SS3 Physics Lesson Note (First Term) [year]

SCHEME OF WORK

WEEK TOPIC

1. **Electromagnetic waves**
2. **Gravitational Field, Law, Gravitational Potential, Escape Velocity, Potential Energy in Gravitational Field.**
3. **Electric Field, Coulombs law, electric field intensity, electric potential, Capacitor and Capacitance.**
4. **Electric Cells - Primary and Secondary, Defects of Simple Cells. Cells in series and Parallel.**
5. **Electrolysis - Electrolytes, Electrodes, Ions, Faraday's law, electro-chemical equivalent.**
6. **Electric Measurement Resistivity, Conductivity, Conversion of galvanometer to ammeter and Voltmeter, Measuring resistance ammeter - voltmeter methods.**

MID-TERM PROJECT

7. **Magnetic field - Magnetic and magnetic materials, temporary and permanent magnets, magnetization, demagnetization, Theory of magnetization, magnetic flux, Earth magnetic field.**
8. **Magnetic field around current carrying conductor - Straight conductor, circular conductor, solenoid, applications- electromagnets, uses, electromagnet-electric bell, telephone ear piece.**
9. **Electromagnetic field – Flemings left hand rule. Application - DC. Motor, moving coil. Galvanometers**
10. **Electromagnetic induction - induced current, laws of electromagnetic induction, induction coil, A. c and D.C. Generator transformer and power transmission**
11. **Revision**
12. **Examination**

WEEK 1

ELECTROMAGNETIC WAVES

CONTENT

- **Definition and Concept**
- **Types of radiation**
- **Detectors**
- **Uses**

DEFINITION AND CONCEPT

Electromagnetic waves are produced by electromagnetic vibrations. Electromagnetic waves have electrical origin and the ability to travel in vacuum. So, electromagnetic waves are regarded as a combination of traveling electric and magnetic forces which vary in value and are directed at right angles to each other and to the direction of travel. In other words, they are *transverse waves*.

TYPES OF RADIATION

The electromagnetic waves consist of the following:

1. **Radio waves with wavelength 10^{-3}m to 1000m.**
2. **Infra-red waves with average wavelengths of 10^{-6}**
3. **Visible spectrum, known as light waves, with wavelengths of 7 x 10^{-7}m for red rays.**
4. **Ultraviolet rays with wavelength of 10^{-8}m**
5. **X-rays with wavelength of 10^{-10}**
6. **Gamma –rays with wavelength of 10^{-11}**
7. ***Radio waves*: Radio waves have the longest wavelengths. Radio waves are emitted from transmitters and carry radio signals to radio sets. The shortest radio waves are called *microwaves*. Microwaves are used in radar and in heating hence they are used in cooking**
8. ***Infra-red waves:*Infra-red waves are found just beyond the red end of the visible spectrum. They are present in the radiation from the sun or from the filament of an electric lamp. Many manufacturing industries used infra-red lamps to dry paints on painted items. They are also used for the treatment of muscular**
9. ***Visible Spectrum or Light Waves:*The visible spectrum is made up of red, orange, yellow, green, blue, indigo and violet rays. These are all colours of the rainbow. When these rays combine, they form a white light. In the visible spectrum, red rays have the**

longest wavelengths while the violet rays have the shortest wavelengths. The main source of light is the sun

10. ***Ultra Violet Rays:*** **Ultra violet rays are located just beyond the violet end of the visible spectrum. Ultraviolet rays can be produced by quarts, mercury filaments, or the sun. Ultraviolet rays can cause certain materials to fluoresce (i.e. glow)**
11. ***X-Rays*****: X. rays are produced when fast moving electrons strike a metal target, which reduces their velocity. X- Rays are used in hospitals to destroy malignment growth in the body and to produce x-ray photographs which can locate broken bones. Much of x-ray in the body is harmful and can lead to sterility and adverse change in the blood. X-rays are used in industry to locate cracks in metal castings and flows in pipes.**

X-rays ionize gases and have a penetrating effect such that they pass through substances opaque to white light are diffracted by crystals and unaffected by either electric or magnetic fields.

6. ***Gamma – Rays:*** **Gamma-rays are emitted by radioactive substances such as cobalt. 60. Like x- rays, gamma rays ionize gases and darken photographic plates. Because of their shorter wavelengths gamma rays have a greater penetrating power.**

DETECTORS

The detectors of the various radiations in the electromagnetic spectrum are

1. **Gamma rays - Geiger-Muller tube**
2. **X- rays - Photographic films**

iii. Ultraviolet rays - Photographic films, fluorescent substances

1. **Visible rays - Eye, photographic film, photo electric cell**
2. **Infra-red rays - Skin, thermometer, photo transistor, photographic film.**
3. **Radio waves - Radio set, Television set, Aerials**

USES

1. **Radio-waves are very important for effective communication especially when radio set, television set, walkie-talkie are involved.**
2. **Knowledge of infra-red rays is used in developing infra-red telescopes, infra-red signaling lamps which are useful to soldiers fighting in darkness.**

3. **With the aid of photographic film which are sensitive to infra-red, it is possible to take clear photographs through mist and haze.**
4. **X-rays are useful in hospitals (e.g. to inspect broken bones), industry (to inspect metal castings), and in science to study crystal structure of matters.**
5. **Gamma rays are used to kill cancer cells in patients' body as well as bacteria in foods and hospital equipment.**
6. **Knowledge of ultraviolet rays is used in developing ultraviolet lamps; the lamps are useful in conducting experiments on photo-electric effect.**

CLASSWORK

1. **A radio station transmits at a frequency of 1200KHZ. What is the wavelength of the radio wave? ($c = 3.0 \times 10^8 ms^{-1}$).**
2. **Give three similarities of electromagnetic waves. Mention two distinguishing properties of infra-red and ultraviolet rays.**
3. **State two properties that distinguish light waves and radio waves**
4. **Mention and describe two important uses of x-rays.**

ASSIGNMENT

SECTION A

1. **Which of the following is not an electromagnetic radiation? (a) x-ray (b) radio waves (c) sunlight (d) sound waves**
2. **In which of the following groups are the radiations arranged in the increasing order of their wavelength? (a) Radio waves, gamma rays, x-rays (b) x-rays, gamma rays, radio waves (c) x-rays, radio waves, gamma rays (d) gamma rays, radio waves, x-rays**
3. **The velocity of light in vacuum is (a) 3.0×10^6m/s (b) 3.0×0^7 m/s (c) 3.0×10^8 m/s (d) 3.010^9 m/s**
4. **Which of the following radiations is found useful by soldiers fighting in darkness? (a) Gamma-rays (b) x- rays (c) infra- red rays (d) ultra violet rays**
5. **Which of the following radiation is of nuclear origin? (a) X- rays (b) Visible –rays (c) Radio waves (d) Gamma rays.**

SECTION B

1. **How can you detect the following radiations? (i) X- rays (ii) Visible rays (iii) Infra-red rays**
2. **(a) What is radar? (b) What type of electromagnetic radiation does it use? (c) How does it function?**
3. **Name five uses of electromagnetic radiations**

WEEK 2

GRAVITATIONAL FIELD

Contents

- **Introduction**
- **Law of Universal Gravitation**
- **Gravitational Potential**
- **Escape Velocity**
- **Potential energy in Gravitational Field.**

INTRODUCTION

Gravitational field is a region or space around a mass in which the gravitational force of the mass can be felt. Gravitation is the force of attraction exerted by a body on all other bodies in the universe. Gravitational force act between all masses and hold together planets, stars and galaxies. Each mass has a gravitational field around it.

LAW OF UNIVERSAL GRAVITATION

Newton's law of universal of gravitation states that *every particle in the universe attracts every other particle with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between them*

K

R

The law can be expressed mathematically as:

$F \propto M_1M_2$ ………………… 1

$F \propto \frac{1}{r^2}$ …………………..2

$F \propto \frac{M_1M_2}{r^2}$ …………………..3

:. $F = G\frac{M_1M_2}{r^2}$ …………………..4

M_1 and M_2 are the masses of the two particles r is the distance between them and G is the universal gravitational constant. The numerical value of $G = 6.67 \times 10^{-11}\ Nm^2\ kg^{-2}$.

GRAVITATIONAL FIELD INTENSITY

Gravitational field intensity at a point is the force per unit mass of an object placed at that point.

$g = \frac{F}{M}$

The unit is N/Kg. It is a vector quantity and it is regarded as acceleration due to gravity.

Relation between g and G

If the force of attraction (F) between two particles of matter separated by a distance r is given by:

$F = \frac{GMm}{R^2}$…………………..1

But $g = \frac{F}{m}$ ………………..2

:. $g = \frac{GMm}{r^2} \times \frac{1}{m}$

$g = \frac{GM}{r^2}$ …………3

This is the gravitational intensity

GRAVITATIONAL POTENTIAL

The gravitational potential at a point is the work done in taking a unit mass from infinity to that point. The unit is Jkg-1.

The gravitational potential, V, is given by

V = Gm

r

m is the mass producing the gravitational field and r is the distance of the point to the mass. ***The gravitational potential decreases as r increases and becomes zero when r is infinitely large*****. The negative sign indicates that the potential at infinity (zero) is higher than the potential close to the mass.**

ESCAPE VELOCITY

This is the minimum velocity required for an object (e.g. satellite, rocket) to just escape or leave the gravitational influence or filed of an astronomical body (e.g. the earth) permanently.

r m

R

M_e = mass of the earth, m = mass of the satellite

Then F = GM_em

r_2

The work done in carrying a mass *m* from a point at a distance *r* from the centre of the earth, to a distance so great is

W = GMm x r

r^2

This work must equal the Kinetic energy of the body of mass m at this point, having a velocity, V_e

Thus KE = ½ mV^2

:. $^1/_2 mV_e^2$ = $\underline{GM_e m}$ x r

r^2

If the mass was launched from the earth surface where r = R.

Then V_e^2 = $\underline{2GM_e}$

R

V_e^2 = $\underline{2Gm}$ x R

R^2

But g = $\underline{Gm}$

R^2

Ve^2 = 2gR

Ve^2 = √2gR

<u>Energy in Gravitational Field</u>

A satellite moving in an orbit round the earth has both kinetic and potential energy

The centripetal force = $\underline{mv^2}$ = $\underline{GMm}$

r^2 r^2

KE = ½ mv^2 = $\underline{GMm}$

r

PE of mass in orbit = - $\underline{GMm}$

r

The total energy in orbit = PE + KE

= - $\underline{GMm}$ + $\underline{GMm}$

r 2r

= $\underline{GMm}$

2r

The following conclusions can be drawn from the equation.

1. **The magnitude of the total energy is equal to that of the k.e of the satellite.**
2. **The kinetic energy of a satellite in an orbit increases as the radius of the orbit decreases.**

iii. The kinetic energy of a satellite in an orbit increases as the speed of the satellite increases.

1. **The potential energy of the satellite in orbit is twice its kinetic energy and of opposite sign.**

CLASSWORK

1. **State Newton's law of universal gravitation and give the mathematical relation**
2. **Calculate the gravitational potential at a point on the Earth surface. Mass of earth is 6.0x 10^{24}/kg, radius of earth = 6400km and G = 6.67x10^{-11}Nm^{2}kg^{-2}**
3. **Calculate the escape velocity of a satellite from the earth's gravitational field (g = 9.8m/s2, R = 6.4 x 10^6m)**
4. **What is escape velocity?**

ASSIGNMENT

section a

1. **A satellite is in a parking orbit if its period is (a) equal to the period of the earth (b) less than the period of the earth (c) the square of the period of the earth (d) more than the period of the earth**
2. **The magnitude of the gravitational attraction between the earth and a particle is 40N. if the mass of the particle is 4kg, calculate the magnitude of the gravitational field intensity of the earth on the particle (a) 10.0Nkg^{-1}(b) 12.6Nkg^{-1} (c) 25.0Nkg^{-1} (d) 160.0Nkg^{-1}**
3. **What is the escape velocity of a satellite launched from the earth's surface? {g=10ms^{-2}; radius of the earth = 6.4x10^6}**
4. **Calculate the escape velocity for a rocket fired from the earth's surface at a point where the acceleration due to gravity is 10m/s2 and the radius of the earth is 6.0 x 10^6m(a) 7.8 x 103m/s (b) 1.1 x 104m/s (c) 3.5 x 107m/s (d) 6.0 x 107m/s**

5. **If g = 9.8m/s^2. G = 6.7 x 10-11Nm2kg-2, calculate the mass of the earth if the radius is 64000km (a) 6.14 x 10^{23}kg (b) 5.99 x 10^{24}kg (c) 3.98 x 10^{26}kg (d) 4.02 x 10^{25}kg**

SECTION B

1. **(a) State Newton's law of universal gravitation (b) write down the expression for the gravitational force between two masses. Explain the meaning of each term in your expression (c) the mass of proton is 1.67x10^{-27}kg and the mass of an electron is 9.11x10^{-31}kg, calculate the force of gravitation between: (i) a proton and an electron (ii) two electrons (iii0 two protons [G= 6.67x10^{-11}Nm^{2}kg^{-2}; distance between the protons = 4.0m; distance between the electrons = 2x10^{-2}m; distance between the proton and the electron = 5.4x10^{-11}m]**
2. **Two small objects of masses 100kg and 90kg respectively are separated by a distance of 1.2m. Determine the force of attraction between the two objects. (G = 6.67 x 10^{-11}NM^{2}Kg^{-2})**
3. **If the mass of the earth is 5.78 x 10 ^{24}Kg and gravitational constant is 6.67 x 10^{-11} Nm^{2}kg^{-2}. Calculate the gravitational field intensity due to earth. Radius of earth is 6400km**
4. **Derive an expression for the total energy in a gravitational field. What conclusions can you draw from the equation?**
5. **If the mass of a proton is 1.67x10^{-27}kg and the mass of an electron is 9.11x10^{-31}kg, calculate the force of gravitation between: (i) a proton and an electron (ii) two electrons (iii) two protons {Take G= 6.67x10^{-11}Nm^{2}kg^{-2}, distance between the protons = 4.0m., distance between the electrons = 2x10^{-2}m, distance between the proton and the electron = 5.4x10^{-11}m}**

WEEK 3

Electric Field

CONTENTS

- **Electric Field**
- **Coulomb's Law**
- **Electric Field Intensity**
- **Electric Potential**

ELECTRIC FIELD

An electric field is a region of space which surrounds a system of electric charges. Electrical forces will act on any electric charge which is placed within the region. Electric field is a vector quantity. The direction of the filed can be determined using a test charge (a small positive charge)

Fundamental Law of Electrostatics

The fundamental law of electrostatic states that: *"Like charge repels, unlike charges attract.*

COULOMB'S LAW

Coulomb's law states that the force between two point charges is proportional to the product of their charges and inversely proportional to the square of the distance between them.

Mathematically,

$$F \propto \frac{q_1 q_2}{r^2}$$

$$F = k\frac{q_1 q_2}{r^2}$$

Where $k = \frac{1}{4\pi\varepsilon_\circ} = 8.99\times10^9$

Thus,

$$F = \frac{q_1 q_2}{4\pi\varepsilon_\circ r^2}$$

ELECTRIC FIELD INTENSITY OR STRENGTH (E)

The electric field intensity, E, at any point in an electric field is the force experienced by a unit positive test charge at that point. It is a vector quantity whose S. I unit is (N/C), mathematically.

$$E = \frac{F}{Q}$$

E= Electric field intensity (NC^{-1}); F = Force, q = charge.

r

Q q

From the diagram above, F between Q and q is given as

$$F = \frac{Qq}{4\pi\varepsilon_0 r^2}$$

$$\text{But } E = \frac{F}{Q} = \frac{Qq}{4\pi\varepsilon_0 r^2} \times \frac{1}{q}$$

$$\therefore E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

ELECTRIC POTENTIAL

The electric potential (V) at a point is the work done in bringing a unit positive charge from infinity to that point against the electrical forces of the field. It is measured in volts. It is scalar quantity.

Mathematically, $v = \frac{w}{q}$

Where V= electric potential (volts); W= work done in joules; q = charge in coulombs

The electric potential at a point due to a charge Q at a distance r from the charge Q at a distance r from the charge is given as:

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

If the work done is against the field, the potential is positive. If the work done is by the field, the potential is negative. The potential an infinity is zero. Also the potential of the earth is zero. The earth is used to test the potential of the body. This is done by connecting a wire form the body to the earth (the body is said to be earthed). If electrons flow from the body to the earth, the body is at a negative potential. If electron flows from the earth to the body, the body is at positive potential. Positive points are at higher potential while negative points are at lower potential.

POTENTIAL DIFFERENCE

The potential difference between any two points in an electric field is the work done is taking a unit positive charge from one point to another in the field.

If a charge Q is moved from a point at a potential V_1 to another at a potential V_2, the potential difference $(V_1 – V_2)$ is the work done by the field.

Work done on the charge, $W = Q (V^1 – V^2)$

Q

A B

x

If Q moves from A to B, then the work done,

W = Force x distance

W = F.X

But E = F

Q

EQ = F

: .W = EQ.X

But W = Q(Va – Vb)

Q (Va – Vb) = EQ. X

Va – Vb = E X

E = Va – Vb

X

: . E =p.d.

distance

i.e, E = V

X

V = E X

: . V =Q

4πε◦

<u>ELECTRON VOLT</u> (eV)

The electron volt is the quantity of energy gained by an electron in accelerating through a potential difference of one volt.

Electronic charge = $1.6 \times 10^{-1}9C$

I e V = $1.6 \times 10^{-19} \times 1 = 1.6 \times 10^{-19}J$

The energy acquired by a charged particle accelerated by an electronic field in a vacuum depends only on its charge and the p.d. through which it falls. When the electron is in motion, its kinetic energy will be ½ mv^2. If the electron moves in a circle of radius r, the force towards the centre in $\underline{mv^2}$ (centripetal force), and it is provided by the electrical force of attraction

Force of attraction = $\underline{e^2}$

$4\pi\varepsilon_\circ r^2$

: . ½ mv^2 = $\underline{e^2}$

$4\pi\varepsilon_\circ r^2$

= $^1/_2$ $\underline{e^2}$

$4\pi\varepsilon_\circ r^2$

<u>WORKED EXAMPLE</u>

1. **Calculate the energy in eV and in Joule of an α particle (helium nucleus) accelerated through a p.d. of 4×10^6V.**

<u>SOLUTION</u>

The charge on an α particle is 2e.

KE = work done

KE = charge x p.d. = q x v

= $2 \times 4 \times 10^6$

= 8×10^6 eV = 8 MeV

1eV = 1.6×10^{-19}J.

KE gained = $8 \times 10^6 \times 1.6 \times 10^{-19}$

= 1.48×10^{-12}J

2. **An electron gun releases an electron. The p.d. between the gun and the collector plate is 100V. What is the velocity of the electron just before it touches the collector plate? ($e = -1.6 \times 10^{-19}$C, $M_e = 9.1 \times 10^{-31}$kg)**

<u>SOLUTION</u>

Kinetic energy = QV

= $100 \times 1.6 \times 10^{-19}$

= 1.6×10^{-19}J

Also, kinetic energy = $\frac{1}{2}MV^2$

Thus, $\frac{1}{2}M_eV^2 = 1.6 \times 10^{-19}$J

$\frac{1}{2}(9.1 \times 10^{-31})\, V^2 = 1.6 \times 10^{-19}$

$V^2 = \frac{3.2 \times 10^{-16}}{9.1 \times 10^{-31}}$

$V^2 = 0.35 \times 10^{14}$

: .V = 6×10^6 ms^{-1}

CAPACITORS AND CAPACITANCE

CAPACITORS

A Capacitor is a device for storing electrical energy or charges. In general, capacitors can be in the form of two conductors which are insulated electrically from the surroundings. However, most common types of capacitors are in the form of two parallel plate conductors which are separated by a very small distance, d. The two plates of the capacitor can be made to carry equal and opposite charges by connecting the capacitor across the terminals of a battery such that the potential difference across the plate is V.

Capacitor is represented as

CAPACITANCE

The capacitance of a capacitor is defined as the ratio of the charge Q on either conductor to the potential difference V between the two conductors

$C = Q/V$

$Q = CV$

The SI unit of capacitance is the farad (F) which is equivalent to coulomb per volts (CV^{-1})

Factors that affect the capacitance of a capacitor are:

1. **The area of the plates**
2. **The separation between the plates**

- **The di-electric substance between the plates**

For a parallel plate capacitor, the capacitance C is given by

$C = \frac{\varepsilon A}{d}$

Where:

A= area of the plates

d= their separation

ε= permittivity of the dielectric medium (Fm^{-1})

CAPACITOR IN SERIES AND IN PARALLEL

If two or more capacitors is c_1, c_2 … are connected in series, it can be shown that the equivalent or net capacitance, c of the combination is given by:

$1/c = 1/c_1 + 1/c_2 + \ldots$

If they are connected in parallel the net capacitance C in this is given by:

$C = c_1 + c_2 + \ldots$

Note that the opposite is the case if these were resistance.

SIMPLE PROBLEMS

A capacitor contain a charge of 4.0×10^{-4} coulomb when a potential difference of 400 v is applied across it. Calculate the capacitance of the capacitor

The capacitance $C = q/v$

$= \frac{4.0 \times 10^{-4}}{400}$

$= 10^{-6}F$

= 1.0f

ENERGY STORED IN CAPACITOR

A charged is a store of electrical energy. When a charge, q , is moved through a p.d , the work done is given by

W = average p.d x charge

= ½ qv = ½ QV

But v = q /c; V = <u>Q</u>

C

W= ½ $^{q}/c$ x q = ½ q^2/c

W = ½ $^{Q}/C$

Using Q=CV

W =1/2CV^2

Therefore the work done is either

¼ q^2/c or $^1/2cv^2$ W = ½ CV^2

This work is stored in the capacitor as electrical potential energy

CLASSWORK

1. **(a)State Coulomb's law (b) Calculate the electric field intensity in vacuum at a distance of 5cm from a charge of 5.0x 10^{-4}c ($1/4\pi\varepsilon_\circ$= 9.0 x 10^9 NM^2C^{-2}).**

2 (a) Define electric field intensity (b) Two similar but opposite point charges –q and +q each of magnitude 6μC are separated by a distance of 12cm in vacuum as shown below:

r

+q -q

Calculate the magnitude and direction of the resultant electric field intensity at p

3. **Calculate the electric potential due to a positive charge of 10^{-12}C at a point distance 10cm away ($1/4\pi = 9.0 \times 10^9$m/F)**

4. **(a) Explain the term capacitor (b) Give three factors that can affect the capacitance of a capacitor (c) The net charge on capacitor which is charged to a p.d of 200 is 1.0×10^{-4}coulomb. What is the capacitance of capacitor and the energy stored in the capacitor?**

5. **A point, A, is a potential of 120v. Determine the work done in moving an electric charge 25C from A to B.**

ASSIGNMENT

SECTION A

1. **The electric force between two-point charges each of magnitude q at a distance r apart in air of permittivity $\varepsilon_\circ$is**

2. **q B. 4π q C. rε◦ D. q^2**

$4\pi\varepsilon_\circ r^2$ $\varepsilon_\circ$ q $4\pi\varepsilon_\circ r^2$

2. **The net capacitance in the circuit below is(a) 8.0μF (b) 6.0μF (c) 4.0μF (d)2.0μF**

2μF

P 4μF

2μF

3. **The magnitude of the electric field intensity at a distance r from a point charge q is**

4. **q^2 B. q C. q D. q**

$4\pi\varepsilon_\circ r$ $4\pi\varepsilon_\circ r^2$ $4\pi\varepsilon_\circ r$ $4\pi\varepsilon_\circ^2 r$

4. **Calculate the force acting on an electron carrying a charge of 1.6×10^{-19}C in an electric field of intensity 5.0×10^8N/C is (a) 3.2×10^{-29}N (b) 8.0×10^{-11}(c) 3.1×10^{27}N (d) 4.6×10^{-6}N**

5. **Find the electric field intensity in a vacuum at a distance of 10cm from a point charge of 15μc If $1/4\pi\varepsilon_\circ = 9.0 \times 10^9$**

6. **1.35×10^7NC^{-1}B. 1.4×10^{10}NC^{-1}C. 1.3×10^{11}NC^{-1} D.1.5×10^{10}NC^{-1}**

Use the diagram shown below to answer questions 6 and 7

6μF 6μF 6μF

100V

6. **What is the effective capacitance in the circuit? (a) 2 μF (b) 6 μF (c) 18 μF (d) 216 μF**
7. **What is the total energy store by the capacitors? (a) $2.0x10^{-4}$J (b) $1.0x10^{-4}$J (c) $9.0x10^{-2}$J (d) $1.0x10^{-2}$J**
8. **Which of the following statements is I are true about an isolated positively charged sphere? (I.) It contains excess positive charges (II.) It has an electric field associated with it. (III.) It carries electric current. (IV.) It has excess negative charges. (a) I and II only (b) I, II and III only (c) II and IV only (d) III and IV (e) I and III only**
9. **The potential difference across a parallel plate capacitor is 500V while the charge on either plate is 12μC. Calculate the capacitance of the capacitor (a) $6.0x10^{-3}$F (b) $2.4x10^{-4}$F (c) $6.0x10^{-5}$F (d) $2.4x10^{-8}$F**
10. **As the plates of a charged variable capacitor are moved closer together, the potential difference between them (a) increases (b) decreases (c) remains the same (d) is doubled**

SECTION B

1. **If three charges are distributed as shown in the diagram below.**

+10C 3m 0 – 20C

2m

+16C

Find the resultant force on the +10C charge (take $\frac{1}{4\pi\varepsilon_\circ}$ = 9.0 x 10^9 S.I. units)

2. **A capacitor stores 8 x 10^{-4}c of charge when the potential difference between the plates is 100v. What is capacitance?**

3. **Two charges of +5uc and -10NC are separated by a distance of 8cm in a vacuum as shown below.**

15uc B -10uc

3cm 5cm

Calculate the magnitude and direction of the resultant electric field intensity due to point B.

$\frac{1}{4\pi\varepsilon_0}$ **= 9.0 x 10^9 S.I unit**

WEEK 4

ELECTRIC CELLS

- **Electric Circuit**
- **Types of Electric Cells**

ELECTRIC CIRCUIT

Electric current is simply electric charge in motion. Electric cells are chemical devices, which are capable of causing an electric current to flow. This produces electric force, which pushes the current along.

Electrons flow from the negative terminal or cathode of the cell to the positive terminal or anode

TYPES OF ELECTRIC CELLS

Electric cells are divided into two namely: the primary cells and the secondary cells

PRIMARY CELLS - These are those cells in which current is produced as a result of an irreversible chemical charge.

SECONDARY CELLS - These cells are those which can be recharged when they run down by passing current backwards through them.

There are three components in a cell. Viz:

1. **The anode (positive electrode)**
2. **The cathode (negative electrode)**

- **The electrolyte**

THE SIMPLE PRIMARY CELL (VOLTAIC CELL)

A simple cell can be made by placing two different electrodes (metals) in an electrolyte. Two wires are then used to connect these metals to a voltmeter. If a deflection is noticed it means that the cell creates a voltage.

Defects of a simple cell

The two major deflects of a simple all are *polarization and local action*

1. **<u>Polarization</u>- This cell defect is characterized by the release of "hydrogen bubbles." The bubbles collect at the positive electrode and insulate it. This show down and eventually stops the working of the cell.**

This defect can be corrected either by occasionally brushing the plates, which is highly inconvenient, or by using a depolarizer e.g. manganese oxide.

1. **<u>Local action</u>- This occurs when impure zinc is used. The impurities in the zinc result in the gradual wearing away of the zinc plates. This can be prevented by cleaning the zinc with H_2SO_4 and then rubbed with mercury. The mercury amalgamates the zinc by covering the impurities thereby preventing it from coming into contact with electrolyte.**

LECLANCHE CELL

Leclanche cells are of two types; *the wet and the dried* types.

***The wet Leclanche cell* consists of a zinc rod at the cathode in solution of ammonium chloride contained in a glass vessel. The anode is a carbon rod contained in a porous pot and is surrounded by manganese chloride as a depolarizer. An e.m.f. is set up by the zinc, the carbon and the electrolyte, which drives a current from zinc to carbon through the cell. The e.m.f of a Leclanche cell is 1.5v. Its defect is that when the cell has worked for sometimes, the rate of hydrogen production becomes greater than the rate at which it is oxidized by the manganese dioxide, hence the formation of polarization. Therefore the cell must be allowed to rest from time. The wet Leclanche cells are restricted to intermittent current supply because they do not give continuous service. They are too heavy to carry about without spilling the liquid.**

***For the dry Leclanche cell*, the defect of heaviness is overcome. The ammonium chloride electrolyte is a jelly-like material and not aligned solution. The positive electrode is a carbon rod surrounded by a packed mixture of manganese dioxide and powered carbon, inside a zinc container, which is the negative electrode.**

The dry can be carry about easily e.g. torch batteries, and transistor radio batteries. Due to local action, they deteriorate after sometime.

THE DANIEL CELL

This is also a primary cell invented to counter the problem of polarization. The zinc rod is the negative electrode while the positive electrode is the container. The electrolyte is dilute tetraoxosulphate (vi) acid contained in a porous pot around the zinc rod, and the depolarize is copper tetraoxosulphate (vi) in the surrounding copper container. The Daniel cell is much more efficient than the Leclanche cell. The e.m.f. is of a constant value of l.08V.

SECONDARY CELL

Secondary cells are of two main types - lead acid accumulator, and the alkaline or nickel-iron (Ni-Fe) accumulation.

***The lead-acid accumulator* is the most common one. It consists of lead oxide as the positive electrode, lead as the negative electrode and tetraoxosulphate (vi) acid as the electrolyte. During the discharge, when the cell is given out current both plates gradually charge to lead tetraoxosulphate (vi) while the acid gradually becomes more dilute and the density decreases. When fully charge the relative density and e.m.f. of the cell are 1.25 and 2.2v respectively. But when discharge they are reduced to 1.5 and less than 2.0v respectively. The rod density of the cell should not be allowed to drop 1.15 before it is recharged.**

<u>Maintenance of lead acid accumulators</u>

1. **The liquid level must be maintained by using distilled H_2O**
2. **The cell should be charge appropriately**

- **If the cell is not in use for a long time, it should be discharge from time to time or the acid remove and the cell dried**

1. **The battery should be kept clean so that current dose not leaks away across the casing between the terminals.**

***The alkaline or Ni-Fe accumulators -* The positive electrode is made of nickel hydrogen while the negative plate is either of iron or calcium. The electrolyte is potassium hydroxide dissolve in water. This cell last longer and lead acid cells, keep their charge longer and they require less maintenance. They are used for emergencies in factories and hospitals. They are expensive and bulky with a small e.m.f value, about 1.25v**

CLASSWORK

1. **What is a cell?**
2. **Highlight the defects of cells**
3. **Briefly differentiate between primary cell and secondary cells**

ASSIGNMENT

SECTION A

During an activity, 15 coulombs of charge passed through an ammeter in 2second what is the reading of the ammeter? (a) 2A (b) 5A (c) 8A (d) 10A

The energy transformation taking place when a cell supplies current to a bulb is from (a)light energy to heat energy (b) mechanical energy to light energy (c)solar energy to electrical energy (d) chemical energy to light energy

Which of a-d below is correct? (i) Ordinary torch battery is an example of primary cell; (ii) accumulations have very high interne resistance (a) (i) only (b) (ii) only (c) (iii) only (d) (i) and (ii) only

Which of the following statement is not true? (a) the chemical action in a primary cell is irreversible (b) lead-acid accumulation can be recharged (c) lead-acid accumulator has large internal resistance (d) a secondary cell can be recharged

The defect in simple cell which result in a back e.m.f and increase in internal resistance is known as (a) local action (b) reduction (c) polarization (d) oxidation

The rheostat could serve the following except. (a) as a variable resistor (b) as a potential divider (c) as a means of varying the current in a circuit (d) as a converter of solar energy to electrical energy

Which of the following devices convert sheet energy to electric current? (a) Photo cell (b) battery (c) voltmeter (d) thermocouple

Which of the following devices coverts mechanical energy to electric current (a) battery (b) photocell (c) thermopile (d) dynamo

SECTION B

Using suitable diagram, explain the simple cell

List two defects of a simple cell

WEEK 5

ELECTROLYSIS

CONTENT

- **Definition of simple terms**

- **Faraday's laws of electrolysis**
- **Simple calculations**
- **Applications of electrolysis**

DEFINITION OF SIMPLE TERMS

Electrolysis - Is the process whereby a liquid conducts electricity by the movement of positive and negative ions within the liquid while undergoing chemical changes.

Electrolytes - Are liquid, which allows the electricity through them is called electrolytes. Such electricity is salt solutions, alkalis and dilute acids (acidulated water).

Non-Electrolytes - are liquids, which do not allow electricity to pass through them. Such liquids include distilled water, alcohol, liquid paraffin and sugar solution.

NOTE: Metals and hydrogen are deposited at the cathode, while non-metals and oxygen are deposited on the anode. The anode may dissolve in solution.

Electrolysis does not manufacture electric charges and it is the "splitting' of compounds by electricity. E.g. water decomposes into oxygen and hydrogen by electric current.

FARADAY'S LAWS OF ELECTROLYSIS

Faraday's first law sate that the mass of a substance liberated during the process of electrolysis is proportional to the quantity of electricity passed through the electrolyte

Faraday's second law of electrolysis states that the relative masses of substances liberated by the same quantity of electricity are proportional to their chemical equivalents.

SIMPLE CALCULATIONS

If M is the mass of substance deposited when a current q flows for time t, then the quantity of electricity of electricity which flows is flows is It, and

m = Z It.

Where, Z = electrochemical equivalent of the substance

$$Z = \frac{m}{It}$$

I = current in A

t = time in seconds

m = mass of substance in grams

APPLICATIONS OF ELECTROLYSIS

In industry, electrolysis is used in electroplating of metals, purification of metals and electrolytic production of metals from compounds.

- **Electroplating**
- **The purification of metals**
- **The electrolytic preparation of metals from compounds**

CLASSWORK

1. **What is electrolysis? Mention at least two uses of electrolysis**
2. **What is an electrolyte?**
3. **State Faraday's laws of electrolysis**
4. **A current of 3A maintained for 50 minutes deposits 3.048g of zinc at the cathode. Determine the electrochemical equivalent of zinc.**

ASSIGNMENT

SECTION A

In an electrolysis experiment, a cathode of mass 5g is found to weigh 5.01g after a current of 5A flows for 50 seconds. What is the electrochemical equivalent of the deposited substance (a) 0.00004gC^{-1} (b) 0.00002 gC^{-1} (c) 0.02500 gC^{-1} (d) 0.00001 gC^{-1}

The electrochemical equivalent of a metal is 0.126×10^{-6}kgC^{-1}. The mass of the metal that a current of 5A will deposit from a suitable bath in 1hour is (a) 2.268×10^{-3}kg (b) 0.378×10^{-3}kg (c) 0.0378×10^{-3}kg (d) 0.227×10^{-3}kg

The electrochemical equivalent of platinum is 5×10^{-7}kgC^{-1}. To plate-out 1.0kg of platinum, a current of 100A must be passed through an appropriate vessel for (a) 5.6hours (b) 56hours (c) 1.4×10^{4}hours (d) 2.0×10^{4}hours

Which of the following statement about the defects of simply cells is not correct? (a) Polarization defect is minimized by use of manganese oxide as depolarizer (b) Polarization may also be reduced by brushing the plates occasionally (c) Local action occurs because zinc is not pure (d) Local action also occurs because hydrogen bubbles accumulate at the plate.

Which of the following instrument is most accurate for comparing e.m.f of two cells? (a) Wheatstone bridge (b) galvanometer (c) potentiometer (d) meter bridge

SECTION B

1. **What is meant by the statement "the electrochemical equivalent of copper is 0.000 33 g /coulomb"?**
2. **In electrolysis of copper tetraoxosulphate (vi) using copper electrodes, 1.53g of copper wire deposited in 30 minutes. Determine the average current used ($z=3.29 \times 10^{-4}$)**
3. **(a) Name two industrial applications of electrolysis. (a) Calculate the time to deposit 1.56g of nickel using a current of 2.34A in a nickel-plating process. (Assume that 1/20g of nickel are deposited per ampere-hour)**

WEEK 6

ELECTRIC MEASUREMENT

CONTENT

- **Resistivity and conductivity**
- **Conversion of galvanometer to ammeter and voltmeter**
- **Measuring resistance ammeter- voltmeter method.**

RESISTIVITY AND CONDUCTIVITY

The resistance of a wire maintain at a constant temperature is related to its length L and its cross-sectional area (A) by the expression

$$R = \frac{\rho l}{A}$$

Where ρ is a constant known as resistivity of the material (its unit is ohm-metre, Ωm)

$$\rho = \frac{RA}{l}$$

R = resistance, A = cross-sectional area, l = length of the wire.

The resistance is the ability of a material to oppose the flow of current through it. The greater the resistivity of a wire the poorer it is as an electrical conductor. That is why conductivity is used to specify the current –carrying ability of a material. The greater the conductivity of a material, the more easily can current flow through the material. Hence, materials with high conductivity will have low resistively.

Conductivity, σ is the reciprocal of the resistivity

$$\sigma = \frac{1}{\rho}$$

<u>Electrical Conductivity</u>: This is a measure of the extent to which a material will allow current to flow easily through it when a p.d is applied at a specified temperature. It is the reciprocal of the resistivity.

GALVANOMETER CONVERSION

<u>Conversion of galvanometer to ammeter (Shunt)</u>

An ammeter is used for measuring currents. A galvanometer is used for detecting and measuring very small currents. We can convert galvanometer into ammeter by connecting a suitable resistor in parallel with the galvanometer, this is known as *shunt*. *A shunt is a low resistance wire and is used to divert a large part of the current being measured but to allow only a small current to pass through the galvanometer*

<u>Conversion of Galvanometer to Voltmeter</u>

A galvanometer used for measuring very small current can be converted to voltmeter by connecting a high resistance or multiplier in series with the galvanometer.

CLASSWORK

1. **A steady current of 1.5A flows through a copper wire of length 10m and cross-sectional $3.44 \times 10^{-8} m^2$. What is the voltage applied across the wire if the resistivity of copper is $1.72 \times 10^{-8} \Omega m$?**

2. **A galvanometer of resistance 5 ohms gives a full scale deflection when a current of 50mA flows through it. How will you convert it to an ammeter capable of measuring 2A?**

ASSIGNMENT

SECTION A

1. **When a resistance r is a across a cell, the voltage across the terminals of the cell is reduced to two-thirds of its nominal value. The internal resistance of the cell is (a) 1/3R (b) ½R (c) 2/3R (d) R**

2. **Which of the following does not determine the electrical resistance of a wire? (a) Length (b) Mass (c) Cross-sectional area (d) Temperature**

3. **A wire of 5Ω resistance is drawn out so that its new length is twice the original length. If the resistivity of the wire remains the same and the cross-sectional area is halved, the new resistance is (a) 5Ω (b) 10Ω (c) 20Ω (d) 40Ω**

4. **A cell of e.m.f 1.5V and internal resistance 2.5ohms is connected in series with an ammeter of resistance 0.5 ohms and a resistor of resistance 0.7ohms. Calculate the current in the circuit (a) 6.67A (b) 0.20A (c) 0.60A (d) 0.15A**

5. **A cell of internal resistance 2 ohms supplies a current of a 6-hm resistor. The efficiency of the cell is (a) 12.0% (b) 25.0% (c) 33.3% (d) 75.0%**

SECTION B

A galvanometer of resistance 50Ω which gives a full-scale deflection for 1mA is to be adapted to measure currents up to 5A. (i) calculate the resistance of the resistor required (ii) if the resistor is made of a material of cross-sectional area $4x10^{-4}cm^2$ and resistivity $2x10^{-6}$Ωm, calculate its length

A battery of three cells in series, each of e.m.f. 2 V and internal resistance 0.5 Ω is connected to a 2 Ω resistor in series with a parallel combination of two 3Ω resistors. Draw the circuit diagram and calculate (i) the effective external resistance (ii) the current in the circuit (iii) the lost volts in the battery (iv) the current in one of the 3 Ω

Calculate the length of a constantan wire of diameter 0.6 mm and resistivity 1.1×10^{-6} Ωm required to construct a standard resistor of resistance 35Ω

MIDTERM PROJECT

BOYS*: Draw, write short note and explain the defect of a named dry cell*

GIRLS*: Draw the experimental set-up and write short note on the electrolysis of a named metal and highlight 3 other applications of electrolysis*

NOTE: use white cardboard

WEEKS 7 & 8

MAGNETIC FIELD

CONTENTS

- **Magnets and its properties**
- **Magnetization and demagnetization**
- **Temporary and permanent magnets**
- **Theory of magnetization**
- **Magnetic flux**
- **Earth magnetic field**

MAGNET AND ITS PROPERTIES

A magnet is any material that is capable of attracting other pieces of the same material as well as pieces of iron. A substance is said to be ferromagnetic if it is attracted by a magnet. Examples are iron, cobalt, Nickel, and certain alloys. Substances which cannot be attracted by a magnet are called non-magnetic material e.g. brass, wood, copper, and glass.

Properties of magnets

1. **The ends of a magnet where the attracting power is greatest are called the poles.**
2. **A bar magnet suspended freely in a vertical plane called*magnetic meridian*comes to rest with its axis in the North-South direction. The part which points northwards is called the *north seeking pole or North Pole* while the opposite pole is called the *South Pole***
3. **Like poles of magnet repel each other while unlike poles attract each other.**
4. **The polarity of a magnet can be tested by bringing both poles in turn nearer to the known pole of a suspended magnet. Repulsion indicates similar polarity. Attraction could be due to two unlike poles or a pole and a piece of un-magnetized material. Hence, *repulsion is the only sure test for polarity.***

MAGNETIZATION AND DEMAGNETIZATION

Magnetization is a process whereby a material is made to become magnetic. This can be achieved through any of the following methods:

1. **<u>Electrical method</u>- A cylindrical coil wound with several turns of insulated copper wire is connected in series with a six or twelve volt electric battery and switch. A coil of this type is called a solenoid. A steel bar is placed inside the coil and the current is switched on for some time. On removing and testing the steel, it will be found to have**

been magnetized. It is unnecessary to leave the current for long as length of time makes no difference but causes over-heating. The induced polarity depends on the direction of flow of the current. *Clockwise flow at an end indicates South Pole while an anti-clockwise flow indicates North Pole*.

2. **Single touch method- A steel bar is stroke from end to end several times in the same direction with a known pole of a magnet. Between successive strokes the pole is lifted high above the bar otherwise the magnetism already induced will be weakened. The disadvantage of this method is that it produces magnets in which one pole is nearer the end of the bar than the other.**
3. **Divided touch method- Here the steel bar is stroke from the centre outward with unlike poles of two magnets simultaneously. The polarity produced at the end of the bar where the stroking finishes is of opposite kind to that of the stroking pole.**
4. **Hammering in the earth field- Magnets can be made by hammering red hot steel bar and allow it to cool as it lies in North- South direction.**
5. **Induced Magnetism - When a piece of un-magnetized steel is placed either near or in contact with a pole of a magnet and then removed, it will be magnetized. This is called induced magnetism. The induced pole is of opposite sign to that of inducing pole.**

DEMAGNETIZATION

This is a process whereby a magnet is made to lose its magnetism. Demagnetization can be achieved by:

Electrical Method - The magnet is placed in a solenoid through which an alternating current is flowing. The solenoid is placed with its axis pointing in the East -West direction. After a few seconds, the magnet is slowly withdrawn out of the solenoid to a long distance away. This is the most efficient way of demagnetizing a magnet.

Mechanical Method - Another method of demagnetizing magnets is to hammer it hard when it is pointing in the East West direction.

Heating Method - When magnets are strongly heated, it loses its magnetism.

TEMPORARY AND PERMANENT MAGNET

Soft iron is pure iron while steel is an alloy of iron and carbon. Steel is a much harder and stronger material than soft iron. Steel and iron have different magnetic properties.

Iron is easily magnetizes than steel but it readily loses its magnetism. Steel produces a stronger magnet that is the reason why steel is used for making permanent magnet such as compass needle. In temporary magnets where the magnetism is required for a short

MAGNETIC FIELDS

Magnetic field is the space surrounding the magnets in which magnetic force is exerted. It is a vector quantity and it is represented by magnetic lines. The direction of the magnetic flux at any point is the direction of the force on a north pole placed at that point.

In the neighborhood of two magnets placed closed together, there exists a field in which the direction of the magnetic flux changes rapidly in a confined space. The magnetic flux can be obtained by using iron fillings.

Magnetic meridian at any place is a vertical plane containing the magnetic axis of a freely suspended magnet at rest under the action of the earth field.

The geographical meridian at a place is a plane containing the place and the earth axis of rotation.

The angle between the magnetic and geographical meridian is called the magnetic declination.

The angle of dip or inclination is the angle between the direction of the earth magnetic flux and the horizontal.

CLASSWORK

1. **With the aid of a suitable diagram, explain the following: magnetic flux, angle of inclination, angle of declination.**
2. **Differentiate between steel and iron with respect to magnetism.**

ASSIGNMENT

SECTION A

1. **Which of the following statements is CORRECT about the earth's magnetic field? (a) The angle of dip is the angle which a freely suspended magnet makes with the vertical (b) the angle of declination is the angle between the magnetic meridian and the geographic meridian (c) the angle of inclination is the difference between the angle of dip and the angle of declination (d) the angle of inclination is the angle which a magnetic compass makes with the magnetic meridian**

2. **If the angle of declination in a place is 0^0, calculate the true geographic bearing if the compass needle reads N40^0E (a) N50^0E (b) N40^0E (c) N30^0E (d) N25^0E**
3. **A magnetic substance can be demagnetized by? (a) Dropping on the floor (b) hammering while red hot (c) divided touch (d) single touch**
4. **A freely suspended needle compass needle on earth's surface will come to rest in a plane called (a) geographic equator (b) geographic meridian (c) magnetic equator (d) magnetic meridian**
5. **In other to make a moving electron follow a circular path (a) a magnetic field is applied perpendicular to its path (b) a magnetic field is applied parallel to its path (c) an electric field is applied parallel to its path (d) an electric field is applied perpendicular to its path**

SECTION B

1. **(a) Explain what is meant by a magnetic field (b)(i) describe an experiment to show that a magnetic field exists around a straight wire carrying-current (ii) draw a diagram, to show the pattern and direction of the magnetic field produced around the wire [neglect the earth's magnetic field] (c) Sketch the form of the flux pattern due to two straight parallel wires carrying current un the same direction. Indicate the neutral point in the field (d) Explain, with the aid of diagram, how a delicate material could be protected from the earth's magnetic field**
2. **Explain the tem "angle of dip", and describe how it varies over the earth**
3. **A charge of $1.6x10^{-19}$C enters a magnetic field of flux density 2.0T with a velocity of $2.5x10^{-19}$m/s at an angle of $30^0$with the field. Calculate the magnitude of the force exerted on the charge by the field**

WEEK 9 & 10

ELECTROMAGNETIC FIELD

CONTENT

- **Patterns of magnetic field**
- **Magnetic field around a straight conductor carrying current**
- **Force on a current carrying conductor in a magnetic field**

- **Force between conductors carrying current**

PATTERNS OF MAGNETIC FIELDS

Magnetic field pattern can easily be observed using iron fillings. The magnetic is put on paper and the iron fillings are sprinkled lightly on the paper around the magnet. The paper is tapped gently and the iron fillings are found to turn and set to in definite direction.

MAGNETIC FIELD AROUND A STRAIGHT CONDUCTOR CARRYING CURRENT

A straight conductor carrying current can be shown that it has magnet filed around it. Allow a thick isolated copper wire to pass vertically through a hole in a card board shit. As shown below, sprinkle some iron fillings uniformly on the cardboard around the vertical wire connect the ends of the wire to a battery, switch on the current and place some compass needles around the wire. Note the direction to which the compass needle point. Switch on the current and note the swing of the needles and how they point.

It will be observed that when current is switch on and the card board is gently tapped, the fillings arrange themselves in a series of concentric circles about the wire as centre. Also as soon as the current is switch on, the needles will swing around and form a circle with the wire as centre. The direction of the filed depends on the direction of flow of the current. Such a direction can always be obtained by applying the Right Hand Grip Rule.

Compass needle

Card board

Sprinkled with iron fillings

FORCE ON A CURRENT CARRYING CONDUCTOR IN A MAGNETIC FIELD

A conductor carrying an electric current, when placed in the magnetic field experiences a mechanical force. This can be demonstrated by using two metal rails fixed on each side of a powerful horse-shoe magnet. A copper rod is placed across the rays. When the current is passed through this copper rod, it is observed that the copper rod rolls along the rays, toward the right. If by adjusting the rheostat, more current is made to flow through the rod. One will notice that the rod moves faster, thus the force on the rod increases when the current increases.

If the direction of flow of current is reversed by reversing the connections at the battery terminals, the rod will be observed to move towards the left, opposite to the previous direction of motion.

If one turns the magnet such that the magnetic field is parallel to the length of the rod as shown below, it will be observed that the current carrying the rod remains stationary no matter the amount of current hat pass through. There is therefore no force on the rod.

ELECTROMAGNETIC FIELD II

CONTENT

- **Electromagnetic field**
- **Fleming left hand rule**
- **Applications of electromagnetic field**

ELECTROMAGNETIC FIELD: This is a field representing the joint interaction of electric and magnetic forces. It is exerted on charged particles. The force on a charge q moving with velocity v less than the velocity of light is given by

$$F = q (E + v \times B)$$

A conductor carrying an electric current when placed in a magnetic field experiences a mechanical force. It can be demonstrated by using two metal rails fixed on each side of a powerful horse-shoe magnet. A copper rod is placed across the rails. When we pass current through this copper rod, it is observed that the copper rood rolls along the rails, towards the right. If by adjusting the rheostat, we cause more current to flow through the rod, we will observe that the rod moves faster. Thus, the force on the rod increases when the current increases.

***Direction of the force* - The direction of force on a current carrying conductor placed perpendicular to the magnetic field is given by Fleming's left-hand rule which is stated as follows:**

If the thumb, forefinger and middle finger are held mutually at right angles to one another with the *fore-finger pointing in the direction of magnetic field*, and the *second finger in the direction of Current*, then the *thumb will point in the direction of the force* producing motion.

APPLICATIONS OF ELECTROMAGNETIC FIELD

1. ***Electric Motor*- The electric motor is a device for converting electrical energy into chemical energy. It consists:**

(i) A rectangular coil of insulated wire, known as armature

(ii) A powerful magnetic field in which the armature turns is provided by two curve pole pieces of a powerful magnet

(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 lightly against either side of the split-ring commutator

1. ***Moving Coil Galvanometer*- This galvanometer is one of the most sensitive and accurate methods for detecting or measuring extremely small currents or potential differences. It consist essentially of**
2. **A light rectangular vertical coil ABCD pivoted in jeweled bearings such that it can move in a vertical plane**
   2. Two curved pole piece of a horse shoe magnet and a soft iron core or cylinder inserted between the pole pieces.
3. **Two spiral non-magnetic control springs of phosphor bronze, each of which is attached to the jeweled bearing or spindle. Current enters or leaves the rectangular coil through these spiral springs. The springs also provide the control couple.**

CLASSWORK

1. **What do you understand the term electromagnetic field?**
2. **What is a transformer?**
3. **The transformer in a disc video decoder is used to step down 240V supply to 12V. If there are 2400 turns in the secondary coil find: (i) the turn ratio of the transformer (ii) the number of turns in the primary coil**
4. **State Fleming's left hand rule**

ASSIGNMENT

SECTION A

1. **Induced current depends the: (i) the number of turns in the coil (ii) strength of the magnet (iii) speed with which the magnet is plunged into the coil (a) I only (b) II only (c) III only (d) none of the above**

2. **To convert an alternating current dynamo into a direct current dynamo, the (a) the number of turns in the coil is increased (b) strength of the field magnet is increased (c) slip rings are replaced with split ring commutator (d) coil is wound on a soft iron armature**

3. **If a current-carrying coil is mounted on a metal frame, the back e.m.f. induced in the coil causes (a) inductance (b) eddy current (c) electromagnetism (d) dipole moment**

4. **A transformer with 5500 turns in its primary is used between a 240V a.c. supply and a 120V kettle. Calculate the number of turns in the secondary (a) 2750 (b) 460 (c) 11,000 (d) 232**

5. **The direction of induce current in a straight wire balanced in a magnetic field is determined by using ___________ (a) Fleming's right hand rule (b) Maxwell's screw rule (c) Faraday's law (d) Len's law**

6. **Energy losses dues to eddy currents are reduced by using (a) low resistance wires (b) insulated soft iron wires (c) few turns of wire (d) high resistance wires**

7. **From the generating station to each substation, power is transmitted at a very high voltage so as reduce (a) eddy current (b) hysteresis loss (c) heating in the coils (d) magnetic flux leakage**

8. **A devise used to prevent wearing away of the make-and-break contacts of an induction coil is called a/an (a) fuse (b) electroscope (c) resistor (d) capacitor**

9. **The current of a primary coil of a transformer is 2.5A. If the primary coil has 50 turns and the secondary 250 turns. Calculate the current in the secondary coil [neglect energy losses in the transformer] (a) 0.2A (b) 0.5A (c) 2.5A (d) 5.0A**

10. **The voltage and the current in the primary of a transformer are 2000V and 2A respectively. If the transformer is used to light ten 12V, 30W bulbs, calculate its efficiency (a) 100% (b) 90% (c) 50% (d) 75%**

SECTION B

1. **(a) Draw a simple labeled diagram illustrating the principle of a step down transformer and explain how it works (b) state three ways y which energy is lost in a transformer and how they can be minimized (c) if a transformer is used to light a lamp rated at 60W, 220V from a 4400V a.c. supply, calculate (i) ratio of the number of the turns of**

the primary coil to the secondary coil in the transformer (ii) current taken from the mains circuit if the efficiency of the transformer is 95%

2. **(a) State the law of magnetic induction (b) explain how one of the laws illustrate the principle of conservation of energy (c)(i) draw a well labeled diagram of a simple d.c. electric motor and explain how it works (ii) state two reasons why the efficiency of an electric motor is less than 100%**
3. **(a) state Faraday's law of electromagnetic induction (b) draw a labeled diagram of an induction coil and explain how it works (c) state the reason why a capacitor should be included in the primary circuit of the coil (d) how is the effect of eddy current minimized in the coil? (e) state three uses of induction coil.**

WEEK 11

Revision

WEEK 12

Examination