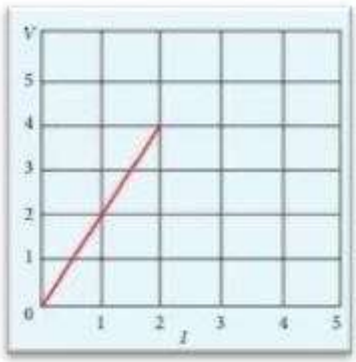
Unit – 2 CURRENT ELECTRICITY
Part – A

I.One Mark Questions

1.The following graph shows currentversus voltage values of some unknownconductor. What is the resistance ofthis conductor?



(a) 2 ohm
(b) 4 ohm
(c) 8 ohm
(d)1 ohm

Answer:- (a) 2 ohm

2.A toaster operating at 240 V has aresistance of 120 Ω. Its power is

a) 4 0 W
b 2 W
c) 480 W
d) 2 0 W

Answer:- c) 480 W

3.A piece of copper and another ofgermanium are cooled from roomtemperature to 80 K. The resistance of

a) each of them increases
b) each of them decreases
c) copper increases and germaniumdecreases
d) copper decreases and germaniumincreases

Answer:- d) copper decreases and germanium increases

4.In Joule's heating law, when R and t areconstant, if the H is taken along the yaxis and I2along the x axis, the graph is

a) straight line
b) parabola
c) circle
d) ellipse

Answer:- a) straight line

5.The resistance of a conductor in the form of a wire depends on its
a) length
b)material
c)diameter
d)temperature
Answer:- a) length

6.Electric Current is rate of change in
a) Electric Potential
b) Electric Charge
c) Electric field
d) Induction
Answer:- b) Electric Charge

7.SI unit of Mobility

a) $\frac{s^2}{V\,m}$ b) $\frac{V\,m}{s^2}$ c) $\frac{m^2}{V\,s}$ d) $\frac{V\,s}{m^2}$

Answer:- C m^2 / V_s

8.Colour of the resister which shows 10% tolerance
a) Gold
b) Silver
c)Brown
d) Colourless
Answer:- b) Silver

9.The terminal voltage of Battery is
a) always less than emf
b) always equal to emf
c) less or equal to emf is depending on the direction of current flow
d) less or equal to emf is depending on internal resistance if the cell
Answer:- a) always less than emf

10.The masses of different substances liberated in electrolysis by the same quantity of electricity are proportional to their relative
a) atomic masses
b) valencies
c) ratios of atomic masses and valency
d) product of atomic masses and valency
Answer:- d) product of atomic masses and valency

Part – B

II.Very Short Answer

1.Write a short note on superconductors?

The ability of certain metals, their compounds and alloys to conduct electricity with zero resistance at very low temperatures is called superconductivity.

2.Define current density.

The current density (J) is defined as the current per unit area of cross section of the conductor

$J = \frac{1}{A}$

The S.I unit of current density.

$\frac{A}{m^2}$

Or

Am^2

3.Define electrical resistivity.

Electrical resistivity of a material is defined as the resistance offered to current flow by a conductor of unit length having unit area of cross section.

4.State Joule's law of heating.

It states that the heat developed in an electrical circuit due to the flow of current varies directly as:

1. **the square of the current**
2. **the resistance of the circuit and**
3. **the time of flow.**

   $H = I^2R$?

5.What is Seebeck effect?

Seebeck discovered that in a closed circuit consisting of two dissimilar metals, when the junctions are maintained at different temperatures, an emf (potential difference) is developed.

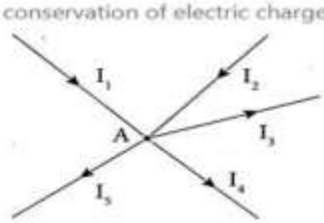
Part – C

III. Short Answer.

1.State and explain Kirchhoff 's rules.

Kirchhoff's first rule (current rule or junction rule):

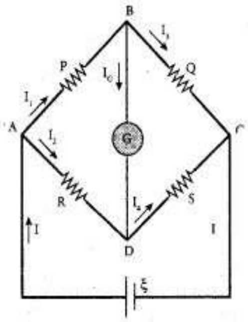
Statement: It states that the algebraic sum of the currents at any junction of a circuit is zero. It is a statement of conservation of electric charge.



Kirchhoff's current rule

2. Obtain the condition for bridge balancein Wheatstone's bridge.

An important application of Kirchhoff's rules is the Wheatstone's bridge. It is used to compare resistances and also helps in determining the unknown resistance in electrical network. The – bridge consists of four resistances P, Q, R and S connected. A galvanometer G is connected between the points B and D. The battery is connected between the points A and C. The current through the galvanometer is I_G and its resistance is G.



Wheatstone's bridge

Applying KirchhofFs current rule to junction B,

$I_1 - I_G - I_3 = 0$ .... (1)

Applying Kirchhoff's current rule to junction D,

$I_2 - I_G - I_4 = 0$ .... (2)

Applying Kirchhoff's voltage rule to loop ABDA,

$I_1P + I_GG - I_2R = 0$ .... (3)

Applying Kirchhoff's voltage rule to loop ABCDA,

$I_1P + I_3Q - I_4S - I_2R = 0$ .... (4)

When the points B and D are at the same potential, the bridge is said to be balanced. As there is no potential difference between B and D, no current flows through galvanometer ($I_G = 0$). Substituting $I_G = 0$ in equation, (1), (2) and (3), we get

$I_1 = I_3$ .... (5)

$I_2 = I_4$ .... (6)

$I_1P = I_2R$ .... (7)

Substituting the equation (5) and (6) in equation (4)

$I_1P + I_1Q - I_2R = 0$

$I_1(P + Q) = I_2 (R + S)$ .... (8)

Dividing equation (8) by equation (7), we get

$\frac{P+Q}{P} = \frac{R+S}{R}$

$1 + \frac{Q}{P} = 1 + \frac{S}{R}$

$\Rightarrow \frac{Q}{P} = \frac{S}{R}$

$\frac{P}{Q} = \frac{R}{S}$ .... (9)

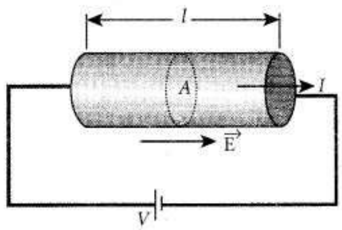
This is the bridge balance condition. Only under this condition, galvanometer shows null deflection. Suppose we know the values of two adjacent resistances, the other two resistances can be compared. If three of the resistances are known, the value of unknown resistance (fourth one) can be determined.

Part – D

IV.Write in detail.

1.Obtain the macroscopic form of Ohm'slaw from its microscopic form anddiscuss its limitation.

Ohm's law: The Ohm's law can be derived from the equation $J = \sigma E$. Consider a segment of wire of length l and cross sectional area A.



When a potential difference V is applied across the wire, a net electric field is created in the wire which constitutes the current. For simplicity, we assume that the electric field is uniform in the entire length of the wire, the potential difference (voltage V) can be written as $V = El$

As we know, the magnitude of current density

$J = \sigma E = \sigma \frac{V}{l}$ .... (1)

But $J = \frac{I}{A}$, so we write the equation as

$\frac{I}{A} \sigma \frac{V}{l}$

By rearranging the above equation, we get

$V = I\left(\frac{l}{\sigma A}\right)$ .... (2)

The quantity $\frac{l}{\sigma A}$ is called resistance of the conductor and it is denoted as R. Note that the oA resistance is directly proportional to the length of the conductor and inversely proportional to area of cross section.

Therefore, the macroscopic form of Ohm's law can be stated as

$V = IR$.

Unit – 3 MAGNAETISM AND MAGNETIC EFFECT OF CURRENT

Part – A

I.One Mark Questions

1.The vertical component of Earth's magnetic field at a place is equal to the horizontal component. What is the value of angle of dip at this place?

(a) 30^o
(b) 45^o
(c) 60^o
(d) 90^o

Answer:- (b) 45^o

2.The potential energy of magnetic dipole whose dipole moment is $\vec{P_m} = (-0.5\hat{i} + 0.4\hat{j})\ Am^2$

kept in uniform magnetic field $\vec{B} = 0.2\hat{i}\ T$

(a) –0.1 J (b) –0.8 J (c) 0.1 J (d) 0.8 J

(a) –0.1 J
(b) –0.8 J
(c) 0.1 J
(d) 0.8 J
Answer:- (a) –0.1 J

3. A non-conducting charged ring carrying a charge of q, mass m and radius r is rotated about its axis with constant angular speed ω. Find the ratio of its magnetic moment with angular momentum is
(a) q/ m
(b) 2q/ m
(c) q /2m
(d) q /4m
Answer:- (c) q /2m

4.Three wires of equal lengths are bent in the form of loops. One of the loops is circle, another is a semi-circle and the third one is a square. They are placed in a uniffrm magnetic field and same electric current is passed through them. Which of the fllowin loop configuration will experience greate torque ?
(a) Circle
(b) Semi-circle
(c) Square
(d) All of them
Answer:- (b) Semi-circle

5.A thin insulated wire forms a plane spiral of N = 100 tight turns carrying a current I = 8 m A (milli ampere). The radii of inside and outside turns are a = 50 mm and b = 100 mm respectively. The magnetic induction at the centre of the spiral is
(a) 5 μT
(b) 7 μT
(c) 8 μT
(d) 10 μT
Answer:- (b) 7 μT

6.Magnetic declination of Chennai City is

(a) $-1^{0}16'$ (b) $-1^{0}16''$ (c) $1^{0}16'$ (d) $1^{0}16''$

Answer:- (a) $-1^{0}16'$

7.SI unit of Magnetic Induction is
(a) (b) (c) (d)

(a) NAm^2 (b) NAm^{-2} (c) NAm^{-1} (d) $NA^{-1}m^{-1}$

Answer:- d) $NA^{-1}m^{-1}$

8.The ratio of Magnetic length and Geometrical length

(a) 6/5
(b) 5/6
(c) 8/5
(d) 5/8
Answer:- (b) 5/6

9.Under what conditions Potential energy of the bar magnet is maximum when it is placed in an external magnetic field
(a) Bar magnet is aligned parallel to the external magnetic field
(b) Bar magnet is aligned anti-parallel to the external magnetic field
(c) Bar magnet is aligned perpendicular to the external magnetic field
(d) none of these
Answer:- (b) Bar magnet is aligned anti-parallel to the external magnetic field

10.According to Curie Law, the graph drawn between magnetic susceptibility and temperature is
(a) a rectangular parabola
(b) a rectangular hyperbola
(c) a circular parabola
(d) a circular hyperbola
Answer:- (b) a rectangular hyperbola

Part – B

II.Very Short Answer.
1.What is meant by magnetic induction?

The magnetic induction (total magnetic field) inside the specimen $\vec{B}$ is equal to the sum of the magnetic field $\vec{B}_0$ produced in vacuum due to the magnetising field and the magnetic field $\vec{B}_m$ due to the induced magnetisation of the substance.

$\vec{B} = \vec{B}_0 + \vec{B}_m = \mu_0\vec{H} + \mu_0\vec{I} = \mu_0(\vec{H} + \vec{I}) = (\vec{H} + \vec{I})$

2.Define magnetic flux

The number of magnetic field lines crossing per unit area is called magnetic flux B.

$\Phi_B = \vec{B}.\vec{A} = BA\cos\theta = B \perp A$

3.Define magnetic dipole moment

The magnetic dipole moment is defined as the product of its pole strength and magnetic length.

$\vec{P} = q_m \vec{d}$

4.State Coulomb's inverse law.

The force of attraction or repulsion between two magnetic poles is directly proportional to the product of their pole strengths and inversely proportional to the square of the distance between them.

$\vec{F} \propto \frac{q_{m_A} q_{m_b}}{r^2} \hat{r}$

5.What is magnetic susceptibility ?

It is defined as the ratio of the intensity of magnetisation ($\vec{M}$) induced in the material due to the magnetising field ($\vec{H}$)

$\chi_m = \left| \frac{\vec{M}}{\vec{H}} \right|$

Part – C

III. Short Answer.

1. **What is tangent law? Discuss in detail**

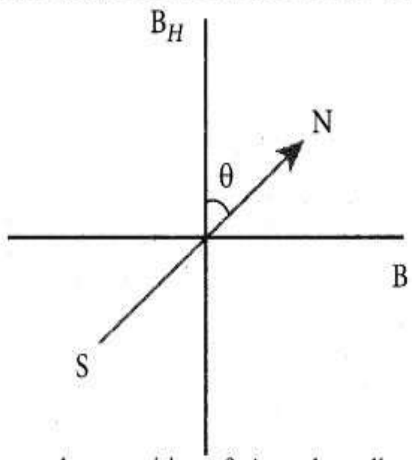
Tangent law:

Statement:

When a magnetic needle or magnet is freely suspended in two mutually perpendicular uniform magnetic fields, it will come to rest in the direction of the resultant of the two fields.

Explanation:

Let B be the magnetic field produced by passing current through the coil of the tangent Galvanometer and B_H be the horizontal component of earth's magnetic field. Under the action of two magnetic fields, the needle comes to rest making angle θ with B_H, such that



resultant position of pivoted needle

$\tan\theta = \frac{B}{B_H}$

$B = B_H \tan\theta$ .... (1)

When no current is passed through the coil, the small magnetic needle lies along horizontal component of Earth's magnetic field. When the circuit is switched ON, the electric current will pass through the circular coil and produce magnetic field. Now there are two fields which are acting mutually perpendicular to each other. They are:

(1) the magnetic field (B) due to the electric current in the coil acting normal to the plane of the coil.

(2) the horizontal component of Earth's magnetic field (B_H)

Because of these crossed fields, the pivoted magnetic needle deflects through an angle θ. From tangent law, $B = B_H \tan\theta$ When an electric current is passed through a circular coil of radius R having N turns, the magnitude of magnetic field at the center is

$B = \mu_0 \frac{NI}{2R}$ .... (2)

From equation (1) and equation (2), we get

$\mu_0 \frac{NI}{2R} = B_H \tan\theta$

The horizontal component of Earth's magnetic field can be determined as

$B = \mu_0 \frac{NI}{2R\tan\theta}$ in tesla .... (3)

Question 10.

Explain the principle and working of a moving coil galvanometer.

Answer:

Moving coil galvanometer:

Moving coil galvanometer is a device which is used to indicate the flow of current in an electrical circuit.

Principle:

When a current carrying loop is placed in a uniform magnetic field it experiences a torque.

Construction:

A moving coil galvanometer consists of a rectangular coil PQRS of insulated thin copper wire. The coil contains a large number of turns wound over a light metallic frame. A cylindrical soft-iron core is placed symmetrically inside the coil. The rectangular coil is suspended freely between two pole pieces of a horse-shoe magnet.

tangent law, $B = B_H \tan\theta$ When an electric current is passed through a circular coil of radius R having N turns, the magnitude of magnetic field at the center is

$B = \mu_0 \frac{NI}{2R}$ .... (2)

From equation (1) and equation (2), we get

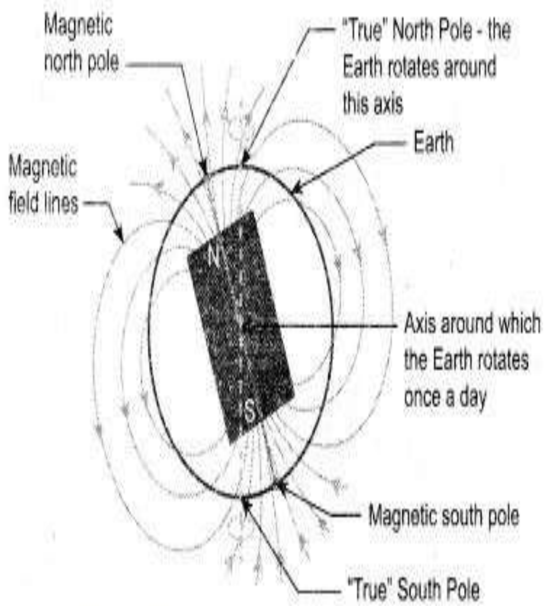
$\mu_0 \frac{NI}{2R} = B_H \tan\theta$

The horizontal component of Earth's magnetic field can be determined as

$B = \mu_0 \frac{NI}{2R\tan\theta}$ in tesla .... (3)

2.Discuss Earth's magnetic field in detail.

Gover suggested that the Earth's magnetic field is due to hot rays coming out from the Sun. These rays will heat up the air near equatorial region. Once air becomes hotter, it rises above and will move towards northern and southern hemispheres and get electrified. This may be responsible to magnetize the ferromagnetic materials near the Earth's surface.



The north pole of magnetic compass needle is attracted towards the magnetic south pole of the Earth which is near the geographic north pole. Similarly, the south pole of magnetic compass needle is attracted towards the geographic north pole of the Earth which is near magnetic north pole. There are three quantities required to specify the magnetic field of the Earth on its surface, which are often called as the elements of the Earth's magnetic field. They are:

(a) Magnetic declination (D):
The angle between magnetic meridian at a point and geographical meridian is called the declination or magnetic declination (D).

(b) Magnetic dip or inclination (I):
The angle subtended by the Earth's total magnetic field $\vec{B}$ with the horizontal direction in the magnetic meridian is called dip or magnetic inclination (I) at that point.

(c) The horizontal component of the Earth's magnetic field (B_H):
The component of Earth's magnetic field along the horizontal direction in the magnetic meridian is called horizontal component of Earth's magnetic field, denoted by B_H.
Let B_E be the net Earth's magnetic field at a point P on the surface of the Earth. B_E can be resolved into two perpendicular components.
Horizontal component $B_H = B_E \cos I$ ...... (1)
Vertical component $B_V = B_E \sin I$ ...... (2)
Dividing the equation, we get $\tan I = \frac{B_V}{B_H}$ ....(3)

(i) At magnetic equator The Earth's magnetic field is parallel to the surface of the Earth (i.e., horizontal) which implies that the needle of magnetic compass rests horizontally at an angle of dip, I = 0°.
B $B_E = B_E$
Bv = 0
This implies that the horizontal component is maximum at equator and vertical component is zero at equator.

(ii) At magnetic poles. The Earth's magnetic field is perpendicular to the surface of the Earth (i.e., vertical) which implies that the needle of magnetic compass rests vertically at an angle of dip, I = 90°
Hence, $B_H = 0$
Bv = B_E
This implies that the vertical component is maximum at poles and horizontal component is zero at poles.

Part – D

IV.Write in detail.

Discuss the working of cyclotron in detail.

Cyclotron:

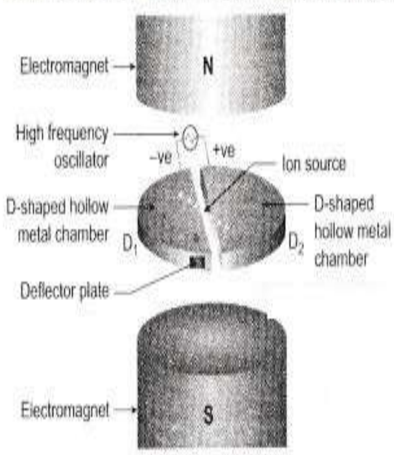
Cyclotron is a device used to accelerate the charged particles to gain large kinetic energy. It is also called as high energy accelerator. It was invented by Lawrence and Livingston in 1934.

Principle:

When a charged particle moves normal to the magnetic field, it experiences magnetic Lorentz force.

Construction:

The particles are allowed to move in between two semicircular metal containers called Dees (hollow D – shaped objects). Dees are enclosed in an evacuated chamber and it is kept in a region with uniform magnetic field controlled by an electromagnet. The direction of magnetic field is normal to the plane of the Dees. The two Dees are kept separated with a gap and the source S (which ejects the particle to be accelerated) is placed at the center in the gap between the Dees. Dees are connected to high frequency alternating potential difference.



Working:

Let us assume that the ion ejected from source S is positively charged. As soon as ion is ejected, it is accelerated towards a Dee (say, Dee – 1) which has negative potential at that time. Since the magnetic field is normal to the plane of the Dees, the ion undergoes circular path. After one semi-circular path in Dee-1, the ion reaches the gap between Dees. At this time, the polarities of the Dees are reversed so that the ion is now accelerated towards Dee-2 with a greater velocity. For this circular motion, the centripetal force of the charged particle q is provided by Lorentz force.

$\frac{mv^2}{r}$ qvB ⇒ r = $\frac{m}{qb}$ v ⇒ r ∝ v

From the equation, the increase in velocity increases the radius of circular path. This process continues and hence the particle undergoes spiral path of increasing radius. Once it reaches near the edge, it is taken out with the help of deflector plate and allowed to hit the target T. Very important condition in cyclotron operation is the resonance condition. It happens when the frequency f at which the positive ion circulates in the magnetic field must be equal to the constant frequency of the electrical oscillator f_{osc} From equation

$f_{osc} = \frac{qB}{2\pi m}$ $T = \frac{1}{f_{osc}}$

The time period of oscillation is

$T = \frac{2\pi m}{qB}$

The kinetic energy of the charged paricle is

$KE = \frac{1}{2} mv^2 = \frac{q^2}{B^2} r^2 2m$

Limitations of cyclotron:

(a) the speed of the ion is limited

(b) electron cannot be accelerated

(c) uncharged particles cannot be accelerated