Moving Charges And Magnetism

Que 1: A long solenoid of length 3m has 4000 turns. Find the current through the solenoid if the magnetic field produced at the centre of the solenoid along its axis is 8 × 10-3T. ***Marks :(3)***

Ans: 4.77A

Que 2: Of the following devices, which has small resistance? ***Marks :(1)***

(a) moving coil galvanometer

(b) ammeter of range 0 – 1A

(c) ammeter of range 0–10 A

(d) voltmeter

Ans: (c) ammeter of range 0–10 A

Que 3: What do you mean by electromagnetic Lorentz force ? ***Marks :(3)***

Ans: The force acting on a charge moving under the effect of both electric and magnetic field is called electromagnetic Lorentz force.

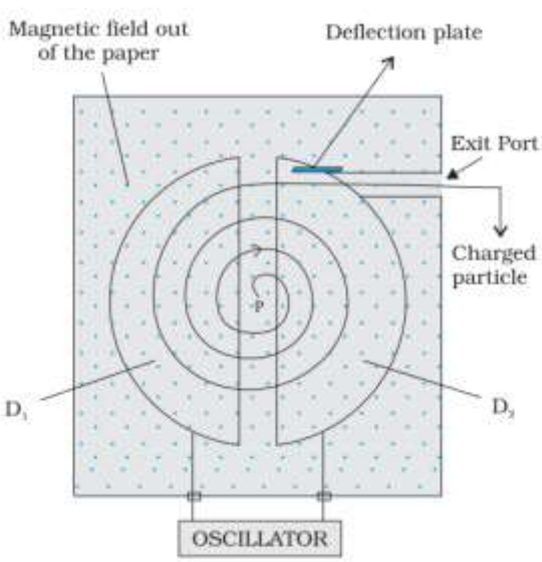
Que 4: Who discovered the phenomenon of magnetic field due to the presence of current in a conductor ? ***Marks :(1)***

Ans: Oersted

(Hans Christian Oersted)

Que 5: Draw the path of a charged particle in a cyclotron ? ***Marks :(3)***

Ans:



Que 6: A 100 turns closely wound circular coil of radius 10 cm carries a current of 3.2 A . A coil is placed in a vertical plane and is free to rotate about a horizontal axis which coincides with its diameter. A uniform magnetic field of 2 T rotates the coil through 90^o . What is the torque on the coil ? ***Marks :(4)***

Ans: $m = NAI = N I \pi r^2$

$= 100 \times 3.2 \times 3.14 \times (0.1)^2$

$m = 10\ A\ m^2$ and $B = 2\ T$

$\tau = m \times B$

$\tau = m B \sin\theta$

$\tau = 10 \times 2 \times \sin 90^o$

$\tau = 20$ Nm

Que 7: A 100 turns closely wound circular coil of radius 10 cm carries a current of 3.2 A. What is the magnetic moment associated with it ? ***Marks :(3)***

Ans: N = 100, I = 3.2 A , r = 0.1 m

$m = NAI = N I \pi r^2$

$= 100 \times 3.2 \times 3.14 \times (0.1)^2$

$m = 10\ A\ m^2$

Que 8: A 100 turns closely wound circular coil of radius 10 cm carries a current of 3.2 A . What is the field at the centre of the coil ? ***Marks :(3)***

Ans: N = 100, I = 3.2 A, R = 0.1 m

$$B = \frac{\mu o N i}{2R}$$

$$B = \frac{4 x 3.14 x 10^{-7} x 100 x 3.2}{2 x 0.1}$$

$B = 2 \times 10^{-3}$ T

Que 9: The horizontal component of the earth 's magnetic field at a certain place is 3.0×10^{-5} T and the direction of the field is from south to north. A very long straight conductor is carrying a steady current of 1 A placed on a horizontal table, what is the force per unit length of the conductor ? ***Marks :(3)***

Ans: $F = I (l \times B)$

$F = I l B \sin\theta$

$F / l = I B \sin\theta$

$= 1 \times 3.0 \times 10^{-5} \sin 90^{O}$

$F / l = 3.0 \times 10^{-5}\ Nm^{-1}$

Que 10: How can we increase the current sensitivity of a moving coil galvanometer ? ***Marks :(2)***

Ans: Current sensitivity of a moving coil galvanometer can be increased by increasing the number of turns (N), area of the coil (A) , magnetic field (B) and decreasing the couple per unit twist of the phosphor bronze fibre (k)

Que 11: What do you mean by current sensitivity ? ***Marks :(2)***

Ans: A galvanometer is sensitive if it shows large deflection for small current. The ratio is a measure of current sensitivity.

$$\frac{\phi}{I} = \frac{NAB}{k}$$

Que 12: Explains the construction and the working of moving coil galvanometer ? ***Marks :(5)***

Ans: Moving coil galvanometer is a sensitive device used to measure very small current in a circuit.

It works on the principle of torque experienced on a rectangular current loop placed in a uniform magnetic field.

In a moving coil galvanometer, the magnet is fixed and the coil is moving.

The torque of the coil due to current,

$T = NIAB$

Torque of the phosphor bronze fiber and the spring,

$T = k\phi$

At equilibrium,

$k\phi = NIAB$

Current in the coil,

$$I = \left(\frac{k}{NAB}\right)\phi$$

$$I \propto \phi$$

Hence current in a circuit is directly proportional to the angle of deflection

Que 13: What is the specialty of a moving coil galvanometer ? ***Marks :(1)***

Ans: In a moving coil galvanometer, the magnet is fixed and the coil is moving.

Que 14: What is the principle of a moving coil galvanometer ? ***Marks :(2)***

Ans: A moving coil galvanometer works on the principle of torque experienced on a rectangular current loop placed in a uniform magnetic field.

Que 15: Write the value of Bohr magneton ? ***Marks :(2)***

Ans: $(\mu_l) = 9.27 \times 10^{-24}\ Am^2$

This value is called the Bohr magneton.

Que 16: Write the equation for Bohr magneton ***Marks :(2)***

Ans:

$$(\mu_l) = \frac{e}{4\pi m_e} \hbar$$

Que 17: Write the value of gyromagnetic ratio? ***Marks :(2)***

Ans:

$$\frac{\mu_l}{l} = 8.8 \times 10^{10}\ C\ kg^{-1}$$

Que 18: What is gyromagnetic ratio ? ***Marks :(2)***

Ans: The ratio of magnetic moment to the angular momentum of the electron is a constant called gyromagnetic ratio.

$$\frac{\mu_l}{l} = \frac{e}{2m_e}$$

Que 19: Explains the angular momentum of electron ? ***Marks :(2)***

Ans: The orbiting electron is similar to that of a circuital current loop and hence it experience magnetic angular momentum.

The magnetic moment due to orbiting electron,

$$\mu_l = -\frac{e}{2m_e} l$$

Where l is the angular momentum of the electron

The negative sign indicates that the angular momentum of the electron is opposite in direction to the magnetic moment.

Que 20: Compares the torque on an electric dipole in a uniform field and magnetic dipole in a uniform magnetic field ? ***Marks :(3)***

Ans: Torque on an electric dipole in uniform electric field

$\tau = p \times E$

$\tau = pE \sin\theta$

Where θ is the angle between the directions of electric field intensity and the electric dipole moment.

Torque on a magnetic dipole in uniform magnetic field

$\tau = m \times B$

$\tau = mB \sin\theta$

Where θ is the angle between the directions of magnetic field and the magnetic dipole moment.

Que 21: What happens to a rectangular current loop placed in a uniform magnetic field ? ***Marks :(2)***

Ans: When a rectangular current loop is placed in uniform magnetic field, it experiences a torque and the loop get rotates in the magnetic field.

$\tau = BAI$

Que 22: Define one Ampere ? ***Marks :(2)***

Ans: Ampere is defined as that constant current which if maintained between two straight parallel conductors of infinite length , negligible area of cross-section placed in free space separated by one metre apart will produce a force per unit length of 2×10^{-7} Newton per meter

Que 23: Write the expression for magnetic force in a current carrying conductor ? ***Marks :(2)***

Ans: F = Bil

B – External magnetic field

i - Current in the conductor

l - Length of the conductor

Que 24: A solenoid of length 0.5 m has a radius of 1 cmand is made up of 500 turns .It carrying a current of 5 A , what is the magnetic field inside the solenoid ? ***Marks :(3)***

Ans: $B = \mu_o n i$

$n = N / l = 500 / 0.5 = 1000$

$B = 4\pi \times 10^{-7} \times 1000 \times 5$

$B = 6.28 \times 10^{-3}$ T

Que 25: Write the equation of the intensity of magnetic field at the center of a current carrying toroid? ***Marks :(2)***

Ans: A current carrying toroid produce magnetic field at its centre,

$B = \mu o\ n\ i$

Que 26: What is a toroid ? ***Marks :(1)***

Ans: A straight solenoid bent into the shape of circle is called a toroid.

Que 27: What is the value of magnetic field outside a current carrying solenoid ? ***Marks :(1)***

Ans: B = 0

Que 28: What is the magnetic field at one end along the axis of a current carrying solenoid ? ***Marks :(1)***

Ans:

$$B = \frac{1}{2}\mu o\ n\ i$$

Que 29: What is the magnetic field at the centre along the axis of a current carrying solenoid? ***Marks :(2)***

Ans: $B = \mu o\ n\ i$

n - Number of turns of the solenoid

i - Current through the solenoid

Que 30: What is the equation of magnetic moment of a current carrying solenoid? ***Marks :(2)***

Ans: Magnetic moment, m = ANI

A – Area of crossection of the solenoid

N – Total number of turns in the solenoid

I – Current through the solenoid

Que 31: Write the expression for magnetic field at a point due to an infinite straight conductor carrying current ? ***Marks :(2)***

Ans:

$$B = \frac{\mu oi}{2\pi r}$$

i - Current through the conductor

r - Distance of the conductor from the point

Que 32: State Amperes' circuital law ? ***Marks :(3)***

Ans: The line integral of the magnetic field through any closed path is equal to μo times the total current through the path.

$$\oint B.dl = \mu o i$$

Que 33: Write the expression for the magnetic field at the centre of a current loop? ***Marks :(2)***

Ans:

$$B = \frac{\mu o i}{2R}$$

i - Current through the loop

R - Radius of the loop

Que 34: State and explain Biot-Savart law ? ***Marks :(5)***

Ans: The magnetic field at a point due to a current carrying conductor is directly proportional to the strength of current, length of the current element, and sine of the angle between the current element and the line joining element to the point and inversely proportional to the square of the distance between the element and the point.

$$B \alpha \frac{i dl \sin\theta}{r^2}$$

$$B = \frac{\mu o}{4\pi} \frac{i dl \sin\theta}{r^2}$$

μo = 4π x 10^{-7}

μo - Permeably of the free space

i - Current through the conductor

dl - Lenght of the current element

sinØ -sine of the angle between the current element and the line joining the element to the point

r - Distance between the element and the point

Que 35: What is the SI unit of magnetic field ? ***Marks :(1)***

Ans: Tesla (T)

Que 36: A cyclotron oscillator frequency is 10 MHz is applied to the dees of radius 60 cm. What is the kinetic energy in MeV of the proton beam produced by the accelerator, if the operating magnetic field is 0.66 T ?(e = 1.60 x10^{-19} C ,m_p = 1.67 x 10^{-27} kg) ***Marks :(3)***

Ans:

$$K.E = \frac{q^2 B^2 R^2}{2m}$$

$$= \frac{(1.6\times10^{-19})^2\times0.66^2\times0.6^2}{2\times1.67\times10^{-27}\times1.6\times10^{-13}}$$

K.E = 7 MeV

Que 37: A cyclotron oscillator frequency is 10 MHz. What should be the operating magnetic field for accelerating protons ? (e = 1.60 x 10^{-19} C ,mp = 1.67 x 10^{-27} kg) ***Marks :(3)***

Ans:

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

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

$$B = \frac{2\pi m\,\nu}{q}$$

$$= \frac{2\times3.14\times1.67\times10^{-27}\times10\times10^{6}}{1.6\times10^{-19}}$$

B = 0.66 T

Que 38: Write the expression for speed of a charged particle in a cyclotron? ***Marks :(2)***

Ans:

$$v = \frac{qBR}{m}$$

q - Charge of the particle

B - Applied magnetic field

R - Radius of the dee

m - Mass of the charged particle

Que 39: Write the expression for energy acquired by a charged particle in a cyclotron and mention the terms ? ***Marks :(3)***

Ans:

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

q – Charge of the particle

m – Mass of the particle

B – Applied magnetic field

R – Radius of the dee

v – Speed of the particle exit from the cyclotron

Que 40: What is a cyclotron ? ***Marks :(2)***

Ans: Cyclotron is a device used to accelerate charged particles, hence it is also called particle accelerator. It is based on the principle of motion of a charged particle in uniform perpendicular magnetic field. The path of the particle within the field is circular.

Que 41: What is cyclotron frequency ? ***Marks :(2)***

Ans: The frequency required for cyclotron to work

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

Que 42: Mention the principle of Cyclotron ? ***Marks :(1)***

Ans: Motion of a charged particle in uniform perpendicular magnetic field.

Que 43: What is velocity selector ? ***Marks :(2)***

Ans: When we apply both electric and magnetic fields in mutually perpendicular directions and we adjust their values such that that the magnitude of the two forces are equal, the total force on a charge is zero. The charge will move in the fields undeflected.

qvB = qE

V = E/B

Que 44: What is the frequency of electron moving with a speed of 3×10^7 ms^{-1} in a magnetic field of 6×10^{-4} T perpendicular to it traces a radius 26 cm? [Given mass of electro 9.1×10^{-31} kg and charge of electro 1.6×10^{-19}] ***Marks :(3)***

Ans:

$$\nu = \frac{v}{2\pi r}$$

$$= \frac{3\times10^{7}}{2\times3.14\times0.26}$$

$\nu = 2 \times 10^{6}$ Hz

Que 45: What is the radius of the path of an electron moving with a speed of 3 x 10^{7} ms^{-1} in a magnetic field of 6 x 10^{-4} T perpendicular to it ? [Given mass of electro 9.1 x 10^{-31} kg and charge of electro 1.6 x 10^{-19}] ***Marks :(3)***

Ans:

$$\frac{mv^2}{r} = qvB$$

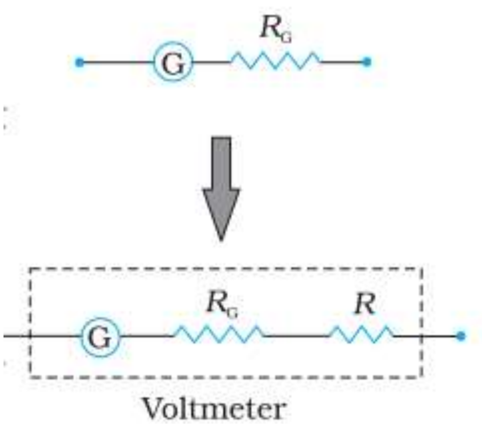
$$r = \frac{mv}{qB}$$

$$= \frac{9.1\times10^{-31}\times3\times10^{7}}{1.6\times10^{-19}\times6\times10^{-4}}$$

r = 0. 26 m

Que 46: How will you convert a galvanometer into voltmeter ? Explain
Marks :(4)

Ans: A galvanometer can be converted into voltmeter by connecting a high resistance in series with the galvanometer



The potential difference across the terminals AB,

$V = I_g (G + R)$

$$R = \frac{V}{I_g} - G$$

R – External resistance

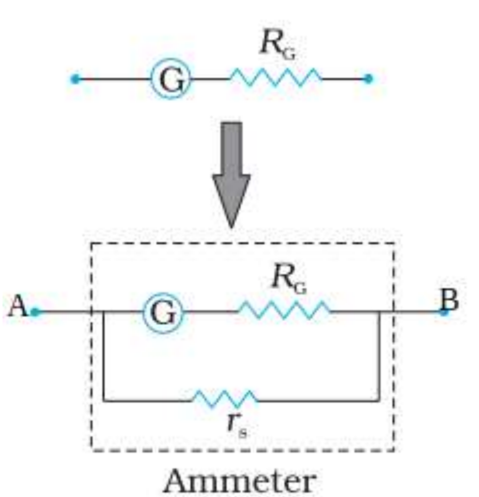
V – Potential difference

I_g – Current through the galvanometer

G – Galvanometer resistance

Que 47: How will you convert a galvanometer into an ammeter ? Explain
Marks :(4)

Ans: A galvanometer can be converted into an ammeter by connecting a shunt. Shunt is a low resistance connected in parallel to the galvanometer.



The potential difference,

$I_g G = (I - I_g) r_s$

$$r_s = \frac{I_g \cdot G}{(I - I_g)}$$

r_s – Shunt resistance

I_g - Galvanometer current

I - Main current

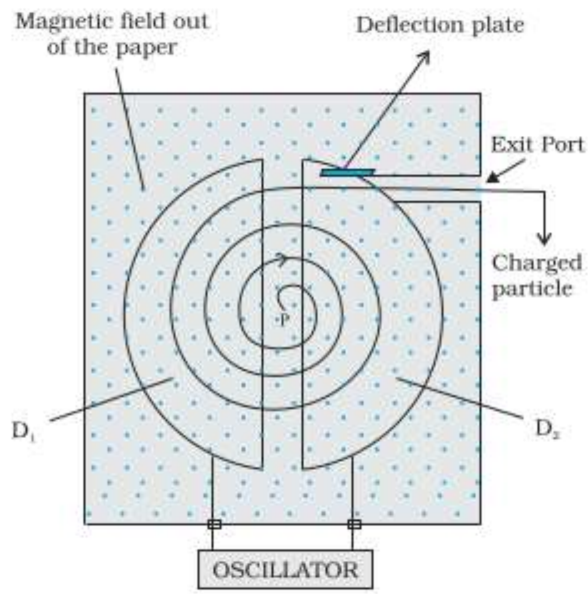
G – Galvanometer resistance

Que 48: Cyclotron is a device used for accelerating charged particles

(a) Draw a neat labelled diagram of a cyclotron and write the Principle behind it, mention each term

(b) A cyclotron's oscillator frequency is 10 MHz. What should be the operating magnetic field for accelerating protons ? ***Marks :(6)***

Ans: (a) The working principle of the cyclotron,



Cyclotron frequency

v = qB / 2 π m

q – Charge of the accelerating particle

B – Applied magnetic field

m – Mass of the particle

(b) f = 10 MHz = !0 x 10 ^{6} Hz , B = ?

m = 1.67 x 10 $^{-27}$ Kg, q = 1.6 x 10 $^{-19}$ C

Cyclotron frequency,

v = qB / 2 π m

B = 2 π m / q

= 2 x 3.14 x 1.67 x 10 $^{-27}$ / 1.6 x 10 $^{-19}$

B = 0.656 T

Que 49: Calculate the maximum kinetic energy of the proton ejected from the cyclotron with dee of radius 2 m .The dees are applied with a uniform magnetic field of 0.8 T ? ***Marks :(4)***

Ans: KE = ? , r = 2 m, B = 0.8 T, q = 1.6 x 10 $^{-19}$ C, m = 1.67 x 10 $^{-27}$ kg

1 MeV = 1.6 x10 $^{-13}$ J

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

$$KE = \frac{(1.6\times10^{-19})^2\times(0.8)^2\times2^2}{2x1.6\times10^{-27}\times1.6\times10^{-13}}$$

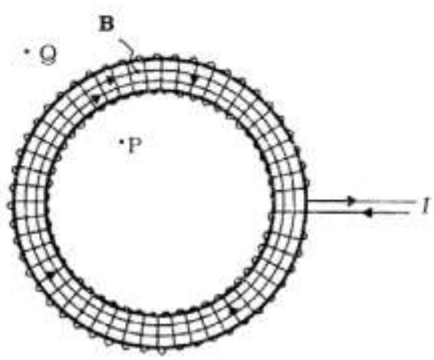
KE = 122.63 MeV

Que 50: Moving charges can produce a magnetic field in the surrounding space

(a) What is a toroid ?

(b) A closely wound solenoid 80 cm long has 5 layers of windings of 400 turns each. If the current carried is 8 A. Calculate the magnitude of the field inside the solenoid near its centre? ***Marks :(6)***

Ans: (a) A toroid solenoid is a hollow circular tube with a large number of turns of wire wound on it.



(b) l = 80 cm , N = 5 x 400 = 2000 , I = 8 A , B = ?

n = N / l = 2000 / 0.8 = 2500

B = μ_0 n I

B = 4 x 3.14 x 10^{-7} x 2500 x 8

B = 25 T

Que 51: (a) State Amperes' circuital law, write its mathematical formula

(b)A solenoid of length 0.5 m has a radius of 1 cmand is made up of 500 turns .It carrying a current of 5 A , what is the magnetic field inside the solenoid ?
Marks :(6)

Ans: (a) Amperes' circuital law state that, the line integral of the magnetic field along any closed path is equal to μ_0 times the net current through the path

$$\oint B \cdot dl = \mu_o i$$

(b) $B = \mu_o n i$

$n = N / l = 500 / 0.5 = 1000$

$B = 4\pi \times 10^{-7} \times 1000 \times 5$

$B = 6.28 \times 10^{-3}$ T