3rd Term scheme of work SSS2

WEEK	Topic	Content
1	Electric Field	Electric Conductor through Liquids (ELECTROLYSIS) (i)Electrolyte and nonelectrolytes (ii) Dynamics of charged particles (ions) in electrolytes (iii) Voltmeter (iv) Examples of electrolysis (v) Application of electrolysis
2	Electric Field	Conduction of electricity through gases – Hot cathode, thermionic emission. The diode valve. Application of hot cathode (thermionic emission) (ii) Cathode ray oscilloscope
3	“	Electric forces between point charges (coulomb’s Law) Concept of electric field (i) Electric Field Intensity (ii) Electric Potential
4	“	Capacitors and capacitances (i) Definition (ii) Arrangement of capacitors , Energy stored in a capacitor, application of capacitors
5	Magnetic Field	Concept of Magnetic Field (i) A bar magnet (ii) A straight conductor carrying onductor (iii) A solenoid- method of making magnets, method of demagnetization
6	“	Magnetic properties of Iron and Steel: Magnetic screening or shielding. Electromagnet and application of electromagnet: Temporary magnet (i) The electric bell (ii) Telephone earpiece etc.
7	“	Magnetic elements of a place: Angle of declination, Angle of dip, Horizontal component of the earth’s magnetic field. Bar magnet in the earth’s magnetic field. Neutral points – Mariner’s compass
8	Electromagnetic Field	Magnetic Force on a charge moving in a magnetic field. Concept of magnetic field: Interaction between magnetic field and currents in (i) A current - carrying wire in a magnetic field (ii) A current carrying solenoid in a magnetic field Application of electromagnetic field: (i) Electric Motor (ii) Moving coil galvanometer
9	“	Electromagnetic Induction: (i)Faraday’s Law (ii) Lenze’s Law (iii) Motor generator effect (iv) Eddy currents
10	“	The transformer (ii) Power Transmission (iii) The induction coil
11/12	Revision/Exam	

WEEK 1 – 2

ELECTRIC CONDUCTION THROUGH LIQUID AND GASES DISCHARGED THROUGH GAS

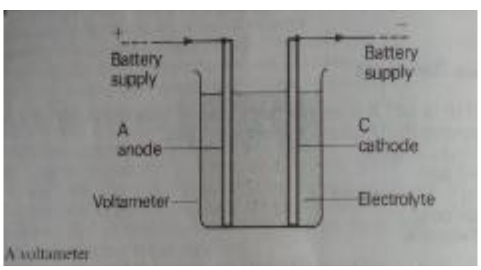
ELECTROLYTE

Electrolyte are liquids that allow the passage of current through them and they are decompose into ions by the current flow. Examples of electrolyte are solutions of acid, bases and salts.

Non electrolytes are liquids that do not allow the passage of current through them e.g. benzene, paraffin and kerosene. Pure water is a poor conductor of current but conducts current moderately when it contains dissolved salt.

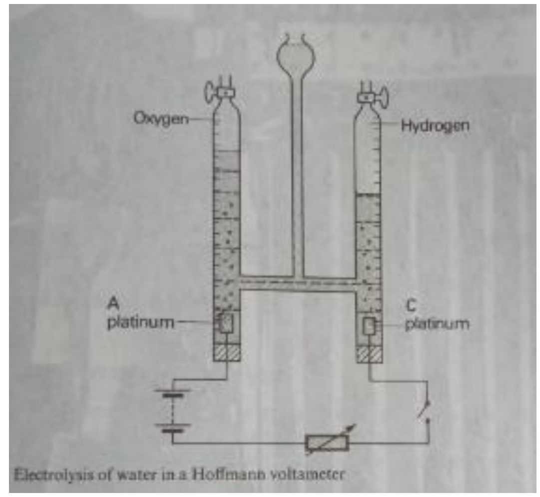
Electrodes: Electrodes are metallic rods or plates through which current enters or leaves the electrolyte.

Voltameter: It is the containing vessel that houses the electrodes and electrolyte.



Ionic Theory: Ionic theory has it that electrolyte dissociates into a negative and positive particle called ions. These ions are in random motion until a battery is connected to the electrodes. When this happened, positive ions drift to the cathode and these ions are called cations. Negative ions drift to the anode and these ions are called anions. The directional movement of these ions is the electric current that is flowing through the electrolyte.

Electrolysis of acidulated water: In the electrolysis of acidulated water, the voltameter used is called Hoffman voltameter.



1. The electrolyte used is water to which a few drops of sulphuric acid is added to make the water more conducting

2. Electrodes used are platinum electrodes.

When current passes through the electrolytes the following happen

$H_2O_{(l)} \rightarrow H^+ + OH^-$

$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

The hydrogen ions (H^+) drifts to the cathode and is discharged i.e. $2H^+ + 2e^-$
$\rightarrow H_{2(g)}$

Hydroxyl ion (OH^-) and SO_4^{2-} ion drift to the anode and OH^- is easily discharged in preference to SO_4^{2-} . This leads to formation of oxygen gas i.e.

$4OH^- \rightarrow \quad 2H_2O_{(l)} + O_{2(g)} + 4e^-$ or

$2OH^- \rightarrow \quad 2H_2O_{(1)} + O$

$O + O \rightarrow O_{2(g)}$

At the end of the process, the concentration of the acidulated water increases due to formation of water in form of hydrogen and oxygen gases.

Electrolysis of copper sulphate solution using copper electrodes

1. Electrolyte used is $CuSO_{4(aq)}$
2. Electrodes are copper plates or rods

When current passes through the electrolyte, the following happens

$H_2O_{(1)}$ $H^+ + OH^-$

$CuSO_4$ $Cu^{2+} + SO_4^{2-}$

At the cathode Cu^{2+} gains $2e^-$ and is deposited at the cathode. At the anode, OH^- is discharged in preference to SO_4^{2-}. There is removal of Cu^{2+} from the anode to compensate for the Cu deposited at the cathode. In the end, the anode decreases in mass, the cathode increases in mass and the concentration of $CuSO_{4(aq)}$ remains constant.

Electrolysis of $CuSO_4$ using platinum Electrodes

1. Electrolyte used is $CuSO_{4(aq)}$
2. Electrodes used are platinum plates

When current passes through, the following happens. The cathode is coated with a bright-red layer of pure copper. The sulphate solutions losses its blue colour.

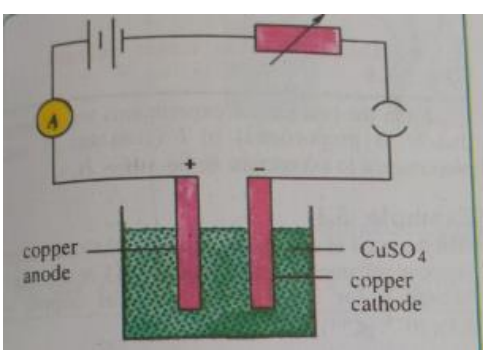
During electrolysis, Cu^{2+} and H^- drift to the cathode where Cu^{2+} is discharged. At the anode, OH^- ion are discharged and it combine to form water and oxygen. The net result is deposit of copper at the cathode, production of oxygen at the anode and reduction in the concentration of $CuSO_{4(aq)}$ solution.

Application of electrolysis

1. It is used in electro plating
2. It is used in the purification of metal
3. It is used in the extraction of metal
4. It is used in the calibration of ammeter

Calibration of ammeter

Consider the diagram below



Weigh the cathode, complete the circuit and allow current to flow for about 25 – 30 minutes. Weigh the cathode again and obtain the increase in mass.

Let the mass of copper deposited be M and the electrochemical equivalent (e.c.e) be Z.

Then $M = ZQ$

but $Q = It$

.: ` $M = Zit$

From the above equation, $I = M/Zt$

Since M, Z and t are known variables, I can be calculated and this calculated value will be compared to the ammeter reading for correction if need arise.

Laws of electrolysis:

The laws of electrolysis were stated by Faraday.

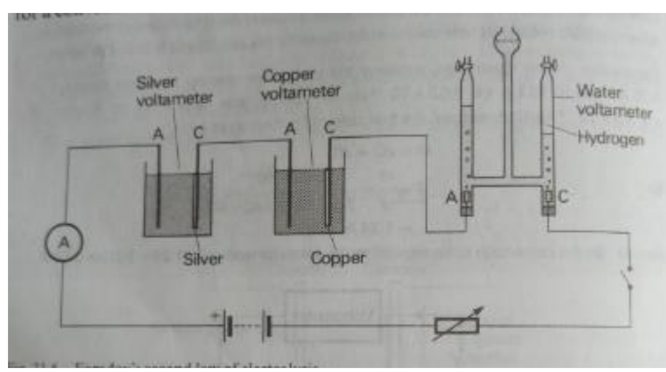
1st law states that the mass, M of substance liberated or deposited during electrolysis is directly proportional to the quantity of charges electricity (Q) passing through the electrolyte.

Mathematically, $M = ZQ$

Where $Q = It$

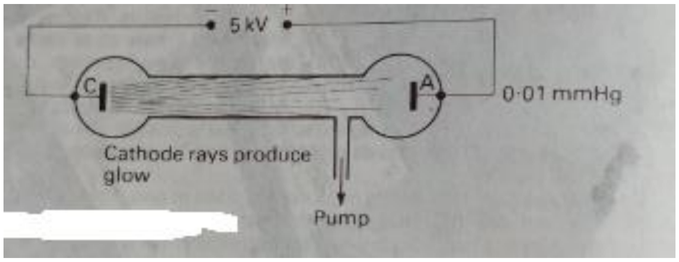
.: $M = Zit$

2nd law states that the masses of different substance deposited or liberated by the same quantity of electricity passing through different electrolytes are inversely proportional to the charges on the ions of the elements.



Discharged through gas:

Discharged tube is used to study the conduction of electricity through gases.



It consists of long glass tube to which two electrodes C and A are connected to high voltage of several thousand volts. C is called the cathode because it is connected to the negative (-ve) terminal of the high voltage and A is the anode since it is connected to the positive (+ve) terminal. The pressure of the gas in the discharged tube can be altered through the vacuum pump connected to a side of it.

Conditions for gases to conduct electricity

Experience shows that at low pressure (0.01mmHg) and high voltage (about 1000v) gases ionizes and conduct electricity. anions (+ve) from the ionized gas at the cathode knock off electrons and these electrons and cations(-ve) from the gas moved to the anode. The electrons produced at the cathode by cations are called cathode rays. This cathode rays produced are called cold cathode rays.

Properties of cathode rays

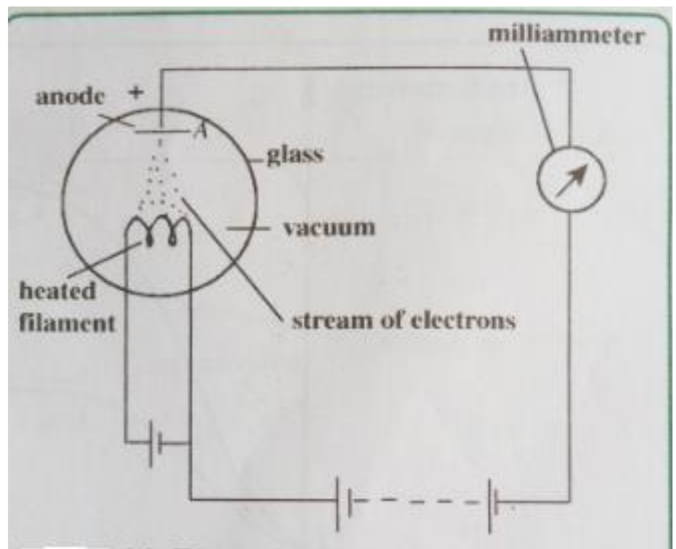
1. They are stream of fast-moving electron and are negatively charged.
2. They travel in a straight line unless acted upon by external force
3. They are deflected by magnetic and electric fields.
4. They cause certain materials like zinc to fluorescence i.e. glow.
5. They have momentum (They turned a light paddle wheel).
6. They produce heat when stop by material i.e. they have energy
7. They affect photographic plates/films
8. They are highly penetrating and can penetrate through metals such as aluminum plate, steel plate and gold for.
9. They produce x-rays when they strike high dense metals
10. They lionize gas

Application of cathode rays

1. It is used in the fluorescent lamp
2. It is used in Neon sign.

Thermionic Emission (Hot cathode)

Thermionic emission is the release of electrons from the surface of hot metal when thermally heated.



Thermionic emission from hot filament

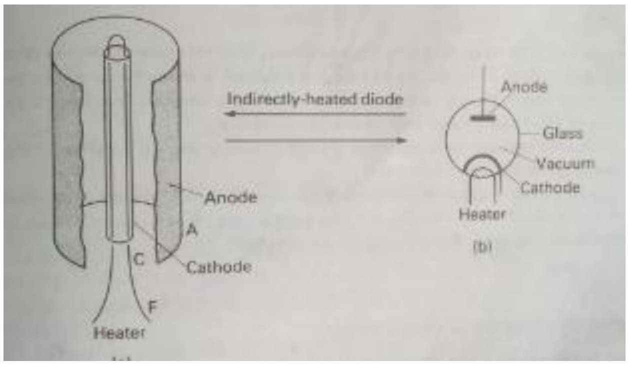
In an experiment first performed by Thomas Edison in 1883, it is observed that if the electrode A was sealed into the evacuated bulb of a carbon filament lamp, whose filament is heated by connecting it to a battery, a current flow through the electrode if it was made positive with respect to the filament. Most current flows when the temperature of the filament is raised. These observations are explained as follows: when the tungsten filament is heated to a high temperature, the extra energy thus given to its free electrons at the surface of the metal enables them to break through the surface of the metal and exist outside it as an electron cloud. When the plate A is the positive(+ve) with respect to the cathode, current flows but when negative(–ve), it repels the electron and no current flow.

Thermionic emission found its application in the

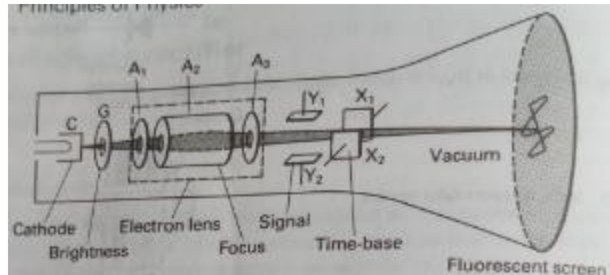
(i) Diode valve and

(ii) Cathode ray oscilloscope

The diode valve allows current to flow in one direction and it is used as a rectifier in television and radio receiving circuit. The diode valve characteristic curves show that it is a non-ohmic conductor.



The cathode ray oscilloscope is used to measure frequencies, amplitude of voltages and current in electronic devices.



2 Cathode ray oscilloscope

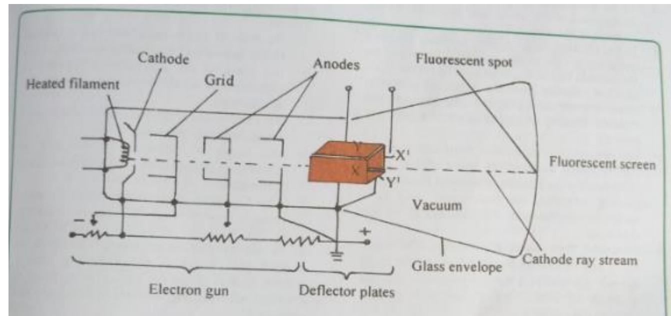


Fig. 5.18 Cathode-ray oscilloscope

Refer to your text-books for diagrams and elaboration on diode valve and cathode ray's oscilloscope.

WEEK THREE

ELECTRIC FIELD – (1) ELECTRIC FORCE BETWEEN POINT CHARGES, ELECTRIC FIELD INTENSITY AND ELECTRIC POTENTIAL

INTRODUCTION

Electric field is related to gravitational field because both are vector quantities. Mass is for gravitational field while point charge is for electric field.

Electric force between point charges: Charles Coulomb (1736 - 1806) investigated the nature and magnitude of the force between two-point charges. Coulomb should that the force (f) between two points charges q_1 and q_2 is proportional to the product of the two charges and inversely proportional to the square of their distance apart.
Mathematically,

$f \propto \frac{q_1 q_2}{r^2}$ or $f = \frac{k q_1 q_2}{r^2}$……………….1

Where f is force in Newton (N)
q_1 and q_2 are charges in coulomb (c)
r is distance separation in metre (m)
k is a constant of proportionality

$$K = \frac{1}{4\pi\varepsilon^o r^2}$$

Where ε^o is a constant known as permittivity of free space and its unit is coulomb square per Newton per metre square i.e. ($C^2N^{-1}m^{-2}$).
Thus;
the unit of k is $Nm^{-2}C^{-2}$ and its value is 9×10^9 $Nm^{-2}C^{-2}$

ε^o =8.85×10^{-12} $C^2N^{-1}m^{-2}$

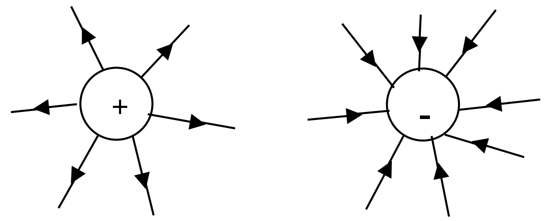
N/B like charges repel and unlike charges attracts.

Repulsion attraction

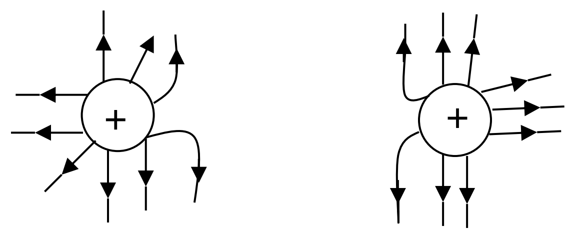
Electric field: An electric field is a region or space surrounding a charge in where its effect is felt by another charged body.

Electric field of simple charge bodies-lines of force

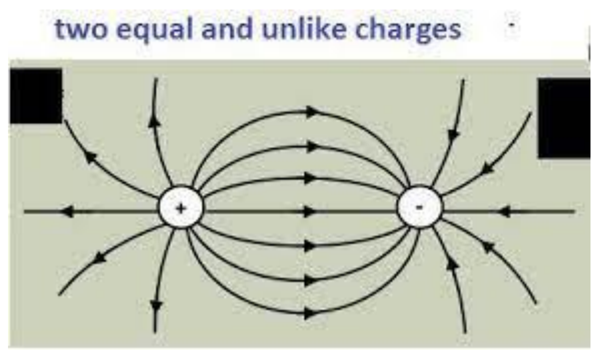
(a) Isolated charges



(b) Two like charges.



(c) Two unlike charges



Electric field intensity/strength (E)

Electric field intensity at a point in the electric force o a unit charge or it is the force per unit positive charge place at that point.
Thus E = f/q. It unit is N/C

But $F = \frac{q1q2}{4\pi\varepsilon^o r^2}$ if q_1 = q_2 = q

$E = \frac{q\,q}{4\pi\varepsilon^o r^2} \times \frac{1}{q} = \frac{q}{4\pi\varepsilon^o r^2}$

$Hence, E = \frac{q}{4\pi\varepsilon^o r^2} = \frac{kq}{r^2}\ Since\ K = \frac{1}{4\pi\varepsilon^o r^2}$

NB . $E = \frac{\Theta}{A}$ where Θ is the electric flux and A is the given surface area.

Electric potential: Like in gravitational potential, work done is done in taking a unit mass from infinity to a point Electric potential (-1) at any point in the electric field is the work done in brining a unit positive charge from infinity to that point. The unit of electric potential is J/C. work done in taking one coulomb of positive charge from one point to another is given by
w = qv

$\mathbf{v = \frac{w}{q}}$ ....(1)

Electric field intensity is related to electric potential between two points through

$E = \frac{v}{d} = \frac{v}{r}$

$\therefore$ v = Ed..........................(2)

where d = r = distance

Recall that

$E = \frac{q}{4\pi\varepsilon^o r^2}$

$V = \frac{q}{4\pi\varepsilon^o r^2} \times r$

$V = \frac{q}{4\pi\varepsilon^o r}$ 3

$\therefore V = \frac{Kq}{r}$ 4

EVALUATION:

1 A small positive charge of 2.8 x 10^{-6} is placed at a distance of 20cm from a negative charge of 1.8 x 10^{-6}c at B . Calculate the strength at

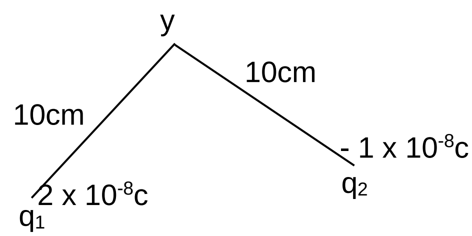
i a point C between A and B where AC = 15CM, BC = 5CM

ii a point x distance 10cm from B on the other side of A

2 What is the force between two points charges of magnitude of 2 x 10^{-7}C and – 1 x 10-8C which are 0.05m apart in air?

3. What is the electric potential at a point 0.06m from a point charge of + 2 x 10^{-7}C?

4.



I Calculate the resultant potential at y due to the positive charge q_1 at +2 x 10^{-8}c and the negative charge q_2 of -1 x 10^{-8}c

II Show approximately the direction at y of the resultant field strength or intensity.

WEEK FOUR

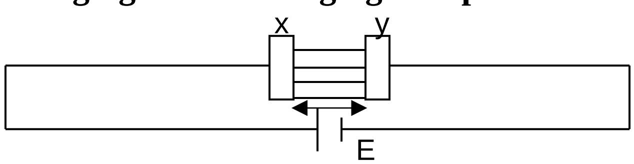
CAPACITORS, CAPACITANCE, ARRANGEMENT OF CAPACITOR IN A CIRCUIT, ENERGY STORED IN A CAPACITOR

INTRODUCTION

Electrical charges can be stored in a device. This device consists of two separate parallel metal plates. This device is called a capacitor.

Capacitor: A capacitor is a device for storing electrical charges. It is made up of two metallic conductors carrying equal number of positive and negative charges. These plates are separated by a small distance, d, of an insulator. A potential difference is maintained across the two plates. The insulating material placed between the plates of a capacitor is called a dielectric material or substance.

Charging and discharging of capacitor



When two plates x and y of a capacitor are connected to a battery terminal such that they have equal and opposite charges, the capacitor is said to be charged.
If the plates of a charged capacitors are joined, the electrons from the negatively charged plate flow round the circuit to the positively charged plate and neutralized the plate when this happens, the capacitor is said to have been discharged.

Applications of capacitors

(1) Capacitors are used for storing electric energy in electronic flashing unit e.g. flashing units by photograph

(2) Capacitors are used for smoothing of rectified current voltages.

(3) In ignition systems system, they are used to eliminate sparking as in kick starters and induction coil.

(4) Capacitors are used as filter in power supply by a combination of R-L-C i.e. the resistor, the inductor and the capacitor, a desired filter characteristic can be designed.

(5) Capacitors are used in electric circuit for varying frequencies of resonance devices e.g. in radio circuit.

Capacitance of capacitors

Experiments show that the quantity of charge is directly proportional to the potential differences across the plates
Thus $q \propto v$ or $q = cv$
Introducing the equality sign, we have that the proportional constant 'c' and it is known as the capacitance of the capacitor.
Hence, C = q/v i.e. capacitance of capacitor is the ratio of charge (q) to the potential difference across the plates. The unit of capacitance is farad.

μF (one micro farad) = 10^{-6}f

ρF (one Pico farad) = 10^{-12}f

Factors affecting capacitances

The three factors affecting capacitance are

(i) Distance between plates: The greater the distance, the smaller the capacitance and vice-versa.

(ii) Common area of plates: The greater the common area, the greater is the capacitance.

(iii) The nature of the electric between plates

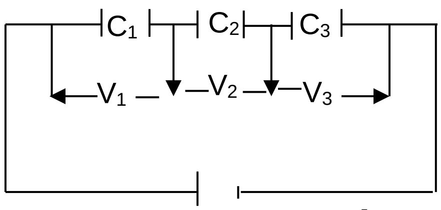
(iv) Size and shape of plates.

Arrangement of capacitor:

Capacitors can be arranged in series or parallel. When capacitors are arranged in series the same charges and current pass through them, but voltage developed are different.

When connected in parallel, different current and charges pass through them but the same voltage is developed.

Series connection

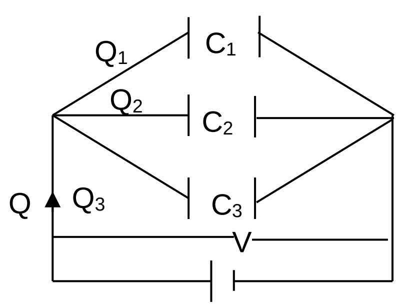


When capacitors are connected in series, the effective capacitance

Is given by

$1/C = 1/C_1 + 1/C_2 + 1/C_3$

Parallel connection



When capacitors are connected in parallel, the effective capacitance

Is given by

$C = C_1 + C_2 + C_3$

Energy stored in a capacitor:

A charged capacitor is a stored of electric energy. When a charge q is moved through a potential difference 'V', the work done is given by i.e. w = average potential difference x charge.

$w \quad = \frac{1}{2}v \times q$........................ (1)

$= \frac{1}{2}vq$

But v = q/c $\text{But } v = \frac{\mathbf{q}}{\mathbf{c}}$

Thus W = ½ x q/c x q

$W \quad = \frac{1}{2} \times \frac{q}{c} \times q$

$w = \frac{q^2}{2c}$ - - (2)

Also, q = CV

$W = \frac{1}{2} \times V \times CV$

$W = \frac{1}{2}CV^2$ - - (3)

$$\boxed{\text{Hence, } W = \frac{1}{2}vq = \frac{q^2}{2c} = \frac{1}{2}CV^2}$$

The above formulae are used to calculate energy stored in a capacitor

NB: W is in Joules

q is in coulomb

v is in volt

c is in farads

WEEK 5

MAGNETIC FIELD

INTRODUCTION

A magnet is a substance that has the ability to attract a metal to itself without contact.

CONCEPT OF A MAGNET

Many years ago, the ancient Greeks came across a piece of rock which possesses the power to attract metals making them stick together. This piece of rock or iron ore is called magnetite which got its origin in a place called Magnesia in Turkey.

A magnet is a name given to a substance (usually iron or steel) that has been magnetized so that it behaves like magnetite. The two ends of a magnet are called the poles. The pole may be either North Pole or South Pole.

PROPERTIES OF MAGNET

1. Experiment shows that the poles of a magnet have the greatest attracting power.
2. the poles of a bar magnet suspended freely in a horizontal plane come to rest pointing approximately to the earth's north and south poles. An instrument used to find the south and north poles is called a compass.
3. Like poles of a magnet repels and unlike poles attract each other.

TEST FOR POLARITY OF A MAGNET

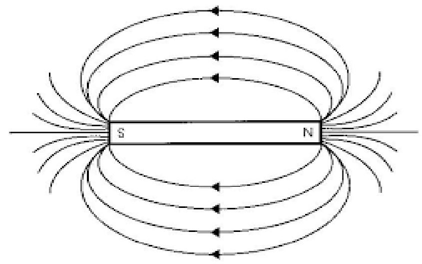
Repulsion is the only sure test for the polarity of a magnet. This is achieved by bringing its pole near a known pole of a suspended magnet.

MAGNETIC FIELD

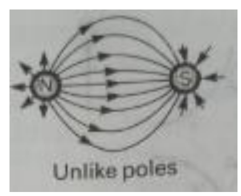
Magnetic field is the region around a magnet where a magnetic force is experienced. Magnetic field lines or magnetic lines of force or magnetic flux are imaginary lines that represent the direction and strength of the field at any point.

Conventionally, the direction of magnetic flux at any point is chosen to be from the North Pole to the South Pole

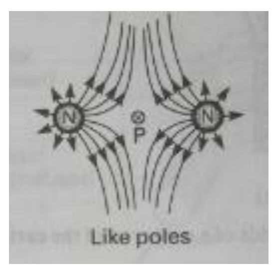
Magnetic field around a permanent magnetic

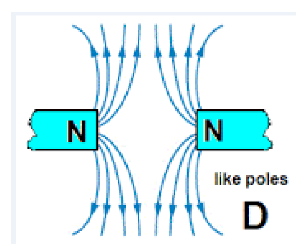


Lines of force due to a bar magnet



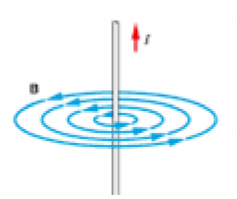
Lines of force between unlike poles



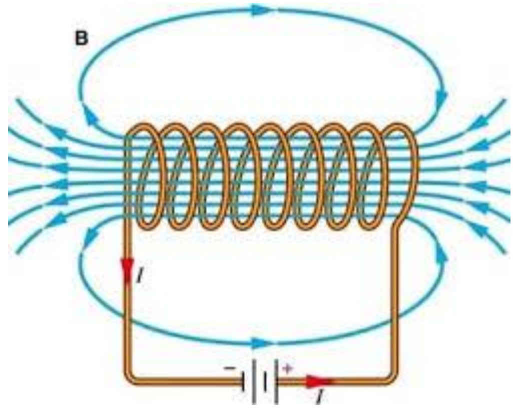


Lines of force between like poles

Magnetic field around a current carrying conductor



The diagram shows the field position pattern of a current carrying wire. The lines are concentric circles with the wire as centre. The right hand grasped is a method of finding the magnetic flux. The thumb points to the current direction and the other fingers point to the field direction.



The diagram shows the field pattern of a solenoid. The field pattern is a long uniform field. Outside the solenoid, the field pattern is like that of a bar magnet.

WEEK 6

MAGNETIC FIELD

INTRODUCTION

Any object that attracts another object (metal) close to itself is called a magnet.

TYPES OF MAGNET

There are basically two types of magnet, which are temporary and permanent magnets.
In the making of magnet, two different metals are used mostly and they have different magnetic properties. These metals are iron and steel.

	Iron	**Steel**
i	Easily magnetized	Not easily magnetized
ii	Easily demagnetized	Not easily demagnetized
iii	Strongly magnetized in a current carrying solenoid	Not strongly magnetized in a current carrying solenoid
iv	Do not retain magnetic properties for long	Do retain magnetic properties for long

Due to the differences of iron and steel as enumerated above:

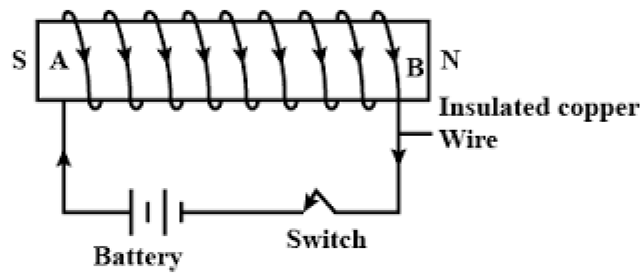
i. iron is used for temporary magnet while steel is used for permanent magnet
ii. Iron is used for making electromagnet where strong magnetism is required for a short time
iii. Steel is used for magnets in area where magnetism can be lost by vibration.
iv. iron is used in an experiment where magnetization and demagnetization are required

MAKING OF MAGNETS

A metal can be made a magnet by:

a) electrical method,
b) single and double touch
c) hammering the metal at an angle to the earth

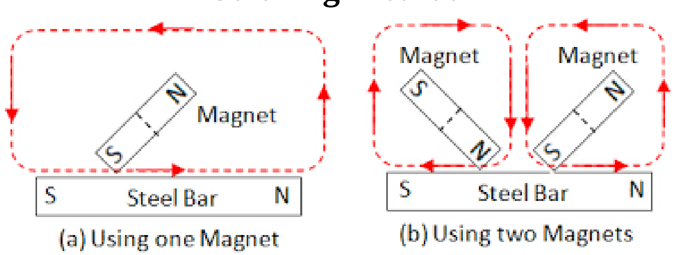
Electrical method



Electrical method

The best method of making a magnet is by inserting a metal bar in a solenoid and allow a steady current from direct current battery to flow for some time. The polarity depends on the direction of passage of current on the solenoid, if we look at one end of the bar, if the current is flowing in a clockwise direction that end will be the South pole, if counter clockwise; it will be the north pole.

Stroking Method



The method of double touch involves using two magnets to stroke a steel bar from centre outwardly with opposite poles simultaneously, this method is better than single touch.
The method of single touch involves using only a bar magnet to stroke a steel bar several times in the same direction with one pole of a magnet.

HAMMERING IN THE EARTH FIELD

A weak magnet can be made by hammering a metal bar at an angle to the horizontal on the earth’s surface while pointing in the north-south direction. The upper end is hammered repeatedly and on testing the lower end, it is found to have a weak north polarity.

DEMAGNETIZATION

Demagnetization is the process by which a magnet loses its magnetic. This can be achieved by:

i) Inserting the bar magnet in a solenoid and connect it to an alternating current. The solenoid should be pointing to east-west direction (electrical method) and it is the best method.

ii) heating the bar magnet until it is red hot and allow it to cool in the east-west direction. This method is not a good method because it destroys the properties of steel

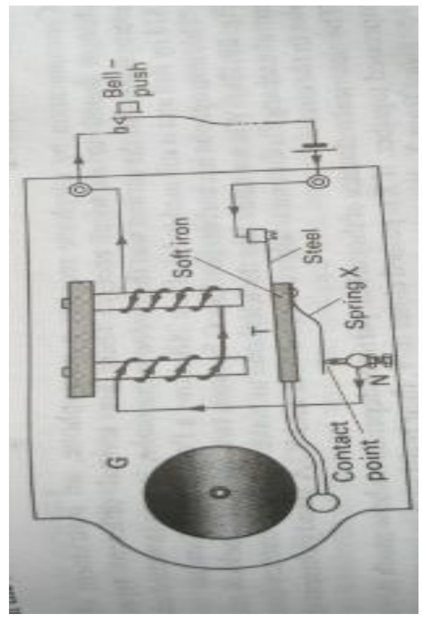
iii) Rough handling, disorderly arrangement and hammering of a magnet, weaken it magnetism

ELECTROMAGNET

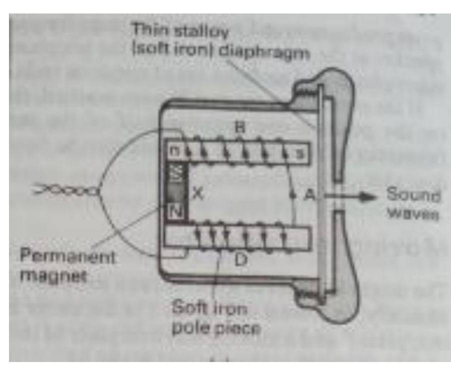
If a coil is wound round a soft iron core and a current is made to flow round the coil, a strong magnet is produced as long as there is flow of current. The magnet produced as a result of flow of current is called electromagnet. The soft iron core loses its magnetism when the current ceased to flow.

APPLICATION OF ELECTROMAGNET

Electromagnet is used in (i) the industry for handling heavy objects (ii) the electrical bell and in the telephone earpiece.



Electric bell works through make and break, when the circuit is completed or closed by pressing the bell knob, current passes through the circuit. The iron core becomes electromagnetic and attracts the striker that hits the gong and breaks at the same time. The striker goes back and completes the circuit and the process is repeated



The telephone earpiece is an equipment that changes sound vibration in form of electric current back to audible sounds.

The earpiece changes the varying speech current into varying sound energy.
The varying speech current from a microphone flows through the speech coils of the earpiece. This causes the magnetic strength of the soft iron pole pieces to rise and fall at the same frequency as the speech current.

The varying magnetism of the magnet causes the soft iron diaphragm to vibrate, the vibration of the diaphragm creates sound waves of the same frequency as that of the speech current, thus, the speaker at the microphone is heard by the listener at a distance earpiece.

WEEK 7
MAGNETIC FIELD (CONT'D)

INTRODUCTION

EARTH MAGNETISM

A bar magnet or magnetic needle will always point roughly in a north south direction when freely suspended, this is due to the earth's magnetism. They origin of the earth's magnetism is believed to be due to the current generated inside the molten hot core of the earth

MAGNETIC ELEMENT OF A PLACE

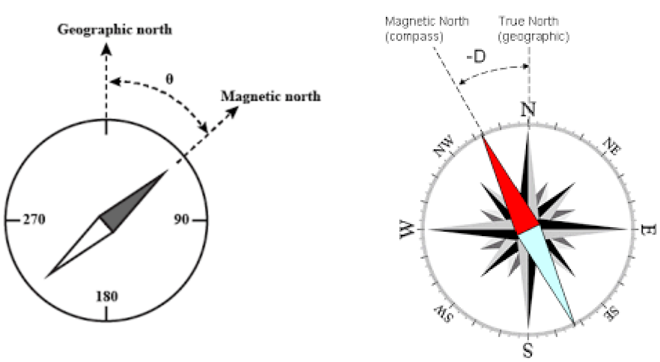
The magnetic element of a place due to the earth magnetism are

(i) angle of declination

(ii) angle of dip

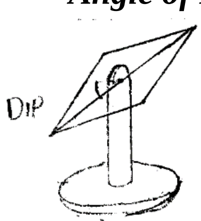
(iii) horizontal component of the earth's magnetic field.

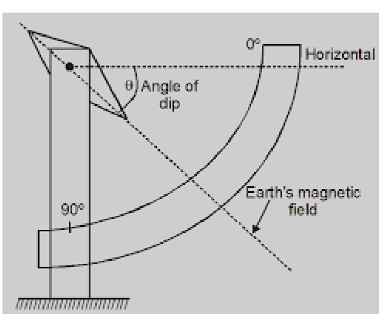
Angle of declination



The angle between the magnetic north and geographical north is called angle of declination of variation. The angle of declination or variation has to be allowed for when navigating by sailors. Maps are marked using true north while compass used to find direction gives magnetic north. The correct angle on map has to be added or subtracted

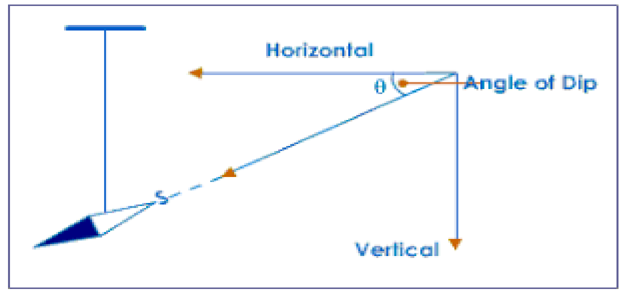
Angle of Dip





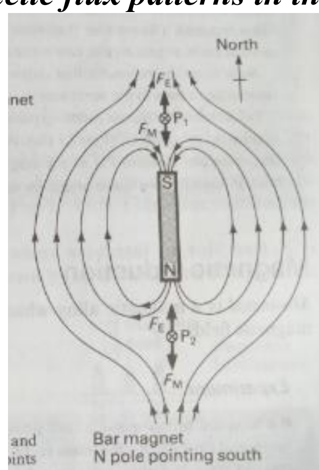
The earth's magnetic flux appears not to act parallel to the earth surface but projected outward from geographical south and inward at the geographical north. The angle between the earth magnetic flux and the horizontal is known as the angel of dip and it varies from place to place. The direction of the earth's magnetic flux is determined using a vertically swinging compass or what is called the dip circle

Horizontal component of the earth magnetic field

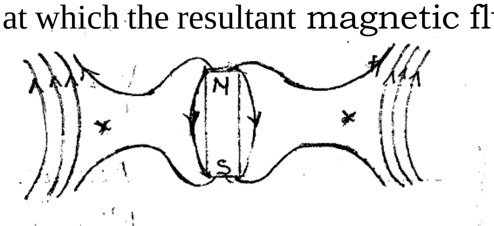


The earth's magnetic flux has magnitude, the horizontal component of the earth's magnetic flux at a point is the strength of its magnetic flux acting in a horizontal direction

Magnetic flux patterns in the earth's field



The symbol "x" indicates the neutral point and is a point at which the resultant magnetic flux is zero



North pole pointing geographical north.

WEEK 8

ELECTROMAGNETIC FIELD

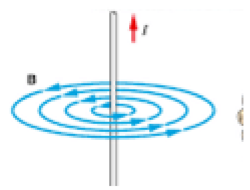
INTRODUCTION.

CONCEPT OF ELECTROMAGNETIC FIELD

It was discovered that when a current pass through a metallic conductor, the metal conductor attracts metal object brought close to it as long as there is current flow. Hence, the current carrying conductor behaves as a magnet as long as there is a current flow. This metallic conductor is called an electromagnet.

Since it exhibits the qualities of magnet as long as there is current flow, the field around the electromagnet is called electromagnetic field. Oersted discovered the magnetic effects of current.

Magnetic field pattern round a straight conductor



The diagrams above showed the magnetic field pattern of a current carrying conductor. The direction of the field is determined using the right hand griped, using the right-hand grip, the thumb points to the direction of the current and the other fingers point to the direction of the field.

Interaction between magnetic field and current carrying wire in a magnetic field

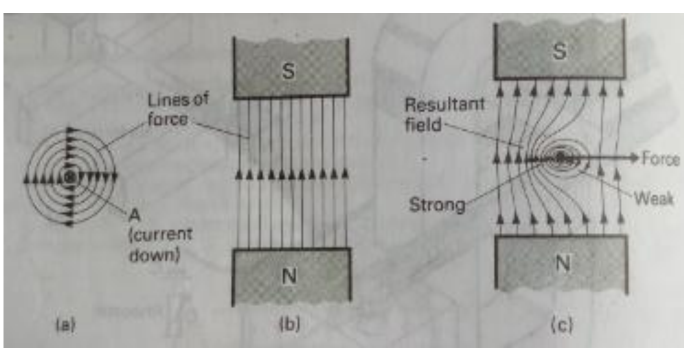
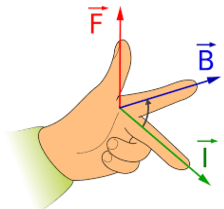


Fig a – Electromagnetic field due to current carrying conduction.

Fig b – Magnetic field due to magnet.

Fig c – Interaction between electromagnetic field, magnetic field and the resultant field direction.



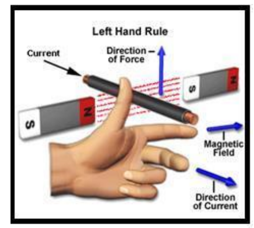


Fig d – A diagrammatical representation of flaming left hand rule for determining the direction of the resultant field.

Flaming left hand rule states that if the left hand is held with the first three mutually at right angles to each other, the fore finger points in the direction of conventional current, then the motion of the conductors is in the direction of the thumb.

If the current is parallel to the magnetic field, no force is experienced. The above field interaction is the principle that an electric motor depends upon.

APPLICATION OF ELECTROMAGNETIC FIELD

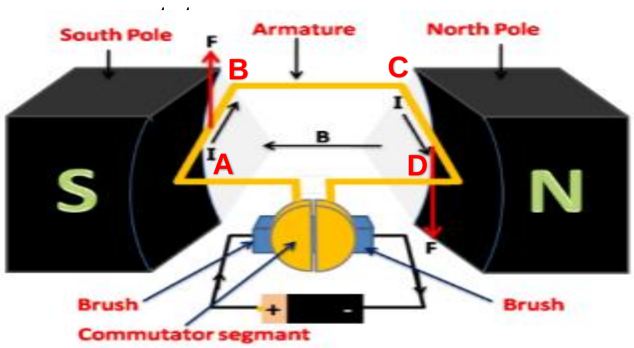
Electromagnetic field finds its application in electric motor and moving coil galvanometer

.

ELECTRIC MOTOR

Electric motor is a device for converting electrical energy into mechanical energy, it consists of:

i) a rectangular coil ABCD of insulated wire known a armature which can turn about a fixed axis
ii) powerful magnetic field
iii) a commutator consisting of a split copper ring, two halves of which are insulated from each other
iv) two carbon brushes which are made to press slightly against either side of the split ring



Assuming that current flows from the battery through the coil in a clockwise direction as shown, under this condition an upward force acts on the arm AB of the coil and a downward force acts on the arm CD of the coil. The two equal and opposite directed forces constitute a couple whose torque causes the coil to rotate in an anti-clockwise direction.

The split rings to which the ends of the coil are attached to rotate along with the coil. The momentum of the moving coil carries it past the vertical position. as soon as the coil passes the vertical position, the two halves of the split-ring commutator automatically change from one brush to the other, thereby reverses the direction of the current flow in the coil and hence, the direction of force on the coil.

PRACTICAL ELECTRIC MOTOR

A practical electric motor has a

1) strong magnetic field produce by electromagnet
2) several coils of wire wound in the slots of a laminated soft-iron cylinder
3) high currents

All these add up to produce a powerful rotation

MOVING COIL GALVANOMETER

The moving coil galvanometer is one of the most sensitive and accurate instruments for detecting or measuring extremely small current or potential difference.

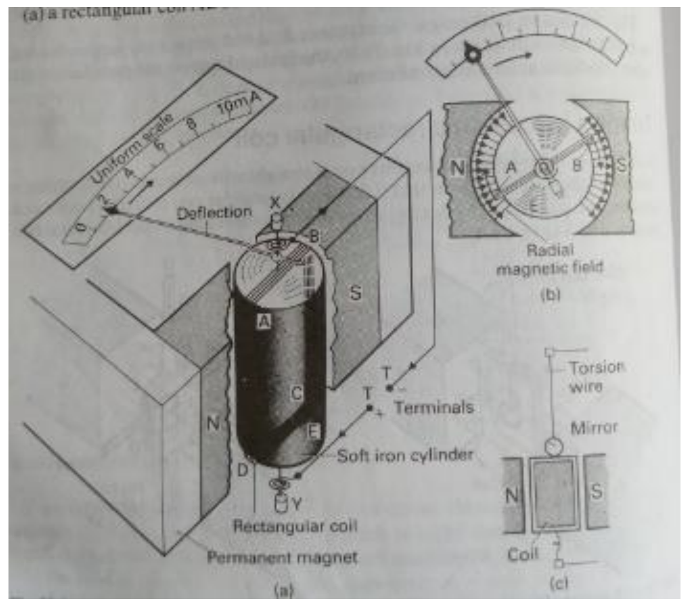


Diagram of moving coil galvanometer

When current flows, it enters the meter from a terminal T connected to the metal spring and goes round the rectangular coil and leaves through the second spring at the top and the other terminal T. The coil rotates about the vertical axis.

The angle of rotation is controlled by the spring. The angle rotation is proportional to the current strength.

WEEK 9

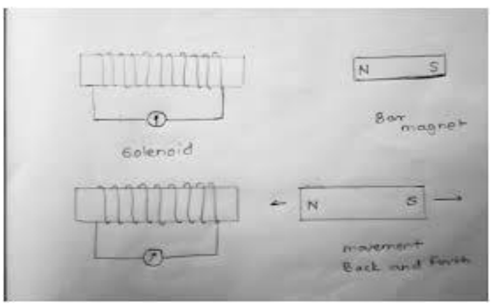
ELECTROMAGNETIC INDUCTION

INTRODUCTION

The knowledge of electromagnetic induction has help in the invention of equipment like generator.

In 1831 – 1832, Michael Faraday an English Scientist discovered that an e.m.f is always induced whenever there is a relative motion between a bar magnet and solenoid, this phenomenon is called electromagnetic induction.

Electromagnetic induction is therefore defined as the induction of an e.m.f as a result of the relative motion between the magnetic field of a bar magnet and a solenoid or a conductor.

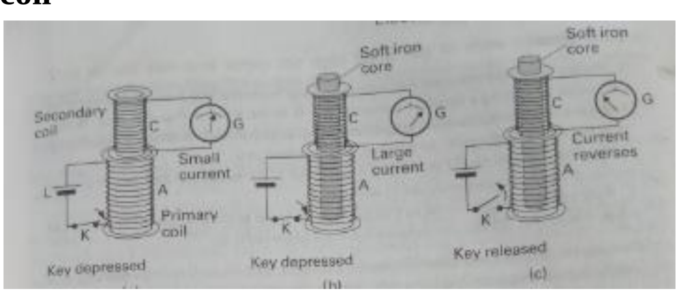


Experiment shows that the magnitude of the emf

i) increases with increases in relative motion of a bar magnetic and a conductor, strength of the magnet, the number of turns of the coil and presence of soft iron core

ii) The direction of the induced current reverses when the direction of motion of the magnet or the core is reversed.

Principle working of primary and secondary coil



When the primary coil (coil A) is connected to the battery and the key closed, current flows. The secondary coil (Coil C) to which the galvanometer is connected to, shows a deflection momentarily in the galvanometer as a result of induced current, when the key is broken, the galvanometer shows also a momentarily deflection but in the opposite direction.

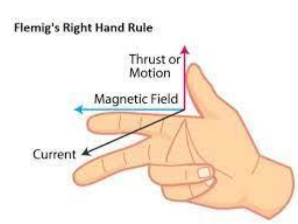
NB: if the circuit is closed or opened, no deflection is observed

FLEMING'S RIGHT HAND RULE

An induced e.m.f is produced in a straight conductor when the conductor moves across the lines of force of a uniform magnetic field. The direction of the induced e.m.f is given by Fleming's Right-Hand Rule.

The rule states that if the first three fingers of the right hand are mutually at right angles to each other with the fore finger pointing in the direction of the field and the thumb pointing in the direction of motion, then, the middle finger will point in the direction of the induced e.m.f or current.

The induced e.m.f is at maximum when the conductor moves at right angles to the lines of magnetic field and to the conductor's own length. It is zero when the conductor moves parallel to the line of magnetic field.



LAWS OF ELECTROMAGNETIC INDUCTION

There are two laws of electromagnetic induction, these are

i) Faraday's law states that whenever there is a change in the magnetic lines of force linked with a circuit, an electromotive force is induced in the circuit and the induced e.m.f is directly proportional to the rate of change of the magnetic lines of force linking the circuit.
ii) Lenz's law states that an induced e.m.f flows in such a direction as to oppose the motion producing it, hence, Lenz's law gives the direction of the induced current or e.m.f

EDDY CURRENT

When a solid metallic sheet (e.g. aluminum sheet) swings in a magnetic field, it cuts through the magnetic flux or field lines. Consequently, according to Lenz's law, an e.m.f is induced in the sheet which opposes the movement of the sheet; hence, the sheet quickly comes to rest and its motion is said to be damped. The induced e.m.f that brings about this produces an induced current on the sheet. This induced current is known as eddy current. Eddy current generates heat in the material leading to wastage of energy in most electrical devices. Eddy current is minimized by laminating the metallic sheet.

WEEK 10

GENERATOR, INDUCTION COIL, TRANSFORMER AND POWER TRANSMISSION

INTRODUCTION

Electromagnetic induction has its application in the generator. A dynamo is a device that converts mechanical energy into electrical energy. A device that converts electrical energy into mechanical energy is called a motor. Generator is some time use in place of dynamo.

PRINCIPLES WORKING OF GENERATOR

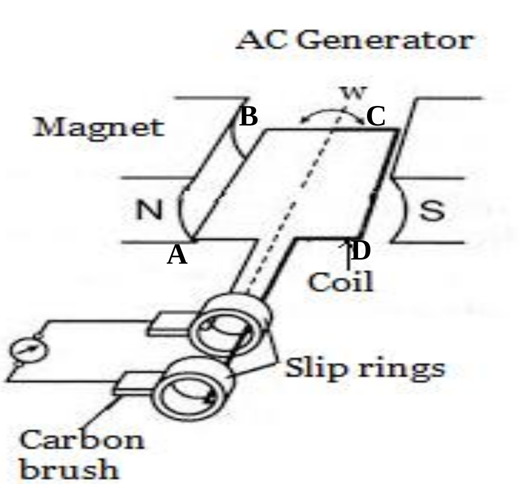
There are two types of generator: the alternating current (A.C) generator and the direct current (D.C) generator.

A simple alternating current generation consists of:

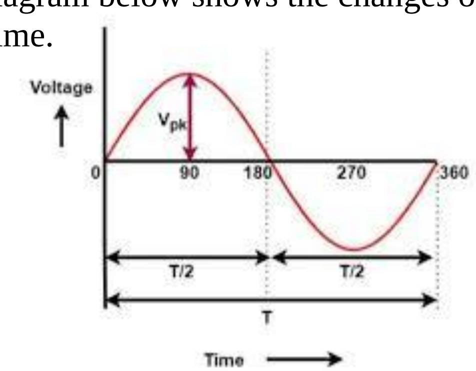
i. An armature: consisting of several turns of wire wound on a soft-iron core. The armature revolves freely between poles of magnet.

ii. A magnet which provide a strong magnetic field

iii. Two slip-rings on which rest two carbon brushes. The slip-rings are connected to the end of the armature coil, the brushes lead current away from the rings to external circuit



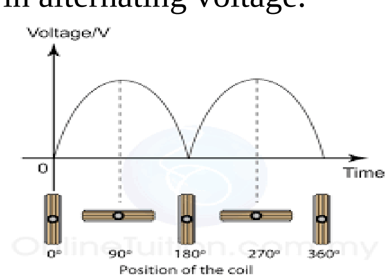
Considering the above diagram, the plane of the armature is parallel to the field. If the armature rotates at a steady speed, the side AB and DC are at right angles to the field, so an e.m.f is produced along AB and DC in the direction described using Fleming right hand rule, when the sides AB and DC move through 90^0 there is no induced e.m.f because the sides do not cut the magnetic field and they are parallel to the field when the coil moves another 90^0, the plane is now horizontal or parallel to the field but the side AB and DC are now in the opposite sides. At this point, an emf is produced again but in the opposite directions: This means that the emf in the whole coil reverses each time the coil passes the vertical or twice in one revolution. The diagram below shows the changes of emf with time.



The emf produced is called alternating voltage and current is called alternative current

Direct current

It works on the same principles with the aforementioned, the only difference is that a split-ring commutator is used instead of a slip-ring as in alternating voltage.



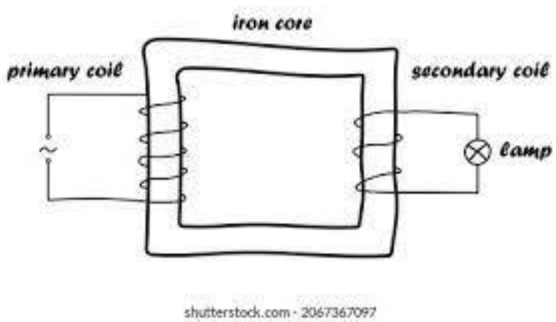
Alternating current can be measured using (i) hot wire ammeter (ii) the moving iron ammeter (iii) a moving coil galvanometer with the help of a rectifier.

Induction coil

The induction coil is a device that uses a small emf to produce an emf that is large enough to cause a spark between two terminals, it operates on d.c

Transformer

The transformer is an electrical device for changing the size of an a.c voltage. It can decrease or increase the emf of current.



It consists of two coils, called the primary and secondary coils, would round a soft iron core that is made of sheet. The soft iron cores are insulated from each other to reduce heat losses. Such a soft iron core is said to be laminated. An alternating current applied at the terminals of the primary coil set up an alternating magnetic flux in the core. This induces an emf in the secondary coil. The induced emf at the secondary coil depends at the emf at the primary coil and the number of turns in both coils such that

$$\frac{Secondary\ e.m.f}{Primary\ e.m.f} = \frac{Number\ of\ turns\ in\ the\ secondary\ coil}{Number\ of\ turns\ in\ the\ primary\ coil}$$

$$i.e.\ \frac{E_s}{E_p} = \frac{N_s}{N_p}, \quad also\ \frac{E_s}{E_p} = \frac{I_p}{I_s}$$

Where E_s and E_p are e.m.f in secondary and primary coils respectively. I_s and I_p are current in secondary and primary coils respectively. Ns and Np are number of turns of secondary and primary coils respectively.

Example: Suppose the e.m.f at the primary coil is 220V a.c and there are 600 turns in the primary coil and 300 turns in the secondary; calculate the voltage developed at the secondary coil.

Solution

$N_p = 600$, $N_s = 300$, $E_p = 200$, E_s =?

$$\frac{E_p}{E_s} = \frac{N_p}{N_s} \Rightarrow \frac{220}{E_s} = \frac{600}{300}$$

:. Es = 110v

Energy losses in transformer

Due to energy losses, the power input in the primary coil is never equal to power output in the secondary coil.

Energy losses arise from

1. energy lost in form of heat in the coil (IRt)
2. energy lost in the form of eddy current formed in the soft iron core
3. energy lost due to linkage of magnetic flux
4. energy lost due to hysteresis in the iron

Reduction of energy losses in transformer

1. Making the coil with wine of low resistance
2. using a soft iron core
3. laminating the cone to reduce energy losses due to eddy current, i.e. unwanted induced current
4. designing an efficient core

Power Transmission

Power generated at power station are distributed to areas of need. Since electric power is a product of current (I) and voltage (v), (p=iv). We can transmit the same at low current and high voltage or low voltage and high current. Since power is lost in the cable as I^2R, Power is transmitted at low current and high voltage to minimize power lost. At the point of use, the high voltage is brought down to a low and less dangerous values by the use of transformer