PHYSICS

The following questions consists of two statements each, printed as Assertion and Reason. While answering these questions you are to choose any one of the following four responses.

(A) If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

(B) If both Assertion and Reason are true but Reason is not correct explanation of the Assertion.

(C) If Assertion is true but the Reason is false.

(D) If Assertion is false but Reason is true

Q. 1 **Assertion:** If a proton and an α-particle enter a uniform magnetic field perpendicularly with the same speed , the time period of revolution of α-particle is double that of proton.

Reason : In a magnetic field, the period of revolution of a charged particle is directly proportional to charge of particle. **[C]**

Sol. Both assertion and reason are true and reason is the correct explanation of assertion.

The period of a charged particle in magnetic field is given by :

$$T = \frac{2\pi n}{qB} \text{, i.e., } T \mu \frac{m}{q}]$$

we know that, $m_p = m$, $m_\alpha = 4$ $q_p = e$, $q\alpha = 2e$

$$\therefore \frac{T_p}{T_\alpha} = \frac{1}{2} \text{ or } T_\alpha = 2\ Tp$$

Q. 2 **Assertion:** If an electron is not deflected while passing through a certain region of space, then only possibility is that there is no magnetic field in the region.

Reason : Force is directly proportional to magnetic field applied. **[D]**

Sol. Assertion is false but reason is true.

In this case, we cannot be sure about the absence of the magnetic field, the angel between velocity and applied magnetic field is zero and force experienced by the electron is zero (F = 0). Then, also electron passes without deflection.

Q.3 **Assertion :** An electric field is preferred in comparison to magnetic field for detecting the electron beam in a television picture tube.

Reason : Electric field require high voltage. **[D]**

Sol. A - False, R-True.

If electric field is used for detecting the electron beam, then very high voltage will have to be applied or very long tube will have to be taken.

Q.4 **Assertion** : If an electron and proton enter an electric field with equal energy, then path of electron is more curved than that of proton.

Reason : Electron has a tendency to form curve. **[D]**

Q.5 **Assertion** : If an electron while coming vertically from outer space enter the earth's magnetic field, it is deflected towards west.

Reason : Electron has negative charge. **[A]**

Q.6 **Assertion** : If a charged particle is moving perpendicular to a uniform magnetic field, no work is done.

Reason : Displacement of the particle is zero. **[C]**

Q.7 **Assertion** : If a charged particle is moving on a circular path in a perpendicular magnetic field, the momentum of the particle is not changing.

Reason : Velocity of the particle is not changing in magnetic field. **[D]**

Q.8 **Assertion** : If a proton and an α- particle enter a uniform magnetic field perpendicularly, with the same speed, then time period of revolution of the α-particle is double than that of proton.

Reason : In a magnetic field, the time period of revolution of a charged particle is directly proportional to mass of particle and is inversely proportional to charge of particle. **[A]**

Q.9 **Assertion** : In a conductor, free electrons keep on moving but no magnetic force acts on a conductor in a magnetic field.

Reason : Force on free electron due to magnetic field always acts perpendicular to its direction of motion. **[B]**

Q.10 **Assertion** : If two long parallel wires, hanging freely are connected to a battery in series, they come closer to each other.

Reason : Force of attraction acts between the two wires carrying current. **[D]**

Q.11 **Assertion/Statement :** The sensitivity of a moving coil galvanometer is increased by placing a suitable magnetic material as a core inside the coil.

Reason/Statement : Soft iron has a high magnetic permeability and cannot be easily magnetized or demagnetized. **[IIT-2008]**

[A]

Q.12 **Assertion :** In electric circuits, wires carrying currents in opposite directions are often twisted together.

Reason : If the wires are not twisted together, the combination of the wires forms a current loop. The magnetic field generated by the loop might affect adjacent circuits or components.

Sol. **[A]**

Both assertion and reason are true and reason is the correct explanation of assertion.

If the wires are twisted together they can be modelled as a single wire carrying current in the opposite directions. In this model, no magnetic field is induced in the wires which does not affect adjacent circuits.

Q.13 **Assertion :** A charged particle undergoes uniform circular motion in a uniform magnetic field. The only force acting on the particle is that exerted by the uniform magnetic field. If now the speed of the same particle is somehow doubled keeping its charge and external magnetic field constant, then the centripetal force on the particle becomes four times.

Reason : The magnitude of centripetal force on a particle of mass m moving in a circle of radius R with uniform speed v is $\frac{mv^2}{R}$. **[D]**

Sol. The magnitude of magnetic force on charged particle undergoing uniform circular motion in uniform magnetic field is F = qvB

$\therefore$ If v is doubled keeping q and B constant, the force F just doubles. Hence assertion is false.

Q.14 **Statement I :** If an electron while coming vertically from outer space enter earth's magnetic field, it is deflected towards west.

Statement II : Electron has negative charge.

[B]

Q.15 **Statement I :** If a charged particle is moving perpendicular to a uniform magnetic field , no work is done.

Statement II : Displacement of the particle is zero. **[C]**

Q.16 **Statement I :** In conductor, free electrons keep on moving but no magnetic force acts on a conductor in a magnetic field.

Statement II : Force on free electron due to magnetic field always act perpendicular to its direction of motion. **[B]**

Q.17 **Statement I :** If two long parallel wires, hanging freely are connected to a battery in series, they come closer to each other.

Statement II : Force of repulsion acts between the two wire carrying current. **[D]**

Q.18 **Statement I :** A current I flows along the length of an infinitely long straight and thin walled pipe. Then the magnetic field at any point inside the pipe is zero.

Statement II : $\oint \vec{B}.d\vec{l} = \mu_0 I$ **[A]**

Q.19 **Statement –I :** The sensitivity of a moving coil galvanometer is increased by placing a suitable magnetic material as a core inside the coil.

and

Statement – II : Soft iron has a high magnetic permeability and cannot be easily magnetized or demagnetized. **[IIT-2008]**

[C]

Q.20 **Statement-1 :** Torque experienced by the bar magnet is maximum when field is applied perpendicular to magnetic moment.

Statement-2 : Torque on a bar magnet depends on the angle between applied magnetic field and magnetic dipole moment.

Sol. **[A]**

$\tau = MB \sin\theta$

PHYSICS

Q.1 Column- I gives situations involving a charged particle which may be realized under the condition given in column-II match the situations in column-I with the condition in column-II.

	Column-I		**Column-II**
(A)	Increase in speed of a changed particle space	(P)	Electric field uniform in space and constant in time
(B)	Exert a force on an electron initially at rest	(Q)	Magnetic field uniform in space and constant in time
(C)	Move a charged particle in a circle with uniform speed	(R)	Magnetic field uniform in space by varying with time
(D)	Accelerate a moving charged particle	(S)	Magnetic field non-uniform in space but constant with time

Sol. **(A)** P, R **(B)** P, R

(C) Q, S **(D)** P,Q,R,S

(A) Speed of charged particle can not be changed by magnetic force because magnetic force does no work on charged particle. Only electric field in case (P) and induced electric field in case (R) can change speed of charged particle

(B) Magnetic field can not exert force on charged particle at rest. Only electric field in case (R) can exert force on charge initially at rest. In case (R) after the charge starts moving even the magnetic field can exert force on charge.

(C) A charged particle can move in a circle with uniform speed due to uniform and constant magnetic field in case. Even within a region of non uniform magnetic field, at all point on a circle field may be uniform for example on any circle coaxial with a current carrying ring.

(D) A moving charged particle is accelerated by electric field and also accelerated by magnetic field (provided $\vec{v}$ is not parallel to $\vec{B}$).

Q.2

	Column I		**Column II**
(a)	Velocity selector	(i)	Electron
(b)	Accelerated charged particle	(ii)	Toroid
(c)	Tokamak	(iii)	Cyclotron
(d)	Intrinsic Magnetic moment	(iv)	Lorentz force

Ans. $A \to S$; $B \to R, S$; $C \to Q$; $D \to P$

Q.3

	Column I		**Column II**
(a)	Tangent galvanometer	(i)	Hysteresis
(b)	Deflection Magnetometer	(ii)	Tangent Law
(c)	Remanence	(iii)	Current
(d)	Cyclotron	(iv)	Alternating emf source

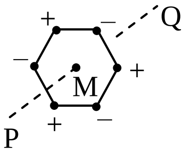
Ans. $A \to Q$; $B \to R$; $C \to P$; $D \to S$

Q.3 Six point charges, each of the same magnitude q, are arranged in different manners as shown in **Column II**. In each case, a point M and a line PQ passing through M are shown. Let E be the electric field and V be the electric potential at M (potential at infinity is zero) due to the given charge distribution when it is at rest. Now, the whole system is set into rotation with a constant angular velocity about the line PQ. Let B be the magnetic field at M and μ be the magnetic moment of the system in this condition. Assume each rotating charge to be equivalent to a steady current. **[IIT-2009]**

Column I **Column II**

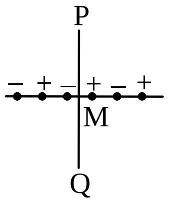
(A) E = 0

(P) Charges are at the corners of a regular hexagon. M is at the centre of the hexagon. PQ is perpendicular to the plane of the hexagon.



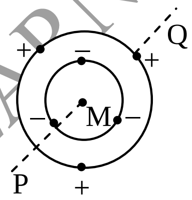
(B) V ≠ 0

(Q) Charges are on a line perpendicular to PQ at equal intervals. M is the mid-point between the two innermost charges.



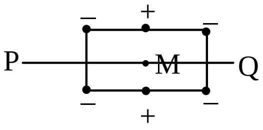
(C) B = 0

(R) Charges are placed on two coplanar insulating rings at equal intervals. M is the common centre of the rings. PQ is perpendicular to the plane of the rings.

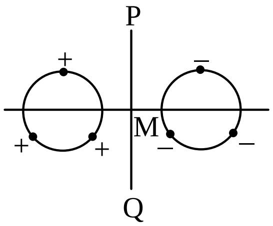


(D) μ ≠ 0

(S) Charges are placed at the corners of a rectangle of sides a and 2a and at the mid points of the longer sides. M is at the centre of the rectangle. PQ is parallel to the longer sides.

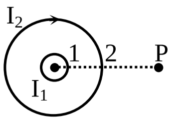
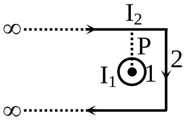
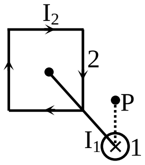
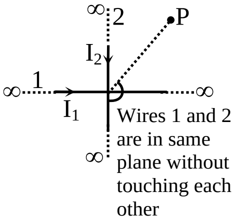


(T) Charges are placed on two coplanar, identical insulating rings at equal intervals. M is the mid-point between the centres of the rings. PQ is perpendicular to the line joining the centres and coplanar to the rings.



Ans. A → P, R, S ; B → R, S ; C→P,Q,T; D → R, S

Q.4 Match the entries of column I with the entries of column II in the following table.

	Column I		**Column II**
(A)		**(P)**	1 and 2 attract each other
(B)		**(Q)**	1 and 2 do not exert any force on each other
(C)		**(R)**	Magnetic fields at point P due to wires 1 and 2 are perpendicular to each other
(D)		**(S)**	Magnetic fields at point P due to wires 1 and 2 are in same direction

Sol. A $\rightarrow$ **Q, R** **B** $\rightarrow$ **Q, R**

C $\rightarrow$ **Q, R** **D** $\rightarrow$ **Q, S**

For A, B and C : Magnetic field at location of 1 due to 2 is parallel or anti parallel to current in 1, so force experienced by 1 due to magnetic field of 2 is zero.

For D : Force experienced by upper half of 2 due to 1 is along left, while on lower half it is towards right.

So, net force of interaction between the two is zero.

Direction of magnetic field at P can be found by using right hand palm rule no. 1.

Q.5

Column I (Equipment Name)	**Column II (Function or working principle)**
(A) Mass spectrometer	(P) Particle of specific speed
(B) Velocity selector	(Q) Find leakage in vacuum systems
(C) Cyclotron	(R) Magnetic force on current carrying conductor
(D) Loudspeaker	(S) Time period is independent of magnitude of velocity of charged particle

Ans. **A $\rightarrow$ Q, B $\rightarrow$ P, C $\rightarrow$ S, D $\rightarrow$ R**

Q. 6

Column - I	**Column II**
(A) α- particle is accelerated using	(P) Betatron
(B) electrons are accelerated using	(Q) Mass spectrometer
(C) Isotopes can be separated using	(R) Cyclotron
(D) Deutrons are separated from protons using	(S) Linear accelerator

Ans. **A $\rightarrow$ R,S ; B $\rightarrow$ P ; C $\rightarrow$ Q ; D $\rightarrow$ Q**

Q. 7 Match the column :

Column-I	**Column-II**
(a) moving coil galvanometer	(p) magnetic field
(b) cyclotron	(q) electric field

(A) a → p, b → p

(B) a → q, b → p

(C) a → q, b → q, b → p

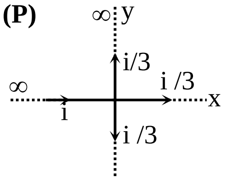
(D) a → p, b → p, b → q **[D]**

Q.8 Column II give five situations in which three or four semi infinite current carrying wires are placed in xy plane as shown. The Magnitude and direction of current is shown in each figure. Column I give statements regarding the x, y and z components of magnetic field at point P whose coordinates are P(0, 0, d). Match the statement in column I with the corresponding figures in column II.

Column –I **Column –I**

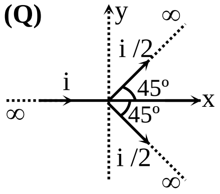
(A) The x component of magnetic field at point P is zero in

(P)



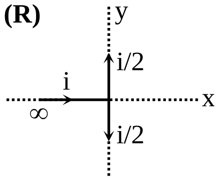
(B) The z component of magnetic field at point P is zero in

(Q)



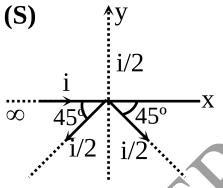
(C) Magnitude of magnetic field at point P is $\frac{\mu_0 i}{4\pi d}$ in

(R)

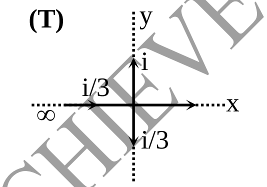


(D) The magnitude of magnetic field at point P is less than $\frac{\mu_0 i}{2\pi d}$ in

(S)



(T)



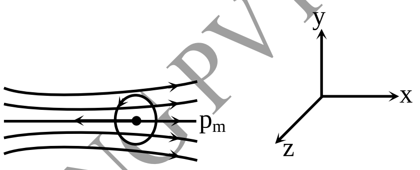
Sol. **A → P,Q,R ; B → P,Q,R,S,T;**
C → R; D → P,Q,S,T

Q.9 Match the following -

Column-I	**Column-II**
(A) Magnetic flux density due to a circular current carrying coil	(P) Zero
(B) Magnetic flux density at a point on a current carrying thin wire	(Q) Maximum at the centre
(C) Electric field strength due to uniformly charged ring	(R) Continuously decrease as we move away from the centre along the axis
(D) Electric potential due to a uniformly charged ring	(S) Continuously increases as we move away from the centre upto a definite distance along the axis

Sol. A → Q, R ; B → P ; C → S; D → Q, R

Q.10 An elementary current loop is placed in a non-uniform magnetic field as shown below. In column-I different orientation of loop is described and in column-II, the corresponding force experienced by the loop.



Match the following -

Column-I	**Column-II**
(A) In the shown situation	(P) Resultant force acting along $\vec{P}_m$
(B) If the loop is rotated such that $\vec{P}_m$ is along +ve z-direction	(Q) Resultant force acting opposite to $\vec{P}_m$
(C) If the loop is rotated such that $\vec{P}_m$ is along –ve z-direction	(R) $F_x = 0, F_y = 0$
(D) If the loop is rotated such that $\vec{P}_m$ is along +ve y-direction	(S) $F_x = 0, F_z = 0$

Sol. A → Q ; B → P, R ;
C → P,R ; D → P,S

Q.11 In magnetic field, for a charged particle, match the entries of column-I with the entries of column-II.

Column-I	**Column-II**
(A) Acceleration	(P) may be zero
(B) Velocity	(Q) is zero
(C) Speed	(R) may be constant
(D) Kinetic energy	(S) is constant

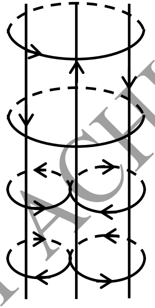
Sol. **A → P ; B → R ; C → S ; D → S**

Q.12 In the motion of charged particles through a region containing either only uniform electric field $\vec{E}$ or only uniform magnetic field or both, certain properties are listed in column I and their possible reason or explanations are given in column II. (Here V denote the velocity of the particle and force means the force acting on the particle)

Column-I	Column-II
(A) V cannot remain constant in $\vec{E}$ only	(P) $\lvert\vec{V}\rvert = \frac{E}{B}$
(B) Magnitude of $\vec{V}$ will remain constant if only B is present	(Q) The force acting on the particle will always be normal to its velocity
(C) $\vec{V}$ may remain constant if only $\vec{B}$ is present	(R) $\vec{V}$ is parallel to $\vec{B}$
(D) $\vec{V}$ may remain constant if both $\vec{E}$ and $\vec{B}$ are present	(S) There must be some component of the force acting on the particle in direction of its motion at same time.

Sol. A→ S B→ Q,R C→ R D→ P

Q.13 Three wires are carrying same constant current i in different direction. Four loops enclosing the wires in different manner are shown. The direction of $\vec{dl}$ is shown in the figure -



Column-I	Column-II
(A) Along closed loop1	(P) $\oint \vec{B}.\vec{dl} = \mu_0 i$
(B) Along closed loop2	(Q) $\oint \vec{B}.\vec{dl} = -\mu_0 i$
(C) Along closed loop3	(R) $\oint \vec{B}.\vec{dl} = 0$
(D) Along closed loop 4	(S) net work done by the magnetic force to move a unit charge along the loop is zero

Sol. A → Q, S B → P, S

C → Q, S D → P, S

for loop (1) $\oint \vec{B}.\vec{dl} = -\mu_0 i$

for loop (2) $\oint \vec{B}.\vec{dl} = \mu_0 i$

for loop (3) $\oint \vec{B}.\vec{dl} = -\mu_0 i$

for loop (4) $\oint \vec{B}.\vec{dl} = \mu_0 i$

options is correct in all cases.

Q.14 Match the following

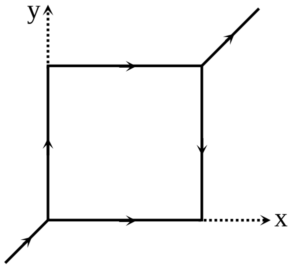
Column -I	Column-II
(A) A charge particle is moving in uniform electric and magnetic field in gravity free space	(P) velocity of the particle may be constant
(B) A charge particle is moving in uniform electric field and gravitational field (where magnetic field is zero)	(Q) Path of the particle may be straight line.
(C) A charge particle is moving in uniform magnetic field and gravitational field (where electric field is zero)	(R) path of the particle may be circular
(D) A charge particle is moving in only uniform electric field.	(S) path of the particle may be helical
	(T) kinetic energy of particle may be constant.

Sol. **A → P,Q,S,T ; B → P,Q,T ; C → P,Q,S,T ; D → Q**

Q.15 A square loop of uniform conducting wire is as shown in figure. A current I(in amp.) enters the loop from one end and exists the loop from opposite end shown in figure. The length of one side of square loop is ℓ metre. The wire has uniform cross section area and uniform linear mass density. In four situations of column-I, the loop is subjected to four different magnetic field.

Column-I	Column-II

(A) $\vec{B} = B_0\hat{i}$ in tesla	(P) Magnitude of net force on loop is $\sqrt{2}\ B_0I\ell$ Newton
(B) $\vec{B} = B_0\hat{j}$ in tesla	(Q) Magnitude of net force on loop is zero
(C) $\vec{B} = B_0(\hat{i}+\hat{j})$ in tesla	(R) Magnitude of net torque on loop about its centre is zero
(D) $\vec{B} = B_0\hat{k}$ in tesla	(S) Magnitude of net force on loop is $B_0I\ell$ Newton
	(T) Magnitude of net torque on loop is non-zero



Sol. A →R,S ; B → R,S ; C → Q,R ; D → P,R

Use $F = I\ \vec{\ell} \times \vec{B}$

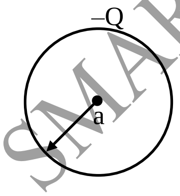
$\tau = \vec{r} \times \vec{F}$

Q.16 In each situation of column-I, some charge distributions are given with all details explained . In column-II the electrostatic potential energy and its nature is given a situation in column-I. The match situation in column-I with the corresponding results in column-II.

Column-I **Column-II**

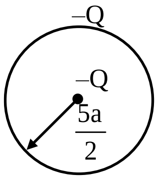
(A) A thin shell of radius ‘a’ and having a charge – Q uniformly distributed over its surface as shown

(P) $\frac{1}{8\pi\varepsilon_0}\frac{Q^2}{a}$ in magnitude



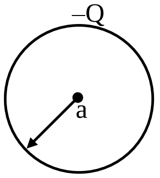
(B) A thin shell of radius $\frac{5a}{2}$ and having a charge – Q uniformly distributed over its surface and a point charge – Q placed at its centre as shown.

(Q) $\frac{3}{20\pi\varepsilon_0}\frac{Q^2}{a}$ in magnitude



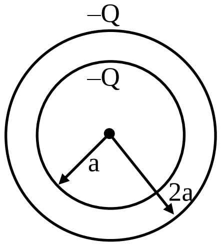
(C) A solid sphere of radius ‘a’ and having a charge – Q uniformly distributed throughout its volume as shown.

(R) $\frac{2}{5\pi\varepsilon_0}\frac{Q^2}{a}$ in magnitude



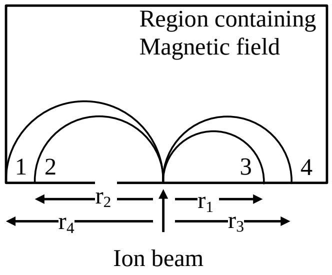
(D) A solid sphere of radius a and having a charge – Q uniformly distributed throughout its volume. The solid sphere is surrounded by a concentric thin uniformly charged spherical shell of radius 2a and carrying charge –Q as shown

(S) Positive in sign



Sol. (A) → (P, S) ; (B) → (Q, S) ; (C) → (Q, S) ; (D) → (S)

Q.17 A beam consisting of four types of ions A, B, C and D enters a region that contains a uniform magnetic field as shown. The field is perpendicular to the plane of the paper, but its precise direction is not given. All ions in the beam travel with the same speed. The table below gives the masses and charges of the ions.



$r_4 > r_3 = r_2 > r_1$

ION	MASS	CHARGE
A	2m	e
B	4m	–e
C	2m	–e
D	m	+e

The ions fall at different positions 1, 2, 3 and 4 as shown . Correctly match the ions with respective falling positions.

Column-I	**Column-II**
(A) A	(P) 1
(B) B	(Q) 2
(C) C	(R) 3
(D) D	(S) 4

Sol. (A) → (S), (B) → (P), (C) → (Q), (D) → (R)

Q.18

Column -I	**Column-II**
(A) Magnetic field due to infinite long wire	(P) $\vec{B} = \frac{\mu_0 I}{2\pi d}$
(B) Magnetic field due to current element	(Q) $\vec{B} = \frac{\mu_0 IN}{2R}$
(C) Magnetic field at centre of current carrying coil	(R) $\vec{B} = \frac{\mu_0 INR^2}{2(x^2 + R^2)^{3/2}}$
(D) Magnetic field at axis of coil	(S) $\delta\vec{B} = \frac{\mu_0 I\, s\ell}{4\pi r^2}\sin\theta$

Sol. (2) A–P, B – S, C – Q, D – R

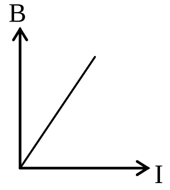
Q.19

Column-I	**Column-II**
(A) A charge particle is moving in uniform electric & magnetic field in gravity free space	(P) velocity of the particle may be constant
(B) A charge particle is moving in uniform electric field and gravitational field (where magnetic field is zero)	(Q) path of the particle may be straight line
(C) A charge particle is moving in uniform magnetic field and gravitational fields (where electric field is zero)	(R) path of the particle may be circular
(D) A charge particle is moving in only uniform electric field	(S) path of the particle may be helical
	(T) kinetic energy of particle may be constant

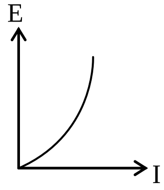
Sol. (A) P, Q, S, T; **(B)** P, Q, T; **(C)** P, Q, S, T; **(D)** Q

Q.1 If B and E denote induction of magnetic field and energy density at the midpoint of a long solenoid carrying a current I, then which of the following graphs is/are correct ?

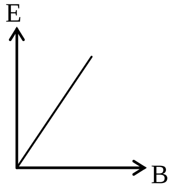
(A)



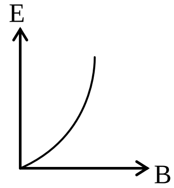
(B)



(C)

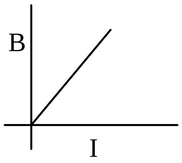


(D)



Sol. **[A,B,D]**

$B = \mu_0 nI$



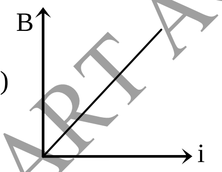
$E = \dfrac{B^2}{2\mu_0} \propto I^2$

Option B is also correct

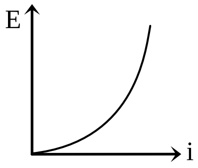
Option D is also correct

Q.2 If B and E denote induction of magnetic field and energy density at the mid-point of a long solenoid carrying a current i, then which of the following graph is/are correct –

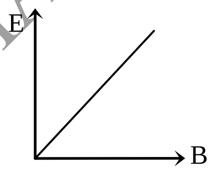
(A)



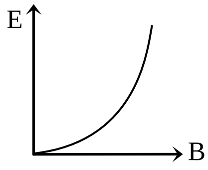
(B)



(C)

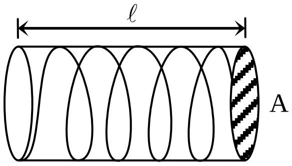


(D)



[A,B,D]

Sol.



$\phi = NBA$

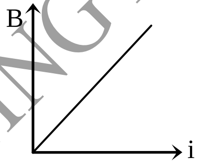
$= N \times \mu_0 ni \times A$

$= \dfrac{N \times \mu_0 NiA}{\ell} = \dfrac{N^2 \mu_0 iA}{\ell}$

$\phi = Li$

$L = \dfrac{N^2 \mu_0 A}{\ell}$

$B = \mu_0 ni$



$\text{Energy} = \dfrac{1}{2} Li^2$

$\text{Energy density} = \dfrac{1}{2} \dfrac{Li^2}{(\text{volume})}$

$= \dfrac{1}{2} \times \dfrac{N^2 \times \mu_0 A \times i^2}{\ell \times A \times \ell}$

$E = i^2 K$ parabolic variation

$B = \mu_0 ni$

$\therefore E = B^2 \times K'$

Q.3 A region has uniform electric field and magnetic field along the positive x-direction. An electron is fired from the origin at an angle θ (< 90°) with the x-axis. It will -

(A) move along a helical path of increasing radius

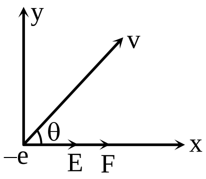
(B) move along a helical path of decreasing pitch initially

(C) return to the y-z plane at some time

(D) come to rest momentarily at some position

[B,C]

Sol.



It will go on helical path of decreasing pitch.

Q.4 When a charged particle moves in electric or magnetic fields, its speed is v and acceleration is a . Then

(A) in a magnetic field, v is constant if the particle moves in a circular path and variable if it moves in a helical path.

(B) in a magnetic field, v is always constant, a may or may not be zero

(C) in an electric field, v can never remain constant

(D) in a uniform electric field, a must be constant in magnitude and direction.

[B,C,D]

Q.5 A long straight wire carries a current along the x–axis. Consider the points A(0, 1, 0), B(0, 1, 1) C(1, 0, 1) and D(1, 1, 1). Which of the following pairs of points will have magnetic fields of the same magnitude ?

(A) A and B (B) A and C

(C) B and C (D) B and D

[B,D]

Q.6 A straight wire carries a current. Assume that all free electrons in the conductor move with the same drift velocity v. A and B are two observers on a straight line xy parallel to the conductor. A is stationary, B moves along xy with a velocity v in the direction of the free electrons.

(A) A and B observe the same magnetic field

(B) A observes a magnetic field, B does not

(C) A and B observe magnetic fields of the same magnitude but opposite directions

(D) A and B do not observe any electric field

[A,D]

Q.7 A current flows through a straight cylindrical conductor of radius r. The current is distributed uniformly over its cross section. The magnetic field at a distance x from the axis of the conductor has magnitude B.

(A) B = 0 at the axis

(B) $B \propto x$ for $0 \le x < r$

(C) $B \propto \frac{1}{x}$ for $x > r$

(D) B is maximum for x = r **[All]**

Q.8 If a charged particle at rest experiences no electromagnetic force -

(A) the electric field must be zero

(B) the magnetic field must be zero

(C) the electric field may or may not be zero

(D) the magnetic field may or may not be zero

[A,D]

Q.9 A charged particle moves in a gravity free space without change in velocity. Which of the following are correct

(A) E = 0, B = 0 (B) $E = 0, B \neq 0$

(C) $E \neq 0, B = 0$ (D) $E \neq 0, B \neq 0$

[A,B,D]

Q.10 A charged particle goes undeflected in a region containing electric and magnetic field. It is possible that -

(A) $\vec{E} \parallel \vec{B}$, $\vec{v} \parallel \vec{E}$

(B) $\vec{E}$ is not parallel to $\vec{B}$

(C) $\vec{v} \parallel \vec{B}$ but $\vec{E}$ is not parallel to $\vec{B}$

(D) $\vec{E} \parallel \vec{B}$ but $\vec{v}$ is not parallel to $\vec{E}$

[A,B]

Q.11 An electron is moving along the positive x-axis, you want to apply a magnetic field for a short time so that the electron may reverse its direction and move parallel to the negative x-axis. This can be done by applying the magnetic field along –

(A) Y-axis (B) Z-axis

(C) Y- axis only (D) Z-axis only

[A,B]

Q.12 When a current carrying loop is placed in a uniform magnetic field -

(A) $\vec{F}_R = 0$ and $\vec{\tau} = 0$

(B) $\vec{F}_R = 0$ and $\vec{\tau} \neq 0$

(C) $\vec{F}_R \neq 0$ and $\vec{\tau} = 0$

(D) $\vec{F}_R \neq 0$ and $\vec{\tau} \neq 0$ **[A,B]**

.

Q.13 H^+, He^+ and O^{+2} all having the same kinetic energy pass through a region in which there is a uniform magnetic field perpendicular to their velocity. The masses of H^+, He^+ and O^{+2} are 1 amu, 4 amu and 16 amu respectively, then-

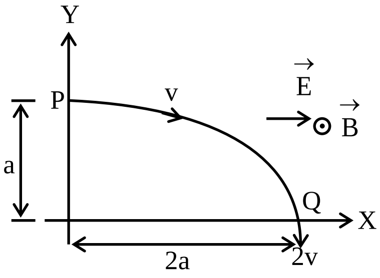
(A) H^+ will be deflected most

(B) O^{+2} will be deflected most

(C) H^+ and O^{+2} will be deflected equally

(D) All will be deflected equally **[A]**

Q.14 A particle of charge +q and mass m moving under the influence of a uniform electric field $E\hat{i}$ and a uniform magnetic field $B\hat{k}$ follows a trajectory from P to Q as shown in the fig. The velocities at P and Q are $v\ \hat{i}$ and $-2v\hat{j}$. Which of the following statement(s) is/are correct? **[IIT-1991]**



(A) $E = \frac{3}{4}\left(\frac{mv^2}{qa}\right)$

(B) Rate of work done by the electric field at P is $\frac{3}{4}\left(\frac{mv^3}{a}\right)$

(C) Rate of work done by the electric field at P is zero

(D) Rate of work done by both the fields at Q is zero. **[A,B,D]**

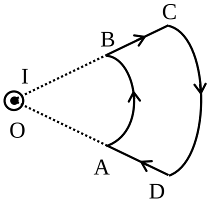
Q.15 A long straight wire along the z-axis carries a current I in the negative z direction. The magnetic vector field $\vec{B}$ at a point having coordinates (x, y) in the z = 0 plane is- **[IIT-2002]**

(A) $\frac{\mu_0 I(y\hat{i} - x\hat{j})}{2\pi(x^2 + y^2)}$ (B) $\frac{\mu_0 I(x\hat{i} + y\hat{j})}{2\pi(x^2 + y^2)}$

(C) $\frac{\mu_0 I(x\hat{j} - y\hat{i})}{2\pi(x^2 + y^2)}$ (D) $\frac{\mu_0 I(x\hat{i} - y\hat{j})}{2\pi(x^2 + y^2)}$

[A,D]

Q.16 An infinite wire carrying current I passes through point O perpendicular to the plane containing a current carrying loop ABCD as shown in the figure. **[IIT-2006]**



(A) Net force on the loop is zero

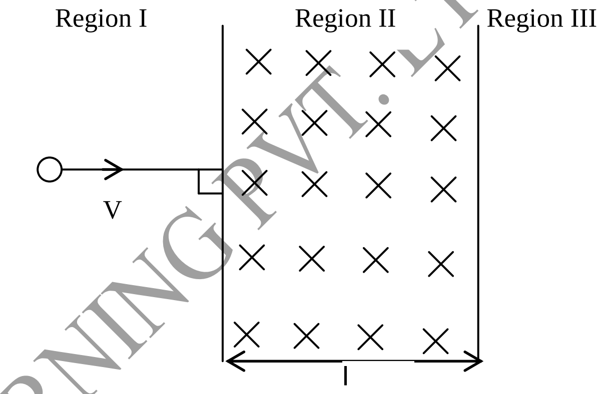
(B) Net torque on the loop is zero

(C) The loop rotates in anticlockwise direction as seen from O

(D) The loop rotates in clockwise direction as seen from O **[A,D]**

Q.17 A particle of mass m and charge q, moving with velocity V enters Region II normal to the boundary as shown in the figure. Region II has a uniform magnetic field B perpendicular to the plane of the paper. The length of the Region II is l. Choose the correct choice(s). **[IIT-2008]**

Figure :



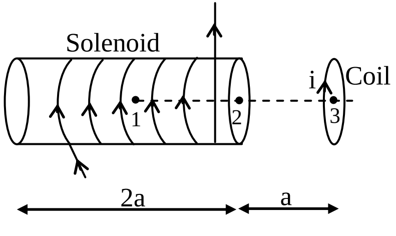
(A) The particle enters Region III only if its velocity $V > \frac{qlB}{m}$

(B) The particle enters Region III only if its velocity $V < \frac{qlB}{m}$

(C) Path length of the particle in Region II is maximum when velocity $V = \frac{qlB}{m}$

(D) Time spent in Region II is same for any velocity V as long as the particle returns to Region I **[A,C,D]**

Q.18 Point 1 is at middle of solenoid, point (2) at an end face and point (3) is outside the solenoid at a distance a. Plane of coil and plane of cross-section of solenoid are parallel -



(A) Force between coil and solenoid is attractive at all three points (i.e. 1, 2, 3)

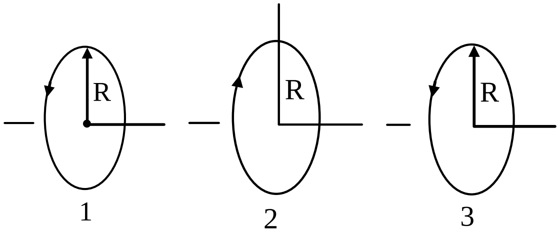
(B) Force between coil and solenoid at the point 1 is zero

(C) Among these three point force between coil and solenoid is maximum at point 2

(D) Among these three point force between coil and solenoid is maximum at point 1

[A,B,C]

Q.19 Direction of current in coil (2) is opposite to direction of current in coil (1) and coil (3). All three coils are coaxial and equidistant coil (1) and coil (3) are fixed while coil (2) is suspended thus able to move freely. Then –



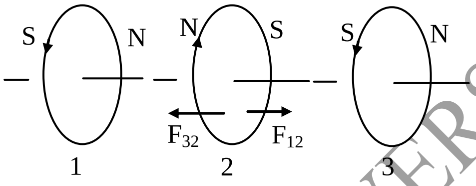
(A) coil (2) is in equilibrium

(B) equilibrium state of coil (2) is stable equilibrium along axial direction

(C) equilibrium state of coil (2) is unstable equilibrium along axial direction

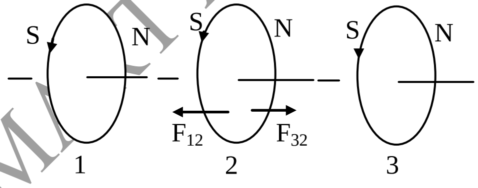
(D) if direction of current in coil (2) is same as that of coil (1) and coil (3) then state of equilibrium of coil (2) along axial direction is unstable **[A,B,D]**

Sol.



$\vec{F}_{32} = -\vec{F}_{12}$ ∴ coil is in equilibrium,

If coil (2) is slightly displaced in left side then F_{12} become greater than F_{32} thus coil (2) go to its previous position i.e. in right side. Thus coil (2) is in equilibrium state along axial direction. If direction of coil (2) is in same direction, then



$$\vec{F}_{12} = -\vec{F}_{32}$$

If coil (2) is displaced in left side then $\left|\vec{F}_{12}\right| = \left|-\vec{F}_{32}\right|$, then coil will go in left side. Therefore equilibrium is unstable.

Q.20 A solenoid is connected to a source of constant emf for a long time. A soft iron piece is inserted into it. Then –

(A) self inductance of the solenoid gets increased

(B) flux linked with the solenoid increases hence steady state current gets decrease

(C) energy stored in the solenoid gets increased

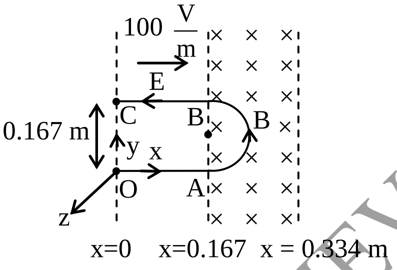
(D) magnetic moment of the solenoid increased

[A,C,D]

Q. 1 There is a constant homogeneous electric field of 100Vm^{-1} within the region x = 0 and x = 0.167 m pointing in the positive x-direction. There is a constant homogeneous magnetic field B within the region x = 0.167 m and x = 0.334m pointing in the z-direction. A proton at rest at the origin (x = 0, y = 0) is released in the positive x-direction. The minimum strength of the magnetic field B, so that the proton will come back at x = 0, y = 0.167 m (mass of the proton= 1.67 × 10^{-27} kg) is...........mT.

Sol. **[0007]**

The situation described in the problem is shown in fig As electric field is along x-axis, so proton will be accelerated by the electric field and will enter the magnetic field at A(i.e., x = 0.167, y = 0) with velocity v along x-axis such that



$$\frac{1}{2}mv^2 = W = Fd = qEd$$

$$\text{i.e. } v = \left[\frac{2qEd}{m}\right]^{1/2}$$

$$= \left[\frac{2\times1.6\times10^{-19}\times100\times0.167}{1.67\times10^{-27}}\right]^{1/2}$$

$$= 4\sqrt{2} \times 10^4 \frac{m}{s}$$

Now as proton is moving perpendicular to magnetic field so it will describe a circular path in the magnetic field with radius r such that

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

And as it comes back at C[x = 0; y = 0.167m] its path in the magnetic field will be a semicircle such that

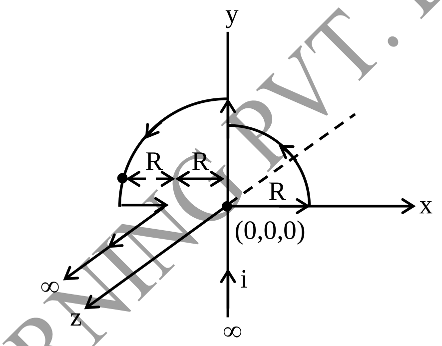
$$y = 2r = \frac{2mv}{qB} \text{ i.e. } B = \frac{2mv}{qy}$$

$$\text{i.e., } B = \frac{2\times1.67\times10^{-27}\times4\sqrt{2}\times10^4}{1.6\times10^{-19}\times0.167}$$

$$= \frac{1}{\sqrt{2}} \times 10^{-2}$$

= 7.07 mT

Q.2

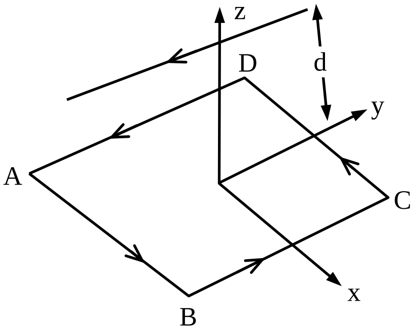


If Magnetic induction at origin is given by $\frac{\mu_0 I}{4R}\left(\frac{a}{4}\hat{k}+\frac{b}{\pi}\hat{j}\right)$

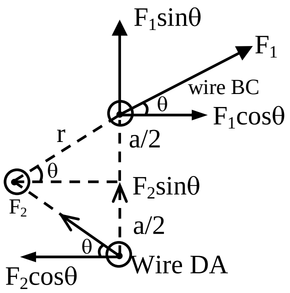
Then a × b = …..

Sol.[3] Magnetic induction at origin is due to one semi-infinite wire and two quarter circle of radii R and 2 R.

Q.3 Figure shows a square loop. 20 cm on each side in the x-y plane with its centre at the origin. The loop carries a current of 7A. Above it at y = 0, z = 12cm is an infinitely long wire parallel to the x axis carrying a current of 10 A. The net force on the loop is ------×10^{-4}N.



Sol. [6]



Total force = $(F_1 + F_2)\sin\theta$

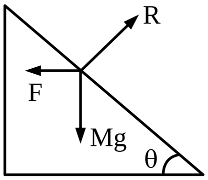
$$F_1 = F_2 = \frac{\mu_0 i_1 i_2}{2\pi r}\frac{a}{2r}$$

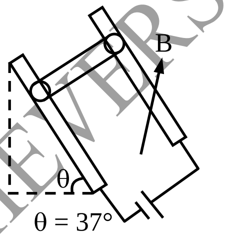
$$= \frac{\mu_0 i_1 i_2 a}{4\pi r^2}$$

$= 6 \times 10^{-4}$ Newton

Q.4 Two conducting rails are connected to a source of emf and form an incline as shown in figure. A bar of mass 50g slides without friction down the incline through a vertical magnetic field B. If the length of the bar is 50 cm and a current of 2.5 A is provided by battery. Value of B for which the bar slide at a constant velocity ……..$\times 10^{-1}$ Tesla. [$g = 10$ m/s^2]

Sol. [3]





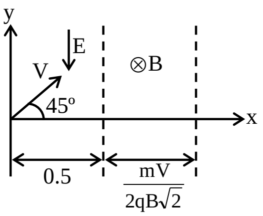
$F\cos\theta = Mg\sin\theta$

$BIL\cos\theta = Mg\sin\theta$

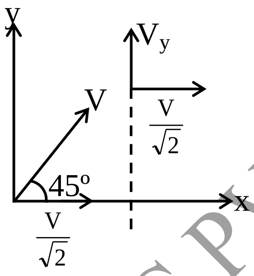
$$B = \frac{Mg}{IL}\tan\theta$$

= 0.3 Tesla

Q.5 A charge particle of charge q and mass m is projected in a region which contains electric and magnetic field as shown in figure with velocity V at an angle 45° with x-direction. If $V = \sqrt{\frac{qE}{m}}$, then net deviation in particle motion will be (neglect the effect of gravity) in clockwise direction approx in radian …….. .



Sol. **[1]**



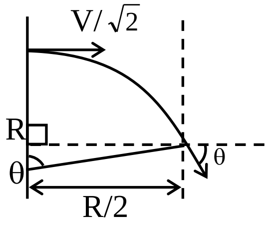
$$0.5 = \frac{Vt}{\sqrt{2}},\ t = \frac{\sqrt{2}\times 0.5}{V}$$

$$V_y = \frac{V}{\sqrt{2}} - \frac{qE}{m}\times t$$

$$V_y = \frac{V}{\sqrt{2}} - \frac{V^2}{\sqrt{2}V},\ V_y = 0$$

$$R = \frac{mV}{qB} = \frac{mV}{\sqrt{2}qB}$$

$$\sin\theta = \frac{R}{2R} = \frac{1}{2},\ \theta = 30^\circ$$



Deviation = 45° + 30° = 75° clockwise.

Q.6 A small plate of a metal (work function = 1.17 eV) is placed at a distance of 2 m from a monochromatic light source of wavelength 4800 Å and power 1.0 watt. The light falls normally on the plate. If a constant magnetic field of strength 10^4 Tesla is applied parallel to metal surface. Find the radius (in cm) of the largest circular path followed by the emitted photo electrons.

Sol. **[4]**

Energy of incident photon is eV is

$$E = \frac{12431}{4800}\text{eV} = 2.58 \text{ eV} = 2.58 \times 1.6 \times 10^{-19} \text{ J}$$

$= 4.125 \times 10^{-19}$J.

The rate of emission of photon from source

$r = I/E = \frac{10\,\text{joule/sec}}{4.125\times10^{-19}\,\text{joule}}$ = 2.424 × 10^{18}/sec

No. of photon striking per square metal per sec on the plate

$= \frac{2.425\times10^{18}}{4\times3.14\times(2)^2}$ = 4.82 × 10^{16} m^{-2} sec^{-1}

The maximum kinetic energy of the photo electrons emitted from the plate having work function ϕ = 1.17 eV is given by

KE_{max} = E – ϕ = 2.58 – 1.17 – 1.41 eV

The maximum velocity of photo electrons ejected is given as 1/2 m V_{max}^2 = 1.41 eV

or $V_{max} = \sqrt{\frac{2\times1.41\times1.6\times10^{-19}}{9.1\times10^{-31}}}$

= 7.036 × 10^5 m/sec

The radius of the circle traversed by photo electrons in magnetic field B is given by

$r = \frac{mV}{qB} = \frac{(9.1\times10^{-31})(7.036\times10^5)}{(1.6\times10^{-19})(10^{-4})}$

= 40.0 × 10^{-3}meter (as qVB = $\frac{mV^2}{r}$) = 4.0 cm.

Q.7 A charged particle is accelerated through a potential difference of 12 kV and acquires a speed of 10^6 ms^{-1}. It is projected perpendicularly into the magnetic field of strength 0.2 T. The radius of circle described is.............. × 10 cm.

Sol.[0001] $R = \frac{mv}{qB}$

$q \times 12 \times 10^3 = \frac{1}{2} m \times (10^6)^2$

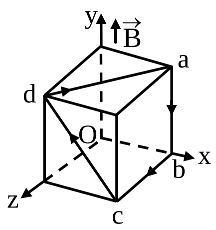
$\frac{24\times10^3}{10^{12}} = \frac{m}{q}$

$R = \frac{24\times10^3\times10^6}{10^{12}\times0.2}$

R = 12 × 10^{-2} m

R = 12 cm

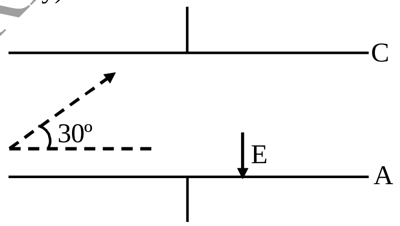
Q.8 In figure, the cube is 40.0 cm on each edge. Four straight segments of wire ab, bc, cd and da form a closed loop that carries a current I = 5.00 A, in the direction shown. A uniform magnetic field of magnitude B = 0.020 T is in the positive y-direction. Determine the magnitude and direction of the magnetic force on each segment.



Sol. $\vec{F}_{ab} = 0, \vec{F}_{bc} = (-0.04N)\,\hat{i}$,

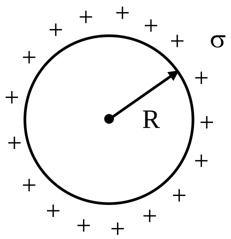
$\vec{F}_{cd} = (-0.04N)\,\hat{k}, \vec{F}_{da} = (0.04\hat{i} + 0.04\hat{k})N$

Q.9 A charged particle having charge 10^{-6} C and mass of 10^{-10} kg is fired from the middle of the plate making an angle 30º with plane of the plate. Length of the plate is 0.17 m and it is separated by 0.1m. Electric field E = 10^{-3} N/C is present between the plates. Just outside the plates magnetic field is present. Find the velocity of projection of charged particle and magnitude of the magnetic field perpendicular to the plane of the figure, if it has to graze the plate at C and A parallel to the surface of the plate.(Neglect gravity)



Sol. 2.0 m/s, 3.46 mT

Q.10 Consider a uniformly charged spherical shell of radius R as shown in figure. Calculate the force experienced by the upper half of shell



Sol. $\frac{\sigma}{2\varepsilon_0}(\pi R^2)$

Q.11 A current I = 10A flows in a ring of radius r_0 =15 cm made of a very thin wire. The tensile strength of the wire is equal to T = 1.5 N. The ring is placed in a magnetic field, which is perpendicular to the plane of the ring so that the forces tend to break the ring. Find B at which the ring is broken.

Sol. 1 T

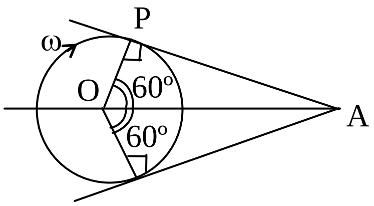
PHYSICS

Q.1 An α particle is moving along a circle of radius R with a constant angular velocity ω. Point A lies in the same plane at a distance 2R from the centre. Point A records magnetic field produced by α particle, if the minimum time interval between two successive times at which A records zero magnetic field is 't' the angular speed ω, in terms of t is :

(A) $\frac{2\pi}{t}$ (B) $\frac{2\pi}{3t}$

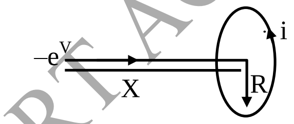
(C) $\frac{\pi}{3t}$ (D) $\frac{\pi}{t}$ **[B]**

Sol. Point A shall record zero magnetic field (due to α-particle) is at position P and Q as shown in figure. The time taken by α-particle to go from P to Q is –



$t = \frac{1}{3}\frac{2\pi}{\omega}$ or $\omega = \frac{2\pi}{3t}$

Q.2 An electron moving with velocity v along the axis approaches a circular current carrying loop as shown in the figure. The magnitude of magnetic force on electron at this instant is-



(A) $\frac{\mu_0}{Z}\frac{eviR^2X}{(X^2+R^2)^{3/2}}$ (B) μ_0

$\frac{eviR^2X}{(X^2+R^2)^{3/2}}$

(C) $\frac{\mu_0}{4\pi}\frac{eviR^2X}{(X^2+R^2)^{3/2}}$ (D) 0 **[D]**

Sol. Direction of electron velocity is along magnetic lines of flux. Hence F = O

Q.3 Cyclotron is used to accelerate –

(A) electrons (B) neutrons

(C) positive ions (D) negative ions

[C]

Q.4 An electron of charge e moves in a circular orbit of radius r around the nucleus at a frequency ν. The magnetic moment associated the orbital motion of the electron is –

(A) $\pi\,\nu\,e\,r^2$ (B) $\frac{\pi\nu r^2}{e}$

(C) $\frac{\pi\nu e}{r}$ (D) $\frac{\pi e r^2}{\nu}$ **[A]**

Sol. M = iA

$= (e\nu)\ \pi r^2$

Q.5 A proton, a dutron and an α particle with the same KE enter in a region of uniform magnetic field, moving at right angles to B. what is the ratio of the radii of their circular paths ?

(A) $1 : \sqrt{2} : 1$ (B) $1 : \sqrt{2} : \sqrt{2}$

(C) $\sqrt{2} : 1 : 1$ (D) $\sqrt{2} : \sqrt{2} : 1$ **[A]**

Sol. $r_P = \frac{\sqrt{2m_pK}}{eB}$

$r_d = \frac{\sqrt{2(2m_p)K}}{eB}$

$r_\alpha = \frac{\sqrt{2(4m_p)K}}{(2e)B}$

Q.6 A long straight wire carrying a current of 30 A is placed in an external uniform magnetic field of induction 4×10^{-4} T. The magnetic field is acting parallel to the direction of current. The magnitude of the resultant magnetic induction in tesla at a point 2.0 cm away from the wire is -

(A) 10^{-4} (B) 3×10^{-4}

(C) 5×10^{-4} (D) 6×10^{-4} **[C]**

Sol. Magnetic field due to wire

$$B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\times10^{-7}}{2\pi} \times \frac{30}{2\times10^{-2}}$$

$= 3 \times 10^{-4}$ T

This magnetic field will be perpendicular to external magnetic field.

∴ Net magnetic field

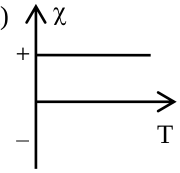
$$B = \sqrt{B^2 + B_0^2}$$

$$= \sqrt{(3\times10^{-4})^2 + (4\times10^{-4})^2}$$

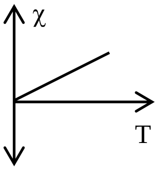
$$= 5 \times 10^{-4} \text{ T}$$

Q.7 Which one of the following graphs represents the behaviour of magnetic susuptibility (χ) of the paramagnetic substance with the temperature T ?

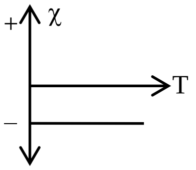
(A)



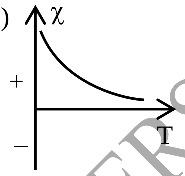
(B)



(C)



(D)

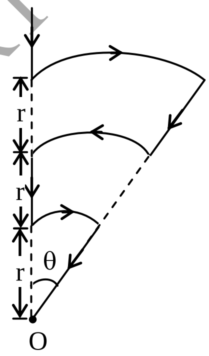


[D]

Sol. From curie law

$$\chi \propto \frac{1}{T}$$

Q. 8 Shown in the figure is a conductor carrying a current I. The magnetic field intensity at the point O(common centre of all the three arcs) is :



(A) $\frac{5\mu_0 I\theta}{24\pi r}$ (B) $\frac{\mu_0 I\theta}{24\pi r}$

(C) $\frac{11\mu_0 I\theta}{24\pi r}$ (D) zero

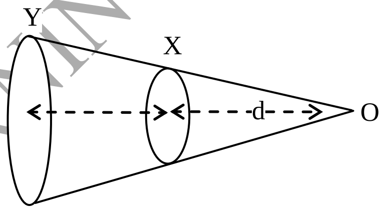
Sol. **[A]**

Hint : Find B due to each arc at O and add them using vector addition.

Since magnetic field at the centre of an arc is equal to $B = \frac{\mu_0 I}{4\pi r}\theta$

hence, net $B = \frac{\mu_0 I}{4\pi}\left[\frac{1}{r} - \frac{1}{2r} + \frac{1}{3r}\right]\theta = \frac{5\mu_0 I\theta}{24\pi r}$

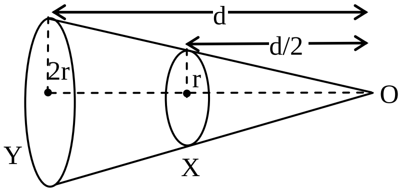
Q. 9 Two circular coils X and Y have equal number of turn and carry equal currents in the same sense and subtend same solid angle at point O. If the smaller coil X is midway between O and Y , then if we represent the magnetic induction due to bigger coil Y at O as B_Y and that due to smaller coil X at O B_x, then :



(A) $\frac{B_Y}{B_X} = 1$ (B) $\frac{B_Y}{B_X} = 2$

(C) $\frac{B_Y}{B_X} = \frac{1}{2}$ (D) $\frac{B_Y}{B_X} = \frac{1}{4}$

Sol. **[C]**



As two coils subtend the same solid angle at O, hence area of coil, Y = 4 × area of coil X

$$\left[\text{Solid angle} = \frac{\text{area}}{(\perp \text{distance})^2}\right]$$

i.e. radius of coil Y = 2 × radius of coil X

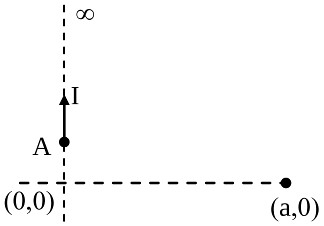
$$\therefore B_Y = \frac{\mu_0}{4\pi} \times \frac{2\pi I(2r)^2}{[(2r)^2 + (d^2)]^{3/2}}$$

$$B_X = \frac{\mu_0}{4\pi} \times \frac{2\pi I(r)^2}{\left[r^2 + \left(\frac{d}{2}\right)^2\right]^{3/2}}$$

$$\therefore \frac{B_Y}{B_X} = \frac{4}{(4r^2 + d^2)^{3/2}} \times \left[\frac{4r^2 + d^2}{4}\right]^{3/2}$$

$$= \frac{4}{(4)^{3/2}} = \frac{4}{8} = \frac{1}{2}$$

Q.10 An infintely long wire carrying current I is along y-axis such that its one end is at point A(0, b) while the wire extends upto + ∞. The magnitude of magnetic field strength at point (a, 0).



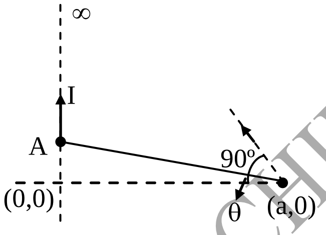
(A) $\frac{\mu_0 I}{4\pi a}\left(1+\frac{b}{\sqrt{a^2+b^2}}\right)$

(B) $\frac{\mu_0 I}{4\pi a}\left(1-\frac{b}{\sqrt{a^2+b^2}}\right)$

(C) $\frac{\mu_0 I}{4\pi a}\left(\frac{b}{\sqrt{a^2+b^2}}\right)$

(D) None of these

Sol. **[B]**



$$B = \frac{\mu_0}{4\pi}\ \frac{i}{a}\ (\sin 90^\circ + \sin(-\theta))$$

$$= \frac{\mu_0}{4\pi}\ \frac{i}{a}\left(1-\frac{b}{\sqrt{a^2+b^2}}\right)$$

Q.11 A point charge is moving in clockwise direction in a circle with constant speed. Consider the magnetic field produced by the charge at a point P (not centre of the circle) on the axis of the circle.

(A) it is constant in magnitude only

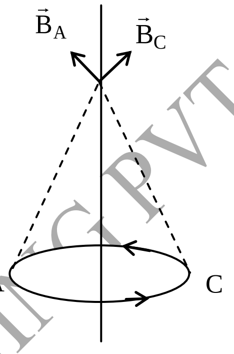
(B) it is constant in direction only

(C)it is constant in direction and magnitude both

(D) it is not constant in magnitude and direction both

Sol. **[A]**

The point charge moves in circle as shown in figure. The magnetic field vectors at a point P on axis of circle are $\vec{B}_A$ and $\vec{B}_C$ at the instants the point charge is at A and C respectively as shown in the figure.



Hence as the particles rotates in circle, only magnitude of magnetic fiels remains constant at the point on axis P but it's direction changes.

⇒ Alternate solution ⇒

The magnetic field at point on the axis due to charged particle moving along a circular path is given by

$$\frac{\mu_0}{4\pi}\ \frac{q\vec{v}\times\vec{r}}{r^3}$$

It can be seen that the magnitude of the magnetic field at on point on the axis remains constant. But the direction of the field keeps on changing.

Q.12 A particle of charge Q and of negligible initial speed is accelerated through a potential difference of U. The particle reaches a region of uniform magnetic field of induction B, where it undergoes circular motion . If potential difference is doubled and B is also doubled then magnetic moment of the circular current due to circular motion of charge Q will become.

(A) double (B) half

(C) four times (D) remain same

Sol. **[A]**

K.E = QU

magnetic moment = i × Area

$$= \frac{Q}{T} \times \pi R^2$$

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

$$R = \sqrt{\frac{2mKE}{qB}} = \sqrt{\frac{2mU}{qB}}$$

$$\text{Magnetic moment} = \frac{Q^2 \times B}{2\pi m} \times \frac{\pi \times 2m \times U}{QB}$$

Magnetic moment = QU

Q.13 Consider a toroid of circular cross-section of radius b, major radius R much greater than minor radius b. Find the total energy stored in toroid. (I is current)

(A) $\frac{\mu_0 N^2 I^2 b^2}{2R}$ (B) $\frac{\mu_0 N^2 I^2 b^2}{3R}$

(C) $\frac{\mu_0 N^2 I^2 b^2}{6R}$ (D) $\frac{\mu_0 N^2 I^2 b^2}{4R}$

Sol. **[D]**

$$B = \frac{\mu_0 Ni}{2\pi R}$$

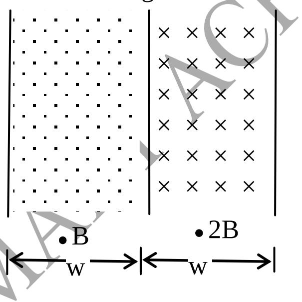
$$\phi = \pi b^2 \times B \times N$$

$$\phi = Li$$

$$L = \frac{\phi}{i} = \frac{\mu_0 N^2 b^2}{2R} \text{ with } b < << R$$

$$\text{energy} = \frac{1}{2} Li^2 = \frac{\mu_0 N^2 I^2 b^2}{4R}$$

Q. 14 The magnetic field shown in the figure consist of the two magnetic filled.

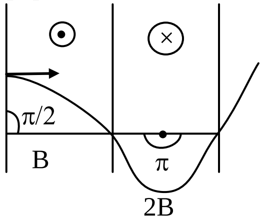


if v is the velocity just required for a charge particle of mass m and charge q to pass through the magnetic field. Particle is projected with velocity "v" then, how much time does such a charge spend in the magnetic field.

(A) $\frac{\pi m}{2qB}$ (B) $\frac{\pi m}{qB}$

(C) $\frac{\pi m}{4qB}$ (D) $\frac{3\pi m}{2qB}$

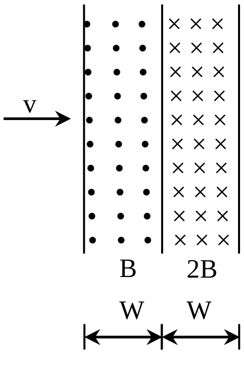
Sol. **[B]**



$$\text{Time} = \frac{\pi m}{2qB} + \frac{\pi m}{2qB}$$

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

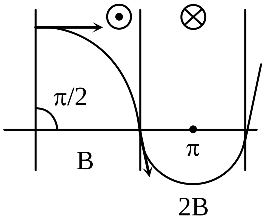
Q.15 Region of the magnetic field shown in the figure consist of two uniform magnetic fields. If v is the velocity just required for a charge q of particle of mass m and charge to pass through the region of magnetic field. Particle is projected with velocity "v' then how much time does such a charge spend in the region of magnetic field ?



(A) $\frac{\pi m}{2qB}$ (B) $\frac{\pi m}{qB}$

(C) $\frac{\pi m}{4qB}$ (D) $\frac{3\pi m}{2qB}$

Sol. **[B]**



$$\text{Time} = \frac{\pi m}{2qB} + \frac{\pi m}{2qB}$$

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

Q.16 Two long concentric cylindrical conductors of radii a & b (b < a) are maintained at a potential difference V & carry equal & opposite currents I. An electron with a particular velocity "U" parallel to the axis will travel undeviated in the evacuated region between the conductors. Then U =

(A) $\dfrac{4\pi V}{\mu_0 I \ell n\left(\frac{b}{a}\right)}$ (B) $\dfrac{2\pi V}{\mu_0 I \ell n \frac{a}{b}}$

(C) $\dfrac{2\pi V}{\mu_0 I \ell n\left(\frac{b}{a}\right)}$ (D) $\dfrac{8\pi V}{\mu_0 I \ell n\left(\frac{a}{b}\right)}$

Sol. **[B]**

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

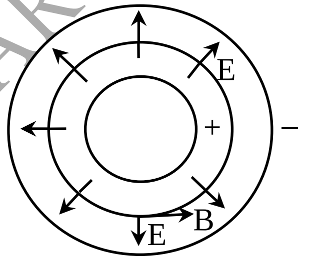
p.d. $V = \dfrac{\lambda}{2\pi\varepsilon_0}\ell n\left(\dfrac{a}{b}\right)$

$$E = \frac{V}{r\ell n\left(\frac{a}{b}\right)}$$

B varies with r

$$B = \frac{\mu_0 I}{2\pi r}$$

B & E are perpendicular to each other

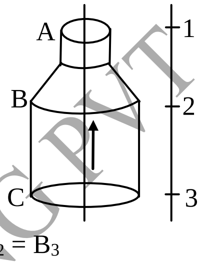


$\therefore$ qUB = qE

(if particle travel undeviated)

$$U = \frac{E}{B} = \frac{2\pi V}{\mu_0 I \ell n\left(\frac{a}{b}\right)}$$

Q.17 A long, straight, hollow conductor (tube) carrying a current has two sections A and C of unequal cross-sections joined by a conical section B. 1, 2 and 3 are points on a line parallel to the axis of the conductor. The magnetic fields at 1, 2 and 3 have magnitudes B_1, B_2 and B_3 respectively, then :



(A) $B_1 = B_2 = B_3$

(B) $B_1 = B_2 \neq B_3$

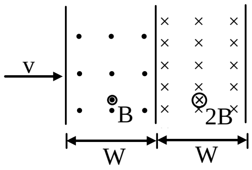
(C) $B_1 < B_2 < B_3$

(D) B_2 cannot be found unless the dimensions of the section B are known

Sol. **[A]**

To find the magnetic field outside a thick conductor, the current may be assumed to flow along the axis. As points 1 , 2 , 3 are equidistant from the axis, $B_1 = B_2 = B_3$

Q.18 The magnetic field shown in the figure consist of the two magnetic fields.

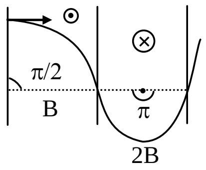


If v is the velocity just required for a charge particle of mass m and charge q to pass through the magnetic field. Particle is projected with velocity 'v' then how much time does such a charge spend in the magnetic field –

(A) $\dfrac{\pi m}{2qB}$ (B) $\dfrac{\pi m}{qB}$

(C) $\dfrac{\pi m}{4qB}$ (D) $\dfrac{3\pi m}{2qB}$ **[B]**

Sol.



$$\text{Time} = \frac{\pi m}{2qB} + \frac{\pi m}{2qB} = \frac{\pi m}{qB}$$

Q.19 Fig. shows a circular wire of radius r carrying a current i. The force of compression on the wire is –

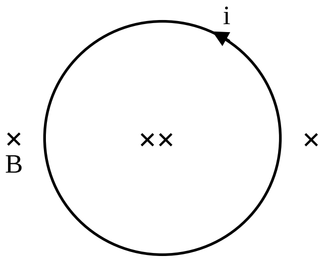


Fig.

(A) 2iaB (B) iaB

(C) 2πiaB (D) None of these

[B]

Sol. dF = idlB

$$F = \int idlB = iaB$$

Q.20 A coil having N turns is wound tightly in the form of a spiral with inner and outer radii **a** and **b** respectively. When current I passes through the coil, the magnetic field at the centre is –

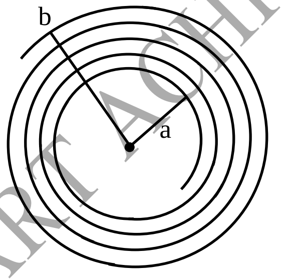


Fig.

(A) $\frac{N\mu_0 i}{2(b-a)} \log_e \frac{b}{a}$

(B) $\frac{N\mu_0 i}{2(b-a)} \log_e \frac{b+a}{b-a}$

(C) $\frac{2N\mu_0 i}{(b+a)} \log_e \frac{b}{a}$

(D) None of these **[A]**

Sol. Magnetic induction due to a circular current-carrying loop at x is dB = $\frac{\mu_0 i}{2x}$ (dN)

Total magnetic field at the centre (due to all loops)

$$B = \int \frac{\mu_0 i}{2x} dN$$

$$= \int_a^b \frac{\mu_0 i}{2x} \frac{N}{(b-a)} dx$$

$$= \frac{\mu_0 i N}{2(b-a)} \log_e \frac{b}{a}$$

Q.21 A particle of charge q = 4 μC and mass m = 10 mg starts moving from the origin under the action of an electric field $\vec{E} = 4\hat{i}$ and magnetic field $\vec{B} = (0.2T)\hat{k}$. Its velocity at (x, 3, 0) is $(4\vec{i} + 3\vec{j})$. The value of x is –

(A) $\frac{115}{16}$m (B) $\frac{125}{16}$m

(C) $\frac{135}{16}$m (D) $\frac{145}{16}$m **[B]**

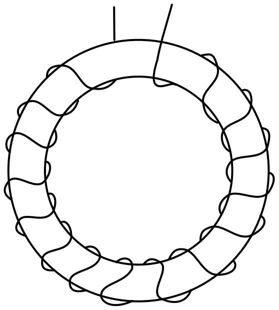
Sol. W (qE) = $\frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2 - 0$

⇒ $4 \times 10^{-6} \times 4x = \frac{1}{2} m (4^2 + 3^2)$

$$4 \times 10^{-6} \times 4 \times x = \frac{1}{2} \times 10 \times 10^{-6} \times 25$$

$$x = \frac{250}{32} m = \frac{125}{16} m$$

Q.22 Consider a toroid of circular cross-section of radius b, major radius R much greater than minor radius b, (see diagram) find the total energy stored in magnetic field of toroid –



(A) $\frac{B^2\pi^2b^2R}{2\mu_0}$ (B) $\frac{B^2\pi^2b^2R}{4\mu_0}$

(C) $\frac{B^2\pi^2b^2R}{8\mu_0}$ (D) $\frac{B^2\pi^2b^2R}{\mu_0}$ **[D]**

Sol. $B = \frac{\mu_0 Ni}{2R}$

$\phi = \pi b^2 \times B \times N$

$\phi = Li$

$L = \frac{\phi}{i} = \frac{\mu_0 N^2 b^2}{2R}$, with $b <<< R$

$\text{Energy} = \frac{1}{2} Li^2 = \frac{\mu_0 N^2 i^2}{4R} b^2$

Q.23 Two circular coils made of similar wires but of radius 20 cm and 40 cm are connected in parallel. The ratio of magnetic fields at their centre is -

(A) 4 : 1 (B) 1 : 4

(C) 2 : 1 (D) 1 : 2 **[A]**

Sol. $\frac{B_1}{B_2} = \frac{I_1}{I_2} \times \frac{r_2}{r_1}$

But $\frac{I_1}{I_2} = \frac{V/R_1}{V/R_2} = \frac{R_2}{R_1} = \frac{\rho \ell_2 / A}{\rho \ell_1 / A} = \frac{\ell_2}{\ell_1}$

$= \frac{2\pi r_2}{2\pi r_1} = \frac{r_2}{r_1}$

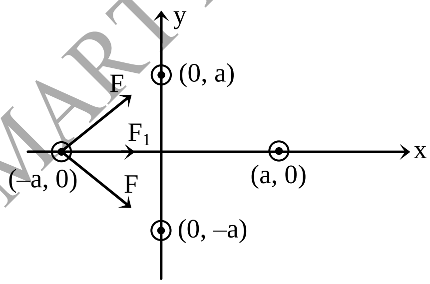
$\therefore \frac{B_1}{B_2} = \frac{r_2}{r_1} \times \frac{r_2}{r_1} = \left(\frac{40}{20}\right)^2 = 4$

Q.24 Four very long straight wires carry equal electric currents in the + z-direction. They intersect the x-y plane at (x, y) = (– a, 0), (0, a) (a, 0) and (0, – a). The magnetic force exerted on the wire at position (– a, 0) is along –

(A) + y-axis (B) – y-axis

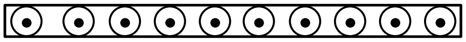
(C) + x-axis (D) – x-axis **[C]**

Sol.



Net force is along +x-axis.

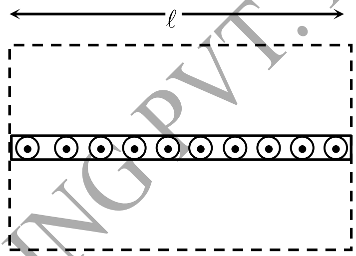
Q.25 A large metal sheet carries an electric current along its surface. Current per unit length is λ. Magnetic field near the metal sheet is –



(A) $\frac{1}{2}\mu_0\lambda$ (B) $\frac{\lambda\mu_0}{2\pi}$

(C) $\lambda\ \mu_0$ (D) $\frac{\mu_0}{2\lambda\pi}$ **[A]**

Sol. Applying Ampere's law



$\oint \vec{B}.\vec{d\ell} = \mu_0(\lambda\ell)$

$2B\ell = \mu_0\lambda\ell$

$B = \frac{1}{2}\mu_0\lambda$

Q.26 O^{++}, C^+, He^{++} and H^+ ions are projected on the photographic plate with same velocity in a mass spectrograph. Which one will strike farthest ?

(A) O^{++} (B) C^+

(C) He^{++} (D) H^+ **[B]**

Sol. D = diameter $= 2r = \frac{2mv}{qB}$

$D \propto \frac{m}{q}$

Here $\frac{m}{q}$ is maximum for C^+.

Q.27 The magnetic field B due to a current carrying circular loop of radius 12 cm at its centre is 0.5×10^{-4} T. The magnetic field due to this loop at a point on the axis at a distance of 5 cm from the centre -

(A) 3.9×10^{-5} T

(B) 5.2×10^{-5} T

(C) 2.1×10^{-5} T

(D) 9×10^{-5} T **[A]**

Sol. $B_0 = \frac{\mu_0 I}{2a}$

At axial point

$$B = \frac{\mu_0 I a^2}{2(a^2 + x^2)^{3/2}}$$

$$\frac{B}{B_0} = \frac{a^3}{(a^2 + x^2)^{3/2}}$$

$$\Rightarrow B = B_0 \;\frac{a^3}{(a^2 + x^2)^{3/2}}$$

$$= 0.5 \times 10^{-4} \times \frac{(12\text{cm})^3}{(144\text{cm}^2 + 25\text{cm}^2)^{3/2}}$$

$= 3.9 \times 10^{-5}$ T.

Q.28 A wire along x-axis carries a current 3.5 A. Find the force on a 1 cm section of the wire exerted by:

$B = 0.74\text{ T } \hat{j} - 0.3\text{ T } \hat{k}$

(A) $(2.59\,\hat{k} + 1.26\,\hat{j}) \times 10^{-2}$

(B) $(1.26\,\hat{k} - 2.59\,\hat{j}) \times 10^{-2}$

(C) $(-2.59\,\hat{k} - 1.26\,\hat{j}) \times 10^{-2}$

(D) $(-1.26\,\hat{k} + 2.59\,\hat{j}) \times 10^{-2}$ **[A]**

Sol. $F = I(\vec{l} \times \vec{B})$

$= 3.5[10^{-2}\,\hat{i} \times (.74\,\hat{j} - 0.36\,\hat{k})]$

$= (2.59\,\hat{k} + 1.26\,\hat{j}) \times 10^{-2}$

Q.29 An electric current i enters and leaves a uniform circular wire of radius 'a' through diametrically opposite points. A charged particle 'q' moving along the axis of the circular wire passes through its centre at speed v. The magnetic force acting on the particle when it passes through the centre has a magnitude-

(A) $qv\frac{\mu_0 i}{2a}$ (B) $qv\frac{\mu_0 i}{2\pi a}$

(C) $qv\frac{\mu_0 i}{a}$ (D) zero **[D]**

Q.30 Two particles X and Y having equal charges, after being accelerated through the same potential difference, enter a region of uniform magnetic field and describe circular paths of radii R_1 and R_2 respectively. The ratio of the masses of X to that of Y is-

(A) $\left(\frac{R_1}{R_2}\right)^{1/2}$ (B) $\frac{R_2}{R_1}$

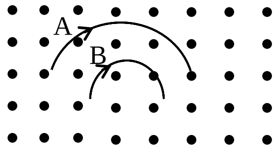
(C) $\left(\frac{R_1}{R_2}\right)^{2}$ (D) $\frac{R_1}{R_2}$ **[C]**

Q.31 A negative charged particle falling freely under gravity enters a region having horizontal magnetic field pointing towards north. The particle will be deflected towards-

(A) East (B) West

(C) North (D) South **[B]**

Q.32 Two particle A and B of masses m_A and m_B respectively and having the same charge are moving in a plane. A uniform magnetic field exists perpendicular to this plane. The speeds of the particles are v_A and v_B respectively and the trajectories are as shown in the figure. Then-



(A) $m_A v_A < m_B v_B$

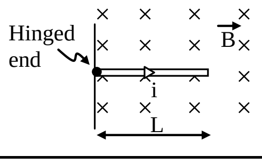
(B) $m_A v_A > m_B v_B$

(C) $m_A < m_B$ and $v_A < v_B$

(D) $m_A = m_B$ and $v_A = v_B$

Sol. **[B]** use $r = \frac{mv}{qB}$

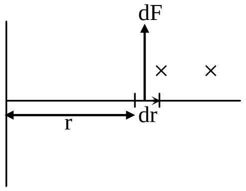
Q.33 A straight conductor of mass m and carrying a current i is hinged at one end and placed in a plane perpendicular to the magnetic field B as shown in figure. At any moment if the conductor is let free, then the angular acceleration of the conductor will be (neglect gravity) –



(A) $\frac{3iB}{2m}$ (B) $\frac{2}{3}\frac{iB}{m}$

(C) $\frac{iB}{2m}$ (D) $\frac{3i}{2mB}$ **[A]**

Sol.



Torque

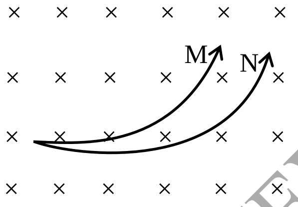
$d\tau = dF \times r$

$= iBdr \times r$

$$\tau = \int_0^L iBrdr = \frac{iBL^2}{2}$$

$$\alpha = \frac{\tau}{I} = \frac{iBL^2}{\frac{2mL^2}{3}} = \frac{3}{2}\frac{iB}{m}$$

Q.34 Two charged particle M and N are projected with same velocity in a uniform magnetic field. Then M and N respectively



(A) an electron and a proton

(B) a deuteron and a proton

(C) a deuteron and an electron

(D) a proton and α - particle **[D]**

Q.35 A charge q is moving with a velocity $\vec{v}_1 = 1\hat{i}$ m/s at a point in a magnetic field and experiences a force $\vec{F}_1 = q\,(-1\hat{j} + 1\hat{k})$N. If the charge is moving with a velocity $\vec{v}_2 = 1\hat{j}$ m/s at the same point, it experiences and a force $\vec{F}_2 = q\,[1\hat{i} - 1\hat{k}]$ N. The magnetic induction $\vec{B}$ at that point is-

(A) $(\hat{i}+\hat{j}+\hat{k})$ Wb/m^2

(B) $(\hat{i}-\hat{j}+\hat{k})$ Wb /m^2

(C) $(-\hat{i}+\hat{j}-\hat{k})$ Wb/m^2

(D) $(\hat{i}+\hat{j}-\hat{k})$ Wb/m^2 **[A]**

Q.36 A particle moves in a circular path of diameter 1.0 m under the action of magnetic field of 0.40 Tesla . An electric field of 200 V/m makes the path of particle straight. Find the charge/mass ratio of the particle.

(A) 2.5×10^5 cb/kg (B) 2×10^5 cb/kg

(C) 3.5×10^5 cb/kg (D) 3×10^5 cb/kg

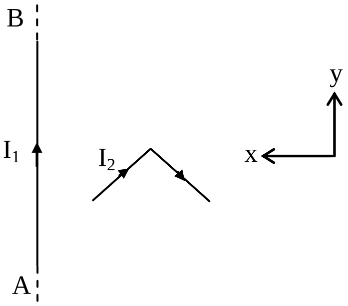
[A]

Q.37 A charged particle is released from rest in a region of steady and uniform electric and magnetic field which are parallel to each other. The particle will move in a -

(A) straight line (B) circle

(C) helix (D) cycloid **[A]**

Q.38 In the figure shown a current I_1 is established in the long straight wire AB. Another wire CD carrying current I_2 is placed in the plane of the paper. The line joining the ends of this wire is perpendicular to the wire AB. The resultant force on the wire CD is-



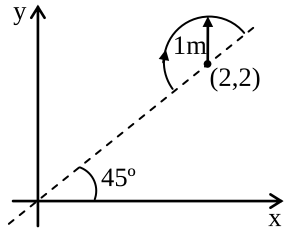
(A) zero

(B) towards negative x-axis

(C) towards positive y-axis

(D) none of these **[D]**

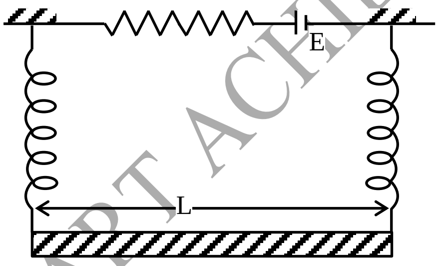
Q.39 A uniform magnetic field $\vec{B} = (3\hat{i} + 4\hat{j} + \hat{k})$ exists in region of space. A semicircular wire of radius 1 m carrying current 1 A having its centre at (2, 2, 0) is placed in x-y plane as shown in figure. The force on semicircular wire will be-



(A) $\sqrt{2}(\hat{i} + \hat{j} + \hat{k})$ (B) $\sqrt{2}(\hat{i} - \hat{j} + \hat{k})$

(C) $\sqrt{2}(\hat{i} + \hat{j} - \hat{k})$ (D) $\sqrt{2}(-\hat{i} + \hat{j} + \hat{k})$ **[B]**

Q.40 A straight rod of mass m and length L is suspended from the identical springs as shown in the figure. The spring stretched a distance x_0 due to the weight of the wire. The circuit has total resistance R. When the magnetic field perpendicular to the plane of paper is switched on, springs are observed to extend further by the same distance. The magnetic field strength is.........



(A) $\frac{2mgR}{LE}$ (B) $\frac{mgR}{EL}$

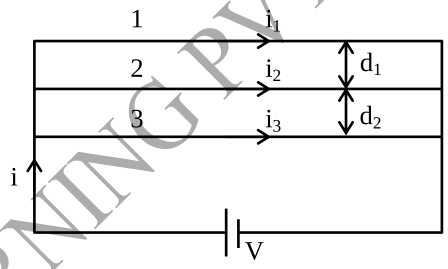
(C) $\frac{mgR}{2LE}$ (D) $\frac{mgR}{E}$ **[B]**

Q.41 A hypothetical magnetic field existing in a region is given by $\vec{B} = B_0 \hat{r}$. Where $\hat{r}$ denotes the unit vector along the radial direction. A circular loop of radius a carrying a current i, is placed with its plane parallel to the x-y plane and centre at (0, 0, d) . The magnitude of magnetic force acting on the loop is-

(A) $\frac{2\pi a^2 iB_0}{d}$ (B) $\frac{2\pi a^2 iB_0}{\sqrt{a^2 + d^2}}$

(C) $\frac{\pi a^2 iB_0}{d}$ (D) $\frac{\pi a^2 iB_0}{\sqrt{a^2 + d^2}}$ **[B]**

Q.42 Three long wires of resistances in the ratio 3 : 4 : 5 are connected in parallel to each other as shown in figure . If net force on middle wire is zero then $\frac{d_1}{d_2}$ will be –



(A) 9 : 25 (B) 5 : 3

(C) $\sqrt{5} : \sqrt{3}$ (D) 1 : 1 **[B]**

Q.43 A charged particle of mass m and charge q is accelerated through a potential difference of V volts. It enters a region of uniform magnetic field which is directed perpendicular to the direction of motion of the particle. The particle will move on a circular path of radius given by -

(A) $\sqrt{\frac{Vm}{qB^2}}$ (B) $\frac{2Vm}{qB^2}$

(C) $\sqrt{\frac{2Vm}{q}}\left(\frac{1}{B}\right)$ (D) $\sqrt{\frac{Vm}{q}}\left(\frac{1}{B}\right)$

[C]

Q.44 A particle of de-Broglie wavelength 2.21×10^{-13} m and charge 1.6×10^{-19} cb is projected with a speed 2×10^6 m/s at an angle 60° to the x-axis. If a uniform magnetic field of 0.3T is applied along the y-axis , the path of the particle is -

(A) a circle of radius 0.03 m and time period $6.25\ \pi \times 10^{-8}$ sec

(B) a circle of radius 0.01 m and time period $\frac{6.25\pi}{3} \times 10^{-8}$ sec

(C) a helix of radius 0.03 m and time period $6.25\,\pi \times 10^{-8}$ sec

(D) a helix of radius 0.01 m and time period $\frac{6.25\pi}{3} \times 10^{-8}$ sec **[C]**

Q.45 A rigid circular loop of radius r and mass m lies in the x-y plane on a flat table and has a current I flowing in it. At this particular place. The earth's magnetic field is $\vec{B} = B_x\hat{i} + B_y\hat{j}$. The minimum value of I for which one end of the loop will lift from the table is

(A) $\frac{mg}{\pi r Bx}$ (B) $\frac{mg}{\pi r B_y}$

(C) $\frac{mg}{2\pi r\sqrt{B_x^2 + B_y^2}}$ (D) None of these

Q.46 Magnetic induction at the centre of a circular coil is given by -

(A) $\frac{\mu_0 NI}{2r}$ (B) $\frac{\mu_0 NIr^2}{(r^2+x^2)^{3/2}}$

(C) $\frac{\mu_0 NI}{2r^2}$ (D) $\frac{\mu_0 NI}{r}$ **[A]**

Sol. $B = \frac{\mu_0 NI}{2r}$

Q.47 A charge q moves in a region where electric field and magnetic field both exist, then force on it is -

(A) $q(\vec{v}\times\vec{B})$ (B) $q\vec{E}+q(\vec{B}\times\vec{v})$

(C) $q\vec{B}+q(\vec{E}\times\vec{v})$ (D) $q\vec{E}+q(\vec{v}\times\vec{B})$

[D]

Sol. $\vec{F} = \vec{F}_E + \vec{F}_B$

$= q\,[\vec{E}+(\vec{v}\times\vec{B})]$

PHYSICS

Q.1 A circular coil of 200 turns has a radius of 10 cm and carries a current of 2.0 A.

(a) Find the magnitude of the magnetic field $\vec{B}$ at the centre of the coil.

(b) At what distance from the centre along the axis of the coil will the field B drop to half its value at the centre? ($\sqrt[3]{4} = 1.5874\ldots$)

Ans. (1) 2.51 mT (2) 7.66 cm

Q.2 A magnetic field of ($4.0 \times 10^{-3}\ \vec{k}$) T exerts a force of $(4.0\ \vec{i} + 3.0\ \vec{j}) \times 10^{-10}$ N on a particle having a charge of 1.0×10^{-9} C and going in the X-Y plane. Find the velocity of the particle.

Ans. $(-75\hat{i} + 100\hat{j})$ m/s

Q.3 A uniform field of magnetic Induction B points horizontally from south to north; its magnitude is 1.5 Wbm^{-2}. If a 5 MeV proton moves vertically downward through this field. What force will act on it?

Ans. 7.4×10^{-12} N towards east

Q.4 A 10 eV electron is circulating in a plane at right angle to a uniform field of magnetic induction of 1×10^{-4} Wb/m^2.

(a) What is its orbit radius ?

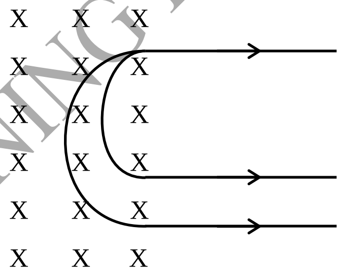
(b) What is the cyclotron frequency ?

(c) What is period of revolution ?

(d)What is the direction of circulation as viewed by an observer sighting along the field ?

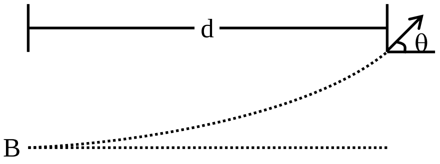
Ans. (a) 11 cm, (b) 2.8×10^6 rev/s, (c) 3.6×10^{-7}, (d) clockwise

Q.5 A narrow beam of singly-charged carbon ions, moving at a constant velocity of 6.0×10^4 m/s, is sent perpendicularly in a rectangular region having uniform magnetic field B = 0.5T(figure). It is found that two beams emerge from the field in the backward direction, the separations from the incident beam being 3.0 cm and 3.5 cm. Identify the isotopes present in the ion beam. Take the mass of an ion = A (1.6×10^{-27}) kg, where A is the mass number.



Ans. ^{12}C and ^{14}C

Q.6 A particle of mass m and charge q is projected into a region having a perpendicular magnetic field B. Find the angle of deviation (figure) of the particle as it comes out of the magnetic field if the width d of the region is very slightly smaller than.



(a) $\frac{mv}{qB}$ (b) $\frac{mv}{2qB}$ (c) $\frac{2mv}{qB}$

Ans. (a) π/2, (b) π/6, (c) π

Q.7 An electron flies into a plane horizontal capacitor parallel to its plates with a velocity of $v_0 = 10^7$ m/s. The length of the capacitor l = 5 cm and the intensity of its electric field E = 100 V/cm. When the electron leaves the capacitor, it gets into a magnetic field whose force lines are perpendicular to those of the electric field. The induction of the magnetic field $B = 10^{-2}$ T. Find:

(a) the radius of the helical trajectory of the electron in the magnetic field, and

(b) the pitch of the helical trajectory of the electron.

Ans. R = 5 mm , l = 3.6 cm

Q.8 The cyclotron's oscillator frequency is equal to $\boldsymbol{v}$ = 10 MHz. Find the effective accelerating voltage applied across the dees of that cyclotron if the distance between the neighbouring trajectories of protons is not less than Δr = 1.0 cm, with the trajectory radius being equal to r = 0.5 m.

Ans. $V \geq \dfrac{2\pi^2 v^2 mr\Delta r}{e} = 0.10$ MV

Q.9 A particle having mass m and charge q is released from the origin in a region in which electric field and magnetic field are given by

$$\vec{B} = -B_0\vec{j} \text{ and } \vec{E} = E_0\vec{k}.$$

Find the speed of the particle as a function of its z-coordinate.

Ans. $\sqrt{\dfrac{2qE_0 z}{m}}$

Q.10 A charge of 3.14×10^{-6}C is distributed uniformly over a circular ring of radius 20.0 cm. The ring rotates about its axis with an angular velocity of 60.0 rad/s. Find the ratio of the electric field to the magnetic field at a point on the axis at a distance of 5.00 cm from the centre.

Ans. 1.88×10^{15} m/s

Q.11 In the Bohr model of the H-atom the electron circulates the nucleus in a path of radius 5.1×10^{-11} m at a frequency ν of 6.8×10^{15} rev/s.

(a) What value of B is set up at the centre of the orbit ?

(b) What is the equivalent magnetic dipole moment

Ans. 14 T, 9×10^{-24} Am^2

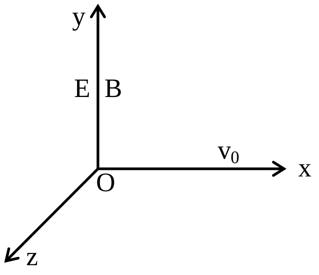
Q.12 Singly charged ions He^+ are accelerated in a cyclotron so that their maximum orbital radius is r = 60 cm. The frequency of a cyclotron's oscillator is equal to ν = 10.0 MHz, the effective accelerating voltage across the dees is V = 50 kV. Neglecting the gap between the dees, find:

(a) the total time of acceleration of the ion;

(b) the approximate distance covered by the ion in the process of its acceleration.

Ans. (a) $t = \dfrac{\pi^2 \nu m r^2}{eV} = 17\ \mu s$; (b) $s \approx \dfrac{4\pi^2 \nu^2 m r^2}{3eV}$ = 0.74 km

Q.13 Uniform electric and magnetic fields with strength E and induction B respectively are directed along the y axis (Fig.) A particle with specific charge q/m leaves the origin O in the direction of the x axis with an initial non-relativistic velocity v_0. Find :

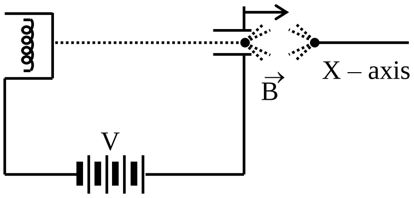


(a) the coordinate y_n of the particle when it crosses the y axis for the nth time;

(b) the angle α between the particle's velocity vector and the y axis at that moment.

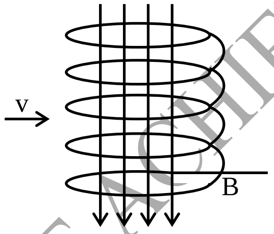
Ans. (a) $y_n = \dfrac{2\pi^2 mEn^2}{qB^2}$; (b) $\tan\alpha = \dfrac{v_0 B}{2\pi En}$

Q.14 Electrons emitted with negligible speed from an electron gun are accelerated through a potential difference V along the X-axis. These electrons emerge from a narrow hole into a uniform magnetic field B directed along this axis. However, some of the electrons emerging from the hole make slightly divergent angles as shown in figure. Show that these paraxial electrons are refocused on the X-axis at a distance $\sqrt{\frac{8\pi^2 mV}{eB^2}}$



Ans.

Q.15(a) A direct current flowing through the winding of a long cylindrical solenoid of radius R produces in it a uniform magnetic field of induction $\vec{B}$. An electron flies into the solenoid along the radius between its turns (at right angles to the solenoid axis) at a velocity $\vec{v}$ (Figure). After a certain time, the electron deflected by the magnetic field leaves the solenoid. Determine the time *t* during which the deuteron moves in the solenoid.



(b) A coil of radius R carries current *I*. Another concentric coil of radius r (r <<R) carries current *i*. Planes of two coils are mutually perpendicular and both the coils are free to rotate about common diameter. Find maximum kinetic energy of smaller coil when both the coils are released, masses of coils are *M* and *m* respectively.

Ans. (a) $t = \frac{2m}{eB}$ arc tan $\left(\frac{eBR}{mv}\right)$ (b) $U = \frac{\mu_0 \pi IiMRr^2}{2(MR^2 + mr^2)}$

Q.16 A circular coil of radius 8.8 cm has 10 turns. Find the magnetic induction at the centre produced by a current of 1.0 A passing through it. Find the resultant field at its centre when the plane of the coil is vertical and

(a) in the magnetic meridian

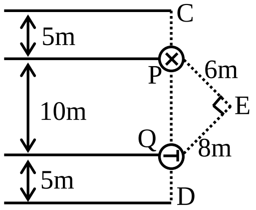
(b) perpendicular to the magnetic meridian.

The horizontal component of the earth's magnetic induction = $B_H = 0.4 \times 10^{-4}$ T, $B_V = 0$

Ans. (a) 0.818×10^{-4} T, $\tan^{-1}(1.79)$ with magnetic meridian

(b) 1.114×10^{-4} T towards north (magnetic south) or 0.314×10^{-4} T towards south (magnetic north) along the magnetic meridian

Q.17 Two long straight parallel wires P and Q are 10 m apart as shown in figure, the wires being perpendicular to the plane of the figure. The current in P is into the plane and equals $i_1 = 6$ A.



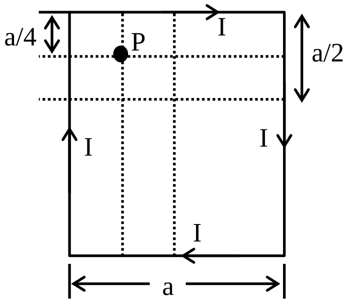
(a) Find the direction and magnitude of the current i_2 in Q for a null point at 'D'. Then,

(b) find the magnetic induction at C and E.

Ans. (a) 2A outward

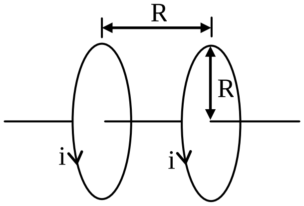
(b) 2.133×10^{-7} W m^{-2} to the Right, 2.06×10^{-7} W m^{-2} at an angle $\alpha = \tan^{-1} 4$ with E_P

Q.18 Calculate B at point P in Figure. Assume that I = 10 A and a = 8.0 cm.



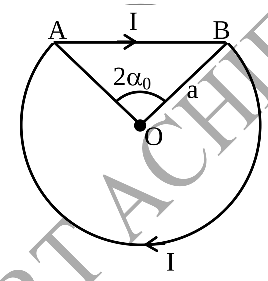
Ans. 2×10^{-4} weber / metre^2

Q.19 Two 300-turn coils are arranged a distance apart equal to their radius, as in *Fig*. For R = 5.0 cm and i =50 A, plot B as a function of distance x along the common axis over the range x = –5 cm to x = +5 cm, taking x = 0 at point P.



Ans.

Q.20 Current I is along a thin conductor bent as shown in figure. Find the magnetic induction B at point *O*.



Ans. $\frac{\mu_0 I}{2\pi a}[\pi - \alpha_0 + \tan \alpha_0]$