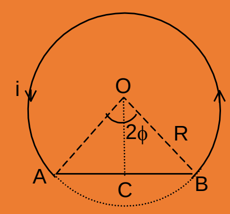
JEE-ADVANCE LEVEL PROBLEMS

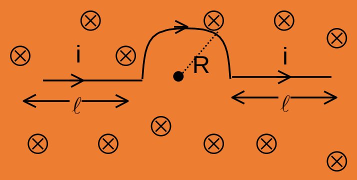
LEVEL – I

1. In a region of space having the magnetic field $\vec{B} = 1\hat{i} - 0.3\hat{j}$, a coil of area $\vec{A} = \hat{i} + 6\hat{j} - 3\hat{k}$ is placed in this uniform field. Find the magnetic flux ϕ linked with this area.

2. A wire is bent in the form of a circular arc with a straight portion AB. If current flowing in the wire is i, find the magnetic induction at the centre O.

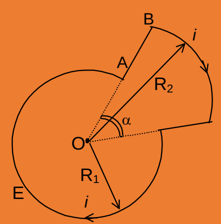


3. A wire is bent in the shape as shown in the figure. The wire carries a current i and is placed in a magnetic field of induction B which is perpendicular to the plane of paper and directed outward. What will be the force acting on the wire?



4. A loop of flexible conducting wire of length 0.5 m lies in a magnetic field of 1.0T perpendicular to the plane of the loop. Show that when a current is passed through the loop, it opens into a circle. Also calculate the tension developed in the wire if the current is 1.57 amp.

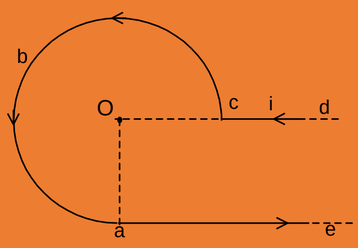
5. In the frame work of wires shown in figure, a current of i amperes is allowed to flow. Calculate the magnetic induction at the centre O. If angle α is equal to 90, than what will be the value of magnetic induction at O ?



6. (i) A proton is moving in a magnetic field. The field $\vec{B}$ is into the plane of the page. The velocity vector $\vec{v}$ lies in the plane of the page, perpendicular to $\vec{B}$. Describe the motion of proton.
(ii) In part (i), if the radius of the circle is 0.5m and the magnitude of the magnetic field is 1.2 Wbm^{-2} , find the frequency of revolution and the kinetic energy of the proton. Charge of the proton = 1.60×10^{-19} C. Mass of the proton=1.67×10^{-27} kg.

7. A circular coil of average radius 6 cm has 20 turns. A current of 1.0 A passes through it. Calculate the magnetic induction at
(i) the centre of the coil (ii) at a point on the axis 8 cm away from the centre.

8. Calculate the magnetic induction at the point O, if the current-carrying wire is in the shape shown in figure. The radius of the curved part of the wire is a and linear parts are assumed to be very long and parallel.



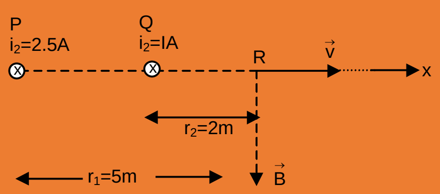
9. A beam of protons with a velocity 4×10^5 m/sec enters a uniform magnetic field of 0.3 Tesla at an angle of 60^o to the magnetic field. Find the radius of the helical path taken by the proton beam. Also find the pitch of the helix, which is the distance travelled by a proton in the beam parallel to the magnetic field during one period of rotation. [mass of proton = 1.67×10^{-27} Kg, charge on proton = 1.6×10^{-19} coulomb]

10. 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 directions (Given $\mu_o = 4\pi \times 10^{-7}$ Tm/A).

LEVEL – II

1. Calculate the magnetic induction at the centre of a rectangular frame of wire carrying a current i. The length of any diagonal of the rectangular frame is d and the acute angle between its diagonals is ϕ.

2. Two long parallel wires carrying currents 2.5 A and I A in the same direction (directed into 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 distance of 5 meters and 2 meters respectively from a collinear point R.

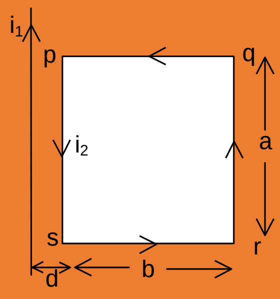


(i) An electron moving with a velocity of 4×10^5 m/s along the positive x-direction experiences a force of magnitude 3.2×10^{-20} N at the point R. Find the value of I.
(ii) Find all the positions at which a third long parallel wire carrying a current of magnitude 2.5 amperes may be placed so that magnetic induction at R is zero.

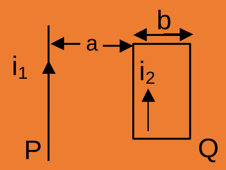
3. A particle of mass m accelerated by a potential difference V flies through uniform transverse magnetic field induction B. The field occupies a region of space d in thickness. Prove that the angle α through which the particle deviates from the initial direction of its motion is given by

$$\alpha = \sin^{-1}\left[dB\sqrt{\frac{q}{2Vm}}\right]$$

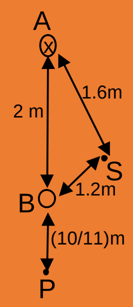
4. In the adjoining diagram, a current-carrying loop pqrs is placed with its sides parallel to a long current-carrying wire. The currents i_1 and i_2 in the wire and loop are 20 A and 16 A respectively. If a = 15 cm, b = 6 cm and d = 4 cm, what will be the force on current-loop pqrs? What will be the difference in the force, if the current i_2 in the loop becomes clockwise instead of anticlockwise?



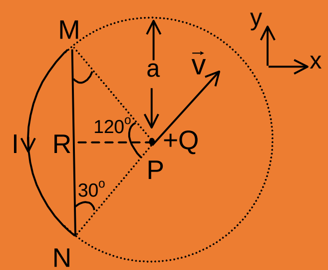
5. Consider a conducting wire P and conducting strip Q. P and Q are placed in the plane of paper, currents flowing in them being i_1 and i_2 respectively. The width of the strip Q is b and separation between P and Q is a as shown. Find the magnetic force per unit length on Q.



6. Two long straight parallel wires are 2 meters apart, perpendicular to the plane of the paper. The wire A carries a current of 9.6A, directed into the plane of the paper. The wire B carries a current such that the magnetic field of induction at the point P, at a distance of (10/11) metre from the wire B, is zero. Find
(i) the magnitude and direction of the current in B,
(ii) the magnitude of the magnetic field induction at the point S,
(iii) the force per unit length on the wire B.



7. A wire loop carrying a current I is placed in the x-y plane as shown in the figure.
(i) If a particle with charge +Q and mass m is placed at the centre P and given a velocity $\vec{v}$ along NP, find its instantaneous acceleration.
(ii) If an external uniform magnetic induction field $\vec{B} = B\hat{i}$ is applied, find the force and the torque acting on the loop due to this field.



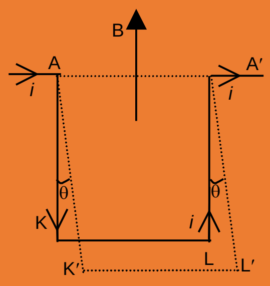
8. A regular polygon of n sides is formed by bending a wire of total length $2\pi r$ which carries a current i. (a) Find the magnetic field B at the centre of the polygon. (b) By letting $n \to \infty$, deduce the expression of the magnetic field at the centre of a circular current.

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

$$\vec{B} = B_o\left(1+\frac{x}{l}\right)\vec{k} .$$

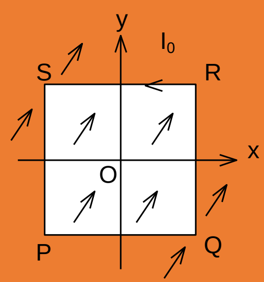
A square loop of edge l and carrying a current i, is placed with its edges parallel to the X-Y axes. Find the magnitude of the net magnetic force experienced by the loop.

10. A framework AKLA' forming three sides of a square is made from a copper wire having cross –sectional area 2.5×10^{-6} meter^2. The framework can turn about a horizontal axis AA', as shown in figure. The wire is placed in a vertical uniform magnetic field. If on passing a current of 16 amp, through the wire, the framework deflects through an angle $\theta = 20^o$, then what is the value of magnetic induction? Given that density of copper = 8.9 gms/c.c.



LEVEL – III

1. A uniform, constant magnetic field $\vec{B}$ is directed at an angle of 45^0 to the x-axis in the xy-plane. PQRS is 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.



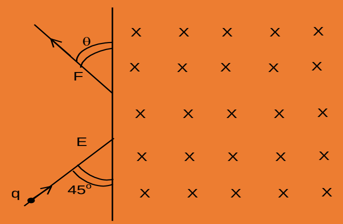
(i) What is the torque $\vec{\tau}$ about O acting on the frame due to the magnetic field?

(ii) 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.) The moment of inertia of the frame about an axis through its center perpendicular to its plane is (4/3) ML^2.

2. Electrons are observed to be ejected with negligible speed from the negative plate of a parallel plate capacitor when the plate is illuminated by a light of certain wavelength. The plates are separated by a distance d and a potential difference V is applied between them. Show that none of these electrons will reach the positive plate if a magnetic field is applied at right angles to the electric field and the magnetic induction has a value $B > (2Vm/ed^2)^{½}$, where e is the electronic charge and m is the mass of the electron.

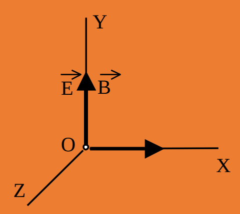
3. A particle of mass $m = 1.6 \times 10^{-27}$ Kg and charge $q = 1.6 \times 10^{-19}$ C enters a region of uniform magnetic field of strength 1T along the direction shown in figure. The speed of the particle is 10^7 m/s.

(i) The magnetic field is directed along the inward normal to the plane of the paper. The particle leaves the region of the field at the point F. Find the distance EF and the angle θ.



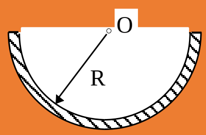
(ii) If the direction of the magnetic field is along the outward normal to the plane of the paper, find the time spent by the particle in the region of the magnetic field after entering it at E.

4. Uniform elecric and magnetic fields with strength E and induction B both are directed along the y axis (fig.). A particle with specific charge q/m leaves the origin O in the direction of the x axis with an initial non-relativistic velocity v_o. Find:
(i) the coordinate y_n of the particle when it crosses the y axis for the nth time;
(ii) the angle α between the particle's velocity vector and the y axis at that moment.

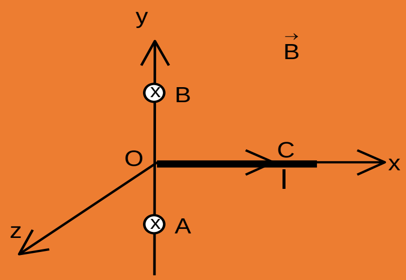


5. A non-conducting thin disc of radius R charged uniformly over one side with surface density σ rotates about its axis with an angular velocity ω. Find
(i) the magnetic induction at the centre of the disc,
(ii) the magnetic moment of the disc.

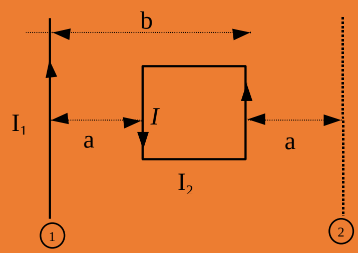
6. A current I flows in a long straight wire with cross-section having the form of a thin half-ring of radius R (fig.). Find the induction of the magnetic field at the point O.



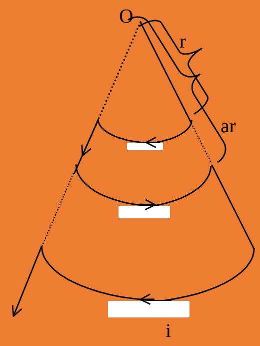
7. A straight segment OC (of length L meter) of a circuit carrying a current I amp is placed along the x-axis. Two infinitely long straight wires A and B, each extending from z=-∞ to +∞ are fixed at y=–a metre and y = +a metre respectively, as shown in figure. If the wires A and B each carry current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



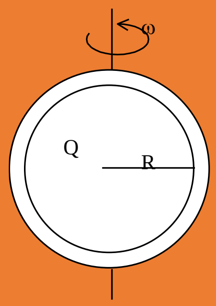
8. What is the work done in transferring the wire from position (1) to position (2)?



9. A wire carrying current i is bent into radial straight lines & circular segments subtending equal angles at the common centre O such that each circular position has the radius a times greater than that of its previous arc. Find the magnetic field induction at the common centre O.



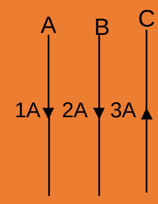
10. A uniformly charged thin hollow conducting spherical shell of radius R and charge Q is rotated with constant angular velocity ω about its diameter. Find the magnetic dipole moment of the system



JEE-MAIN LEVEL PROBLEMS

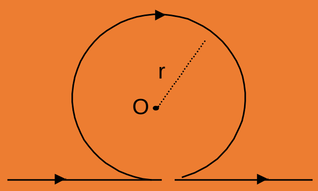
LEVEL – I

1. Three inifinite straight wires A, B and C carry currents as shown in figure. The resultant force on wire B is directed:



(A) towards A (B) towards
(C) zero
(D) perpendicular to the plane of the page

2. An infinitely long straight conductor is bent into shape as shown in figure. It carries a current I A. and the radius of circular loop is r metre. Then the magnetic induction at the centre of the circular loop is:



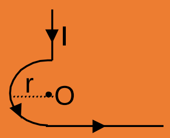
(A) 0 (B) ∞
(C) $\frac{\mu_0 i}{2\pi r}(\pi+1)$ (D) $\frac{\mu_0 i}{2\pi r}(\pi-1)$

3. An electron (mass = 9×10^{-31} kg, charge = 1.6×10^{-19} C) moving with a velocity of 10^6 m/s enters a region where magnetic field exists. If it describes a circle of radius 0.10 m, the intensity of magnetic field must be:
(A) 1.8×10^{-4} T (B) 5.6×10^{-5} T
(C) 14.4×10^{-5} T (D) 1.4×10^{-6} T

4. Electrons at rest are accelerated by a potential of V volt. These electrons enter the region of space having a uniform, perpendicular magnetic induction field B. The radius of the path of the electrons inside the magnetic field is:
(A) $\frac{1}{B}\sqrt{\frac{mV}{e}}$ (B) $\frac{1}{B}\sqrt{\frac{2mV}{e}}$
(C) $\frac{V}{B}$ (D) $\frac{1}{B}\sqrt{\frac{V}{e}}$

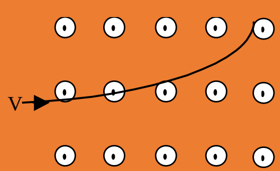
5. A proton enters in a magnetic field of strength B (Tesla) with speed v parallel to the direction of magnetic lines of force. The force on the proton is :
(A) evB (B) zero
(C) ∞ (D) evB/2

6. In the given figure, what is the magnetic field induction at point O?



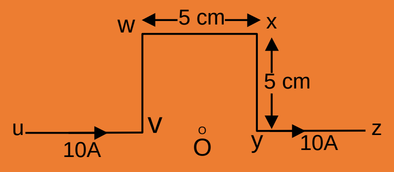
(A) $\frac{\mu_0 I}{4\pi r}$ (B) $\frac{\mu_0 I}{4r}+\frac{\mu_0 I}{2\pi r}$
(C) $\frac{\mu_0 I}{4r}+\frac{\mu_0 I}{4\pi r}$ (D) $\frac{\mu_0 I}{4r}-\frac{\mu_0 I}{4\pi r}$

7. A particle enters the region of a uniform magnetic field as shown in figure. The path of the particle inside the field is shown by dark line.
The particle is:



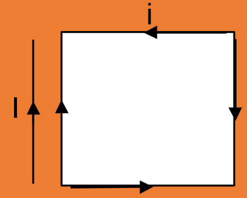
(A) electrically neutral
(B) positively charged
(C) negatively charged
(D) information given is inadequate

8. The resulting magnetic field at the point O due to the current carrying wire shown in the figure:



(A) points out of the page
(B) points into the page
(C) is zero
(D) is the same as due to the segment WX along.

9. A rectangular loop carrying a current i is situated near a long straight wire such that the wire is parallel to one of the sides of the loop and is in the plane of the loop. If a steady current I is established in the wire as shown in the figure, the loop will:

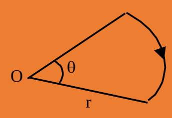


(A) rotate about an axis parallel to the wire
(B) move away from the wire
(C) move towards the wire
(D) remain stationary

10. Two thin long parallel wires separated by a distance b are carrying a current i amp each. The magnitude of the force per unit length exerted by one wire on the other is:
(A) $\mu_0(i^2/b^2)$
(B) $\mu_0 i^2/2\pi b$
(C) $\pi_0 i/2\pi b$
(D) $\mu_0 i/4\pi b$

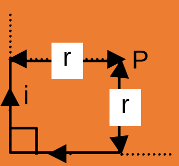
LEVEL – II

1. A wire bent in the form of a sector of radius r subtending an angle θ^o at centre, as shown in figure is carrying a current i. The magnetic field at O is:



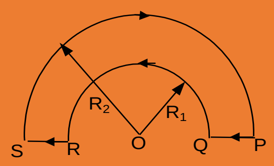
(A) $\frac{\mu_0 i}{2r}\theta$
(B) $\frac{\mu_0 i}{2r}(\theta/180)$
(C) $\frac{\mu_0 i}{2r}(\theta/360)$
(D) zero

2. The magnetic field strength at a point P distant r due to a finite straight wire as shown in the figure carrying a current i is:



(A) μ_0
(B) $\mu_0 i/2\sqrt{2}r$
(C) $(\mu_0 i/\sqrt{2}\pi r)$
(D) $\frac{\mu_0 i}{r}\left[2+\sqrt{2}\right]$

3. The wire loop shown in figure carries a current as shown. The magnetic field at the centre O is:



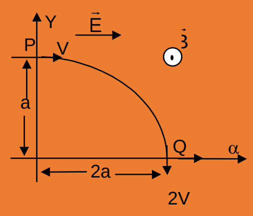
(A) zero

(B) $\frac{\mu_0 i}{4}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

(C) $\frac{\mu_0 i}{4}\left(\frac{1}{R_2}+\frac{1}{R_1}\right)$

(D) $\frac{\mu_0 i}{2}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

4. 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 trajectory from P to Q as shown in figure. The velocities at P and Q are $V\hat{i}$ and $-2V\hat{j}$ respectively. Which of the following statement(s) is/are correct?



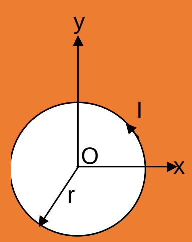
(A) $E = \frac{3}{4}\frac{mv^2}{qa}$

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

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

(D) Rate of work done by both the fields at Q is non-zero.

5. A circular loop of mass m and radius r is kept in a horizontal position (X – Y plane) on a table as shown in figure. A uniform magnetic field B is applied parallel to x-axis. The current I in the loop, so that its one edge just lifts from the table, is:



(A) $mg/\pi r^2 B$

(B) $mg/\pi rB$

(C) $mg/2\pi rB$

(D) $\pi rB/mg$

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

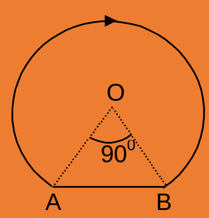
(A) $\left(\frac{R_1}{R_2}\right)^{1/2}$

(B) $\frac{R_2}{R_1}$

(C) $\left(\frac{R_1}{R_2}\right)^2$

(D) $\frac{R_1}{R_2}$

7. A current i flows along a thin wire shaped as shown in figure. The radius of the curved part of the wire is r. The field at the centre O of the coil is :



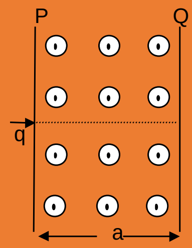
(A) $\frac{\mu_0}{4}\cdot\frac{i}{r}$

(B) $\frac{\mu_0}{2\pi r}$

(C) $\frac{\mu_0 i}{2\pi r}$

(D) $\frac{\mu_0 i}{8\pi r}(3\pi+4)$

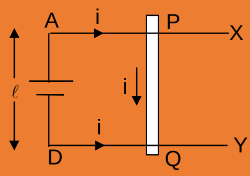
8. A charged particle having kinetic energy K and charge q enters into the region of a uniform magnetic field between two plates P and Q as shown in figure. The charged particle just misses hitting the plate Q. The magnetic field in the region between the two plates is :



(A) mK/qa (B) 2mk/qa

(C) √(mK)/qa (D) √(2mK)/qa

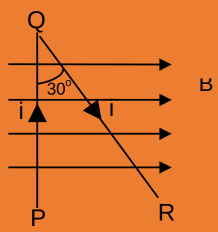
9. A conducting bar PQ of mass m can slide over rails AX and DY as shown in figure. A current i is sent through bar PQ by a battery. The whole arrangement is placed in a region of space having a uniform magnetic field B perpendicular to the plane XADY. The frictional force between bar PQ and rails is f. The acceleration of bar PQ is :



(A) $iB\ell/m$ (B) $(iB\ell-f)/m$

(C) $(iB\ell-2f)/m$ (D) $(iB\ell+f)/m$

10. A wire PQR carrying a current i is bent as shown in figure. The wire is placed in the region of a uniform magnetic induction field B. PQ = 1 m and QR = 1.5 m. The ratio of the force on PQ and QR is :



(A) 1 : 1.5 (B) 1 : 0.75

(C) 1 : 1.3 (D) 0.96 : 1

ANS KEY FOR ADVANCE LEVEL PROBLEMS
LEVEL - I

1. –0.8 unit
2. $\frac{\mu_0 i}{2\pi R}(\pi - \phi + \tan\phi)$
3. 2iB (ℓ + R)
4. 0.125 N
5. $\frac{\mu_0 i}{4\pi}\left(\frac{\alpha}{R_2} + \frac{2\pi - \alpha}{R_1}\right)$
6. (i) circular motion (ii) 1.83×10^{7} Hz, 2.759×10^{-12} J
7. (i) 2.09×10^{-4} T (ii) 3.6×10^{-6} T
8. $\frac{\mu_0 i}{4\pi a}\left(\frac{3\pi}{2} + 1\right)$
9. 1.205×10^{-2} m, 4.371×10^{-2} m
10. (i) 3.46×10^{-5} T (ii) 2×10^{-5} T

LEVEL – II

1. $\frac{4\mu_0 i}{\pi d \sin\phi}$
2. (i)4 A (ii)x = ± 1 m w. r. t. R
4. 1.44×10^{-4} N, force in opposite direction.
5. $\frac{\mu_0 i_1 i_2}{2\pi b}\log_e\left[1 + \frac{b}{a}\right]$
6. (i) 3 A (ii) $\frac{13\mu_0}{4\pi}$ T (iii) 2.88×10^{-6} N/m
7. (i) $\frac{0.109\mu_0 IQv}{ma}$ at an angle 30^0 to –ve x-axis (ii) 0, $0.6136\ a^2$ IB
8. (i) $\frac{\pi_0 ni}{2\pi r}\tan\left(\frac{\pi}{n}\right)$ (ii) $\frac{\mu_0 i}{2r}$
9. $iB_0\ell$
10. 9.9×10^{-3} T

LEVEL – III

1. (i) $I_0 L^2 B$ (ii) $\frac{3}{4}\frac{I_0 B}{M}\Delta t^2$

3. (i) 0.1414m , 45° (ii) 4.71×10^{-8} s

4. (i) $y_n = \dfrac{2\pi^2 mEn^2}{qB^2}$ (ii) $\tan\alpha = \dfrac{v_0B}{2\pi En}$

5. (i) $B = (1/2)\,\mu_0\sigma\omega R$ (ii) $\mu_m = (1/4)\,\pi\sigma\omega R^4$

6. $\mu_0 I/\pi^2 R$

7. $\dfrac{\mu_0 I^2}{2\pi}\ln\left(1+\dfrac{L^2}{a^2}\right)$, zero

8. $2\left[\dfrac{\mu_0 I_1 I_2 l}{\pi}\ln\dfrac{b}{a}\right]$

9. $\dfrac{\mu_0\theta ai}{4\pi r(a+1)}$

10. $\dfrac{\omega R^2 Q}{3}$

ANS KEY FOR MAIN LEVEL PROBLEMS

LEVEL - I

1.	A	6.	C
2.	D	7.	C
3.	B	8.	B
4.	B	9.	C
5.	B	10.	B

LEVEL - II

1.	C	6.	C
2.	D	7.	D
3.	B	8.	D
4.	A	9.	B
5.	B	10.	C