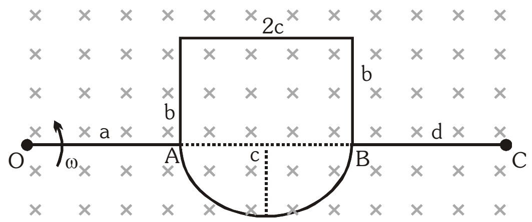
CLASS TEST

PHYSICS CLASS TEST # 54

SECTION-I

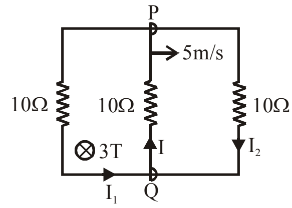
Single Correct Answer Type **8 Q. [3 M (–1)]**

1. A frame is rotating about hinge at O in a uniform transverse magnetic field as shown in the figure. Dimensions of various sections of the rod are shown. Some points are marked on the rod C choose the ***incorrect*** alternative



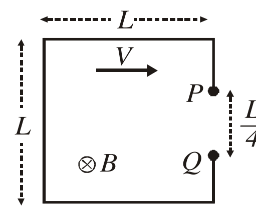
(A) Potential difference between O and A can never be zero
(B) Potential difference between A and C may be zero
(C) Potential difference between O and C does not depend on b
(D) Potential difference between A and B does not depend on a

2. A rectangular loop has a sliding connector PQ of length 2 m and resistance 10 Ω and it is moving with a speed 5 m/s as shown. The set-up is placed in a uniform magnetic field 3T going into the plane of the paper. The three currents I_1, I_2 and I are :-



(A) $I_1 = I_2 = 3A, I = 1A$ (B) $I_1 = I_2 = 5A, I = 2A$
(C) $I_1 = I_2 = 1A, I = 2A$ (D) $I_1 = I_2 = I = 2A$

3. The loop shown moves with a constant velocity 'V' in a uniform magnetic field of magnitude 'B' directed into the paper. The potential difference between P and Q is :-



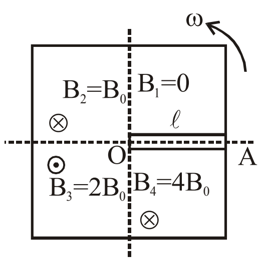
(A) $e = \frac{3}{4}BLV$, Q is positive with respect to P

(B) $e = \frac{1}{4}BLV$, P is positive with respect to Q

(C) e = 0

(D) $e = \frac{1}{4}BLV$, Q is positive with respect to P

4. A thin conducting rod OA of length ℓ is rotated about end O with constant angular frequency ω. The magnetic field in the quadrants are $B_1 = 0$; $B_2 = B_0$; $B_3 = 2B_0$; $B_4 = 4B_0$. B_2 and B_4 are into the plane of the paper whereas B_3 is out of the plane. The average emf induced in one cycle is :



(A) $\frac{13}{16}\omega B_0\ell^2$ (B) $\frac{3}{8}\omega B_0\ell^2$ (C) $\frac{1}{6}\omega B_0\ell^2$ (D) $\frac{3}{4}\omega B_0\ell^2$

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

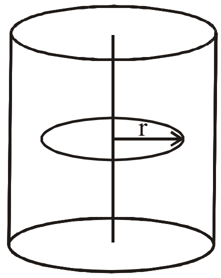
(A) it is constant in magnitude only

(B) it is constant in direction only

(C) it is constant in direction and magnitude both

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

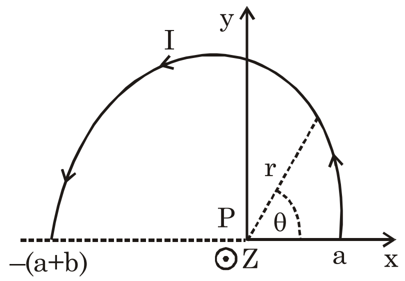
6. The magnetic field inside a solid conducting long wire at distance r from its axis is given as $B = B_0r^3$ where B_0 is constant. Which of the following relations correctly represents current enclosed in the loop of radius r shown in the figure:



(A) $\frac{2\pi B_0 r^3}{5\mu_0}$ (B) $\frac{\pi B_0 r^4}{2\mu_0}$

(C) $\frac{2\pi B_0 r^2}{\mu_0}$ (D) $\frac{2\pi B_0 r^4}{\mu_0}$

7. A wire segment is bent into the shape of an Archimedes spiral (see figure).



The equation that describes the curve in the range $0 \le \theta \le \pi$ is

$$r(\theta) = a + \frac{b}{\pi}\theta, \text{ for } 0 \le \theta \le \pi$$

where θ is the angle from x-axis in radians. Point P is at the origin. I is the current. Magnetic field at point P is

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

8. Consider two identical circular loops of same radius, with the second (right side) coil rotated slightly clockwise relative to the first when looked from above as shown in figure (a). A large current is suddenly injected into the left side loop. What happen to the right side loop?

Top view **Side view**

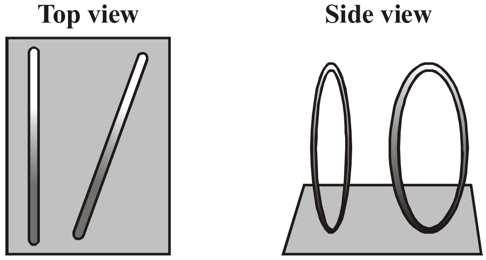


figure (a) figure (b)

(A) Force to the left, torque rotates clockwise (in top view)

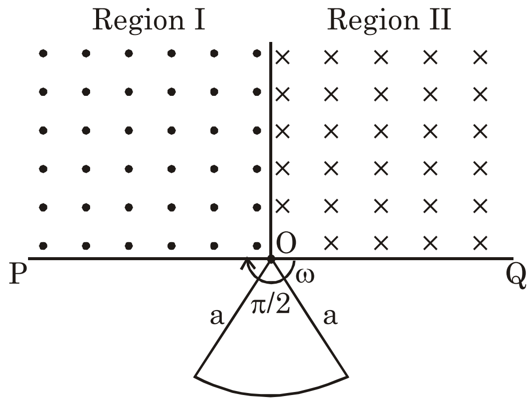
(B) Force to the right, torque rotates clockwise (in top view)

(C) Force to the right, torque rotates counterclockwise (in top view)

(D) Can't tell without knowing which direction current injected into left loop

Multiple Correct Answer Type 1 Q. [4 M (–1)]

9. A wire frame is in the shape of a quadrant of a circle of radius a, having resistance R and is free to rotate about O about axis perpendicular to plane of paper. Above line PQ a uniform magnetic field exist having magnitude B and direction out of plane for region I and inside plane for region II. If frame rotates with constant ω. Mark the **CORRECT** options :-



(A) As frame goes from region I to region II, the thermal energy dissipated is $\frac{B^2\omega\pi a^4}{2R}$

(B) As frame goes from region I to region II, the thermal energy dissipated is $\frac{B^2\omega\pi a^4}{4R}$

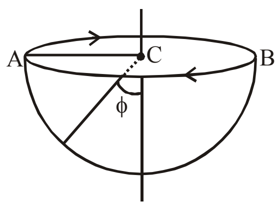
(C) Total thermal energy dissipated in one cycle is $\frac{3B^2\omega\pi a^4}{8R}$

(D) Average power is $\frac{3B^2\omega^2 a^4}{8R}$

Linked Comprehension Type (1 Para × 2Q.) [3 M (-1)]
(Single Correct Answer Type)

Paragraph for Questions 10 and 11

A non conducting hollow hemisphere of radius R is rotated with constant angular velocity ω about a fixed vertical axis as shown in the figure. The surface charge density on the sphere is varying as $\sigma = \sigma_0 \cos\phi$, ϕ being measured with the vertical axis.



10. The magnetic induction at the centre C is

(A) $\left(\frac{\mu_0\sigma_0\omega R}{8}\right)$ (B) $\left(\frac{\mu_0\sigma_0\omega R}{4}\right)$

(C) $\left(\frac{3\mu_0\sigma_0\omega R}{8}\right)$ (D) $\left(\frac{3\mu_0\sigma_0\omega R}{4}\right)$

11. If a small conducting ring of radius a is held co-axially at the centre C, and the hemisphere starts rotating with the constant angular acceleration α, then find the current flowing in the ring. Given that the resistance of the ring is r.

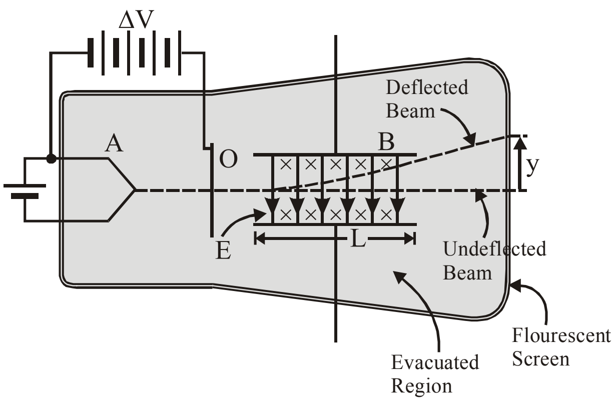
(A) $\frac{\mu_0\sigma_0\pi a^2 R\alpha}{4r}$ (B) $\frac{3\mu_0\sigma_0\pi a^2 R\alpha}{4r}$

(C) $\frac{3\mu_0\sigma_0\pi a^2 R\alpha}{8r}$ (D) $\frac{\mu_0\sigma_0\pi a^2 R\alpha}{8r}$

SECTION-II

Numerical Answer Type Question 1 Q. [3(0)]
(upto second decimal place)

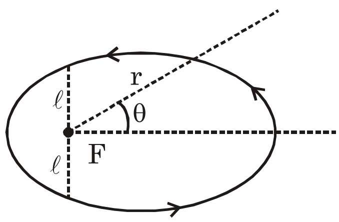
1. In 1897, J.J. Thomson measured the charge-to-mass ratio (e/m) of an electron by using a device similar to that illustrated in figure. Electrons from the heated filament A are accelerated by a potential difference ΔV through a small opening O. The electrons pass through a region where perpendicular electric and magnetic fields can be applied; these electrons eventually collide with a fluorescent screen kept just after the deflecting plates, where they are observed. Thomson measured the vertical deflection 5 cm at the screen that a certain known electric field 1.6×10^4 N/C produced, and then he applied a magnetic field of strength 10^{-4} T that returned the beam to its undeflected position. If 1 m is the length of the deflecting plates, he calculated the charge to mass ratio as $\alpha \times 10^9$ (in S.I. units). Fill the value of α in OMR sheet.



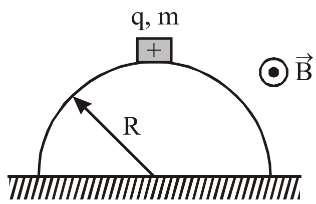
SECTION-III

Numerical Grid Type (Ranging from 0 to 9) 6 Q. [4 M (0)]

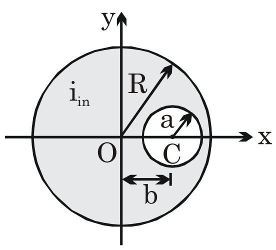
1. Find the magnetic field due to current i flowing in an elliptical loop at it's focus. The equation of ellipse (in polar coordinates as shown) is $\frac{\ell}{r} = (1 + e\cos\theta)$. Here e is eccentricity which is a constant. Take $\ell = 50$ cm, e = 0.8, i = 2A, if your answer is $n\pi \times 10^{-7}$ T, fill n in OMR sheet.



2. A small body of mass m, having a positive charge q begins to slide from the top of a smooth fixed half-cylinder of radius R = 10 m. At what height (in m), measured from the base of the half-cylinder, the body detaches itself from cylinder ? Movement occurs in a uniform magnetic field B directed perpendicular to the plane of the drawing and the observer. Take $B = \frac{m}{2q}\sqrt{\frac{g}{R}}$.



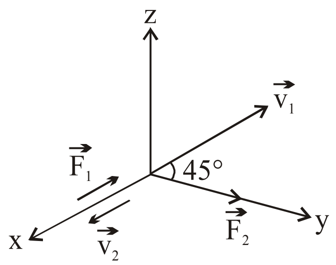
3. A very long straight conductor has a circular cross-section of radius R and carries a current density J. Inside the conductor there is a cylindrical hole of radius *a* whose axis is parallel to the axis of the conductor and a distance b from it. Let the z-axis be the axis of the conductor, and let the axis of the hole be at x = b. Find the x component of magnetic field on the y–axis at y = 2R. If your answer is $B_x = \mu_0 JR\left(\frac{1}{A} - \frac{a^2}{BR^2 + b^2}\right)$ fill value of |A| + |B|.



4. A non conducting rod of length 2m is hinged at one end and a charge of $\frac{1}{10}$C is distributed uniformly over it. At t = 0, it is released from the position shown. There exist a uniform magnetic field of $\sqrt{15}$ T inside the plane of motion of rod. If mass of rod is 100 g, then find the value of hinge force (in N) when rod is rotated by $\frac{\pi}{2}$ due to gravity.

5. A neutral atom of atomic mass number 100 which is stationary at the origin in gravity free space emits an α-particle (A) in z-direction. The product ion is P. A uniform magnetic field exists in the x-direction. Disregard the electro magnetic interaction between A and P. If the angle of rotation of A after which A and P will meet for the first time is $\frac{12n\pi}{25}$ radians, what is the value of n ?

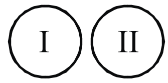
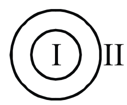
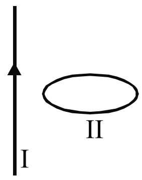
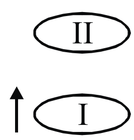
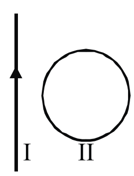
6. A particle has a charge of 4nC. When it moves with a velocity $v_1 = 3 \times 10^4$ m/s at 45° above y axis in yz plane, a uniform magnetic field exerts a force of F_1 along –ve x axis on it. When it moves with a velocity of $v_2 = 2 \times 10^4$ m/s along x axis, the same magnetic field exerts a force F_2 of 16×10^{-5} N along y axis. What is the magnitude of the magnetic field (in T)?



SECTION-IV

Matrix Match Type (4 × 5) **1 Q. [8 M (for each entry +2(0)]**

1. In all the situations current in loop-I is i_1 and current in loop-II is i_2. Consider the infinite wire as the side of infinite large loop. Column-II describes the variation in current i_1 in different arrangements and column-I describes the various effects.

Column I	Column-II	
(A) Current is clockwise in loop-II.	(P) Current i_1 is clockwise and decreasing at constant rate.	
(B) Current is anticlockwise in loop-II.	(Q) Current i_1 is clockwise and decreasing at constant rate.	
(C) Flux of current i_1 through loop-II is less than flux of current i_1 through loop-I	(R) Current in infinite wire is i_1 and decreasing at constant rate. The wire is perpendicular to plane of loop.	
(D) Loop-II tends to reduce its area due to magnetic force applied by magnetic field of i_1	(S) Loop-I having constant current in clockwise direction moving upward with retardation. Both loops are co-axial.	
	(T) Current in infinite wire is i_1 upward and decreasing at constant rate. The wire is parallel to the plane of loop.	

CLASS TEST # 54	ANSWER KEY

SECTION-I

Single Correct Answer Type — **8 Q. [3 M (–1)]**

1. Ans. (B)	2. Ans. (C)	3. Ans. (B)	4. Ans. (B)
5. Ans. (A)	6. Ans. (D)	7. Ans. (D)	8. Ans. (B)

Multiple Correct Answer Type — **1 Q. [4 M (–1)]**

9. Ans. (A, D)

Linked Comprehension Type — **(1 Para × 2Q.) [3 M (-1)]**

(Single Correct Answer Type)

10. Ans. (A) 11. Ans. (D)

SECTION-II

Numerical Answer Type Question — **1 Q. [3(0)]**

(upto second decimal place)

1. Ans. 160

SECTION-III

Numerical Grid Type (Ranging from 0 to 9) — **6 Q. [4 M (0)]**

1. Ans. 8	2. Ans. 5	3. Ans. 8	4. Ans. 4
5. Ans. 4	6. Ans. 2		

SECTION-IV

Matrix Match Type (4 × 5) — **1 Q. [8 M (for each entry +2(0)]**

1. Ans. (A) QT, (B) PS (C) PQRST (D) QS