EXERCISE-1

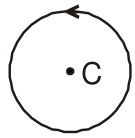
SECTION (A) : MAGNET AND MAGNETIC FIELD DUE TO A MOVING CHARGE

A 1*. A magnetic needle (small magnet) is kept in a nonuniform magnetic field. It .
(A) may experience a force and torque (B) may experience a force but not a torque
(C) may experience a torque but not a force (D) will experience neither a force nor a torque

A 2. A point charge is moving in a circle with constant speed. Consider the magnetic field produced by the charge at a fixed 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.

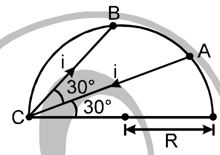
A 3. The magnetic moment of a dipole is, 1 A m^2. What is the magnitude of the magnetic induction in air at 10 cm from the dipole on a line making an angle of 30º from the axis of the dipole?

A 4. A particle of negative charge of magnitude 'q' is revolving in a circle of radius 'R'. Find the magnetic field (magnitude and direction) at the following points :
(i) centre of the circle (magnitude and direction)
(ii) a point on the axis and at a distance 'x' from the centre of the ring magnitude only). Is its direction constant all the time?



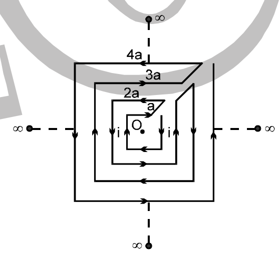
SECTION (B) : MAGNETIC FIELD DUE TO A STRAIGHT WIRE

B 1. A current carrying wire is placed in the grooves of an insulating semi circular disc of radius 'R', as shown. The current enters at point A and leaves from point B. Determine the magnetic field at point D.



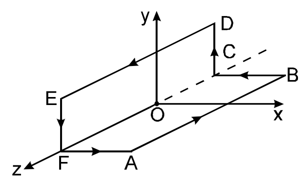
(A) $\dfrac{\mu_0 I}{8\pi R\sqrt{3}}$ (B) $\dfrac{\mu_0 I}{4\pi R\sqrt{3}}$ (C) $\dfrac{\sqrt{3}\,\mu_0 I}{4\pi R}$ (D) none of these

B 2. Determine the magnetic field at the centre of the current carrying wire arrangement shown in the figure. The arrangement extends to infinity. (The wires joining the successive squares are along the line passing through the centre)



(A) $\dfrac{\mu_0 i}{\sqrt{2}\,\pi a}$ (B) 0 (C) $\dfrac{2\sqrt{2}\,\mu_0 i}{\pi a}$ ln2 (D) none of these

B 3. In the figure shown A B C D E F A was a square loop of side ℓ , but is folded in two equal parts so that half of it lies in x z plane and the other half lies in the y z plane. The origin ' O ' is centre of the frame also. The loop carries current ' i '. The magnetic field at the centre is:



(A) $\dfrac{\mu_0 i}{2\sqrt{2}\,\pi \ell}\left(\hat{i}-\hat{j}\right)$ (B) $\dfrac{\mu_0 i}{4\,\pi \ell}\left(-\hat{i}+\hat{j}\right)$

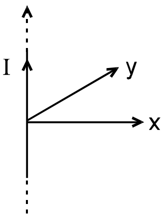
(C) $\dfrac{\sqrt{2}\,\mu_0 i}{\pi \ell}\left(\hat{i}+\hat{j}\right)$ (D) $\dfrac{\mu_0 i}{\sqrt{2}\,\pi \ell}\left(\hat{i}+\hat{j}\right)$

***B 4.** The magnetic field at the origin due to a current element i $d\vec{l}$ placed at a position $\vec{r}$ is

(A) $\dfrac{\mu_0 i}{4\pi}\dfrac{d\vec{l}\times\vec{r}}{r^3}$ (B) $-\dfrac{\mu_0 i}{4\pi}\dfrac{\vec{r}\times d\vec{\ell}}{r^3}$ (C) $\dfrac{\mu_0 i}{4\pi}\dfrac{\vec{r}\times d\vec{\ell}}{r^3}$ (D) $-\dfrac{\mu_0 i}{4\pi}\dfrac{d\vec{\ell}\times\vec{r}}{r^3}$

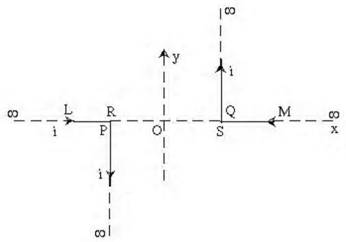
***B 5.** A long, straight wire carries a current along the Z-axis. One can find two points in the X-Y plane such that
(A) the magnetic fields are equal
(B) the directions of the magnetic fields are the same
(C) the magnitudes of the magnetic fields are equal
(D) the field at one point is opposite to that at the other point.

B. 6 A current carrying long wire is placed along the z-axis. The current is flowing along the +ve z-direction.



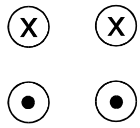
Find the $\vec{B}$ due to this wire at
(i) (d, 0, 0) (ii) (0, d, 0) (iii) (0, 0, d) (iv) (d, d, 0) (v) (d, 0, d) (vi) (0, d, d)
(vii) (d, d, d)

B 7. A pair of stationary and infinitely long bent wires is placed in the X-Y plane as shown in figure. The wires carry currents of 10A each as shown. The segments L and M are along the axis. The segments P and Q are parallel to the Y - axis such that OS = OR = 0.02 m. Find the magnitude and direction of the magnetic induction at the origin O.



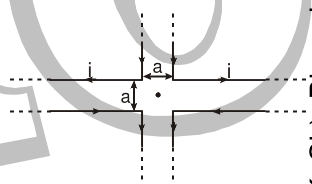
B 8. Two straight infinitely long and thin parallel wires are spaced 0.1 m apart and carry a current of 10 ampere each. Find the magnetic field at a point distant 0.1 m from both wires in the two cases when the currents are in the
(i) Same and (ii) Opposite direction.

B 9. A system of long four parallel conductors whose sections with the plane of the drawing lie at the vertices of a square where flow four equal currents. The directions of these currents are as follows : Those marked ⊗ point away from the reader, while those marked with a dot point towards the reader. How is the vector of magnetic induction directed at the centre of the square?

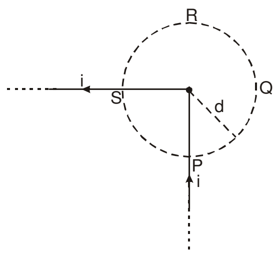


B 10. A long straight wire carries a current of 10 A directed along the negative y-axis. A uniform magnetic field B_0 of magnitude 10^{-6} T is directed parallel to the x-axis. What is the resultant magnetic field at the following points?
(a) x = 0, z = 2 m (b) x = 2 m , z = 0 (c) x = 0 , z = – 0.5 m

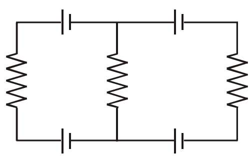
B 11. Four infinitely long 'L' shaped wires, each carrying a current i have been arranged as shown in the figure. Obtain the magnetic field intensity at the point 'O' equidistant from all the four corners.



B 12. Figures shows a long wire bent at the middle to form a right angle. Show that the magnitudes of the magnetic fields at the points P, Q, R and S are equal and find this magnitude. The wire and the circumference of circle are coplaner.



B 13. Each of the batteries shown in figuer has an emf equal to 5 V. Show that the magnetic field B at the point P is zero for any set of values of the resistances.



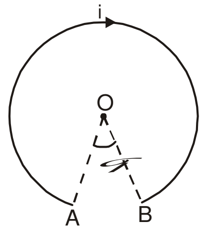
B 14. A square loop of wire of edge a carries a current i. Show that the value of B at the center is given by, $B = \dfrac{2\sqrt{2}\mu_0 i}{\pi a}$.

B 15. **(a)** Show that B at the center of a rectangle of length 'ℓ' & width d, carrying a current i, is given by $B = \dfrac{2\mu_0 i}{\pi}\dfrac{\left(\ell^2+d^2\right)^{1/2}}{\ell d}$.

(b) What does B reduce to for ℓ >> d? Is this a result that you expect?

SECTION (C) : MAGNETIC FIELD DUE TO A CIRCULAR LOOP

C 1. A current carrying wire AB of the length $2\pi R$ is turned along a circle, as shown in figure. The magnetic field at the centre O.

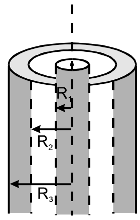


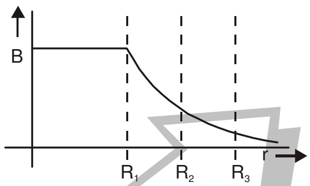
(A) $\frac{\mu_0 i}{2R}\left(\frac{2\pi-\theta}{2\pi}\right)^2$ (B) $\frac{\mu_0 i}{2R}\left(\frac{2\pi-\theta}{2\pi}\right)$

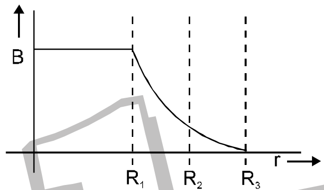
(C) $\frac{\mu_0 i}{2R}(2\pi-\theta)$ (D) $\frac{\mu_0 i}{2R}(2\pi+\theta)^2$

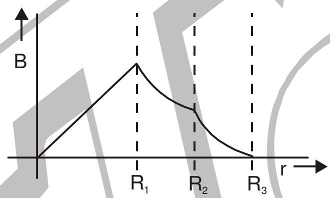
C 2. A wire is wound on a long rod of material of relative permeability $\mu_r = 4000$ to make a solenoid. If the current through the wire is 5 A and number of turns per unit length is 1000 per metre, then the magnetic field inside the solenoid is :
(A) 25.12 mT (B) 12.56 m T (C) 12.56 T (D) 25.12 T

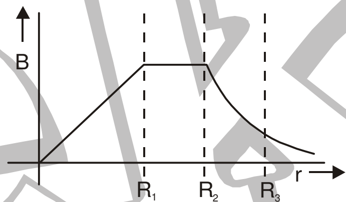
C 3. A coaxial cable is made up of two conductors. The inner conductor is solid and is of radius R_1 & the outer conductor is hollow of inner radius R_2 and outer radius R_3. The space between the conductors is filled with air. The inner and outer conductors are carrying currents of equal magnitudes and in opposite directions. Then the variation of magnetic field with distance from the axis is best plotted as:



(A)


(B)


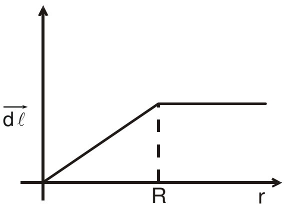
(C)


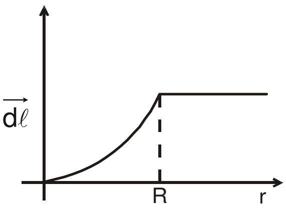
(D)


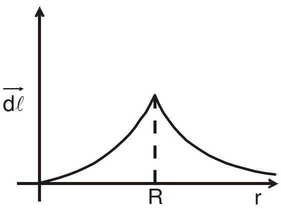
C 4. Axis of a solid cylinder of infinite length and radius R lies along y-axis it carries a uniformly distributed current 'i' along +y direction. Magnetic field at a point $\left(\frac{R}{2}, y, \frac{R}{2}\right)$ is :-

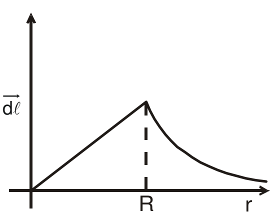
(A) $\frac{\mu_0 I}{4\pi R}(\hat{i}-\hat{k})$ (B) $\frac{\mu_0 i}{2\pi R}(\hat{j}-\hat{k})$ (C) $\frac{\mu_0 i}{4\pi R}\hat{j}$ (D) $\frac{\mu_0 I}{4\pi R}(\hat{i}+\hat{k})$

C 5. A cylindrical wire of radius R is carrying current i uniformly distributed over its cross-section. If a circular loop of radius 'r' is taken as amperican loop, then the variation value of $\oint \vec{B}\cdot\vec{d\ell}$ over this loop with radius 'r' of loop will be best represented by:

(A) $\oint \vec{B}\cdot\vec{d\ell}$


(B) $\oint \vec{B}\cdot\vec{d\ell}$


(C) $\oint \vec{B}\cdot\vec{d\ell}$


(D) $\oint \vec{B}\cdot\vec{d\ell}$


C 6. A circular loop is kept in that vertical plane which contains the north-south direction. It carries a current that is towards north at the topmost point. Let A be a point on axis of the circle to the east of it and B a point on this axis to the west of it. The magnetic field due to the loop
(A) is towards east at A and towards west at B
(B) is towards west at A and towards east at B
(C) is towards east at both A and B
(D) is towards west at both A and B

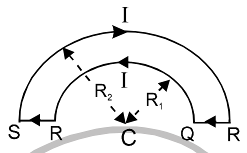
C 7. Two parallel, long wires carry currents i_1 and i_2 with $i_1 > i_2$. When the current are in the same direction, the magnetic field at a point midway between the wire is 10μT. If the direction of i_2 is reversed, the field becomes 30μT. The ratio i_1/i_2 is
(A) 4 (B) 3 (C) 2 (D) 1

C 8. (i) Two circular coils of radii 5.0 cm and 10 cm carry equal currents of 2.0 A. The coils have 50 and 100 turns respectively and are placed in such a way that their planes as well as the centre coincide. Find the magnitude of the magnetic field B at the common centre of the currents in the coils are (a) in the same sense (b) in the opposite sense.
(ii) If the outer coil of the above problem is rotated through 90º about a diameter, what would be the magnitude of the magnetic field B at the centre?

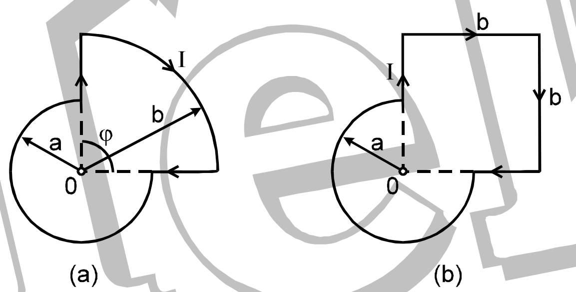
C 9. A charge of 3.14×10^{-6} C is distributed uniformly over a circular ring of radius 20.0 cm. The ring rotates about its axis with an angular velocity of 60.0 rad/s. Find the ratio of the electric field to magnetic field at a point on the axis at a distance of 5.00 cm from the centre.

SECTION (D) : MAGNETIC FIELD DUE TO A STRAIGHT WIRE AND CIRCULAR ARC

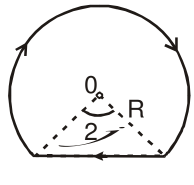
D 1. Two wire loops PQRSP formed by joining two semicircular wires of radii R_1 and R_2 carries a current I as shown in (fig.) The magnitude of the magnetic induction at the center C is.....



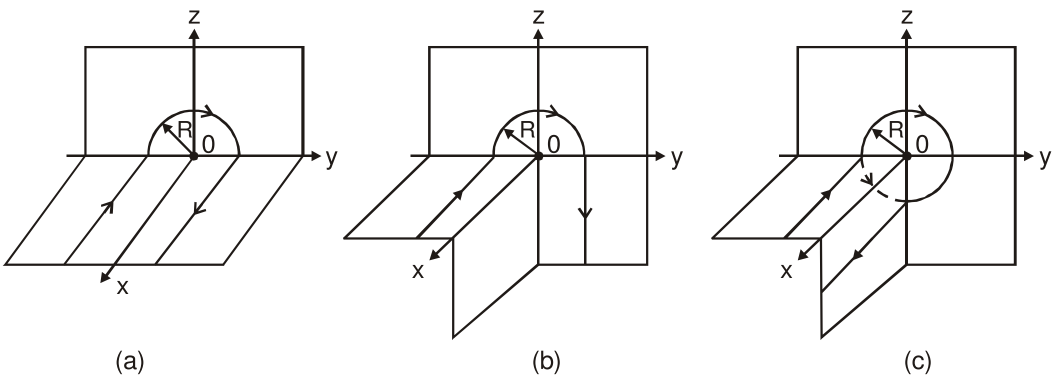
D 2. Find the magnetic induction of the field at the point O of a loop with current I , whose shape is illustrated



(a) In figure a the radii a and b, as well as the angle φ are known,
(b) In figure b, the radius a and the side b are known.
(c) A current I = 5.0 A flows along a thin wire shaped as shown in figure. The radius of a curved part of the wire is equal to R = 120 mm, the angle 2φ = 90°. Find the magnetic induction of the field at the point O.



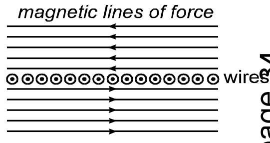
D 3. Find the magnetic induction at the point O if the wire carrying a current I = 8.0 A has the shape shown in figure a, b, c. The radius of the curved part of the wire is R = 100 mm, the linear parts of the wire are very long.



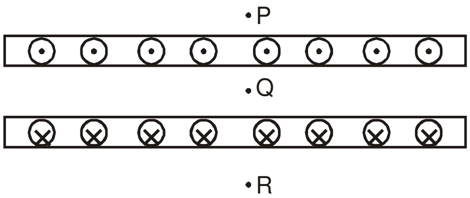
D 4. A regular polygon of n sides is formed by bending a wire of total length $2\pi r$ which carries a current i. (a) Find the magnetic field B at the centre of the polygon. (b) By letting $n \to \infty$, deduce the expression for the magnetic field at the centre of a circular current.

SECTION (E) : MAGNETIC FIELD DUE TO A CYLINDER, LARGE SHEET, SOLENOID, TOROID AND AMPERE'S LAW

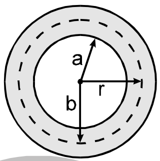
E 1. A conductor consists of an infinite number of adjacent wires, each infinitely long & carrying a current i. Show that the lines of B will be as represented in figure & that B for all points in front of the infinite current sheet will be given by, $B = (1/2)\,\mu_0 ni$, where n is the number of conductors per unit length.



E 2. Two large metal sheets carry surface currents as shown in figure. The current through a strip of width dl is Kdl where K is a constant. Find the magnetic field at the point P, Q and R.



E 3. Figure shows a cylindrical conductor of inner radius a & outer radius b which carries a current *i* uniformly spread over its cross section. Show that the magnetic field B for points inside the body of the conductor (i.e. $a < r < b$) is given by, $B = \dfrac{\mu_0 i}{2\pi\,(b^2 - a^2)}\,\dfrac{r^2 - a^2}{r}$. Check this formula for the limiting case of $a = 0$.



E 4. A thin but long, hollow, cylindrical tube of radius r carries a current i along its length. Find the magnitude of the magnetic field at a distance r/2 from the surface (a) inside the tube (b) outside the tube.

E 5. A copper wire having resistance 0.01 ohm in each metre is used to wind a 400 turn solenoid of radius 1.0 cm and length 20 cm. Find the emf of a battery which when connected across the solenoid will cause a magnetic field of 1.0×10^{-2} T near the centre of the solenoid.

E 6. A constant direct current of density $\vec{j}$ is flowing in an infinitely long cylindrical conductor. The conductor contains an infinitely long cylindrical cavity whose axis is parallel to that of the conductor and is at a distance ℓ from it. Determine the magnetic induction $\vec{B}$ inside the cavity.

E 7. A tightly wound solenoid of radius a and length l has n turns per unit length. It carries an electric current i. Consider a length dx of the solenoid at a distance x from one end. This contains n dx turns and may be approximated as a circular current i n dx. (a) Write the magnetic field at the centre of the solenoid due to this circular current. Integrate this expression under proper limits to find the magnetic field at the centre of the solenoid. (b) Verify that if $\ell >> a$, the field tends to $B = \mu_0 ni$ and if $a >> 1$, the field tends to $B = \dfrac{\mu nil}{2a}$. Interpret these results.

E 8. A tightly-wound, long solenoid is kept with its axis parallel to a large metal sheet carrying a surface current. The surface current through a width dl of the sheet is Kdl and the number of turns per unit length of the solenoid is n. The magnetic field near the centre of the solenoid is found to be zero. (a) Find the current in the solenoid. (b) If the solenoid is rotated to make its axis perpendicular to the metal sheet, what would be the magnitude of the magnetic field near its centre?

SECTION (F) : MAGNETIC FORCE ON A CHARGE

F 1. A positively charged particle projected towards east is deflected towards north by a magnetic field. The field may be
(A) towards west (B) towards south (C) upward (D) downward.

F 2. Which of the following particles will describe the smallest circle when projected with the same velocity perpendicular to a magnetic field?
(A) electron (B) proton (C) He^+ (D) $L1^+$

F 3. 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 υ. The magnetic force acting on the particle when it passes through the centre has a magnitude

(A) $q\nu \frac{\mu_0 i}{2a}$ (B) $q\nu \frac{\mu_0 i}{2\pi a}$ (C) $q\nu \frac{\mu_0 i}{a}$ (D) zero

F 4. A negative charged particle falling freely under gravity enters a region having uniform horizontal magnetic field pointing towards north. The particle will be deflected towards

(A) East (B) West (C) North (D) South

F 5. A proton of mass m and charge q enters a magnetic field B with a velocity v at an angle θ with the direction of B. The radius of the resulting path is

(A) $\frac{mv}{qB}$ (B) $\frac{mv\sin\theta}{qB}$ (C) $\frac{mv}{qB\sin\theta}$ (D) $\frac{mv\cos\theta}{qB}$

F 6. A current I flows along the length of an infinitely long, straight, thin walled pipe. Then

(A) the magnetic field at all points inside the pipe is the same, but not zero

(B) the magnetic field at any point inside the pipe is zero

(C) the magnetic field is zero only on the axis of the pipe

(D) the magnetic field is different at different points inside the pipe.

***F 7.** H^+, He^+ and O^{2+} all having the same kinetic energy pass through a thin region in which there is a uniform magnetic field perpendicular to their velocity. The masses of H^+, He^+ and O^{2+} are 1 amu, 4amu and 16 amu respectively, then

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

(C) He^+ and O^{2+} will be deflected equally (D) All will be deflected most

***F 8.** A beam of electron moving with a momentum p enters a uniform magnetic field of flux density B perpendicular to its motion. Which of the following statement(s) is (are) true?

(A) Energy gained is $\frac{p^2}{2m}$ (B) Centripetal force on the electron is $Be\frac{m}{p}$

(C) Radius of the electron's path is $\frac{p}{Be}$ (D) Work done on the electrons by the magnetic field is zero

F 9. A particle is projected in a plane perpendicular to a uniform magnetic field. The area bounded by the path described by the particle is proportional to

(A) the velocity (B) the momentum (C) the kinetic energy (D) none of these

F 10. A proton of mass 1.67×10^{-27} kg and charge 1.6×10^{-19} C is projected with a speed of 2×10^6 m/s at an angle of 60° to the x-axis. If a uniform magnetic field of 0.104 T is applied along the y-axis, the path of the proton is:

(A) A circle of radius 0.2 m and time period $\pi \times 10^{-7}$ s

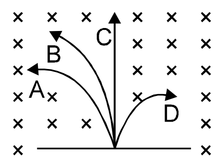
(B) A circle of radius 0.1 m and time period $2\pi \times 10^{-7}$ s

(C) A helix of radius 0.1 m and time period $2\pi \times 10^{-7}$ s

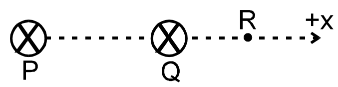
(D) A helix of radius 0.2 m and time period $4\pi \times 10^{-7}$ s

F 11. A charged particle is accelerated through a potential difference of 12 kV and acquires a speed of 1.0×10^6 m/s. It is then injected perpendicularly into a magnetic field of strength 0.2 T. Find the radius of the circle described by it.

F 12. A neutron, a proton, an electron and an α-particle enters a uniform magnetic field with equal velocities. The field is directed along the inward normal to the plane of the paper. Which of these tracks followed are by electron and α-particle.



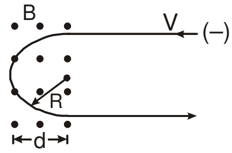
F 13. Two long parallel wires carrying currents 2.5 amps and I amps in the same direction (directed into the plane of the paper) are held at P and Q respectively such that they are perpendicular to the plane of paper. The points P and Q are located at a distance of 5m and 2m respectively from a collinear point R.



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

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

F 14. Prove that a charged particle entering a strong uniform magnetic field experiences specular reflection, if its speed is below some limiting value. Find the kinetic energy of the electrons which experience specular reflection, if the electron beam is perpendicular to the 'magnetic mirror'. The magnetic field with an induction B $= \sqrt{1.9}$T is established in a large region, the thickness of the 'magnetic mirror' is d = 10 cm.

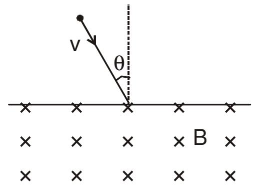


F 15. A magnetic field of $(4.0 \times 10^{-3}\vec{k})$T exerts a force of $(4.0\,\vec{i} + 3.0\,\vec{j}) \times 10^{-10}$ N on a particle having a charge of 1.0×10^{-9} C and going in the X – Y plane. Find the velocity of the particle.

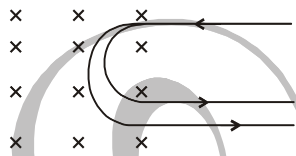
F 16. An experimenter's diary reads as follows; "a charged particle is projected in a magnetic field of $(7.0\,\vec{i} - 3.0\,\vec{j}) \times 10^{-3}$ T. The acceleration of the particle is found to be $(\_\,\vec{i} + 7.0\,\vec{j}) \times 10^{-6}$ m/s^2. The number to the left of $\vec{i}$ in the last expression was not readable. What can this number be?

F 17. A particle having a charge of 2.0×10^{-8} C and a mass of 2.0×10^{-10} g is projected with a speed of 2.0×10^3 m/s in a region aving a uniform magnetic field (B = 0.1 T). Find the radius of the circle formed by the particle and also the time period. (B = 0.1 T)

F 18. A particle of mass m and positive charge q, moving with a uniform velocity v, enters a magnetic field B as shown in figure. (a) Find the radius of the circular arc it describes in the magnetic field. (b) Find the angle subtended by the arc at the centre. (c) How long does the particle stay inside the magnetic field? (d) Solve the three parts of the above problem if the charge q on the particle is negative.

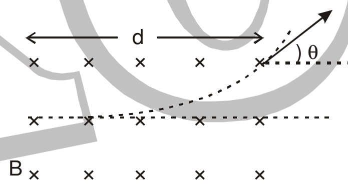


F 19. A narrow beam of singly-charged carbon ions, moving at a constant velocity of 6.0×10^4 m/s, is sent perpendicularly in a rectangular region having uniform magnetic field B = 0.5 T (figure). It is found that two beams emerge from the field in the backward direction, the separations from the incident 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.

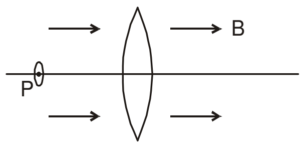


F 20. A particle of mass m and charge q is projected into a region having a perpendicular magnetic field B. Find the angle of deviation (figure) of the particle as it comes out of the magnetic field if the width d of the region is very slightly smaller than

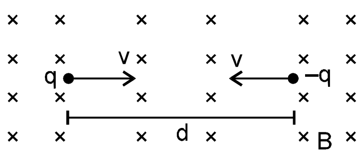
(a) $\dfrac{mv}{qB}$ (b) $\dfrac{mv}{2qB}$ (c) $\dfrac{2mv}{qB}$



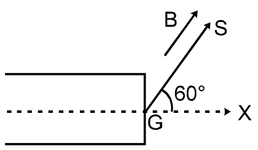
F 21. Figure shows a convex lens of focal length 12 cm lying in a uniform magnetic field B of magnitude 1.2 T parallel to its principal axis. A particle having a charge 2.0×10^{-3} C and mass 2.0×10^{-5} kg is projected perpendicular to the plane of the diagram with a speed of 4.8 m/s. The particle moves along a circle with its centre on the principal axis at a distance of 18 cm from the lens. The axis of the lens and of the circle are same. Show that the image of the particle goes along a circle and find the radius of that circle.



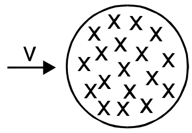
F 22. Two particles, each having a mass m are placed at a separation d in a uniform magnetic field B as shown in figure. They have opposite charges of equal magnitude q. At time t = 0, the particles are projected towards each other, each with a speed v. Suppose the Coulomb force between the charges is switched off. (a) Find the maximum value v_m of the projection speed so that the two particles do not collide. (b) What would be the minimum and maximum separation between the particles if v = $v_m/2$? (c) At what instant will a collision occur between the particle if v = $2v_m$? (d) Suppose v = $2v_m$ and the collision between the particles is completely inelastic. Describe the motion after the collision (neglect the magnetic force between charges).



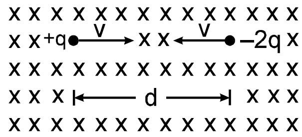
F 23. An electron gun G emits electron of energy 2kev traveling in the positive x-direction. The electrons are required to hit the spot S where GS = 0.1m and the line GS makes an angle of 60^0 with the x-axis, as shown in the fig. A uniform magnetic field $\vec{B}$ parallel to GS exists in the region outside of electron gun. Find the minimum value of B needed to make the electron hit S. [Take mass of electron = 9×10^{-31} kg]



F 24. A uniform magnetic field exists in a circular region of radius R. The magnitude of magnetic field is B and points inward. An electron flies into the region radially as shown in the figure. After a certain time, the electron deflected by the magnetic field leaves the region. Determine the time interval during which the electron moves in the region.



F 25. A charged particle +q of mass m is placed at a distance d from another charge particle – 2q of mass 2 m in a uniform magnetic field of induction vector B as shown in the fig. If the particles are projected towards each other with equal speeds v.



(a) Find the maximum value of the projection speed V_{max} so that the two particles do not collide.

(b) Find the time interval after which collision occurs between the particles if projection speed equals $2V_{max.}$

(c) Assuming the collision to be perfectly inelastic find the radius of the particle in subsequent motion. (Neglect the interaction between the particles)

SECTION (G) : ELECTRIC AND MAGNETIC FORCE ON A CHARGE

***G 1.** 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

***G 2.** If a charged particle kept at rest experiences an electromagnetic force,
(A) the electric field must not be zero (B) the magnetic field must not be zero
(C) the electric field may or may not be zero (D) the magnetic field may no may not be zero

***G 3.** If a charged particle projected in a gravity-free room deflects,
(A) there must be an electric field (B) there must be a magnetic field
(C) both field cannot be zero (D) both fields can be nonzero

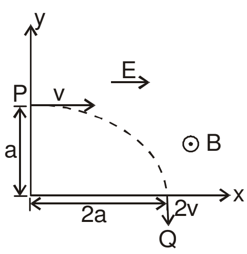
***G 4.** A charged particle moves in a gravity-free space without change in velocity. Which of the following is/are possible ?
(A) E = 0, B = 0 (B) E = 0, B ≠ 0 (C) E ≠ 0, B = 0 (D) E ≠ 0, B ≠ 0

***G 5.** If a charged particle goes unaccelerated in a region containing electric and magnetic fields,
($\vec{\upsilon}$ = velocity of particle, $\vec{E}$ = Electric field, $\vec{B}$ = magnetic field)
(A) $\vec{E}$ must be perpendicular to $\vec{B}$ (B) $\vec{\upsilon}$ must be perpendicular to $\vec{E}$
(C) $\vec{\upsilon}$ must be perpendicular to $\vec{B}$ (D) E must be equal to υB.

***G 6.** Two ions have equal masses but one is singly-ionized and other is double-ionized. They are projected from the same place in a uniform magnetic field with the same velocity perpendicular to the field.
(A) Both ions will go along circles of equal radii.
(B) The circle described by the single-ionized charge will have a radius double that of the other circle
(C) The two circles do not touch each other
(D) The two circles touch each other

***G 7.** 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.

***G 8.** 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 and Q as shown in figure. The velocities at P and Q are $v\hat{i}$ and $-2v\hat{j}$. Which of the following statement(s) is/are correct?



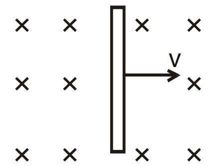
(A) $E = \frac{3}{4}\left(\frac{mv^2}{qa}\right)$

(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 fields at Q is zero.

G 9. An electron beam passes through a magnetic field of 2×10^{-3} Wb/m² and an electric field of 3.2×10^{4} V/m, both acting simultaneously. ($\vec{E} \perp \vec{B} \perp \vec{V}$) If the path of electrons remains undeflected calculate the speed of the electron. If the electric field is removed, what will be the radius of the electron path [m^2 = 9.1×10^{-31} kg]?

G 10. A conducting wire of length l, lying normal to a magnetic field B, moves with a velocity v as shown in figure. (a) Find the average magnetic force on a free electron of the wire. (b) Due to this magnetic force, electrons concentrate at one end resulting in an electric field inside the wire. The redistribution stops when the electric force on the free electrons balances the magnetic force. Find the electric field developed inside the wire when the redistribution stops. (c) What potential difference is developed between the ends of the wire?



G 11. A particle moves in a circle of diameter 1.0 cm under the action of a magnetic field of 0.40 T. An electric field of 200 V/m makes the path straight. Find the charge/mass ratio of the particle.

G 12. A proton goes undeflected in a crossed electric and magnetic field (the fields are perpendicular to each other) at a speed of 2.0×10^{5} m/s. The velocity is perpendicular to both the fields. When the electric field is switched off, the proton moves along a circle of radius 4.0cm. Find the magnitudes of the electric and the magnetic fields. Take the mass of the proton = 1.6×10^{-27} kg.

G 13. 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

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

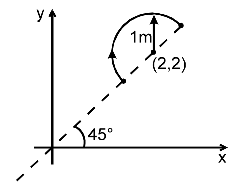
Find the speed of the particle as a function of its z-coordinate.

G 14. 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 $B_x = B_z = 0$, $B_y = 8 \times 10^{-2}$ Wbm^{-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?

G 15. When a proton is released from rest in a room, it starts with an initial acceleration a_0 towards west. When it is projected towards north with a speed v_0, it moves with an initial acceleration $3a_0$ towards west. Find the electric field and the minimum possible magnetic field in the room.

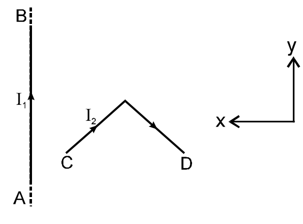
SECTION (H) : MAGNETIC FORCE ON A CURRENT CARRYING WIRE

H 1. 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 fig. 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) $\sqrt{2}(-\hat{i}+\hat{j}+\hat{k})$

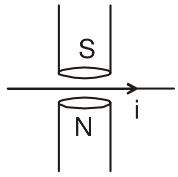
H 2. In the figure shown a current I_1 is established in the long straight wire AB. Another wire CD carrying current I_2 is placed in the plane of the paper. The line joining the ends of this wire is perpendicular to the wire AB. The resultant force on the wire CD is:



(A) zero (B) towards negative x-axis
(C) towards positive y-axis (D) none of these

H 3. Consider a 10 cm long portion of a straight wire carrying a current of 10 A placed in a magnetic field of 0.1 T making an angle of 53º with the wire. What magnetic force does the wire experience?

H 4. A magnetic field of strength 1.0 T is produced by a strong electromagnet in a cylindrical region of radius 4.0 cm as shown in figure. A wire, carrying a current of 2.0 A, is placed perpendicular to and intersecting the axis of the cylindrical region. Find the magnitude of the force acting on the wire.



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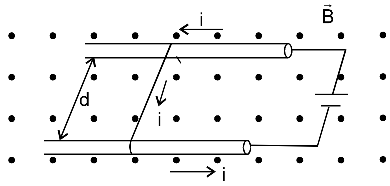
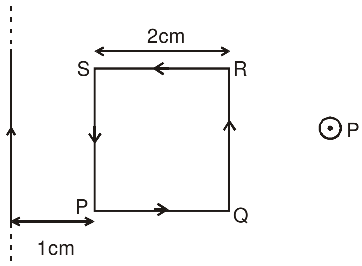
H 5. A metal wire of mass m slides without friction on two horizontal rails spaced at a distance d apart as shown in the figure. The rails are situated in a uniform magnetic field B, directed vertically upward, and a battery is sending a constant current i through them. Find the velocity of the wire as a function of time, assuming it to be at rest initially.

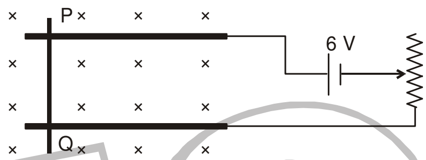


H 6. A square loop PQRS carrying a current of 6.0 A is placed near a long wire carrying 10 A as shown in figure (a) Show that the magnetic force acting on the part PQ is equal and opposite to that on the part RS. (b) Find the magnetic force on the square loop.



H 7. A wire, carrying a current, i, is kept in the X – Y plane along the curve $y = A\sin\left(\frac{2\pi}{\lambda}x\right)$. A magnetic field B exists in the z-direction. Find the magnitude of the magnetic force on the portion of the wire between x = 0 and x = λ.

H 8. A metal wire PQ of mass 10 g lies at rest on two horizontal metal rails separated by 4.90 cm (figure). A vertically downward magnetic field of magnitude 0.800 T exists in the space. The resistance of the circuit is slowly decreased and it is found that when the resistance goes below 20.0 Ω, the wire PQ starts sliding on the rails. Find the coefficient of friction.



H 9. The magnetic field existing in a region is given by

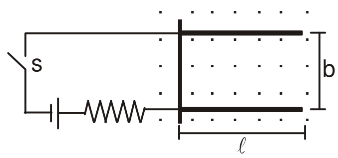
$$\vec{B} = B_0\left(1+\frac{x}{\ell}\right)\vec{k}$$

A square loop of edge ℓ and carrying a current i, is placed with its edges parallel to the X, Y axes. Find the magnitude of the net magnetic force experienced by the loop.

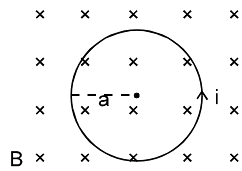
H 10. Three coplanar parallel wires each carrying a current of 10 A along the same direction, are placed with a separation 5.0 cm between the consecutive ones. Find the magnitude of the magnetic force per unit length acting on the wires.

H 11. A straight, long wire carries a current of 20 A. Another wire carrying equal current is placed parallel to it. If the force acting on a length of 10 cm of the second wire is 2.0×10^{-5} N, what is the separation between them ?

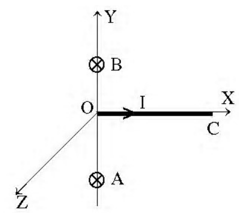
H 12. Two metal strips, each of length ℓ, are clamped parallel to each other on a horizontal floor with a separation b between them. A wire of mass m lies on them perpendicularly as shown in figure. A vertically upward magnetic field of strength B exists in the space. The metal strips are smooth but the coefficient of friction between the wire and the floor is μ. A constant current i is established when the switch S is closed at the instant t = 0. Discuss the motion of the wire after the switch is closed. How far away from the strips will the wire reach?



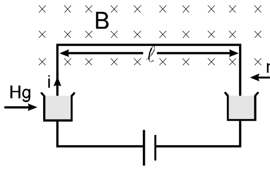
H 13. Figure shows a circular wire-loop of radius a, carrying a current i, placed in a perpendicular magnetic field B. (a) Consider a small part $d\ell$ of the wire. Find the force on this part of wire exerted by the magnetic field. (b) Find the force of compression in the wire.



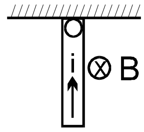
H 14. A straight segment OC (of length L meter) of a circuit carrying a current I amp is placed along the x-axis. Two infinitely long straight wires A and B, each extending form z = – ∞ to + ∞, are fixed at y = –a metre and y = +a metre respectively, as shown in the figure. If the wires A and B each 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?



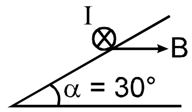
H 15. A U-shaped wire of mass m and length ℓ is immersed with its two ends in mercury (see figure). The wire is in a homogeneous field of magnetic induction B. If a charge, that is, a current pulse $q = \int i\,dt$, is sent through the wire, the wire will jump up. Calculate, from the height h that the 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 $\int F\,dt$, which equals mv. Evaluate q for $B = 0.1\ \frac{Wb}{m^2}$, m = 10gm, ℓ = 20cm & h = 3 meters.



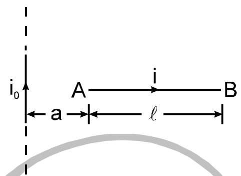
H 16. A uniform rod of length L and mass M is hinged at its upper point and is at rest at that moment at that moment in the vertical plane. A current i flows in it. A uniform magnetic field of strength B exists perpendicular to the rod and in horizontal direction (as shown). Find the force exerted by the hinge on the rod just after releases.



H 17. The figure shows a conductor of weight 1.0 N & length L = 0.5 m placed on a rough inclined plane making an angle 30^0 with the horizontal so that conductor is perpendicular to a uniform horizontal magnetic field of induction B = 0.10 T. The coefficient of static friction between the conductor and the plane is 0.1. A current of I = 10 A flows through the conductor inside the plane of this paper as shown. What is the force needed to be applied parallel to the inclined plane to sustain the conductor at rest?



H 18. A finite conductor AB carrying current i is placed near a fixed very long wire current carrying i_0 as shown in the figure. Find the point of application and magnitude of the net ampere force on the conductor AB. What happens to the conductor AB if it is free to move. (Neglect gravitational field)



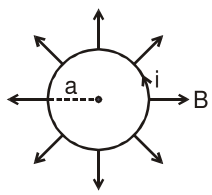
SECTION (I) : MAGNETIC FORCE AND TORQUE ON A CURRENT CARRYING LOOP AND MAGNETIC DIPOLE MOMENT

I 1. A circular loop of area 1 cm^2, carrying a current of 10 A, is placed in a magnetic field of 0.1 T perpendicular to the plane of the loop. The torque on the loop due to the magnetic field is

(A) zero (B) 10^{-4} N-m (C) 10^{-2} N-m (D) 1 N-m

I 2. A circular coil of 100 turns has an effective radius 0.05 m and carries a current of 0.1 amp. How much work is required to turn it in an external magnetic field of 1.5 wb/m^2 through 180^0 about an axis perpendicular to the magnetic field. The plane of the coil is initially perpendicular to the magnetic field.

I 3. (a) A circular loop of radius a, carrying a current i, is placed in a two-dimensional magnetic field. The centre of the loop coincides with the centre of the filed (figure). The strength of the magnetic filed at the periphery of the loop is B. Find the magnetic force on the wire.



(b) A hypothetical magnetic field existing in a region is given by $\vec{B} = B_0\vec{e}_r$, where $\vec{e}_r$ denotes the unit vector along the radial direction of a point relative to the origin and B_0 = constant. A circular loop of radius a, carrying a current i, is placed with its plane parallel to the X-Y plane and the centre at (0, 0, d). Find the magnitude of the magnetic force acting on the loop.

I 4. A rectangular loop of sides 20 cm and 10 cm carries a current of 5.0 A. A uniform magnetic field of magnitude 0.20 T exists parallel to the longer side of the loop. (a) What is the force acting on the loop? (b) What is the torque acting on the loop?

I 5. In a hydrogen atom the electron moves in an orbit of radius 0.5 Å making 10^{16} rev/s. What is the magnetic moment associated with the orbital motion of the electron and the magnetic field at the centre?

I 6. A stationary, circular wall clock has a face with a radius of 15cm. Six turns of wire are wound around its perimeter, the wire carries a current 2.0 A in the clockwise direction. The clock is located, where there is a constant, uniform external magnetic field of 70 mT (but the clock still keeps perfect time) at exactly 1:00 pm, the hour hand of the clock points in the direction of the external magnetic field

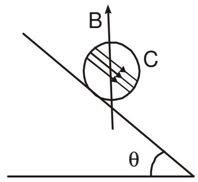
(a) After how many minutes will the minute hand point in the direction of the torque on the winding due to the magnetic field?

(b) What is the magnitude of this torque.

I 7. A length L of wire carries a current i. Show that if the wire is formed into a circular coil the maximum torque in a given magnetic field is developed when the coil has one turn only and the maximum torque has the value $\tau = \frac{1}{4\pi} L^2 iB$.

I 8. Consider a nonconducting plate of radius r and mass m which has a charge q distributed uniformly over it. The plate is rotated about its axis with an angular speed ω. Show that the magnetic moment μ and the angular momentum ℓ of the plate are related as $\mu = \frac{q}{2m}\ell$.

I 9. Figure shows (only cross section) a wooden cylinder C with a mass m of 0.25 kg, a radius R and a length ℓ perpendicular to the plane of paper of 0.1 meter with N equal to ten turns of wire wrapped around it longitudinally, so that the plane of the wire loop contains the axis of the cylinder. What is the least current through the loop that will prevent the cylinder from rolling down a plane whose surface is inclined at angle θ to the horizontal, in the presence of a vertical field of magnetic induction 0.5 weber/meter^2, if the plane of the windings is parallel to the inclined plane?



SECTION (J) : MAGNETIC FIELD DUE TO A MAGNET AND EARTH

J 1. A circular coil of radius 20 cm and 20 turns of wire is mounted vertically with its plane in magnetic meridian. A small magnetic needle (free to rotate about vertical axis) is placed at the center of the coil. It is deflected through 45° when a current is passed through the coil. Horizontal component of earth's field is 0.34×10^{-4} T. The current in coil is:

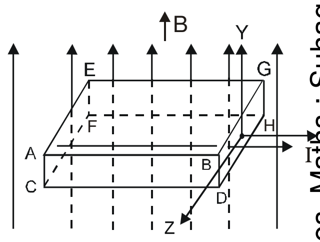
(A) $\frac{17}{10\pi}$ A (B) 6A (C) 6×10^{-3} A (D) $\frac{3}{50}$ A

J 2. Two circular coils each of 100 turns are held such that one lies in the vertical plane and the other in the horizontal plane with there centres coinciding. The radius of the vertical and the horizontal coils are respectively 20 cm and 30 cm. If the directions of the current in them are such that the earth's magnetic field at the centre of the coil is exactly neutralized, calculate the current in each coil. [horizontal component of the earth's field = 27.8 A m^{-1}; angle of dip = 30º]

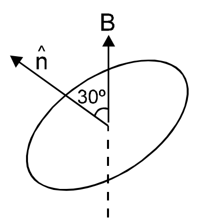
J 3. A coil of 50 turns and 20 cm diameter is made with a wire of 0.2 mm diameter and resistivity $2\times10^{-6}\ \Omega$ cm. The coil is connected to a source of EMF. 20 V and negligible internal resistance.
(a) Find the current through the coil .
(b) What must be the potential difference across the coil so as to nullify the earth's horizontal magnetic induction of 3.14×10^{-5} tesla at the centre of the coil. How should the coil be placed to achieve the above result.

EXERCISE-2

1. A metallic block carrying current I (along positive x axis) is subjected to a uniform magnetic induction B as shown in (fig.) The moving charge experiences a magnetic force $\vec{F}$ given by........which results in the lowering of the potential of the face.........Assume the speed of the carriers to be v. **[JEE - 96 (2 marks)]**



2. An electron in the ground state of hydrogen atom is revolving in anti-clockwise direction in a circular orbit of radius R.
(a) Obtain an expression for the orbital magnetic dipole moment of the electron
(b) The atom is placed in a uniform magnetic induction $\vec{B}$ such that the plane normal of the electron orbit makes an angle of 30° with the magnetic induction. Find the torque experienced by the orbiting electron. **[JEE - 96, (5 marks)]**



3. A long horizontal wire P carries a current of 50 A. It is rigidly fixed. Another fine wire

Q is placed directly above the wire P and parallel to it. The weight of wire Q is 0.075 Nm^{-1} and carries a current of 25 A. Find the position of wire Q from P so that the wire Q remains suspended due to the magnetic repulsion. Also indicate the direction of current in Q with respect to P. **[REE - 96]**

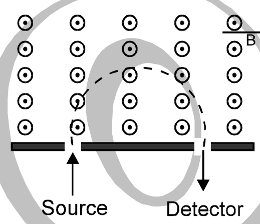
4. Centres of two circular coils P and Q having same number of turns are located at the coordinate (0.4, 0) and (0, 0.3) such that the plane of coils are perpendicular to x and y axis respectively. The area of cross section of coils P and Q is in the ratio 4: 3. P coil has 16 A current in clockwise direction and Q coil has $9\sqrt{3}$ A current in anti clockwise direction as seen from the origin. A small compass needle is placed at the origin. Find the deflection of the needle, assuming the earth's magnetic field negligible and radii of the coils very small compared to their distances from the origin. **[REE - 96]**

***5.** An electron and a proton moving with a same velocity are injected into a region of uniform magnetic field acting perpendicular to the velocity. The two particles will move
(A) with the same linear speed
(B) in circles with radius of proton being greater than that of electron
(C) in circles with radius of electron being greater than that of proton
(D) in circles but the directions will be opposite to each other

6. A proton, a deuteron and an α-particle having the same kinetic energy are moving in circular trajectories in a constant magnetic field. If r_p, r_d and r_α denote respectively the radii of the trajectories of these particles then **[JEE - 97, (1 marks)]**
(A) $r_\alpha = r_p < r_d$ (B) $r_\alpha > r_d > r_p$ (C) $r_\alpha = r_d > r_p$ (D) $r_p = r_d = r_\alpha$

7. Three infinitely long thin wires, each carrying current i in the same direction, are in the x-y plane of a gravity free space. The central wire is along the y-axis while the other two are along x = ± d.
(a) Find the locus of the points for which the magnetic field B is zero.
(b) If the central wire is displaced along the z-direction by a small amount and released, show that it will execute simple harmonic motion. If the linear density of the wires is λ, find the frequency of oscillation **[JEE - 97, (5 marks)]**

8. A uniform magnetic field with a slit system as shown in fig. is to be used as a momentum filter for high-energy charged particles. With a field B Tesla, it is found that the filter transmits α-particle each of energy 5.3 MeV. The magnetic field is increased to 2.3 B Tesla and deuterons are passed into the filter. The energy of each deuteron transmitted by the filter is.....MeV. **[JEE - 97, (1 mark)]**



9. Two coaxial loops of radii 0.5 m and 0.05 m are separated by a distance 0.5 m and carry currents 2A and 1A respectively. What is the force between the loops? **[REE - 97]**

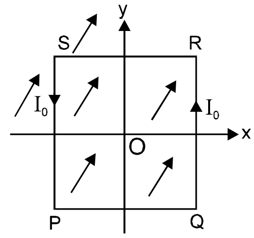
10. Two very long, straight, parallel wires carry steady currents I and – I respectively. The distance between the wires is d. At a certain instant of time, a point charge q is at a point equidistant from the two wires, in the plane of the wires. Its instantaneous velocity $\vec{v}$ is perpendicular to this plane. The magnitude of the force due to the magnetic field acting on the charge at this instant is: **[JEE - 98, (2 marks)]**
(A) $\frac{\mu_0 Iqv}{2\pi d}$ (B) $\frac{\mu_0 Iqv}{\pi d}$ (C) $\frac{2\mu_0 Iqv}{\pi d}$ (D) 0

***11.** Let $[\epsilon_0]$ denote the dimensional formula of the permittivity of the vacuum and $[\mu_0]$ that of the permeability of the vacuum. If M = mass, L = length, T = time and I = electric current,
(A) $[\epsilon_0] = M^{-1} L^{-3} T^2 I$ (B) $[\epsilon_0] = M^{-1} L^{-3} T^4 I^2$
(C) $[\mu_0] = MLT^{-2} I^{-2}$ (D) $[\mu_0] = ML^2 T^{-1} I$ **[JEE - 98]**

12. Two particles, each of mass m and charge q, are attached to the two ends of a light rigid rod of length 2 R. The rod is rotated at constant angular speed about a perpendicular axis passing through its centre. The ratio of the magnitudes of the magnetic moment of the system and its angular momentum about the centre of the rod is: **[JEE - 98]**
(A) $\frac{q}{2m}$ (B) $\frac{q}{m}$ (C) $\frac{2q}{m}$ (D) $\frac{q}{\pi m}$

13. A particle of mass m and charge q is moving in a region where uniform, constant electric and magnetic $\vec{E}$ & $\vec{B}$ fields are present, $\vec{E}$ & $\vec{B}$ are parallel to each other. At time t = 0 the velocity $\vec{v}_0$ of the particle is perpendicular to $\vec{E}$. (Assume that its speed is always <<c, the speed of light in vacuum). Find the velocity $\vec{v}$ of the particle at time t. You must express your answer in terms of t, q, m, the vectors $\vec{v}_0$, $\vec{E}$ & $\vec{B}$ and their magnitudes v_0, E and B. **[JEE - 98, (8 marks)]**

14. A uniform, constant magnetic field $\vec{B}$ is directed at an angle of 45º to the x-axis in the xy-plane, PQRS is a rigid square wire frame carrying a steady current I_0, with its centre at the origin O. At time t = 0, the frame is at rest in the position shown in the figure, with its sides parallel to the x and y axes. Each side of the frame is of mass M and length L



(a) What is the torque $\vec{\tau}$ about O acting on the frame due to the magnetic field?
(b) Find the angle by which the frame rotates under the action of this torque in a short interval of time Δt, and the axis about which this rotation occurs. (Δt is so short that any variation in the torque during this interval may be neglected). Given the moment of inertia of the frame about an axis through its centre perpendicular to its plane is 4/3 ML^2 **[JEE - 98, (8 marks)]**

15. A potential difference of 500 V is applied to a parallel plate condenser. The separation between plates is 2×10^{-3} m. The plates of the condenser are vertical. An electron is projected vertically upwards between the plates with a velocity of 10^5 ms^{-1} and it moves undeflected between the plates. The magnetic field acting perpendicular to the electric field has a magnetic of
(A) 1.5 Wm^{-2} (B) 2.0 Wm^{-2} (C) 2.5 Wm^{-2} (D) 3.0 Wm^{-2}
[REE - 98]

16. The region between x = 0 and x = L is filled with uniform, steady magnetic field $B_0\hat{k}$. A particle of mass m positive charge q and velocity $v_0\hat{i}$ travels along X-axis and enters the region of magnetic field. Neglect the gravity throughout the question.
(a) Find the value of L if the particle emerges from the region of magnetic field with its final velocity at an angle 30º to its initial velocity.
(b) Find the final velocity of the particle and the time spent by it is the magnetic field, if the magnetic field now extends upto 2.1 L. **[JEE - 99, (10 marks)]**

17. A charged particle is released from rest in a region of steady and uniform electric and magnetic fields which are parallel to each other. The particle will move in a **[JEE - 99, (2 marks)]**
(A) Straight line (B) Circle (C) Helix (D) Cycloid

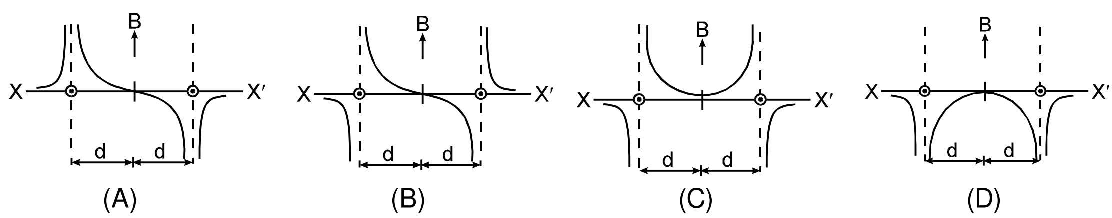
***18.** The radius curvature of the path of a charged particle moving in a static uniform magnetic field is **[REE - 99]**
(A) Directly proportional to the magnitude of the charge on the particle
(B) Directly proportional to the magnitude of the linear momentum of the particle
(C) Directly proportional to the kinetic energy of the particle
(D) Inversely proportional to the magnitude of the magnetic field

***19.** If the acceleration of a charged particle, moving with velocity $\vec{v}$ through a uniform electric field $\vec{E}$ and a uniform magnetic field $\vec{B}$, is zero, then **[REE - 99]**
(A) $\vec{E}$ must be perpendicular to $\vec{B}$ (B) $\vec{v}$ must be perpendicular to both $\vec{E}$ and $\vec{B}$
(C) $\vec{E}$ must be perpendicular to both $\vec{v}$ and $\vec{B}$ (D) $\vec{E}$ and $\vec{B}$ must be same direction

20. A pulsar is a neutron star having a magnetic field of 10^{12} T at its surface. the 'maximum' magnetic force experienced by an electron moving with velocity 0.9 c is **[REE - 99]**

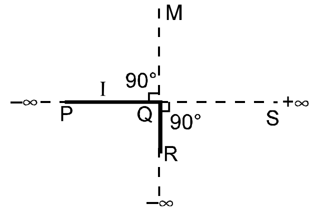
21. A particle of charge q and mass m moves in a circular orbit of radius r with angular speed ω.The ratio of the magnitude of its magnetic moment to that of its angular momentum depends on
[JEE 2000 Screening]
(A) ω and q (B) ω, q and m (C) q and m (D) ω and m

22. Two long parallel wires are at a distance 2d apart. They carry steady equal currents flowing out of the plane of the paper, as shown. The variation of the magnetic field B along the XX' is given by
[JEE 2000 Screening]



23. An infinitely long conductor PQR is bent to form a right angle as shown. A current I flows through PQR. The magnetic field due to this current at the point M is H_1. Now, another infinitely long straight conductor QS is connected at Q so that the current in PQ remaining unchanged. The magnetic field at M is now H_2. The ratio H_1/H_2 is given by

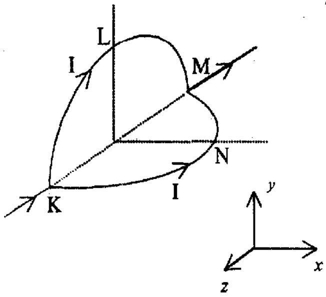
(A) 1/2 (B) 1 (C) 2/3 (D) 2



[JEE 2000 Screening]

24. An ionized gas contains both positive and negative ions. If it is subjected simultaneously to an electric field along the +x direction and a magnetic field along the +z direction, then
(A) positive ions deflect towards +y direction and negative ions towards −y direction
(B) all ions deflect towards +y direction
(C) all ions deflect towards −y direction
(D) positive ions deflect towards −y direction and negative ions towards +y direction.

25. A circular loop of radius R is bent along a diameter and given a shape as shown in the figure. One of the semicircles (KNM) lies in the $x-z$ plane and the other one (KLM) in the $y-z$ plane with their centers at the origin. Current I is flowing through each of the semicircles as shown in figure.



(i) A particle of charge q is released at the origin with a velocity $v = -v_0\hat{i}$. Find the instantaneous force f on the particle. Assume that space is gravity free.

(ii) If an external uniform magnetic field $B\hat{j}$ is applied, determine the forces F_1 and F_2 on the semicircles KLM and KNM due to this field and the net force F on the loop. **[JEE 2000 Mains, (4 + 6 marks)]**

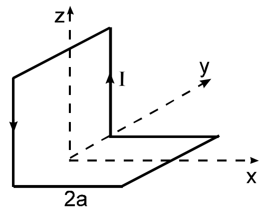
26. The magnetic moment of a nickel atom is 5.5×10^{-24} JT^{-1}. The saturation magnetization of a nickel sample (containing 9×10^{28} atoms m^{-3}) is about **[REE - 2000]**
(A) 4×10^5 Am^{-1} (B) 5×10^5 Am^{-1} (C) 4×10^6 Am^{-1} (D) 5×10^6 Am^{-1}
[Not in JEE Syllabus]

27. A bar magnet of magnetic moment M is rotated about its center through 360° in a uniform magnetic field B. The work done in the process is **[REE - 2000]**
(A) 2π MB (B) 2 MB (C) 1 MB (D) Zero

28. A homogeneous electric field $\vec{E}$ and a uniform magnetic field $\vec{B}$ are pointing in the same direction. A proton is projected with its velocity parallel to $\vec{E}$. It will
(A) Go on moving in the same direction with increasing velocity
(B) Go on moving in the same direction with constant velocity
(C) Turn to its right
(D) Turn to its left **[REE - 2000]**

***29.** A proton moving with a constant velocity passes through a region of space without any change in its velocity. If E and B represent the electric field and magnetic fields respectively, this region of space may have **[REE - 2000]**
(A) E = 0, B = 0 (B) E = 0, $B \neq 0$
(C) $E \neq 0$, B = 0 (D) $E \neq 0$, $B \neq 0$

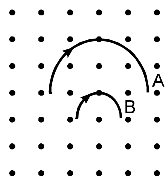
Ans. A, B, D



30. A non-planer loop of conducting wire carrying a current I is placed as shown in the figure. Each of the straight sections of the loop is of length 2a. The magnetic field due to this loop at the point P(a, 0, a) points in the direction. **[JEE 2001 (Screening]**

(A) $\frac{1}{\sqrt{2}}(-\hat{j}+\hat{k})$ (B) $\frac{1}{\sqrt{3}}(-\hat{j}+\hat{k}+\hat{i})$ (C) $\frac{1}{\sqrt{3}}(\hat{i}+\hat{j}+\hat{k})$ (D) $\frac{1}{\sqrt{2}}(\hat{i}+\hat{k})$

31. Two particles 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 **[JEE 2001 (Screening]**
(A) $m_Av_A < m_Bv_B$ (B) $m_Av_A > m_Bv_B$
(C) $m_A < m_B$ and $v_A < v_B$ (D) $m_A = m_B$ and $v_A = v_B$

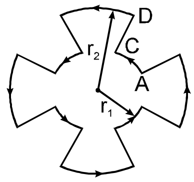


32. A coil having N turns is wound tightly in the form of a spiral with inner and outer radii a and b respectively. When a current I passes through the coil, the magnetic field at the centre is

(A) $\frac{\mu_0 NI}{b}$ (B) $\frac{2\mu_0 NI}{a}$ (C) $\frac{\mu_0 NI}{2(b-a)} \ln\frac{b}{a}$ (D) $\frac{\mu_0 Ni}{2(b-a)} \ln\frac{b}{a}$

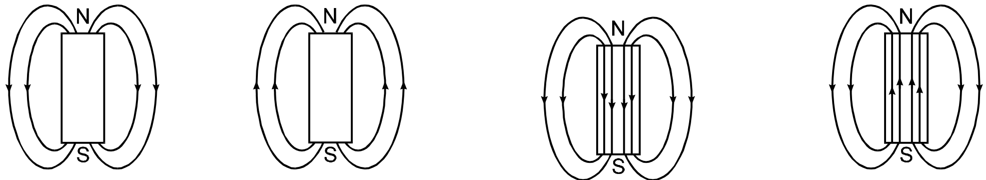
[JEE 2001 (Screening)]

33. A current of 10 A flows around a closed path in a circuit which is in the horizontal plane. The circuit consists of eight alternating arcs of radii r_1 = 0.08 m and r_2 = 0.12 m. Each arc subtends the same angle at the centre.



(i) Find the magnetic field produced by this circuit at the centre.
(ii) An infinitely long straight wire carrying a current of 10 A is passing through the centre of the above circuit vertically with the direction of the current being into the plane of the circuit. What is the force acting on the wire at the centre due to the current in the circuit? What is the force acting on the arc AC and the straight segment CD due to the current in the central wire. **[JEE 2001 (Mains) (10 marks)]**

34. The magnetic field lines due to a bar magnet are correctly shown in:



(A) (B) (C) (D)

[JEE 2002 (Screening)]

35. A particle of mass 'm' and charge 'q' moves with a constant velocity 'v' along the positive x direction. It enters a region containing a uniform magnetic field B directed along the negative z direction, extending from x = a to x = b. The minimum value of v required so that the particle can just enter the region x > b is: **[JEE 2002 (Screening)]**

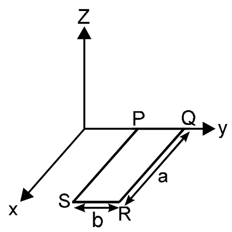
(A) $\frac{qbB}{m}$ (B) $\frac{q(b-a)B}{m}$ (C) $\frac{qaB}{m}$ (D) $\frac{q(b+a)B}{2m}$

36. A long straight wire along the z – axis carries a current I in the negative z direction. The magnetic vector field B at a point having coordinates (x, y) in the z = 0 plane is:

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

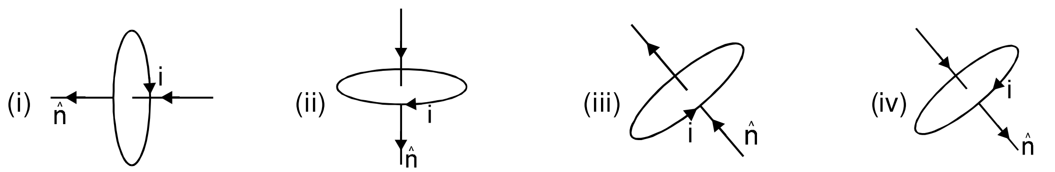
[JEE 2002 (Screening)]

37. A rectangular loop PQRS made from a uniform wire has length a, width b and mass m. It is free to rotate about the arm PQ, which remains hinged along a horizontal line taken as the y-axis as shown in figure.Take the vertically upward direction as the z – axis. A uniform magnetic field $\vec{B} = (3\hat{i}+4\hat{k})\,B_0$ exists in the region. The loop is held in the x – y plane and a current I is passed through it. The loop is now released and is found to stay in the horizontal position in equilibrium.



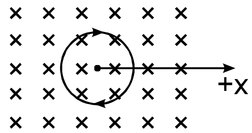
(a) What is the direction of the current I in PQ?
(b) Find the magnetic force on the arm RS.
(c) Find the expression for I in terms of B_0, a, b and m. **[JEE 2002 (Mains)]**

38. A current carrying loop is placed in a uniform magnetic field towards right in four different orientations, I, II, III & IV, arrange them in the decreasing order of Potential Energy. **[JEE 2003 Scr]**



(A) I, III, II, IV (B) I, II, III, IV (C) I, IV, II, III (D) III, IV, I, II

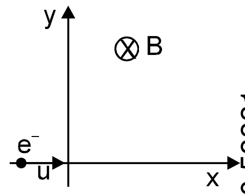
39. A conducting loop carrying a current I is placed in a uniform magnetic field pointing into the plane of the paper as shown. The loop will have a tendency to.



(A) move along the positive x direction
(B) move along the negative x direction
(C) contract
(D) expand **[JEE 2003 Scr]**

40. A proton and α particle, after accelerating through same potential difference enters into a uniform magnetic field perpendicular to their velocities, find the radius ratio of proton : α particle. **[JEE 2004 (Mains)]**

41. An electron traveling with a speed u along the positive x-axis enters into a region of magnetic field where $B = -B_0\,\hat{k}$ (x > 0). It comes out of the region with speed v then



(A) v = u at y > 0 (B) v = u at y < 0
(C) v > u at y > 0 (D) v > u at y < 0

[JEE 2004 Scr., 3]

42. Relation for a Galvanometer having number of turns N, area of cross section A and moment of inertia I is given as : τ = Ki where K is a positive constant and 'i' is current in the coil placed in the magnetic field B.

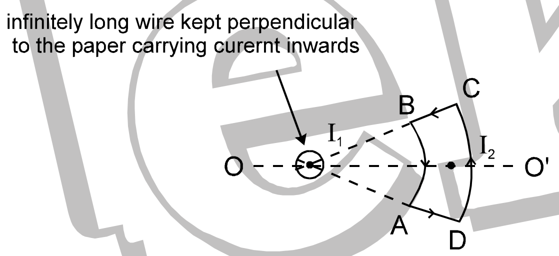
(i) Find K in terms of B, N and A

(ii) Find torsional constant of spring if a current I_0 produces a deflection of $\frac{\pi}{2}$

(iii) If an instant charge Q is flown through the galvanometer, find the maximum deflection in the coil.

[JEE 2005 Mains, 6]

***43.** Which of the following statement is correct in the given figure. **[JEE 2006]**



(A) net force on the loop is zero
(B) net torque on the loop is zero
(C) loop will rotate clockwise about axis OO' when seen from O
(D) loop will rotate anticlockwise about OO' when seen from O

ANSWER

EXERCISE # 1

SECTION (A) :

A 1*. ABC **A 2.** A **A 3.** $\frac{\sqrt{13}}{2} \times 10^{-4}$ wb/m^2

A 4. (i) $\frac{\mu_0 qv}{4\pi R^2}$, inwards (ii) $\frac{\mu_0 qv}{4\pi(x^2+R^2)}$, No

SECTION (B) :

B 1. B **B 2.** C **B 3.** C
B 4. CD **B 5.** BCD

B. 6 (i) $\frac{\mu_0 i}{2\pi d}(\hat{j})$ (ii) $\frac{-\mu_0 i}{2\pi d}(\hat{i})$ (iii) 0

(iv) $\frac{\mu_0 i}{4\pi d}(\hat{j}-\hat{i})$ (v) $\frac{\mu_0 i}{2\pi d}(\hat{j})$ (vi) $\frac{-\mu_0 i}{2\pi d}(\hat{i})$

(vii) $\frac{\mu_0 i}{4\pi d}(\hat{j}-\hat{i})$

B 7. 1×10^{-4} wb/m^2, towards the reader

B 8. (i) $2\sqrt{3} \times 10^{-5}$ tesla (ii) 2×10^{-5} T

B 9. In the plane of the drawing from right to left

B 10. (a) 0 (b) 1.41×10^{-6} T, 45º in xz-plane
(c) 5×10^{-6} T, + x-direction

B 11. 0 **B 12.** $\frac{\mu_0 i}{4\pi d}$ **B 13.** (b) $\frac{2\mu_0 i}{\pi d}$, yes

SECTION (C) :

C 1. A **C 2.** D **C 3.** C
C 4. A **C 5.** B **C 6.** D
C 7. C **C 8.** (i) (a) $8\pi \times 10^{-4}$ (b) zero (ii) 1.8 mT

C 9. $\frac{15}{8} \times 10^{+15}$ m/s

SECTION (D) :

D 1. $\frac{\mu_0 I}{4}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

D 2. (a) $B = \frac{\mu_0 I}{4\pi}\left(\frac{2\pi-\varphi}{a}+\frac{\varphi}{b}\right)$; (b) $B = \frac{\mu_0 I}{4\pi}\left(\frac{3\pi}{2a}+\frac{\sqrt{2}}{b}\right)$

(c) $B = (\pi = \varphi + \tan\varphi)\ \mu_0\ I/2\pi R = 28\mu T$.

D 3. (a) $B = \frac{\mu_0}{4\pi}\frac{\left(\sqrt{4+\pi^2}\right)I}{R} = 0.3\ \mu T$

(b) $B = \frac{\mu_0}{4\pi}\frac{\left(\sqrt{2+2\pi+\pi^2}\right)I}{R} = 0.34\ \mu T$

(c) $B = \frac{\mu_0}{4\pi}\frac{\sqrt{2}\,I}{R} = 0.11\ \mu T$

D 4. (a) $\frac{\mu_0 i n^2 \sin\frac{\pi}{n}\tan\frac{\pi}{n}}{2\pi^2 r}$

SECTION (E) :

E 1. 0, μ_0 K towards right in the figure, 0

E 2. (a) zero (b) $\frac{\mu_0 i}{3\pi r}$

E 3. 1 V **E 4.** $B = \frac{\mu_0\left(\vec{j}\times\vec{\ell}\right)}{2}$

E 5. (a) $\frac{\mu n i}{\sqrt{1+\left(\frac{2a}{\ell}\right)^2}}$ **E 6.** (a) $\frac{K}{2n}$ (b) $\frac{\mu_0 K}{\sqrt{2}}$

SECTION (F) :

F 1. D **F 2.** A **F 3.** D
F 4. B **F 5.** B **F 6.** B
F 7. A C **F 8.** C, D **F 9.** C
F 10. C **F 11.** 12 cm
F 12. D – electron , B – α-particle
F 13. (a) 4 A, (b) (i) current directed into the plane of paper, 1 m from R on RQ (away from Q) (ii) current directed out of from paper, 1 m from R on RQ (between R and Q)

F 14. $KE < \frac{e^2B^2d^2}{2m} = 2.67 \times 10^{-10}$

F 15. $(-75\,\vec{i} + 100\,\vec{j})$ m/s **F 16.** 3.0

F 17. 20 cm, 6.3×10^{-4} s

F 18. (a) $\frac{mv}{qB}$ (b) $\pi - 2\theta$ (c) $\frac{m}{qB}(\pi - 2\theta)$

(d) $\frac{mv}{qB}(\pi + 2\theta)$, $\frac{m}{qB}(\pi + 2\theta)$

F 19. ^{12}C and ^{14}C **F 20.** (a) $\pi/2$ (b) $\pi/6$ (c) π

F 21. 8 cm

F 22. (a) $\frac{qBd}{2m}$ (b) $\frac{d}{2}, \frac{3d}{2}$ (c) $\frac{\pi m}{6qB}$

(d) the particles stick together and the combined mass moves with constant speed v_m along the straight line drawn upward in the plane of figure through the point of collision.

F 23. $15\pi \times 10^{-4}$ T **F 24.** $\frac{2m\tan^{-1}\frac{eBr}{mV}}{eB}$

F 25. (a) $V_{max} = \frac{qBd}{2m}$ (b) $\frac{\pi d}{12V_{max}}$ (c) $\sqrt{3}$

SECTION (G) :

G 1. AD **G 2.** AD **G 3.** CD
G 4. ABD **G 5.** ABCD **G 6.** BD
G 7. AB **G 8.** A, B, D
G 9. 1.6×10^7 m/s, 4.55 cm

G 10. (a) evB (b) vB (c) $vB\ell$

G 11. 2.5×10^5 C/kg

G 12. 1.0×10^4 N/C. 0.05 T

G 13. $\sqrt{\dfrac{2qE_0z}{m}}$ **G 14.** (6.4, 0, 0) (6.4, 0, 2)

G 15. $\dfrac{ma_0}{e}$ towards west, $\dfrac{2ma_0}{ev_0}$ downward

SECTION (H) : **H 1.** B **H 2.** D

H 3. 0.08 N perpendicular to both the wire and the field

H 4. 0.16 N **H 5.** $\dfrac{Bidt}{m}$

H 6. (b) 16 N towards right.

H 7. $i\lambda B$ **H 8.** 0.12 **H 9.** $iB_0\ell$

H 10. zero on the middle wire and 6.0×10^{-4} N towards the middle wire on each of the rest two

H 11. 40 cm **H 12.** $\dfrac{i\ell bB}{\mu mg}$

H 13. (a) $id\ell B$ towards the centre (b) iaB

H 14. $\left(\dfrac{\mu_0 I^2}{2\pi}\right) \ell n \left(\dfrac{L^2+a^2}{a^2}\right) \left(-\hat{k}\right)$, zero

H 15. 3.8 C **H 16.** mg (up) , $\dfrac{iLB}{4}$ (right)

H 17. 0.62 N to 0.88 N

H 18. $F = \dfrac{\mu_0}{2\pi}(i_0\, i)\, \ell n\left(1+\dfrac{\ell}{a}\right)$ in the direction of i_0. $x = \dfrac{\ell}{\ell n\left(1+\frac{\ell}{a}\right)}$, where x is the perpendicular distance from the wire i_0. It will try to become antiparallel to i_0.

SECTION (I) :

I 1. A **I 2.** $\pm 7.5\,\pi \times 10^{-2}$ J

I 3. (a) $2\pi aiB$, perpendicular to the plane of the figure going into it. (b) $\dfrac{2\pi a^2 iB_0}{\sqrt{a^2+d^2}}$

I 4. (a) zero (b) 0.02 N-m parallel to the shorter side.

I 5. $M = 12.56 \times 10^{-24}$ A-m^2, $B = 32\pi / 5 = 6.4\pi$ Wb/m^2

I 6. (a) 20 min. (b) 5.94×10^{-2} Nm

I 9. $i = \dfrac{mg}{2BN\ell} = 2.5$ A

SECTION (J) :

J 1. A **J 2.** $I_V = \dfrac{278}{\pi}$ kA, $I_H = \dfrac{139\sqrt{3}}{\pi}$ kA

J 3. (a) 1.0 A
(b) 2.0 V perpendicular to the magnetic meridian

EXERCISE # 2

1. $evB\hat{k}$, ABCD **2.** (a) $\mu = \dfrac{eh}{4\pi m}$ (b) $|\vec{\tau}| = \dfrac{ehB}{8\pi m}$

3. 3.33 mm, opposite $\theta = 60^\circ$ ***5.** A, B, D **6.** A

7. (a) $x = 0$ and $x = \pm\dfrac{d}{\sqrt{3}}$ (b) $\dfrac{I}{2\pi d}\sqrt{\dfrac{\mu_0}{\pi\lambda}}$

8. 14MeV **9.** 2.09×10^{-8} N

10. D **11.** BC **12.** A

13. $\vec{v} = v_x\hat{i} + v_y\hat{j} + v_z\hat{k}$

$\vec{v}_x = \dfrac{qE}{m}t$, $v_y = v_0 \cos\left(\dfrac{qB}{m}t\right)$

$v_z = -v_0 \sin\left(\dfrac{qB}{m}t\right) \Rightarrow i = \dfrac{\vec{E}}{|\vec{E}|} = \dfrac{\vec{B}}{|\vec{B}|}$

$\hat{j} = \dfrac{\vec{v}_0}{|\vec{v}_0|}$, $\hat{k} = \dfrac{-\vec{v}_0 \times \vec{B}}{|\vec{v}_0 \times \vec{B}|} = \dfrac{\vec{v}_0 \times \vec{E}}{|\vec{v}_0 \times \vec{E}|}$

14. (a) $\vec{\tau} = \dfrac{BI_0L^2}{\sqrt{2}}\left(-\hat{i}+\hat{j}\right)$

(b) $\theta = \dfrac{3}{4}\dfrac{BI_0}{M}(\Delta t)^2$

15. C **16.** (a) $\dfrac{mv_0}{2qB}$ (b) $-v_0\hat{i}$, $\dfrac{\ell m}{2qB}$

17. A **18.** B, D **19.** A, C

20. 43.2 **21.** C **22.** B

23. C **24.** C

25. (i) $-\dfrac{\mu_0 I}{4R} q v_0 \hat{k}$ (ii) $4 I R B \hat{i}$

26. B **27.** D **28.** A

29. A, B, D **30.** D **31.** B

32. C **33.** (i) $B_C = \dfrac{5\pi \times 10^{-4}}{24}$ T

(ii) F on central wire = 0 ; $F_{AC} = 0$; $F_{CD} = 2 \times 10^{-5} \ln\left(\dfrac{3}{2}\right)$

34. D **35.** B **36.** A

37. (a) from P to Q (b) $ibB_0(3\hat{k} - 4\hat{i})$ (c) $\dfrac{mg}{6bB_0}$

38. A **39.** D

40. $R_P : R_\alpha = 1 : \sqrt{2}$ **41.** B

42. (i) K = NAB (ii) $\dfrac{2NABI_0}{\pi}$ (iii) $\dfrac{NABQ}{\sqrt{I}}$

43. (A, C)