Date: 14/11/2021

Subject: **Physics**

Topic : Moving Charges and Magnetism   Class: Standard XII

1. An electron is projected into a uniform magnetic field of 3 T and moves along a helical path of radius 1 cm with pitch 2π cm. Find the angle of projection of the electron with the magnetic filed.

   ❌ **A.** $30°$

   ✔️ **B.** $45°$

   ❌ **C.** $60°$

   ❌ **D.** $75°$

   We know, radius of the circular path is,

   $$r = \frac{mv_\perp}{qB}$$
   $$= \frac{mv\sin\theta}{qB} \ldots\ldots(1)$$

   and Pitch (P) is,

   Pitch $(P) = v_\parallel \times T$

   $$= v\cos\theta \times T = v\cos\theta \times \left(\frac{2\pi m}{qB}\right) \ldots\ldots\ldots(2)$$

   On dividing (1) and (2) we get,

   $$\frac{r}{p} = \frac{\tan\theta}{2\pi}$$

   $$\Rightarrow \tan\theta = 2\pi \times \frac{r}{p} = 2\pi \times \frac{1}{2\pi}$$

   $$\Rightarrow \tan\theta = 1$$

   $$\therefore \theta = 45°$$

   Hence, option (b) is the correct answer.

Why this question ?
Tip : Ratio of pitch and radius of the helical path only depends on the angle of projection.

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2. A beam of electron passes, un-deflected through mutually perpendicular electric and magnetic fields. If the electric field is switched off, and the same magnetic field is maintained, the electrons moves

✔ **A.** in a circular orbit

✘ **B.** along a parabolic path

✘ **C.** along a straight line
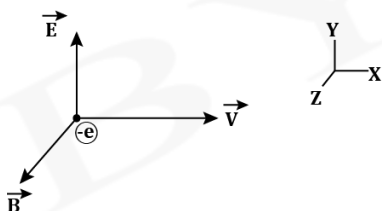
✘ **D.** in an elliptical orbit.

Total force acting on the electron when switch is on

$$\vec{F}_{net} = \vec{F}_B + \vec{F}_E = q(\vec{V} \times \vec{B}) + q\vec{E}$$

Where,
$q =$charge
$\vec{V} =$velocity of charge q

When switch is off then $\vec{E}$ becomes zero and only $\vec{B}$ exists.

∴ only $\vec{F}_B$ is applied on e^- beam,
$F_{net} = \vec{F}_B = q(\vec{V} \times \vec{B})$

$$\Rightarrow \vec{F}_B = -e(\vec{V} \times \vec{B})$$

This force $\vec{F}_B$ will make the e^- beam to move in circular orbit as magnetic force doesnot increase the speed of the particle.

Alternate solution:

Since, direction of motion of electron must be perpendicular to the both electric and magnetic fields.When electric field is switch off then the magnetic field is perpendicular to the direction of motion of charge particle and therefore, the electrons starts exibiting circular motion.

Hence, option (a) is the correct answer.

3. A cyclotron can accelerate

    ✖ **A.** neutrons

    ✔ **B.** α-particles

    ✖ **C.** high velocity γ-particles

    ✖ **D.** high velocity x-rays

    Cyclotron, is an apparatus used to accelerate atomic and subatomic particles by an alternating electric field in a constant magnetic field.

    But the cyclotron accelerates only charged particles.

    Particles which are electrically neutral or particles having no charge cannot be accelerated by the cyclotron.

    Since, Gamma particles, neutrons and x- rays have zero charge , they can't be accelerated through Cyclotron.

    Only α-particle (He^{2+}) having charge $+2e$, and mass 4 amu will be accelerated by cyclotron.
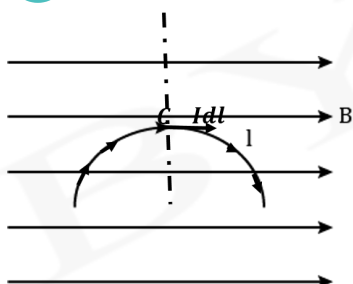
    Hence, option (B) is the correct answer.

    Note: "amu" is a unit of mass of atomic scale particles which will be discussed in detail in Modern physics.

4. What is the force experienced by a semicircular wire of radius R when it is carrying a current I and is placed in a uniform magnetic field of induction B as shown in figure?
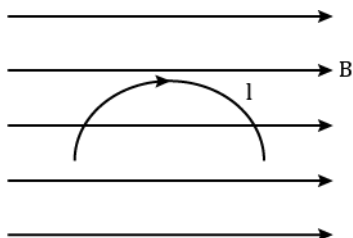
- ✔ **A.** Zero
- ✘ **B.** $2IRB$
- ✘ **C.** IRB
- ✘ **D.** $2\pi IRB$

Magnetic force, $\vec{F} = I(\vec{l} \times \vec{B})$

Except point C, the length vector $\vec{l}$ along the direction of current I are symmetry about the point C.

These symmetry elements will lead to the force on the wire which are equal in magnitude but opposite in direction.

Thus, the net force will be zero on the wire.

At point C, vector $\vec{l}$ is parallel to the magentic field $\vec{B}$ so, the force at this point also be zero.

Hence, the net force on the wire will be zero.
So, option (a) is the correct answer.

5. A circular loop of wire having a radius of 8.0 cm carries a current of 0.2 A. A vector of unit length and parallel to the dipole moment $\vec{\mu}$ of the loop is given by $0.60\hat{i} - 0.80\hat{j}$. If the loop is located in uniform magnetic field given by $\vec{B} = (0.25)\hat{i} + (0.30)\hat{k}$. Find the torque acting on the loop.

(✗) **A.** $(-9.6\hat{i} - 7.2\hat{j} + 8.0\hat{k}) \times 10^{-3} \text{ Nm}$

(✗) **B.** $(-9.6\hat{i} - 7.2\hat{j} - 8.0\hat{k}) \times 10^{-4} \text{ Nm}$

(✗) **C.** $(9.6\hat{i} + 7.2\hat{j} + 8.0\hat{k}) \times 10^{-4} \text{ Nm}$

(✓) **D.** $(-9.6\hat{i} - 7.2\hat{j} + 8.0\hat{k}) \times 10^{-4} \text{ Nm}$

Torque acting on a loop is given by

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

From the data given in the question,

$$\vec{\mu} = I\vec{A} = 0.2 \times \left(\pi \times (0.08)^2 \right) (0.6\hat{i} - 0.8\hat{j}) = (2.4\hat{i} - 3.2\hat{j}) \times 10^{-3} \text{ Am}^2$$

$$\vec{\tau} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0.0024 & -0.0032 & 0.0 \\ 0.25 & 0.0 & 0.30 \end{vmatrix} = \hat{i}(-0.0032 \times 0.3) - \hat{j}(0.0024 \times 0.3) + \hat{k}(0.0032 \times 0.25)$$
$$= (-9.6\hat{i} - 7.2\hat{j} + 8.0\hat{k}) \times 10^{-4} \text{ Nm}$$
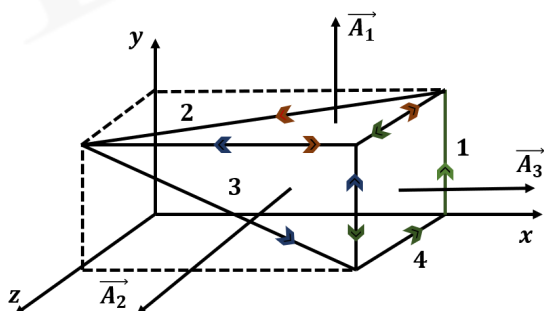
Hence, option (d) is the correct answer.

6. A wire carrying a 10 A current is bent to pass through various sides of a cube of side 10 cm as shown in the figure. A magnetic field $\vec{B} = (2\hat{i} - 3\hat{j} + \hat{k})$ T is present in the region. Find the magnetic moment vector of the loop.
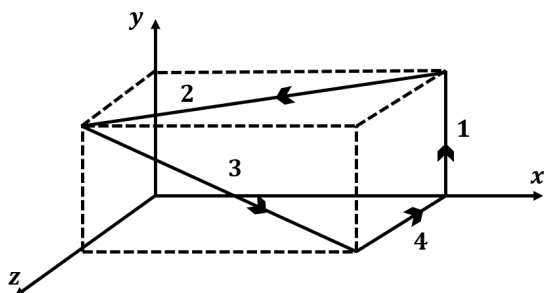
(×) **A.** $(0.1\hat{i} + 0.05\hat{j} - 0.05\hat{k})$ Am^2

(✔) **B.** $(0.1\hat{i} + 0.05\hat{j} + 0.05\hat{k})$ Am^2

(×) **C.** $(0.1\hat{i} - 0.05\hat{j} + 0.05\hat{k})$ Am^2

(×) **D.** $(0.1\hat{i} - 0.05\hat{j} - 0.05\hat{k})$ Am^2

Let us consider the given loop to be a super position of three loops as shown in the figure. The area vector of the loops (1) , (2) and 3) are also shown.

From the figure, $\vec{A_1} = \left(\dfrac{1}{2} \times 10 \times 10 \times 10^{-4}\right) \hat{j}$ Am^2

$\vec{A_2} = \left(\dfrac{1}{2} \times 10 \times 10 \times 10^{-4}\right) \hat{k}$ Am^2

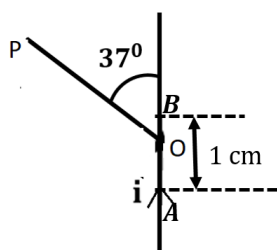$\vec{A_3} = \left(10 \times 10 \times 10^{-4}\right) \hat{i}$ Am^2

Therefore, Magnetic moment vectorr, $\vec{\mu} = 10(0.01\hat{i} + 0.005\hat{j} + 0.005\hat{k})$ Am^2

$\Rightarrow \vec{\mu} = (0.1\hat{i} + 0.05\hat{j} + 0.05\hat{k})$ Am^2

Hence, option (b) is the correct answer.

7. A wire carries a steady current of $50\ \mathrm{A}$ as shown in the figure. Find the magnetic field caused by segment AB of length $1\ \mathrm{cm}$ of the wire at a point P where $OP = 1\ \mathrm{m}$.

A. $30\ \mathrm{nT}\ \otimes$ ✗

B. $50\ \mathrm{nT}\ \otimes$ ✗

C. $30\ \mathrm{nT}\ \odot$ ✓

D. $50\ \mathrm{nT}\ \odot$ ✗

Since the length of the element is very small as compared, the distance between the point P and the wire. So, we can use Biot-Savart law to calculate the magnetic field at point P. Thus,

$$B_P = \frac{\mu_0}{4\pi}\ \frac{il\sin\theta}{r^2}$$

$$= 10^{-7} \times \frac{50 \times 0.01 \times \sin 37^\circ}{1^2} = 3 \times 10^{-8}\ \mathrm{T} = 30\ \mathrm{nT}$$

From right-hand thumb rule, the direction of magnetic field is outwards of the plane.

8. A current $i = 2.5$ A flows along the circular coil of three turns in anticlockwise direction. The equation of circle is given by $x^2 + y^2 = 9$ cm^2 (x & y are in cm). The magnetic field at point $P(0, 0, 4\,\text{cm})$ is :

   [consider x and y axis in the plane of paper and perpendicular outward direction as $+z$ - axis]

   ✖ **A.** $(36\pi \times 10^{-7}\,\text{T})\,\hat{k}$

   ✔ **B.** $(108\pi \times 10^{-7}\,\text{T})\,\hat{k}$

   ✖ **C.** $\left(\dfrac{9\pi}{5} \times 10^{-7}\,\text{T}\right)(-\hat{k})$
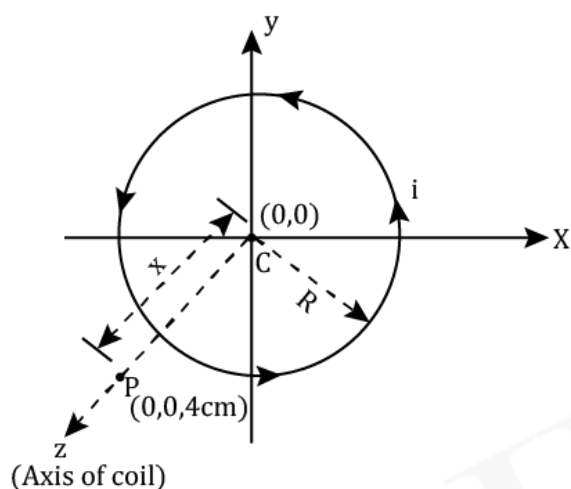
   ✖ **D.** $(36\pi \times 10^{-7}\,\text{T})(-\hat{k})$

From the equation of circle,
$x^2 + y^2 = 9 \text{ cm}^2$
Comparing it with $x^2 + y^2 = a^2$

We find that the circular coil is placed in $x - y$ plane with centre at origin $(0, 0)$ and radius $R = 3$ cm.

From the shown figure it is clear that point $\mathrm{P}(x = 0, y = 0, z = 4 \text{ cm})$ lies along the axis of coil line (i.e. $z-$axis)

Using the relation;

$$B_P = \frac{(\mu_0 i R^2)n}{2(R^2 + x^2)^{3/2}}$$

$$B_P = \frac{(4\pi \times 10^{-7}) \times 2.5 \times (3 \times 10^{-2})^2 \times 3}{2[(3 \times 10^{-2})^2 + (4 \times 10^{-2})^2]^{3/2}}$$

$$B_P = \frac{27 \times 10\pi \times 10^{-11}}{2[(25 \times 10^{-4})]^{3/2}}$$

$$B_P = 108\pi \times 10^{-7} \text{ T}$$

Also, from right-hand thumb rule direction of field at P is along $+z$- axis.

$$\therefore \overrightarrow{B_P} = (108\pi \times 10^{-7}) \, \hat{k}$$

Ans : (b)

Why this question ?
Tip: Just focus on the equation of circle, it will give the clue for plane of coil (XY), centre $(0, 0)$ & the radius (R). Thus, we can easily visualize the point P and apply the formula for magnetic field due to coil.
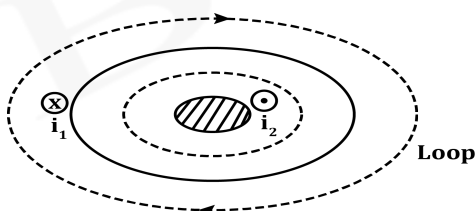
9. In a coaxial, straight cable, the central conductor and the outer conductor carry equal currents in opposite directions. The magnetic field is zero at
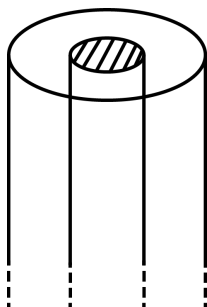
✔ **A.** Outside the cable

✘ **B.** Inside the inner conductor

✘ **C.** Inside the outer conductor

✘ **D.** In between the two conductors

The direction of current in central and outer conductor is opposite. hence using Ampere's circular law:

So, $i_1 = i_2$

Using Ampere's circuital law

$$\oint \overrightarrow{B} . \overrightarrow{dl} = \mu_0 (I_{enclosed})$$

So, applying this law on outer loop given in figure

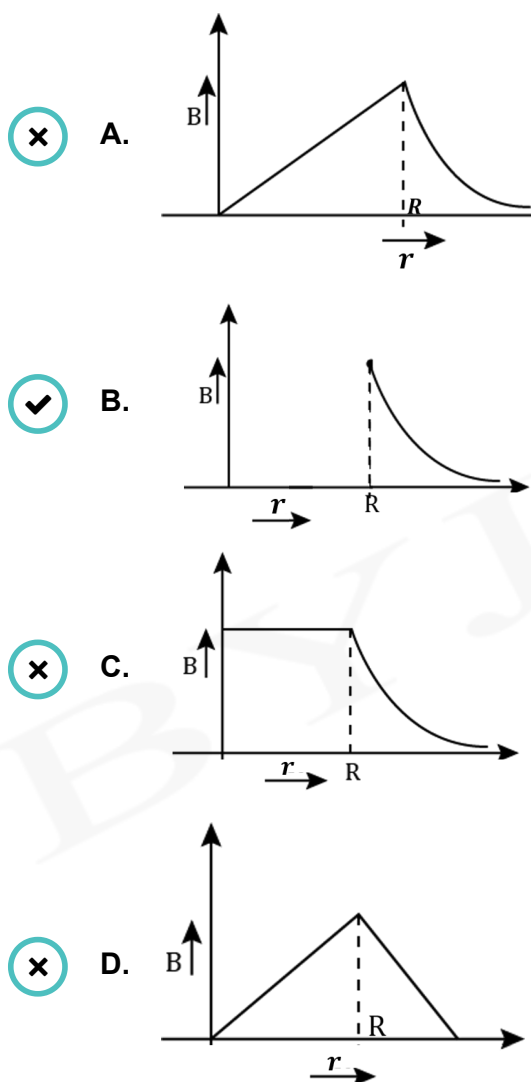$$\oint \overrightarrow{B} . \overrightarrow{dl} = \mu_0 (I_{enclosed}) = \mu_0 (i_1 - i_2) = 0$$

The net magnetic field can only be zero outside cable, since the term I_{enclosed} could become zero.

Thus, option (a) is correct.

10. Draw a graph for a thin current carrying hollow conductor for variation of magnetic field with respect to distance R from its axis along the radius.

A. ✗

B. ✓

C. ✗

D. ✗

For a thin conductor, the magnetic field inside it at every point is,

$B_{inside} = 0$

Magnetic field outside it at distance r from the axis is,

$B_{outside} = \dfrac{\mu_o I}{2\pi r}$

$\therefore B_{outside} \propto \dfrac{1}{r}$

Hence, option (B) is the correct answer.

11. Statement A : A current carrying wire is placed parallel to the external magnetic field. The force on it due to the external magnetic field is zero.

Statement R : The net charge on current wire is zero.

  ✖ **A.**   Both A and R are true, and R is the correct explanation of A.

  ✔ **B.**   Both A and R are true but R is not correct explanation of A.

  ✖ **C.** A is true, but R is false.

  ✖ **D.** A is false, but R is true.

Magnetic force on the current carrying conductor,

$$\vec{F}_B = \left(i \vec{l} \times \vec{B} \right)$$

$$\Rightarrow F_B = ilB \sin 0^\circ = 0 \qquad [\because \vec{l} \, || \vec{B} \,]$$

$\therefore$ Statement A is correct.

Due to the presence of equal number of electrons and protons inside a conductor, the net charge on the current wire would be zero.

So, statement R is also correct but reason behind statement A is $\vec{F}_B = (i \vec{l} \times \vec{B}) \ \& \ \theta = 0^\circ$

Hence, option (b) is the correct alternative.

12. Assertion : A rectangular current loop is in an arbitrary orientation in an external uniform magnetic field. No work is required to rotate the loop about an axis perpendicular to its plane.

Reason :All positions represent the same level of energy.

  ✔ **A.** Both Assertion and Reason are correct and Reason is the correct explanation for Assertion.

  ✘ **B.** Both Assertion and Reason are correct but Reason is not the correct explanation for Assertion.

  ✘ **C.** Assertion is correct, Reason is incorrect.

  ✘ **D.** Assertion is incorrect, but Reason is correct.

Potential energy of a current carrying loop in a magnetic field:

$$\therefore U = -\overrightarrow{\mu} . \overrightarrow{B} = -\mu B \cos\theta$$

If the loop is rotated about an axis perpendicular to the plane of the loop, θ does not change. Hence, $\overrightarrow{\mu}$ remains constant.

$\therefore U$ does not change.

Thus, No work is done to rotate the loop.

Hence, option (a) is the correct alternative.

13. Consider the following statements about the Oersted experiment.

    Statement P : The magnetic field due to a straight current carrying conductor is in the form of circular loops around it.

    Statement Q : The magnetic field due to a current carrying conductor is strong at far points from the conductor, compared to the near points.

    ⊗ **A.** Both P and Q are true

    ✔ **B.** P is true but Q is false

    ⊗ **C.** P is false but Q is true

    ⊗ **D.** Both P and Q are false

    From the experiment, the diagrams show the magnetic field pattern around a straight conductor carrying current.
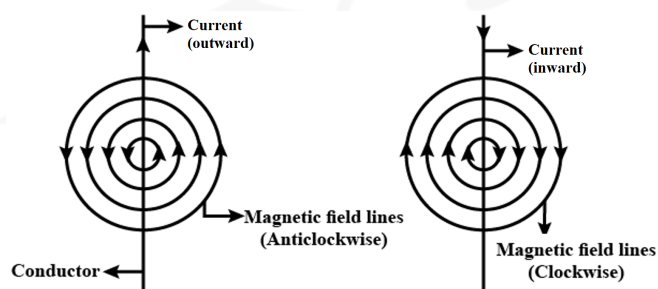
    The magnetic field lines around a straight conductor carrying current are concentric circles whose centres lie on the wire.

    According to Biot- Savart Law,

    $$dB = \frac{\mu_0}{4\pi} \frac{idl \sin\theta}{r^2}$$

    $$\Rightarrow dB \propto \frac{1}{r^2}$$

    Therefore, the magnetic field at the near points will be more compared to the far points.

    Hence, option (B) is the correct answer.

14. In the question given below, a statement of Assertion (A) is given followed by a corresponding statement of Reason (R) just below it. Of the statements mark the correct answer.

Assertion (A): Power of a magnetic force on a charged particle is always zero.

Reason (R): Power of electric force on charged particle cannot be zero.

(✕) **A.** Both 'A' and 'R' are true and 'R' is the correct explanation of 'A'.

(✕) **B.** Both 'A' and 'R' are true and 'R' is not the correct explanation of 'A'

(✔) **C.** 'A' is true and 'R' is false

(✕) **D.** 'A' is false and 'R' is true

Power of a magnetic force , $P_b = \vec{F_b} \cdot \vec{v}$

Since, a charged particle moving in the presence of a magnetic field , moves in a circular path $\vec{F_b} \perp \vec{v} \Rightarrow P_b = 0$

∴ Power of magnetic force is always zero.

But ,

Electric force , $\vec{F_e} = q\vec{E}$

If $\vec{F_e}$ is also perpendicular to $\vec{v}$, then its power is also zero else it is non zero.

15. Assertion(A): If an electron, while coming vertically from outerspace, enter the earth's magnetic field, it is deflected towards west.
Reason(R): Electron has negative charge.

✓ **A.** Both A and R are true and R is correct explanation of A

✗ **B.** Both A and R are true but R is not the correct explanation of A

✗ **C.** A is true but R is false

✗ **D.** A is false but R is true

We know that the direction of the earth's magnetic field ($\vec{B}$) is towards north and the velocity of electron ($\vec{v}$) is vertical downwards.
Using $\vec{F} = q\,(\vec{v} \times \vec{B})$ and right hand thumb rule, an electron coming from outer space will be deflected towards west.
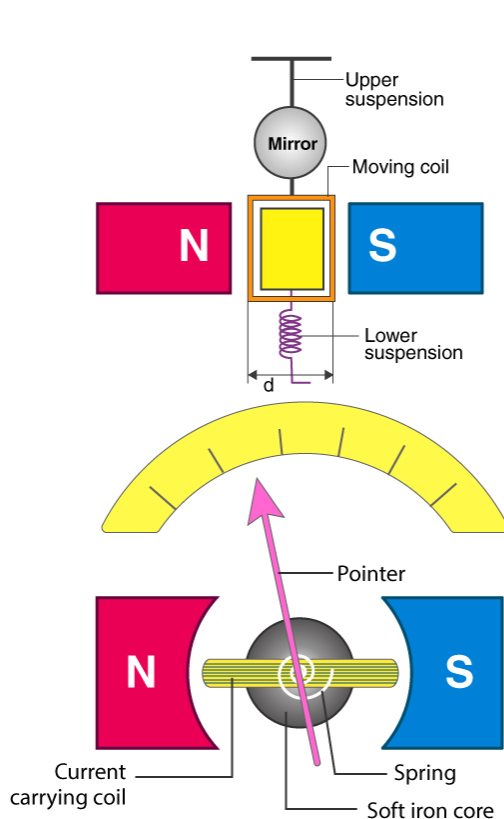
16. Moving coil galvanometer operates on Permanent Magnet Moving Coil (PMMC) mechanism.

Moving coil galvanometers are of two types
(a) Suspended coll
(b) Pivoted coil type or tangent galvanometer,

Its working is based on the fact that when a current carrying coil is placed in a magnetic field, it experiences a torque. This torque tends to rotate the coil about its axis of suspension in such a way that the magnetic flux passing through the coil is maximum.

Moving coil galvanometer

(i) A moving coil galvanometer is an instrument which

  ✗   **A.** is used to measure emf

  ✗   **B.** is used to measure potential difference

  ✗   **C.** is used to measure resistance

  ✔   **D.** gives a deflection when a current flows through its coil

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A moving coil galvanometer is an instrument which is used to measure electric current.

Principle: A current-carrying coil when placed in an external magnetic field experiences magnetic torque. The angle through which the coil is deflected due to the effect of the magnetic torque is proportional to the magnitude of current in the coil.
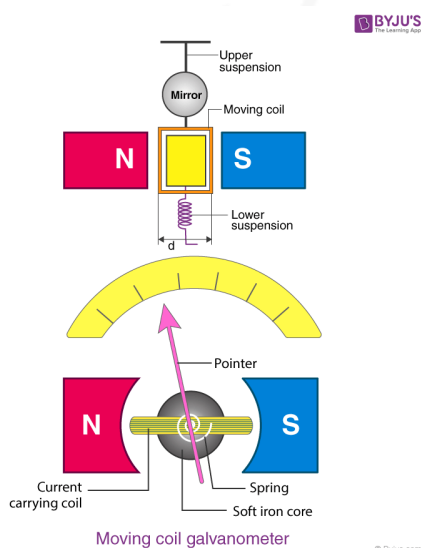
It is a sensitive electromagnetic device which can measure low currents even of the order of a few microamperes via deflection of the coil.

17. Moving coil galvanometer operates on Permanent Magnet Moving Coil (PMMC) mechanism.

Moving coil galvanometers are of two types
(a) Suspended coll
(b) Pivoted coil type or tangent galvanometer,

Its working is based on the fact that when a current carrying coil is placed in a magnetic field, it experiences a torque. This torque tends to rotate the coil about its axis of suspension in such a way that the magnetic flux passing through the coil is maximum.

Moving coil galvanometer

(ii) To make the field radial in a moving coil galvanometer

   ✗ **A.**   number of turns of coil is kept small

   ✗ **B.**   magnet is taken in the form of horse-shoe

   ✗ **C.**   poles are of very strong magnets

   ✔ **D.**   poles are cylindrically cut

Uniform field in between permanent poles is made radial by cutting poles cylindrically
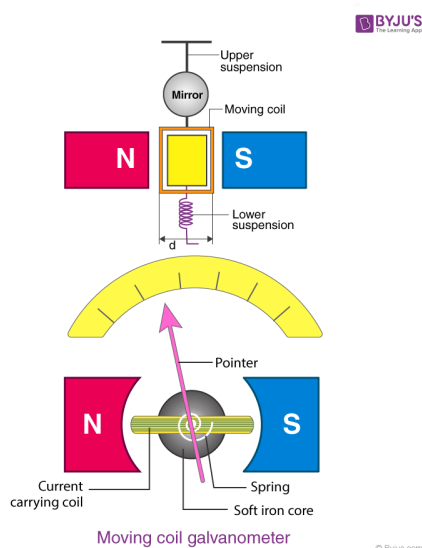
18.

Moving coil galvanometer operates on Permanent Magnet Moving Coil (PMMC) mechanism.

Moving coil galvanometers are of two types
(a) Suspended coil
(b) Pivoted coil type or tangent galvanometer,

Its working is based on the fact that when a current carrying coil is placed in a magnetic field, it experiences a torque. This torque tends to rotate the coil about its axis of suspension in such a way that the magnetic flux passing through the coil is maximum.

Moving coil galvanometer

(iii)The deflection in a moving coil galvanometer is

⊗ **A.** directly proportional to torsional constant of spring

✔ **B.** directly proportional to the number of turns in the coil

⊗ **C.** inversely proportional to the area of the coil

⊗ **D.** inversely proportional to the current in the coil

The deflection in amoving coil galvanometer is defined as
$$\phi = \frac{NABI}{k}$$
$$\therefore \phi \propto N$$

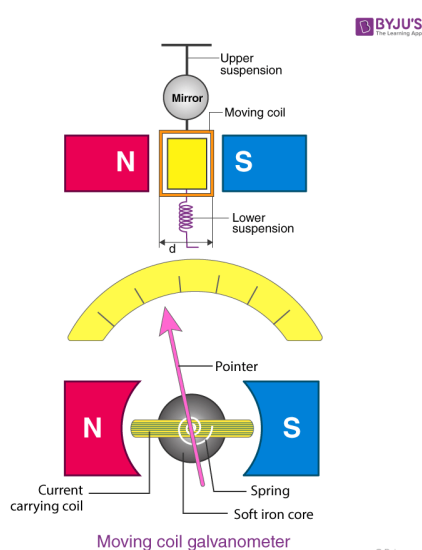Where N is number of turns of the coil
Hence option B

19.

Moving coil galvanometer operates on Permanent Magnet Moving Coll (PMMC) mechanism.

Moving coil galvanometers are of two types
(a) Suspended coll
(b) Pivoted coil type or tangent galvanometer,

Its working is based on the fact that when a current carrying coil is placed in a magnetic field, it experiences a torque. This torque tends to rotate the coil about its axis of suspension in such a way that the magnetic flux passing through the coil is maximum.

Moving coil galvanometer

(iv) In a moving coil galvanometer, having a coil of N-turns of area A and carrying current I is placed in a radial field of strength B. The torque acting on the coil is

❌ **A.** NA^2B^2I

❌ **B.** $NABI^2$

❌ **C.** N^2ABI

✔ **D.** $NABI$

The deflecting torque acting on the coil is $\tau = NIAB$

20.
Moving coil galvanometer operates on Permanent Magnet Moving Coll (PMMC) mechanism.

Moving coil galvanometers are of two types
(i) Suspended coil
(ii) Pivoted coil type or tangent galvanometer,

Its working is based on the fact that when a current carrying coil is placed in a magnetic field, it experiences a torque. This torque tends to rotate the coil about its axis of suspension in such a way that the magnetic flux passing through the coil is maximum.

Moving coil galvanometer
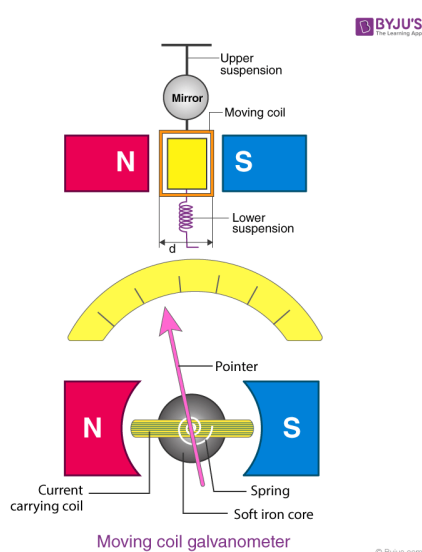
(v) To increase the current sensitivity of a moving coil galvanometer, we should decrease

✗ **A.** strength of magnet

✓ **B.** torsional constant of spring

✗ **C.** number of turns in coil

✗ **D.** area of coil

Current sensitivity of galvanometer is
$$\frac{\phi}{I} = S_i = \frac{NAB}{k}$$

Hence to increase current sensitivity torsional constant of spring must decrease