25	104.16	22.50
Store	50		24	100	21.60
Workshop	200		7.5	31.2	6.75
Implement Shed	200		72.22	300.9	64.99
Livestock Unit	50		26.4	110	23.76
TOTAL			**219.49**		**197.54**
Total PML excluding the largest					**83.61**

Length of run up to the meter = 180m
Total electrical load = 219.49A
For a length of run of 180m and current of 219.49A,
wire size = wire guage 000 by interpolation from Table 11B

Unit	Length of run measured	Load	Wire size read from Table 11B (2 marks)
Office	150	41.6	4
Feedmill	100	104.16	2^{a}
Store	50	100	6^{e}
Workshop	200	31.2	6
Implement Shed	200	300.9	300M
Livestock Unit	50	110	6^{e}

LABORAORY 1
TITLE: Power Generation
OBJECTIVES:

1. To understand how power is generated in a magnetic field
2. To understand the principles of standby power generation systems.

NOTES:
Electric power is generated when a coil moves inside a magnetic field. The coil movement is usually by hydraulic power or thermal energy. Power is generated nationwide by a National Institution orNational Electric Power Authority (NEPA.) Sometimes when NEPA power fails, farms resort to standby electric power generator.

PROCEDURE

a) The generator
   1. You will be shown the electric power generator that is driven by the mains supply.
   2. Connect the rotor to the stator and switch on the system
   3. Observe and write a report on what you see.

b) Stand by generator
   1. You will be shown a 1 – cylinder, single phase standby electric power generator
   2. Identify the engine parts and the shaft that serves as rotor
   3. Describe how the machine operates
   4. Using the total load and the critical load systems, design a standby generator for the Agric. Engineering block (Use the procedures taught in class).

c) Answer the following questions
   1. Explain the differences and similarities between a hydro- and thermo – electric power station
   2. List the advantages of having a stand-by generating plant.

LABORATORY 2

TITLE: Power Distribution

OBJECTIVES

1. To enable to identify one-way and two-way switches and socket outlets
2. To be able to connect the fusebox to the various switches and outlets

NOTES:

When electricity is generated, it is transmitted through cables and tansformers until it finally arrive farm. The farm will have a switch that connects it to the transformer serving that area. It is from the switch that electricity is distributed throughout the entire farmstead.

PROCEDURE

a) Fixing of fusebox
   1. You are provided with a distribution board. Following the instructor instructions, connect fuse box with a cable (assumed to be coming directly from the meter)
   2. Connect outlet cables to each of the fuses.
   3. Draw your connections on paper

b) Outlet points
   1. Describe the types of fuses in use for electrical installation and distribution.
   2. What sort of care is necessary to avoid electric shock while connecting or disconnecting cables?

LABORATORY 3

TITLE: Specification and Maintenance of Electric Motors
OBJECTIVES:

1. Understanding of electric motor maintenance procedures
2. Understanding the information on motor name plate

NOTE:
Electric motors do not brake down very often especially when they are properly maintained. Cleaning of motor can be achieved by using solvent and brush on parts with no windings.

PROCEDURE:

A. Name plate information

Observe and record the following information if available on motor
Manufacturer – Insulation
Serial Number – Temperature rise
Hp – Service factor
RPM - phase
Voltage - Cycles
Amps - Code
Frame - Overload protector
Model – Any other information

B. Disassembly

1.Disassemble and clean the motor following the directions of instructor
3. Draw a schematic of the circuitry in the motor and assemble

c) Answer the following questions

1. What are the differences between single-phase and three –phase motors and under what circumstance are the latter used?
2. Explain, with diagrams, how the power factor of an induction motor can be corrected.

LABORATORY 4

TITLE: Circuit Control Operation

OBJECTIVE: To understand circuit control using time switch.

NOTES: While it is possible to control electric power by manual switch, it is sometimes necessary to use automatic on-off devices. Example of these include, pressure switch, thermostat, time switch and humidstat. They are used when equipment is to be switched on and off without operator assistance. Examples of such equipment include, automatic milking machines and automatic feeders for livestock.

PROCEDURE

A. Switch-on timer
    1. Connect a bulb to the switch – on timer
    2. Set the timer to 5 minutes
    3. Observe the light come on
    4. Draw the circuit diagram

B. Switch off timer
    Repeat as in A.

C. Switch on and off
    1. Combine the two times and watch the light go on and off
    2. Sketch the circuit diagram

D. Answer the following questions
    1. List 6 equipment where the use of automatic switches may be necessary
    2. Explain the operation of a thermostat

UNIVERSITY OF AGRICULTURE, ABEOKUTA
FIRST SEMESTER EXAMINATION (2010/2011 SESSION)
AGE 405 (3 UNITS): FARM ELECTRIFICATION

INSTRUCTION: ANSWER **QUESTION ONE AND ANY OTHER TWO** **TIME**: $2^1/_2$HOURS

Present appropriate diagrams, sketches and calculations where necessary

QUESTION ONE (30 Marks)

a. What are the safety steps recommended to prevent electrical hazards on the farm?

b. Explain briefly, the generation and flow of electricity using the atomic theory.

c. Using your answers in (c) briefly describe how the principle can be used to explain the conductivity and resistance to electricity for conductive materials.

d. Using fluid flow phenomenon, briefly define the electrical terms similar to the parameters in fluid system.

e. Heavy machineries are known to start with high current, state and explain briefly the principle of operation of the device used to prevent these machines from affecting others during starting.

f. Determine the cost of using the following appliances for the period indicated. Use PHCN domestic rate. (i) 2000W water heater for 3 hours

   i. Sixty 60W bulbs in a poultry from 7pm till 7am for a month.

   ii. An hammer mill with 2000W electric motor in a feedmill. It is normally operated non-stop only during official government working hours for 22 days in a month.

QUESTION TWO (20 Marks)

a. List at least six different types of work that can be done with 1KWhr of electricity.

b. Wire guage No 10 on the American Wire Guage has a current carrying capacity of 30A and a resistance of 0.9998 Ohm per 330 m. Calculate the voltage drop and the power loss if the wire is used to transmit power from a poultry house to the feed store which is about 0.33km away.

c. During the operations in a feedmill, the meter disk makes 8.5 rev in 30 seconds. The meter K = 0.6 Watt/rev. What is the energy consumption? Calculate the monthly cost of operating the feedmill if the production capacity is an average of 3 bags/minute for a requirement of 1360 bags per day. The PHCN Industrial tariff rate is ₦8.00 per KWhr.

QUESTION THREE (25 Marks)

In a farm settlement, there are 5 pepper grinders using 2kW electric motor; 20 households (each with 12, 60W light bulbs; 5, 13A sockets; 2, 15A sockets; 2, 5A, sockets; 3, electric ceiling fans

20W); two saw mills each consuming 5kW; a feedmill (20kW), a livestock farm (20kW), palm oil processing mill (50kW), 2 cassava processing centres (15Kw each), Village market/recreation centre and hall (100kW).

i. Calculate the amount the PHCN will be realising from the settlement on a monthly basis assuming an average 8 operating hours for all the users. (PHCN TARRIF = ₦4.00 per kW-Hr)
ii. As the only Agricultural Engineer in your states Rural Electrification Board, justify the reason why you are recommending that the 300kVA transformer in use should be changed.
iii. Recommend and appropriate transformer to the Board.

QUESTION FOUR (25 Marks)

b. Differentiate between the terms "Total Connected Load (TCL)" and "Probable Maximum Load (PML)".
c. Design the interior lighting system using "LUMEN method" for the fertilizer store with a floor dimension of 8m x 15m using Tungsten Lamp. Take E = 50 lux, Hm = 3, Coeff of utilization (C) for RI of 1.74 for medium surface = 0.55, Maintenance factor (M) = 0.7

QUESTION FIVE (25 Marks)

c. The Farmstead layout shown in Figure 1 with the total connected loads for each unit indicated is the layout design developed by the UNAAB AGENG Consultancy Unit for an integrated farm for production and processing of selected arable crops for export. This is to be sited in all the states of the federation.
   i. Explain briefly the steps to take in designing for the main service switch.
   ii. If the length of run to the Service entrance meter (M) is 180m from any of the main PHCN overhead cable, calculate the wire size required for supply to the service meter. Measure the length of the path of run from the meter to each building and the feeder wire size required for each of the building. Assume 90% of the TCL is the PML in each of the building and the local service voltage supply is 240V.