PHYSICS

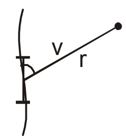
Crash Course for JEE Main 2020

MAGNETIC EFFECT OF CURRENT

MAGNETIC EFFECT OF CURRENT & MAGNETIC FORCE ON CHARGE/CURRENT

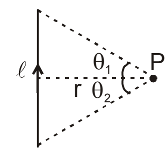
1. Magnetic field due to a moving point charge

$$\vec{B} = \frac{\mu_0}{4\pi} \cdot \frac{q(\vec{v} \times \vec{r})}{r^3}$$



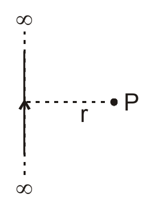
2. Biot-savart's Law

$$\overrightarrow{dB} = \frac{\mu_0 I}{4\pi} \cdot \left(\frac{\overrightarrow{d\ell} \times \vec{r}}{r^3} \right)$$



3. Magnetic field due to a straight wire

$$B = \frac{\mu_0}{4\pi} \frac{I}{r} (\sin \theta_1 + \sin \theta_2)$$

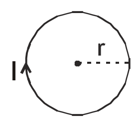


4. Magnetic field due to infinite straight wire

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

5. Magnetic field due to circular loop

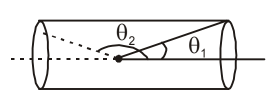
(i) At centre



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

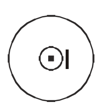
(ii) At Axis $B = \frac{\mu_0}{2} \left(\frac{NIR^2}{(R^2 + x^2)^{3/2}} \right)$

6. Magnetic field on the axis of the solenoid



$$B = \frac{\mu_0 nI}{2} (\cos \theta_1 - \cos \theta_2)$$

7. Ampere's Law

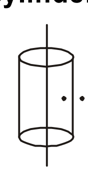


$$\oint \vec{B} . d\vec{\ell} = \mu_0 I$$

8. Magnetic field due to long cylinderical shell

$B = 0, r < R$

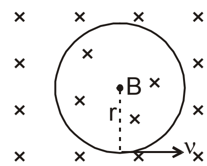
$= \frac{\mu_0}{2\pi} \frac{I}{r}, r \geq R$



9. Magnetic force acting on a moving point charge

a. $\vec{F} = q(\vec{v} \times \vec{B})$

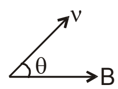
(i) $\vec{v} \perp \vec{B}$



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

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

(ii)



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

$$T = \frac{2\pi m}{qB} \qquad \text{Pitch} = \frac{2\pi m v\cos\theta}{qB}$$

b. $\vec{F} = q\left[(\vec{v} \times \vec{B}) + \vec{E}\right]$

10. Magnetic force acting on a current carrying wire

$\vec{F} = I\left(\vec{\ell} \times \vec{B}\right)$

11. Magnetic Moment of a current carrying loop

M = N · I · A

12. Torque acting on a loop

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

13. Magnetic field due to a single pole

$$B = \frac{\mu_0}{4\pi}.\frac{m}{r^2}$$

14. Magnetic field on the axis of magnet

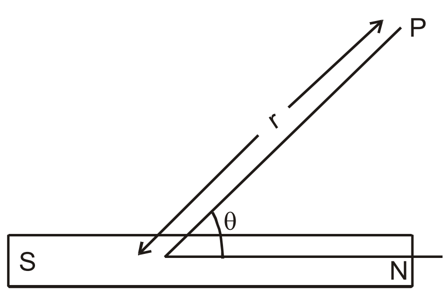
$$B = \frac{\mu_0}{4\pi}\cdot\frac{2M}{r^3}$$

15. Magnetic field on the equatorial axis of the magnet

$$B = \frac{\mu_0}{4\pi}\cdot\frac{M}{r^3}$$

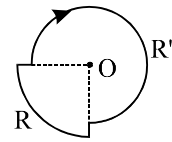
16. Magnetic field at point P due to magnet

$$B = \frac{\mu_0}{4\pi}\frac{M}{r^3}\sqrt{1+3\cos^2\theta}$$



SCQ

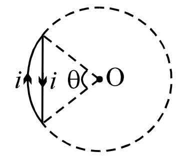
Q.1 A current of i ampere is flowing through each of the bent wires as shown the magnitude and direction of magnetic field at 0 is



(A) $\frac{\mu_0 i}{4}\left(\frac{1}{R}+\frac{2}{R'}\right)$ (B) $\frac{\mu_0 i}{4}\left(\frac{1}{R}+\frac{3}{R'}\right)$

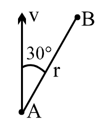
(C) $\frac{\mu_0 i}{8}\left(\frac{1}{R}+\frac{3}{2R'}\right)$ (D) $\frac{\mu_0 i}{8}\left(\frac{1}{R}+\frac{3}{R'}\right)$

Q.2 Net magnetic field at the centre of the circle O due to a current carrying loop as shown in figure is ($\theta < 180°$)



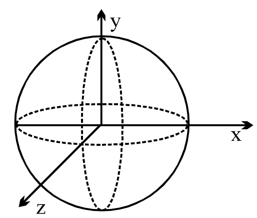
(A) zero
(B) perpendicular to paper inwards
(C) perpendicular to paper outwards
(D) is perpendicular to paper inwards if $\theta \le 90°$ and perpendicular to paper outwards if $90° \le \theta < 180°$

Q.3 A charge particle A of charge q = 2 C has velocity v = 100 m/s. When it passes through point A and has velocity in the direction shown. The strength of magnetic field at point B due to this moving charge is (r = 2 m).



(A) 2.5 μT (B) 5.0 μT (C) 2.0 μT (D) None

Q.4 Three rings, each having equal radius R, are placed mutually perpendicular to each other and each having its centre at the origin of co-ordinate system. If current I is flowing thriugh each ring then the magnitude of the magnetic field at the common centre is



(A) $\sqrt{3}\frac{\mu_0 I}{2R}$ (B) zero (C) $\left(\sqrt{2}-1\right)\frac{\mu_0 I}{2R}$ (D) $\left(\sqrt{3}-\sqrt{2}\right)\frac{\mu_0 I}{2R}$

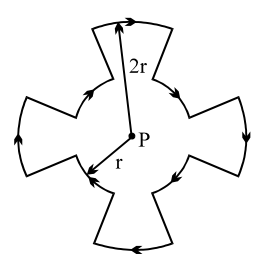
Q.5 Two concentric coils X and Y of radii 16 cm and 10 cm lie in the same vertical plane containing N-S direction. X has 20 turns and carries 16 A. Y has 25 turns & carries 18A. X has current in anticlockwise direction and Y has current in clockwise direction for an observer, looking at the coils facing the west. The magnitude of net magnetic field at their common centre is

(A) $5\pi \times 10^{-4}$ T towards west (B) $13\pi \times 10^{-4}$ T towards east
(C) $13\pi \times 10^{-4}$ T towards west (D) $5\pi \times 10^{-4}$ T towards east

Q.6 The dimension of $\sqrt{\frac{\mu}{\in}}$ where μ is permeability & ε is permittivity is same as :

(A) Resistance (B) Inductance
(C) Capacitance (D) None of these

Q.7 A current I flows around a closed path in the horizontal plane of the circle as shown in the figure. The path consists of eight arcs with alternating radii r and 2r. Each segment of arc subtends equal angle at the common centre P. The magnetic field produced by current path at point P is



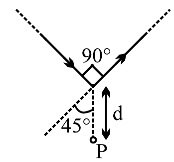
(A) $\frac{3}{8}\frac{\mu_0 I}{r}$; perpendicular to the plane of the paper and directed inward.

(B) $\frac{3}{8}\frac{\mu_0 I}{r}$; perpendicular to the plane of the paper and directed outward.

(C) $\frac{1}{8}\frac{\mu_0 I}{r}$; perpendicular to the plane of the paper and directed inward.

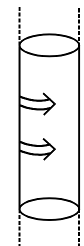
(D) $\frac{1}{8}\frac{\mu_0 I}{r}$; perpendicular to the plane of the paper and directed outward..

Q.8 Find the magnetic field at P due to the arrangement shown



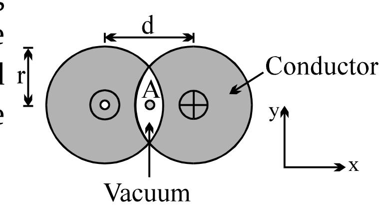
(A) $\frac{\mu_0 i}{\sqrt{2}\pi d}\left(1-\frac{1}{\sqrt{2}}\right)\otimes$ (B) $\frac{2\mu_0 i}{\sqrt{2}\pi d}\otimes$ (C) $\frac{\mu_0 i}{\sqrt{2}\pi d}\otimes$ (D) $\frac{\mu_0 i}{\sqrt{2}\pi d}\left(1+\frac{1}{\sqrt{2}}\right)\otimes$

Q.9 A hollow cylinder having infinite length and carrying uniform current per unit length λ along the circumference as shown. Magnetic field inside the cylinder is



(A) $\frac{\mu_0\lambda}{2}$ (B) $\mu_0\lambda$ (C) $2\mu_0\lambda$ (D) none

Q.10 Two long conductors are arranged as shown above to form overlapping cylinders, each of raidus r, whose centers are separated by a distance d. Current of density J flows into the plane of the page along the shaded part of one conductor and an equal current flows out of the plane of the page along the shaded portion of the other, as shown. What are the magnitude and direction of the magnetic field at point A?



(A) $(\mu_0/2\pi)\pi dJ$, in the +y-direction
(B) $(\mu_0/2\pi)d^2/r$, in the +y-direction
(C) $(\mu_0/2\pi)4d^2J/r$, in the –y-direction
(D) $(\mu_0/2\pi)Jr^2/d$, in the –y-direction
(E) There is no magnetic field at A.

Q.11 An electron is moving along positive x-axis. A uniform electric field exists towards negative y-axis. What should be the direction of magnetic field of suitable magnitude so that net force of electron is zero

(A) positive z- axis (B) negative z-axis (C) positive y-axis (D) negative y-axis

Q.12 A particle of charge q and mass m starts moving from the origin under the action of an electric field $\vec{E} = E_0\hat{i}$ and $\vec{B} = B_0\hat{i}$ with velocity $\vec{v} = v_0\hat{j}$. The speed of the particle will become $2v_0$ after a time

(A) $t = \frac{2mv_0}{qE}$ (B) $t = \frac{2Bq}{mv_0}$ (C) $t = \frac{\sqrt{3}Bq}{mv_0}$ (D) $t = \frac{\sqrt{3}mv_0}{qE}$

Q.13 An electron is projected with velocity v_0 in a uniform electric field E perpendicular to the field. Again it is projetced with velocity v_0 perpendicular to a uniform magnetic field B/ If r_1 is initial radius of curvature just after entering in the electric field and r_2 is initial radius of curvature just after entering in magnetic field then the ratio r_1/r_2 is equal to

(A) $\frac{Bv_0^2}{E}$ (B) $\frac{B}{E}$ (C) $\frac{Ev_0}{B}$ (D) $\frac{Bv_0}{E}$

Q.14 Two protons move parallel to each other, keeping distance r between them, both moving with same velocity $\vec{V}$. Then the ratio of the electric and magnetic force of interaction between them is

(A) c^2/v^2 (B) $2c^2/v^2$ (C) $c^2/2v^2$ (D) None

Q.15 An electron having kinetic energy T is moving in a circular orbit of radius R perpendicular to a uniform magnetic induction $\vec{B}$. If kinetic energy is doubled and magnetic induction tripled, the radius will become

(A) $\frac{3R}{2}$ (B) $\sqrt{\frac{3}{2}}R$ (C) $\sqrt{\frac{2}{9}}R$ (D) $\sqrt{\frac{4}{3}}R$

Q.16 A electron experiences a force $(4.0\hat{i}+3.0\hat{j})\times 10^{-13}$ N in a uniform magnetic field when its velocity is $2.5\hat{k}\times 10^7$ ms^{-1}. When the velocity is redirected and becomes $(1.5\hat{i}-2.0\hat{j})\times 10^7$ ms^{-1}, the magnetic force of the electron is zero. The magnetic field vector $\vec{B}$ is :

(A) $-0.075\hat{i}+0.1\hat{j}$ (B) $0.1\hat{i}+0.075\hat{j}$ (C) $0.075\hat{i}-0.1\hat{j}+\hat{k}$ (D) $0.075\hat{i}-0.1\hat{j}$

Q.17 A particle having charge of 1 C, mass 1 kg and speed 1 m/s enters a uniform magnetic field, having magnetic induction of 1 T, at an angle $\theta = 30°$ between velocity vector and magnetic induction. The pitch of its helical path is (in meters)

(A) $\frac{\sqrt{3}\pi}{2}$ (B) $\sqrt{3}\pi$ (C) $\frac{\pi}{2}$ (D) π

Q.18 A particle of specific charge (charge/mass) α starts moving from the origin under the action of an electric field $\vec{E} = E_0\hat{i}$ and magnetic field $\vec{B} = B_0\hat{k}$. Its velocity at $(x_0, y_0, 0)$ is $(4\hat{i}-3\hat{j})$. The value of x_0 is:

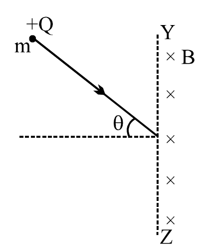
(A) $\frac{13}{2}\frac{\alpha E_0}{B_0}$ (B) $\frac{16\alpha B_0}{E_0}$ (C) $\frac{25}{2\alpha E_0}$ (D) $\frac{5\alpha}{2B_0}$

Q.19 A particle of specific charge (q/m) is projected from the origin of coordinates with initial velocity [u**i** – v**j**]. Uniform electric magnetic fields exist in the region along the +y direction, of magnitude E and B. The particle will definitely return to the origin once if

(A) $[vB/2\pi E]$ is an integer (B) $(u^2 + v^2)^{1/2}\,[B/\pi E]$ is an integer

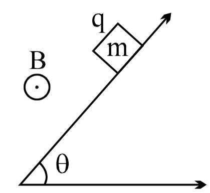
(C) $[vB/\pi E]$ in an integer (D) $[uB/\pi E]$ is an integer

Q.20 A particle with charge +Q and mass m enters a magnetic field of magnitude B, existing only to the right of the boundary YZ. The direction of the motion of the particle is perpendicular to the direction of B. Let $T = 2\pi\frac{m}{QB}$. The time spent by the particle in the field will be



(A) $T\theta$ (B) $2T\theta$ (C) $T\left(\frac{\pi+2\theta}{2\pi}\right)$ (D) $T\left(\frac{\pi-2\theta}{2\pi}\right)$

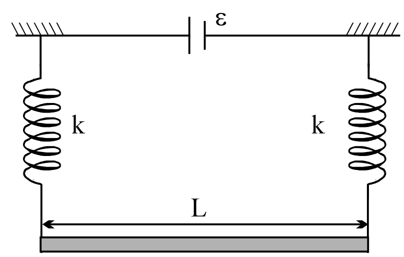
Q.21 A block of mass m & charge q is released on a long smooth inclined plane magnetic field B is constant, uniform, horizontal and parallel to surface as shown. Find the time from start when block loses contact with the surface.



(A) $\frac{m\cos\theta}{qB}$ (B) $\frac{m\,\mathrm{cosec}\,\theta}{qB}$

(C) $\frac{m\cot\theta}{qB}$ (D) none

Q.22 A straight rod of mass m and length L is suspended from the identical spring as shown in the figure. The spring stretched by a distance of x_0 due to the weight of the wire. The circuit has total resistance RΩ. When the magnetic field perpendicular to the plane of the paper is switched on, springs are observed to extend further by the same distance. The magnetic field strength is



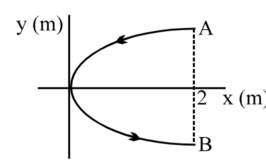
(A) $\frac{mgR}{\varepsilon L}$; directed outward from the plane of the paper

(B) $\frac{mgR}{2\varepsilon x_0}$; directed outward from the plane of the paper

(C) $\frac{mgR}{\varepsilon L}$; directed into the plane of the paper

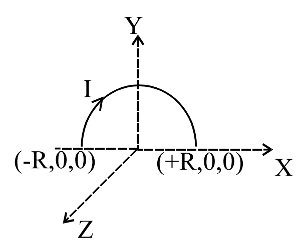
(D) $\frac{mgR}{\varepsilon x_0}$; directed into the plane of the paper

Q.23 A conducting wire bent in the form of a parabola $y^2 = 2x$ carries a current i = 2 A as shown in figure. This wire is placed in a uniform magnetic field $\vec{B} = -4\hat{k}$ Tesla. The magnetic force on the wire is (in newton)



(A) $-16\hat{i}$ (B) $32\hat{i}$ (C) $-32\hat{i}$ (D) $16\hat{i}$

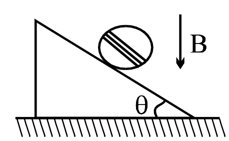
Q.24 A semi circular current carrying wire having radius R is placed in x-y plane with its centre at origin 'O'. There is non-uniform magnetic field $\vec{B} = \frac{B_o x}{2R}\hat{k}$ (here B_o is +ve constant) is existing in the region. The magnetic force acting on semi circular wire will be along



(A) – x-axis (B) + y-axis
(C) – y-axis (D) + x-axis

Q.25 A metal ring of radius r = 0.5 m with its plane normal to a uniform magnetic field B of induction 0.2 T carries a current I = 100 A. The tension in newtons developed in the ring is:
(A) 100 (B) 50 (C) 25 (D) 10

Q.26 In the figure shown a coil of single turn is wound on a sphere of radius R and mass m. The plane of the coil is parallel to the plane and lies in the equatorial plane of the sphere. Current in the coil is i. The value of B if the sphere is in equilibrium is

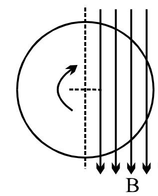


(A) $\frac{mg\cos\theta}{\pi iR}$ (B) $\frac{mg}{\pi iR}$ (C) $\frac{mg\tan\theta}{\pi iR}$ (D) $\frac{mg\sin\theta}{\pi iR}$

Q.27 The magnetic moment of a circular orbit of radius 'r' carrying a charge 'q' and rotating with velocity v is given by

(A) $\frac{qvr}{2\pi}$ (B) $\frac{qvr}{2}$ (C) $qv\pi r$ (D) $qv\pi r^2$

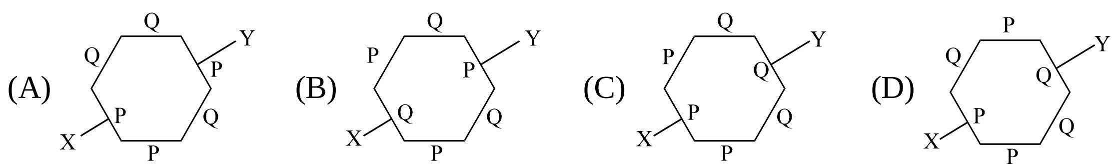
Q.28 A thin non conducting disc of radius R is rotating clockwise (see figure) with an angular velocity w about its central axis, which is perpendicular to its plane. Both its surfaces carry +ve charges of uniform surface density. Half the disc is in a region of a uniform, unidirectional magnetic field B parallel to the plane of the disc, as shown. Then,



(A) The net torque on the disc is zero.
(B) The net torque vector on the disc is directed leftwards.
(C) The net torque vector on the disc is directed rightwards.
(D) The net torque vector on the disc is parallel to B.

MCQ

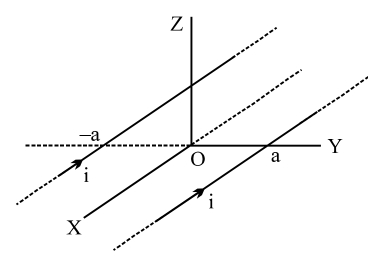
Q.29 In the following hexagons, made up of two different material P and Q, current enters and leaves from points X and Y respectively. In which case the magnetic field at its centre is not zero.



Q.30 Consider three quantities $x = E/B$, $y = \sqrt{1/\mu_0\varepsilon_0}$ and $z = \frac{l}{CR}$. Here, l is the length of a wire, C is a capacitance and R is a resistance. All other symbols have standard meanings.

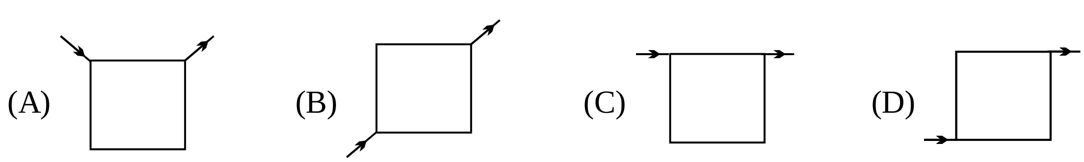
(A) x, y have the same dimensions (B) y, z have the same dimensions
(C) z, x have the same dimensions (D) none of the three pairs have the same dimensions.

Q.31 Two long thin, parallel conductors carrying equal currents in the same direction are fixed parallel to the x-axis, one passing through y = a and the other through y = –a. The resultant magnetic field due to the two conductors at any point is B. Which of the following are correct?



(A) B = 0 for all points on the x-axis
(B) At all points on the y-axis, excluding the origin, B has only a z-component.
(C) At all points on the z-axis, excluding the origin, B has only a y-component.
(D) B cannot have an x-component.

Q.32 Current flows through uniform, square frames as shown. In which case is the magnetic field at the centre of the frame not zero?



Q.33 Which of the following statement is correct :

(A) A charged particle enters a region of uniform magnetic field at an angle 85^0 to magnetic lines of force. The path of the particle is a circle.

(B) An electron and proton are moving with the same kinetic energy along the same direction. When they pass through uniform magnetic field perpendicular to their direction of motion, they describe circular path.

(C) There is no change in the energy of a charged particle moving in a magnetic field although magnetic force acts on it.

(D) Two electrons enter with the same speed but in opposite direction in a uniform transverse magnetic field. Then the two describe circle of the same radius and these move in the same sense.

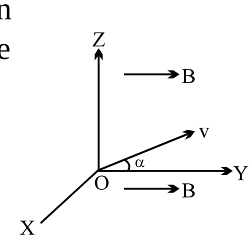
Q.34 Two identical charged particles enter a uniform magnetic field with same speed but at angles 30° and 60° with field. Let a, b and c be the ratio of their time periods, radii and pitches of the helical paths than

(A) abc = 1 (B) abc > 1 (C) abc < 1 (D) a = bc

Q.35 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

Q.36 In a region of space, a uniform magnetic field B exists in the y-direction. A proton is fired from the origin, with its initial velocity v making a small angle α with the y-direction in the yz plane. In the subsequent motion of the proton,



(A) its x-coordinate can never be positive

(B) its x- and z-coordinates cannot both be zero at the same time

(C) its z-coordinate can never be negative

(D) its y-coordinate will be proportional to the square of its time of flight

Q.37 The value of magnetic flux in each case is given by

(A) Case I: $\Phi = \pi(L^2 + \ell^2)B$; Case II: $\Phi = \pi(L^2 - \ell^2)B$

(B) Case I: $\Phi = \pi(L^2 + \ell^2)B$; Case II: $\Phi = \pi(L^2 + \ell^2)B$

(C) Case I: $\Phi = (L^2 + \ell^2)B$; Case II: $\Phi = (L^2 - \ell^2)B$

(D) Case I: $\Phi = (L + \ell)^2B$; Case II: $\Phi = \pi(L - \ell)^2B$

Q.38 The direction of induced current in the case I is

(A) from a to b and from c to d (B) from a to b and from *f* to e

(C) from b to a and from d to c (D) from b to a and from e to *f*

Q.39 The direction of induced current in the case II is

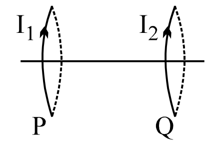
(A) from a to b and from c to d (B) from b to a and from *f* to e

(C) from b to a and from c to d (D) from a to b and from d to c

Q.40 If I_1 and I_2 are the magnitudes of induced current in the cases I and II, respectively, then

(A) $I_1 = I_2$ (B) $I_1 > I_2$ (C) $I_1 < I_2$ (D) nothing can be said

Q.41 Two circular coils P & Q are fixed coaxially & carry currents I_1 and I_2 respectively



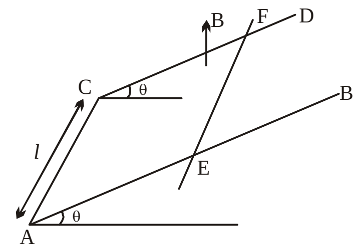
(A) if $I_2 = 0$ & P moves towards Q, a current in the samedirection as I_1 is induced in Q

(B) if $I_1 = 0$ & Q moves towards P, a current in the opposite direction to that of I_2 isinduced in P.

(C) when $I_1 \neq 0$ and $I_2 \neq 0$ are in the same direction then the two coils tend to move apart .

(D) when $I_1 \neq 0$ and $I_2 \neq 0$ are in opposite directions then the coils tends to move apart.

Q.42 AB and CD are smooth parallel rails, separated by a distance l, and inclined to the horizontal at an angle θ. A uniform magnetic field of magnitude B, directed vertically upwards, exists in the region. EF is a conductor of mass m, carrying a current i. For EF to be in equilibrium,



(A) i must flow from E to F (B) Bil = mg tan θ

(C) Bil = mg sin θ (D) Bil = mg

Q.43 In the **previous question**, if B is normal to the plane of the rails

(A) Bil = mg tan θ (B) Bil = mg sin θ

(C) Bil = mg cos θ (D) equilibrium cannot be reached

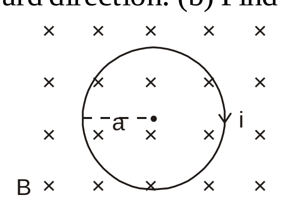
INTEGER TYPE

Q.44 A solenoid of length 0.4 m and diameter 0.6 m consists of a single layer of 1000 turns of fine wire carrying a current of 5.0×10^{-3} ampere. Calculate the magnetic field strength on the axis at the middle and at the ends of the solenoid.

Q.45 A capacitor of capacitance 50 μF is connected to a battery of 20 volts for a long time and then disconnected from it. It is now connected across a long solenoid having 8000 turns per metre. It is found that the potential difference across the capacitor drops to 90% of its maximum value in 2.0 seconds. Estimate the average magnetic field produced at the centre of the solenoid during this period.

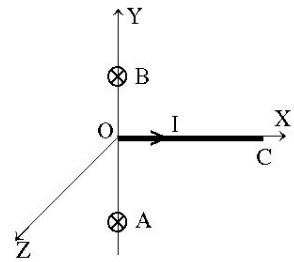
Q.46 A particle of mass 1×10^{-26} kg and charge $+ 1.6 \times 10^{-19}$ C traveling with a velocity of 1.28×10^6 m/s in the +x direction enters a region in which a uniform electric field E and a uniform magnetic field of induction B are present such that $E_x = E_y = 0$, $E_z = -102.4$ kV/m and $B_x = B_z = 0$, $B_y = 8 \times 10^{-2}$ Wb m^{-2}. The particle enters this region at the origin at time t = 0. Determine the location x, y and z coordinates of the particle at $t = 5 \times 10^{-6}$ s. If the electric field is switched off at this instant (with magnetic field still present), what will be the position of the particle at $t = 7.45 \times 10^{-6}$ s ?

Q.47 Figure shows a circular wire-loop of radius a, carrying a current i, placed in a perpendicular magnetic field B. (a) Consider a small part $d\ell$ of the wire. Find the force on this part of wire exerted by the magnetic field in the radially outward direction. (b) Find tension in the wire.

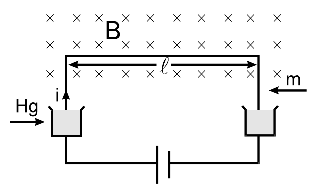


Q.48 Suppose that the radius of cross-section of the wire used in the previous problem is r. Find the decrease in the radius of the loop if the magnetic field is switched off. The Young's modulus of the material of the wire is Y.

Q.49 A straight segment OC (of length L meter) of a circuit carrying a current I amp is placed along the x-axis. Two infinitely long straight wires A and B, each extending form $z = -\infty$ to $+\infty$, are fixed at $y = -a$ metre and $y = +a$ metre respectively, as shown in the figure. If the wires A and B each carry a current I amp into plane of the paper. Obtain the expression for the force acting on the segment OC. What will be the force on OC if current in the wire B is reversed ?

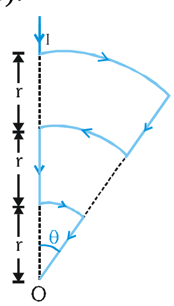


Q.50 A U-shaped wire of mass m and length ℓ is immersed with its two ends in mercury (see figure). The wire is in a homogeneous field of magnetic induction B. If a charge, that is, a current pulse $q = \int i\,dt$, is sent through the wire, the wire will jump up. Calculate, the amount of charge the wire reaches a hight h, assuming that the time of the current pulse is very small in comparison with the time of flight. Make use of the fact that impulse of force equals $\int F\,dt$, which equals mv. Evaluate q for $B = 0.1\ \frac{Wb}{m^2}$, m = 10gm, ℓ = 20cm & h = 3 meters.

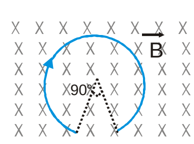


Q.51 A circular coil of 20 turns and radius 10 cm is placed in a uniform magnetic field of 0.10 T normal to the plane of the coil. If the current in the coil is 5.0 A, what is the average force on each electron in the coil due to the magnetic field ? (The coil is made of copper wire of cross–sectional area $10^{-5}m^2$, and the free electron density in copper is given to be about $10^{29}\ m^{-3}$.)

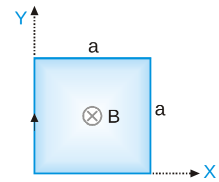
Q.52 A conductor carrying a current I is shown in the figure. Calculate the magnetic field intensity at the point O (common centre of all the three arcs).



Q.53 An arc of a circular loop of radius R is kept in the horizontal plane and a constant magnetic field B is applied in the vertical direction as shown in the figure. If the arc carries current I then find the force on the arc.

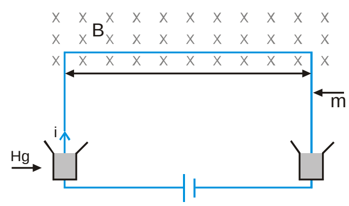


Q.54 A rectangular loop of wire is oriented with the left corner at the origin, one edge along X–axis and the other edge along Y–axis as shown in the figure. A magnetic field is into the page and has a magnitude that is given by $\beta = \alpha y$ where α is constant. Find the total magnetic force on the loop if it carries current i.



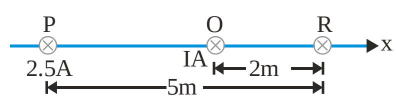
Q.55 A neutral particle is at rest in uniform magnetic field $\vec{B}$. At t = 0, particle decays into two particles each of mass 'm' and one of them having charge 'q'. Both of these move off in separate paths lying in plane perpendicular to $\vec{B}$. At later time, the particles collide. Find this time of collision neglecting the interaction force.

Q.56 A U–shaped wire of mass m and length ℓ is immersed with its two ends in mercury (see figure). The wire is in a homogeneous field of magnetic induction B. If a charge, that is, a current pulse $q = \int idt$, is sent through the wire, the wire will jump up. Calculate, from the height h that the wire reaches, the size of the charge or current pulse, assuming that the time of the current pulse is very small in comparison with the time of flight. Make use of the fact that impulse of force equals $\int Fdt = mv$. Evaluate q for B = 0.1 Wb/m^2, m=10 gm, $\ell = 20\,cm$ & h = 3 m. [g = 10 m/s^2]



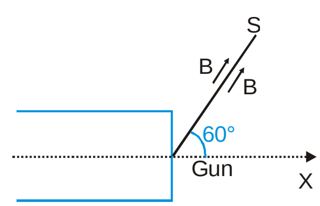
Q.57 Two long parallel wires carrying currents 2.5 A and I (amperes) in the same direction (directed into the plane of the paper) are held at P and Q respectively such that they are perpendicular to the plane of paper. The points P and Q are located at the distance of 5 m and 2 m repetitively from a collinear point R (see figure).

(i) An electron moving with a velocity of 4×10^5 m/s along the positive x–direction experiences a force of magnitude 3.2×10^{-20} N at the point R. Find the value of I.



(ii) Find all the positions at which a third long parallel wire carrying a current of magnitude 2.5 A may be placed, so that the magnetic induction at R is zero.

Q.58 An electron gun G emits electron of energy 2kev travelling in the +ve direction. The electron are required to hit the spot S where GS =0.1 m & the line GS makes an angle of 60° with the x–axis, as shown in the figure. A uniform magnetic field $\vec{B}$ parallel to GS exists in the region outsides to electron gun. Find the minimum value of B needed to make the electron hit at S.



ANSWER KEY

ONLY ONE OPTION IS CORRECT

Q.1	D	Q.2	C	Q.3	A	Q.4	A	Q.5	A
Q.6	A	Q.7	A	Q.8	A	Q.9	B	Q.10	A
Q.11	B	Q.12	D	Q.13	D	Q.14	A	Q.15	C
Q.16	A	Q.17	B	Q.18	C	Q.19	C	Q.20	C
Q.21	C	Q.22	A	Q.23	B	Q.24	A	Q.25	D
Q.26	B	Q.27	B	Q.28	B				

ONE OR MORE THAN ONE OPTION MAY BE CORRECT

Q.29	A	Q.30	A; B; C	Q.31	A; B; C; D	Q.32	C
Q.33	B; C; D	Q.34	A; D	Q.35	A; B	Q.36	A
Q.37	C	Q.38	C	Q.39	B	Q.40	B
Q.41	B,D	Q.42	A,B	Q.43	B		

INTEGER TYPE

Q.44 $\frac{\pi}{\sqrt{13}} \times 10^{-5}$ T; $2\pi \times 10^{-6}$ T Q.45 $16\pi \times 10^{-8}$ T. Q.46 (6.4, 0, 0) (6.4, 0, 2)

Q.47 (a) $id\ell B$ (b) iaB Q.48 $\frac{ia^2B}{\pi r^2 Y}$. Q.49 $\left(\frac{\mu_0 I^2}{2\pi}\right) \ell n \left(\frac{L^2+a^2}{a^2}\right)(-\hat{k})$, zero

Q.50 $\frac{m\sqrt{2gh}}{B\ell}$ C Q.51 5×10^{-25}N Q.52 $\frac{5\mu_0 I\theta}{24\pi r} \otimes$ Q.53 $\sqrt{2}$ IRB

Q.54 $\alpha a^2 i \hat{j}$ Q.55 $\frac{\pi m}{qB}$ Q.56 $\sqrt{15}$ C

Q.57 **(i)** 4A **(ii)** at distance 1m from R to the left or right of it, current is outwards if placed to the left and inwards if placed to the right of R

Q.58 $B_{min} = 4.7 \times 10^{-3}$ T