SELF ASSESSMENT PAPER - 3

SOLUTIONS

I. Multiple Choice Questions **[1 × 4 = 4]**

1. Option (B) is correct.

Explanation: $F = qvB \sin\theta$, when $q = 2C$, $F = 1N$, $\theta = 90°$

then $B = \dfrac{F}{qv\sin\theta} = \dfrac{1}{2\times1\times\sin 90°} = \dfrac{1}{2} = 0.5T$

2. Option (B) is correct.

Explanation: $B \propto \dfrac{1}{r}$

$$\frac{B_1}{B_2} = \frac{r_2}{r_1} = \frac{r/2}{r}$$

So, $B_2 = 2B_1 = 2B$

3. Option (B) is correct.

4. Option (B) is correct.

Explanation: Magnetic field at the end of a current carrying solenoid is half of the magnetic field inside it.

II. Assertion & Reason **[1 × 2 = 2]**

1. Option (D) is correct.

Explanation: The force on a charged particle moving in a uniform magnetic field always acts in direction perpendicular to the direction of motion of the change. So work done by the magnetic field $W = FS \cos\theta = FS \cos 90° = 0$ So, the energy of the charged particle does not change. So, assertion is false and reason is true.

2. Option (B) is correct.

Explanation: The torque on the coil in a magnetic field is given by $\tau = nIBA \sin\theta$. For radial field, $\theta = 90°$ and $\sin\theta = 1$, torque $= nIBA$ and it is maximum. So assertion is true. Torque is the rotational equivalence of force. So, torque will tend to rotate a coil. Reason is also true. But reason cannot explain the assertion that why the torque is maximum in the specified position.

III. Competency Based Questions **[1 × 4 = 4]**

1. Option (A) is correct.

Explanation: Improved mirror galvanometer was developed by William Thomson, later to become Lord Kelvin, in 1858.

2. Option (B) is correct.

Explanation: The fundamental problem was that the transmitting / receiving a signal through a lengthy submarine cable was very low. Instead of increasing the magnitude of the current transmission, Lord Kelvin modified the existing galvanometer so that it became capable to measure the weakest current.

3. Option (C) is correct.

Explanation: The galvanometer, was a means of detecting electric current. It consisted of a needle that was deflected by the magnetic field created by the electric current.

4. Option (B) is correct.

Explanation: The mirror galvanometer consists of a long fine coil of silk-covered copper wire. In the heart of that coil, within a little air-chamber, a small round mirror is hung by a single fibre of floss silk, with four tiny magnets cemented to its back.

5. Option (D) is correct.

Explanation: The air in the little chamber surrounding the mirror is compressed at will, so as to act like a cushion, and deaden the movements of the mirror; the mirror is thus prevented from idly swinging about at each deflections.

IV. Very Short Answer Type Questions **[1 × 3 = 3]**

1. $$i_g R_g = (i - i_g)R_S$$

$$i = \left(1 + \frac{R_g}{R_S}\right)i_g$$

On substituting the values

$$i = 0.15 \text{ A}$$

2. Due to high permeability of the ferromagnetic material, the magnetic field inside the solenoid gets increased to a great extent.

3. When the angle between the magnetic dipole moment and magnetic field is 0° i.e., both are parallel.

V. Short Answer Type Questions-I **[2 × 3 = 6]**

1. Given, a galvanometer coil, Resistance on galvanometer, $G = 10\ \Omega$. Current passing through the galvanometer, $I_g = 3.5$ mA $= 3.5 \times 10^{-3}$ A. Current across the ammeter, $I = 4$A. Using formula,

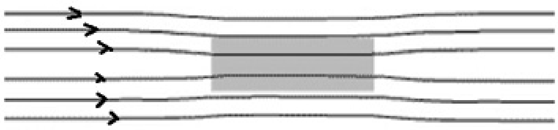
$$S = \frac{I_g G}{I - I_g}$$

Putting values in above equation

$S = 8.7$ m Ω.

Therefore, a resistance of 8.75 mΩ should be connected as shunt so as to convert the galvanometer into an ammeter.

2. The material is paramagnetic. The field pattern gets modified as shown in the figure below.

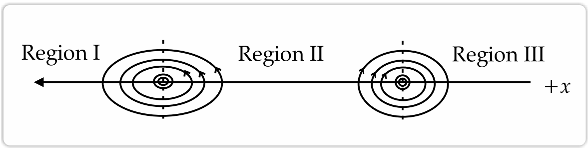


3. Magnetic field strength at a point P (where the resultant magnetic field is zero), at

$$\text{left wire} = B_1 = \frac{\mu_0 I_1}{2\pi r}$$

$$\text{right wire} = B_2 = \frac{\mu_0 I_1}{2\pi r}$$

The fields are oppositely directed.

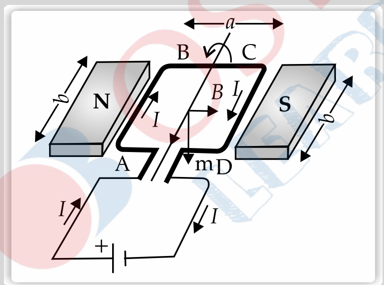


Since, $I_2 > I_1$ the point P cannot be in region II or III. It will be in the region I.

VI. Short Answer Type Questions-II [3 × 2 = 6]

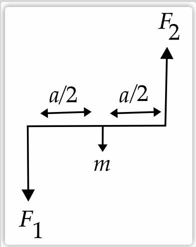
1. **(a) Derivation of expression for torque** 2
   (b) Significance of radial magnetic field. 1

Consider the simple case when a rectangular loop is placed in a uniform magnetic field B that is in the plane of the loop.



½

(a)



(b)

Force on arm $AB = F_1 = IbB$ (directed into the plane of the loop)
Force on arm $CD = F_2 = IbB$ (directed out of the plane of the loop) ½
Therefore the magnitude of the torque on the loop due to these pair of forces ½

$$\tau = F_1\frac{a}{2} + F_2\frac{a}{2}$$
$$= I(ab)B$$
$$= IAB = mB$$ ½

(A = *ab* = area of the loop)

Alternatively,
Also accept if the student does calculations for the general case and obtain the result.
Torque = $IAB\sin\phi$
Alternatively,
Also accept if the student says that the equivalent magnetic moment (m), associated with a current carrying loop is

$$\vec{m} = IA\hat{n} \quad (A = \text{area of the loop})$$

The torque, on a magnetic dipole, in a magnetic field, is given by

$$\vec{\tau} = \vec{m} \times \vec{B}$$
$$\therefore \tau = IA(\hat{n} \times \vec{B})$$

Hence,
Magnitude of torque = $IAB\sin\phi$

(b) When a current carrying coil is kept inside a radial magnetic field, the corresponding moving coil galvanometer would have a linear scale. 1
Alternatively,
"In a radial magnetic field, two sides of the rectangular coil remain parallel to the magnetic field lines while its other two sides remain perpendicular to the magnetic field lines. This holds for all positions of the coil".

[CBSE Marking Scheme, 2019]

2. (a) (i) Work done = $mB(\cos\theta_1 - \cos\theta_2)$

$\theta_1 = 60°, \theta_2 = 90°,$

work done = $mB(\cos 60° - \cos 90°)$

$$= mB\left(\frac{1}{2} - 0\right) = \frac{1}{2}mB$$

work done = $\frac{1}{2} \times 4 \times 0.24$

work done = 0.48 J

(ii) $\theta_1 = 60°, \theta_2 = 180°,$

work done = $mB(\cos 60° - \cos 180°)$

$$= mB\left(\frac{1}{2} - (-1)\right) = \frac{3}{2}mB$$

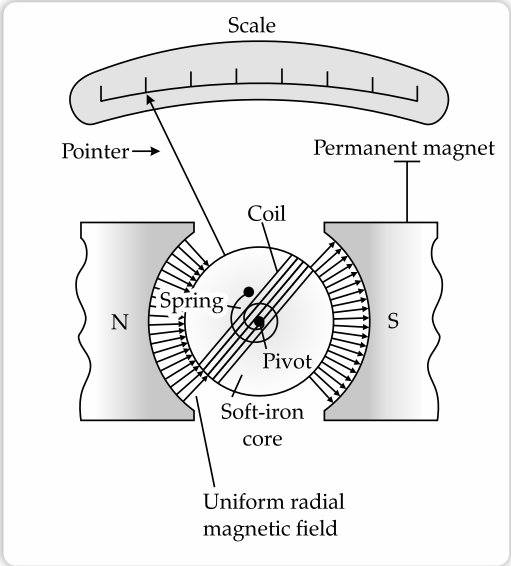
work done = $\frac{3}{2} \times 4 \times 0.24$

work done = 1.44 J

(b) Torque = $mB\sin\theta$, For $\theta = 180°$, we have torque = $4 \times 0.24 \sin 180° = 0$

VII. Long Answer Type Questions **[5 × 1 = 5]**

1.



Principle and working: A current carrying coil, placed in a uniform magnetic field, can experiences a torque.

Consider a rectangular coil for which no. of turns = N,

Area of cross-section $= l \times b = A$,

Intensity of the uniform magnetic field $= B$,

Current through the coil $= I$

$\therefore$ Deflecting torque $= BIl \times b = BIA$

For N turns, $\tau = NBIA$

Restoring torque in the spring $= k\theta$

(k = restoring torque per unit twist)

$$\therefore \quad NBIA = k\theta$$

$$\therefore \quad I = \left(\frac{k}{NBA}\right)\theta$$

$$\therefore \quad I \propto \theta$$

The deflection of the coil is therefore, proportional to the current flowing through it.

(i) The soft iron core not only makes the field radial but also increases the strength of the magnetic field.

(ii) We have

Current sensitivity $= \dfrac{\theta}{I} = \dfrac{NBA}{k}$

Voltage sensitivity $= \dfrac{\theta}{V} = \dfrac{\theta}{IR} = \left(\dfrac{NBA}{k}\right) \cdot \dfrac{1}{R}$

It follows that an increase in current sensitivity may not necessarily increase the voltage sensitivity.