Physicsaholics

DPP –2 (EMI)

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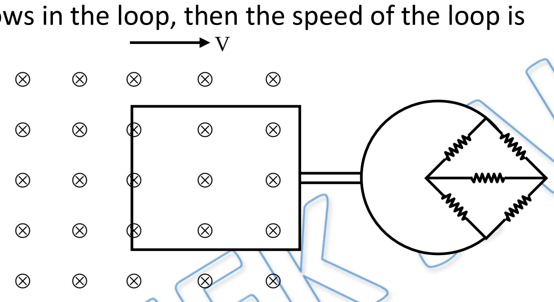
Q 1. A square metal loop of side 10 cm and resistance 1 Ω is moved with a constant velocity partly inside a uniform magnetic field of 2 Wbm–2, directed into the paper, as shown in the figure. The loop is connected to a network of five resistors each of value 3 Ω. If a steady current of 1 mA flows in the loop, then the speed of the loop is

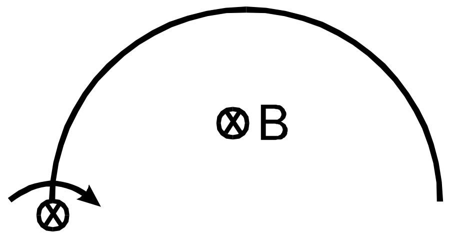


(a) 0.5 cms^{-1} (b) 1 cms^{-1} (c) 2 cms^{-1} (d) 4 cms^{-1}

Q 2. A copper rod AB of length L, pivoted at one end A, rotates at constant angular velocity w, at right angles to a uniform magnetic field of induction B. The e.m.f developed between the mid point C of the rod and end B is

(a) $\frac{B\omega L^2}{4}$ (b) $\frac{B\omega L^2}{2}$ (c) $\frac{3B\omega L^2}{4}$ (d) $\frac{3B\omega L^2}{8}$

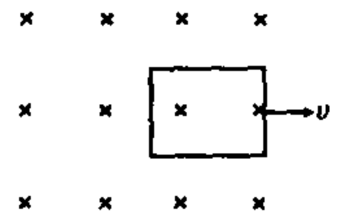
Q 3. A semicircular wire of radius R is rotated with constant angular velocity ω about an axis passing through one end and perpendicular to the plane of the wire. There is a uniform magnetic field of strength B. The induced e.m.f. between the ends is :



(a) $B\omega R^2/2$ (b) $2 B \omega R^2$

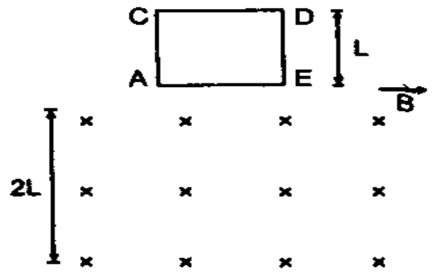
(c) is variable (d) none of these

Q 4. Figure shows a square loop of side 0.5 m and resistance 10 ohm. The magnetic field has a magnitude B = 1.0 T. The work done in pulling the loop out of the field uniformly in 2.0 S is:



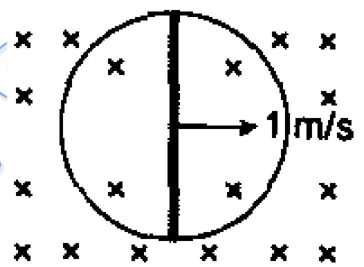
(a) 3.125×10^{-3} J (b) 6.25×10^{-4} J
(c) 1.25×10^{-2} J (d) 5.0×10^{-4} J

Q 5. A square coil ACDE with its plane vertical is released from rest in a horizontal uniform magnetic field $\vec{B}$ of length 2L. The acceleration of the coil is :



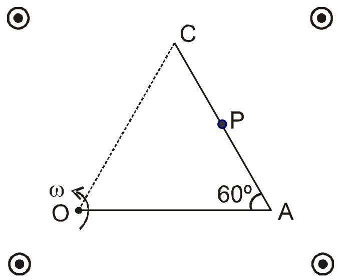
(a) less than g for all time till loop crosses magnetic field completely
(b) less than g when it enters field and greater than g when it comes out of the field
(c) g all the time
(d) less than g when it enters and comes out of the field but equal to g when it is within the field

Q 6. A circular loop of radius 1m is kept in a magnetic field of strength 2 T (plane of 1oop is perpendicular to the direction of magnetic field). Resistance of the loop wire is $\frac{2}{3}$ ohm/m. A conductor of length 2 m in sliding with a speed 1 m/s as shown in the figure. Find the instantaneous force acting on the rod : [assume rod has negligible resistance]



(a) 48 N (b) 15.28 N (c) 32.28 N (d) 64 N

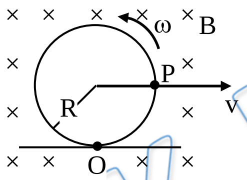
Q 7. A metallic V shaped rod OAC is rotated with respect to one of its end in uniform magnetic field, such that axis of rotation is parallel to the direction of magnetic field. Length of each arm of rod is L and angle between the arms is 60º. P is the mid–point of section AC. Magnitude of magnetic field is B. Then choose the correct relations.



(a) $V_A - V_0 = \frac{\omega BL^2}{2}$ (b) $V_A - V_C = \frac{\omega BL^2}{2}$

(c) $V_C - V_P = \frac{\omega BL^2}{8}$ (d) $V_A - V_P = \frac{\omega BL^2}{8}$

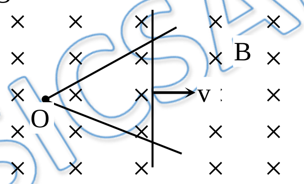
Q 8. A metallic ring of radius R moves in a vertical plane in the presence of a uniform magnetic field B perpendicular to the plane of the ring. At any given instant of time its centre of mass moves with a velocity v while ring rotates with angular velocity ω as shown in the figure. The magnitude of induced e.m.f. between points O and P is –



(a) zero (b) vBR√2 (c) vBR (d) 2 vBR

(Comprehension Q.9 TO Q.11)

The mobile side of the equilateral triangular conducting frame shown in the figure is sliding at uniform speed of v = 0.1 m/s along the other two side. This horizontal frame is in a vertical homogeneous magnetic field with an induction of B = 0.4 T. Resistance per unit length is 1 ohm/m. Initially at t = 0 sliding rod was at O.



Q 9. How induced emf vary with time ?

(a) Increase with time (b) Decrease with time

(c) Remain constant (d) Initially increase, then decrease

Q 10. Induced current in frame is –

(a) increasing with time (b) decreasing with time

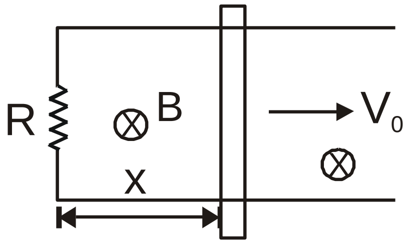
(c) remain constant (d) initially increase then decrease

Q 11. Work required for sliding –

(a) Is equal to joule heating (b) Is greater than joule heating

(c) Is less than joule heating (d) none of these

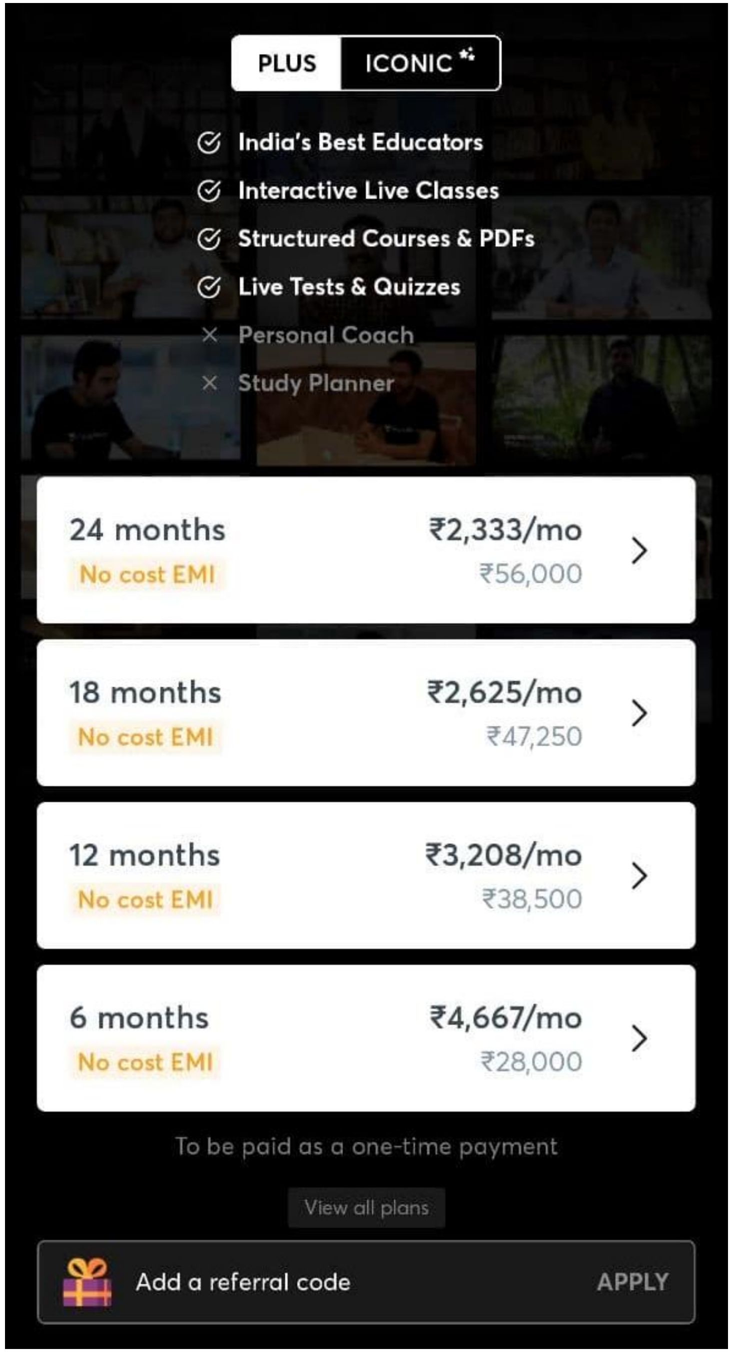
Q 12. A conducting rod of length l is moved at constant velocity 'v_0' on two parallel, conducting, smooth, fixed rails, that are placed in a uniform constant magnetic field B perpendicular to the plane of the rails as shown in figure. A resistance R is connected between the two ends of the rail. Then which of the following is/are correct :



(a) The thermal power dissipated in the resistor is equal to rate of work done by external person pulling the rod.
(b) If applied external force is doubled than a part of external power increases the velocity of rod.
(c) Lenz's Law is not satisfied if the rod is accelerated by external force
(d) If resistance R is doubled then power required to maintain the constant velocity v_0 becomes half.

Answer Key

Q.1 c	Q.2 d	Q.3 b	Q.4 a	Q.5 d
Q.6 b	Q.7 a, c, d	Q.8 c	Q.9 a	Q.10 c
Q.11 a	Q.12 a, b, d			



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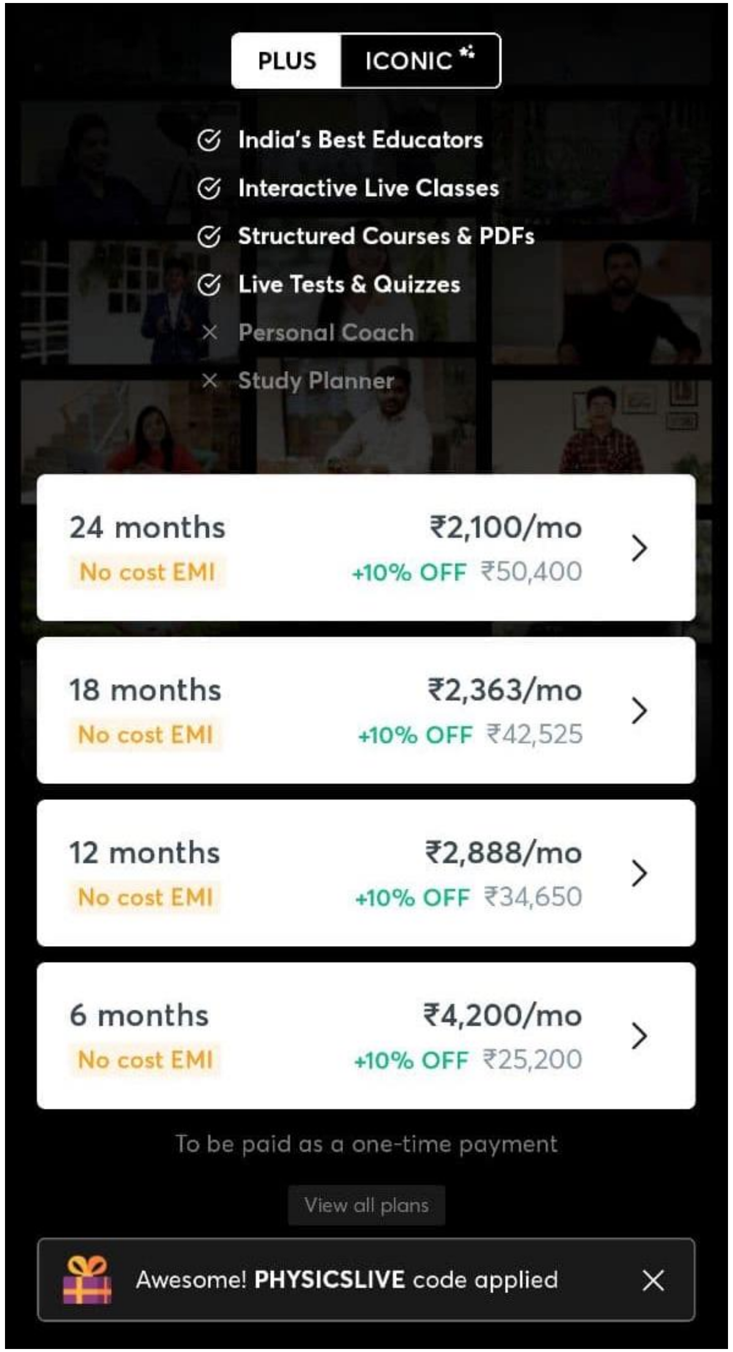

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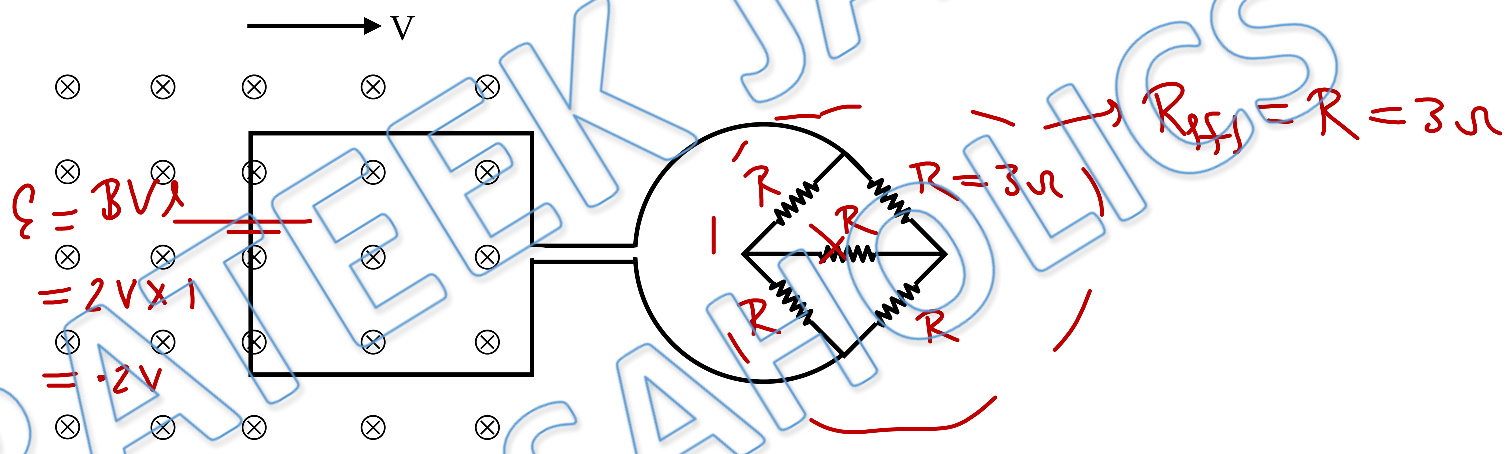
Written Solution

DPP- 2 EMI- Motional EMF

By Physicsaholics Team

Q.1) A square metal loop of side 10 cm and resistance 1 Ω is moved with a constant velocity partly inside a uniform magnetic field of 2 Wbm–2, directed into the paper, as shown in the figure. The loop is connected to a network of five resistors each of value 3 Ω. If a steady current of 1 mA flows in the loop, then the speed of the loop is -



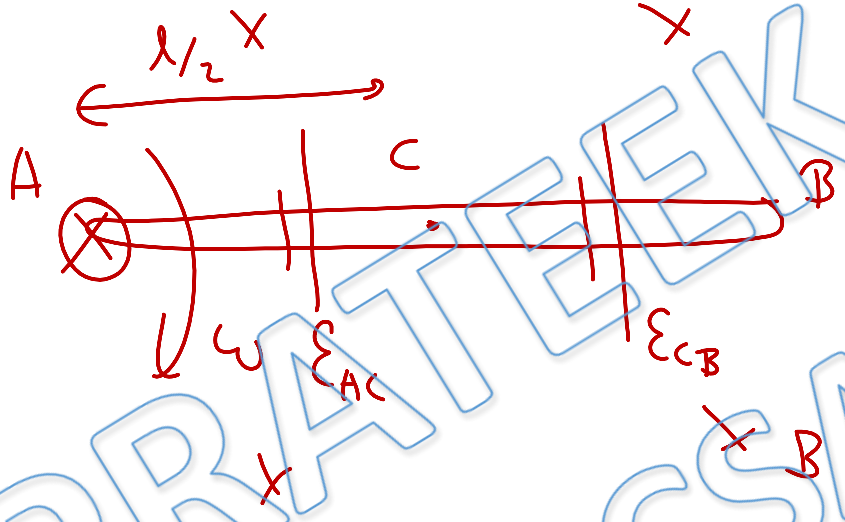
(a) 0.5 cms^{-1} (b) 1 cms^{-1} (c) 2 cms^{-1} (d) 4 cms^{-1}

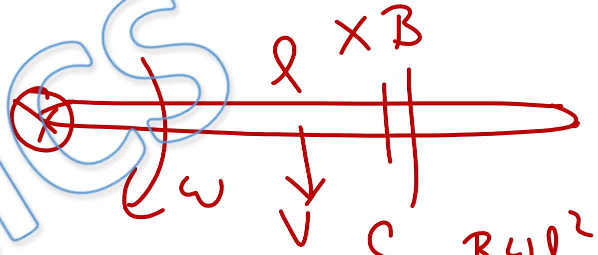
Net resistance of loop = 3 + 1 = 4 Ω.

$\mathcal{E} = I R_{Net} \Rightarrow .2V = 10^{-3} \times 4$

$V = \frac{4 \times 10^{-3}}{2 \times 10^{-1}} = 2 \times 10^{-2}$ m/sec

Q.2) A copper rod AB of length L, pivoted at one end A, rotates at constant angular velocity w, at right angles to a uniform magnetic field of induction B. The e.m.f developed between the mid point C of the rod and end B is





$\varepsilon = \frac{B\omega l^2}{2}$

$\varepsilon_{AC} + \varepsilon_{CB} = \varepsilon_{AB}$

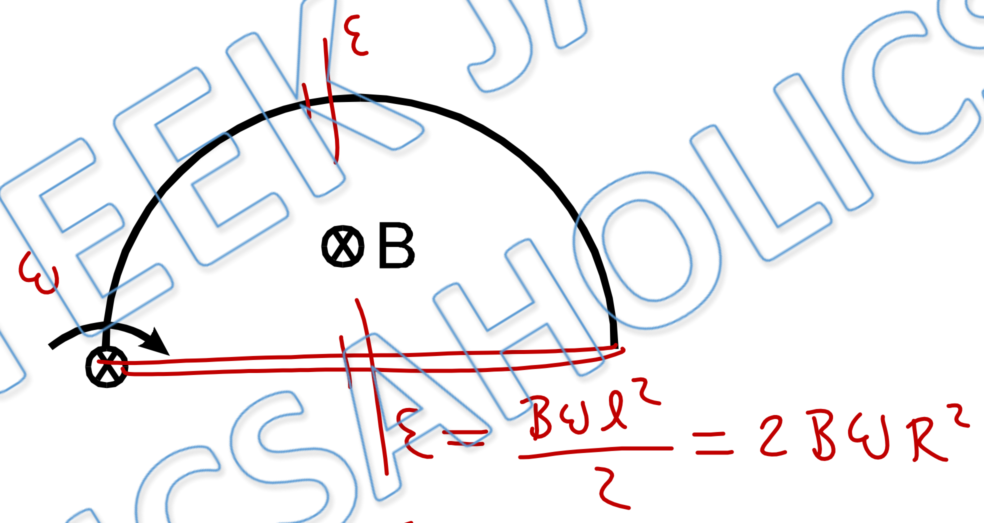
$\frac{B\omega l^2}{8} + \varepsilon_{CB} = \frac{B\omega l^2}{2}$

(a) $\frac{B\omega L^2}{4}$ (b) $\frac{B\omega L^2}{2}$ (c) $\frac{3B\omega L^2}{4}$ (d) $\frac{3B\omega L^2}{8}$

$\varepsilon_{CB} = B\omega l^2\left(\frac{1}{2} - \frac{1}{8}\right)$

$= B\omega l^2\left[\frac{4-1}{8}\right]$

Q.3) A semicircular wire of radius R is rotated with constant angular velocity ω about an axis passing through one end and perpendicular to the plane of the wire. There is a uniform magnetic field of strength B. The induced e.m.f. between the ends is :



(a) $B\omega R^2/2$
(b) $2 B \omega R^2$
(c) is variable
(d) none of these

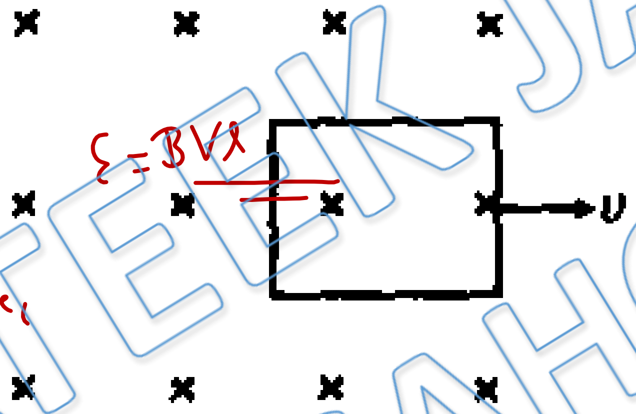
Q.4) Figure shows a square loop of side 0.5 m and resistance 10 ohm. The magnetic field has a magnitude B = 1.0 T. The work done in pulling the loop out of the field uniformly in 2.0 S is:

$l = .5\,m$

$t = 2\,sec$

$V = \frac{.5}{2} = .25\,m/sec$

$\varepsilon = BVl$



$\varepsilon = 1 \times .25 \times .5 = .125\,V$

$Power = \frac{\varepsilon^2}{R} = \frac{(.125)^2}{10}$

$\Delta H = \frac{(.125)^2}{10} \times 2$

(a) 3.125 × 10^{-3} J ✓

(b) 6.25 × 10^{-4} J

(c) 1.25 × 10^{-2} J

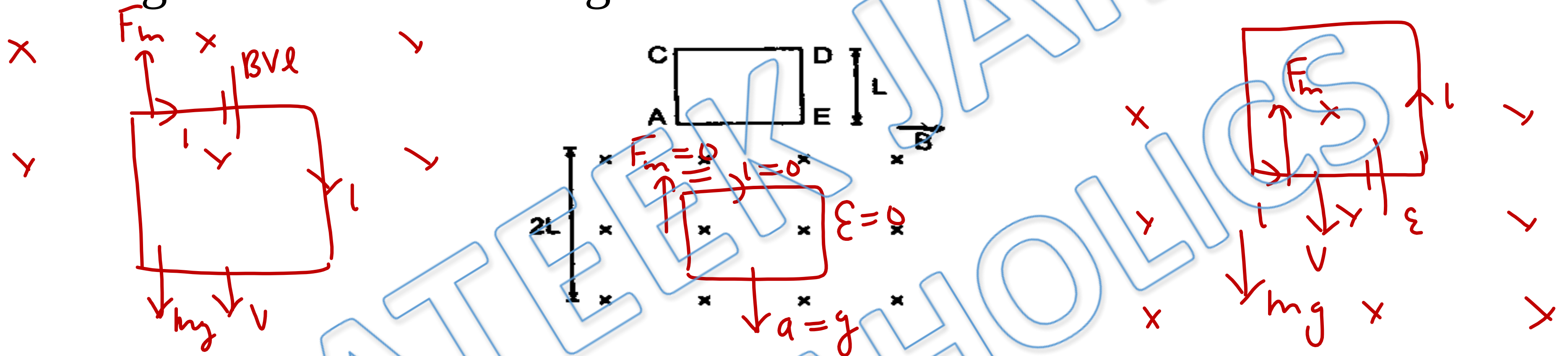
(d) 5.0 × 10^{-4} J

$\Delta H = \frac{25 \times 125}{5} \times 10^{-4}\,J$

$= 31.25 \times 10^{-4}\,J$

$= 3.125 \times 10^{-3}\,J.$

Q.5) A square coil ACDE with its plane vertical is released from rest in a horizontal uniform magnetic field $\vec{B}$ of length 2L. The acceleration of the coil is :



(a) less than g for all time till loop crosses magnetic field completely

(b) less than g when it enters field and greater than g when it comes out of the field

(c) g all the time

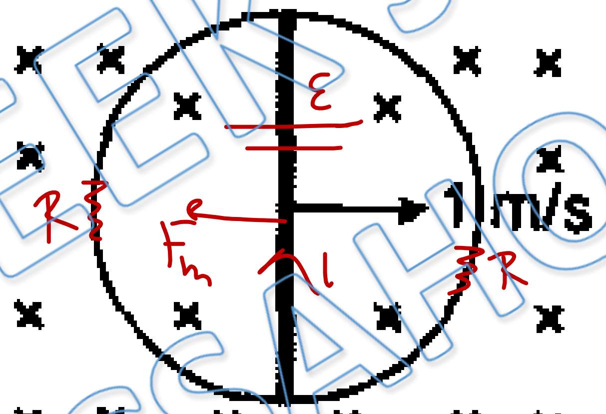
(d) less than g when it enters and comes out of the field but equal to g when it is within the field

Q.6) A circular loop of radius 1m is kept in a magnetic field of strength 2 T (plane of 1oop is perpendicular to the direction of magnetic field). Resistance of the loop wire is $\frac{2}{3}$ ohm/m. A conductor of length 2 m in sliding with a speed 1 m/s as shown in the figure. Find the instantaneous force acting on the rod : [assume rod has negligible resistance]

$\mathcal{E} = BVl = 2 \times 1 \times 2 = 4V$

$R = \frac{2}{3} \times \pi \times 1 = \frac{2\pi}{3}$

$R_{eff} = \pi/3$

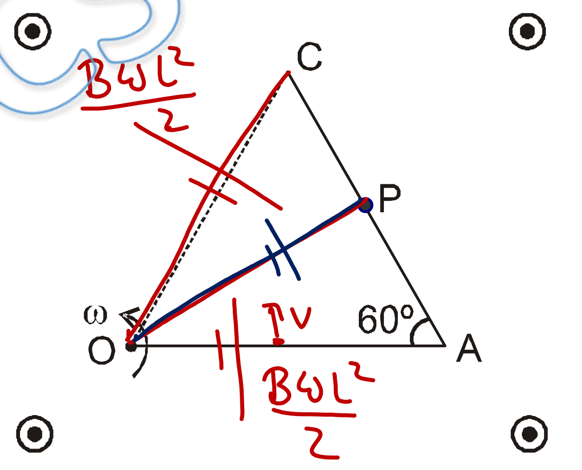


$F_m = IBl = \frac{12}{\pi} \times 2 \times 2 = \frac{48}{\pi}$ N.

(a) 48 N (b) 15.28 N (c) 32.28 N (d) 64 N

$I = \frac{\mathcal{E}}{R_{eff}} = \frac{4 \times 3}{\pi} = \frac{12}{\pi}$

Q.7) A metallic V shaped rod OAC is rotated with respect to one of its end in uniform magnetic field, such that axis of rotation is parallel to the direction of magnetic field. Length of each arm of rod is L and angle between the arms is 60º. P is the mid–point of section AC. Magnitude of magnetic field is B. Then choose the correct relations.



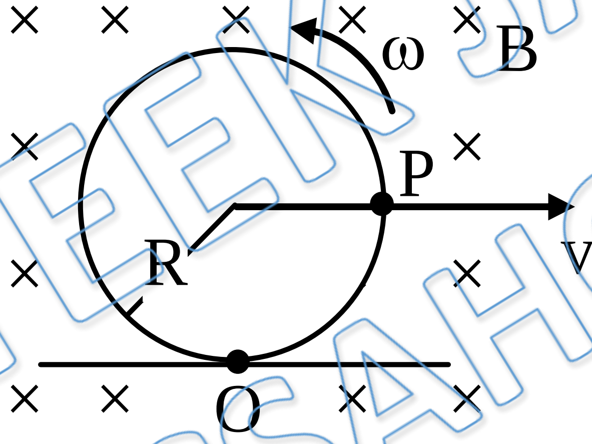
(a) $V_A - V_0 = \frac{\omega B L^2}{2}$

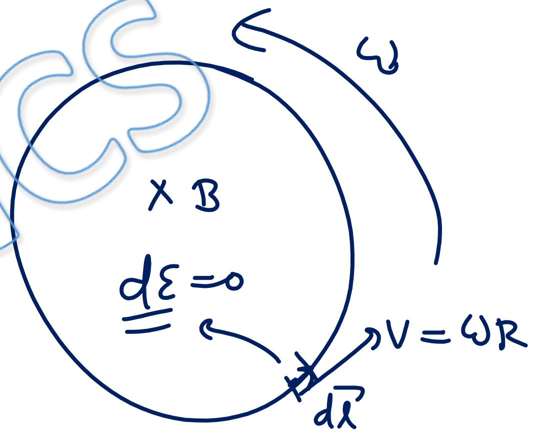
(b) $V_A - V_C = \frac{\omega B L^2}{2}$

(c) $V_C - V_P = \frac{\omega B L^2}{8}$

(d) $V_A - V_P = \frac{\omega B L^2}{8}$

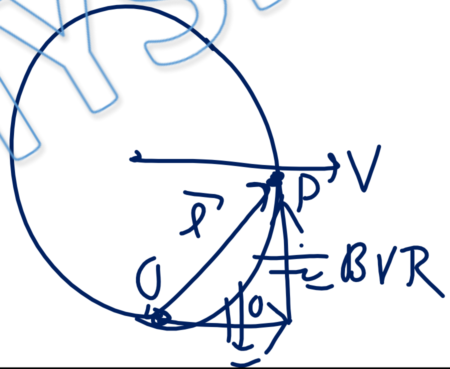
Q.8) A metallic ring of radius R moves in a vertical plane in the presence of a uniform magnetic field B perpendicular to the plane of the ring. At any given instant of time its centre of mass moves with a velocity v while ring rotates with angular velocity ω as shown in the figure. The magnitude of induced e.m.f. between points O and P is -





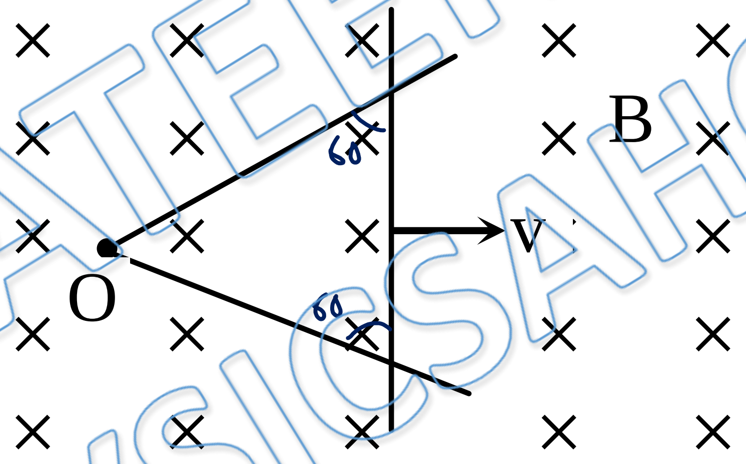
no emf in any $\vec{dl}$ due to ω

(a) zero (b) vBR√2 (c) vBR (d) 2 vBR

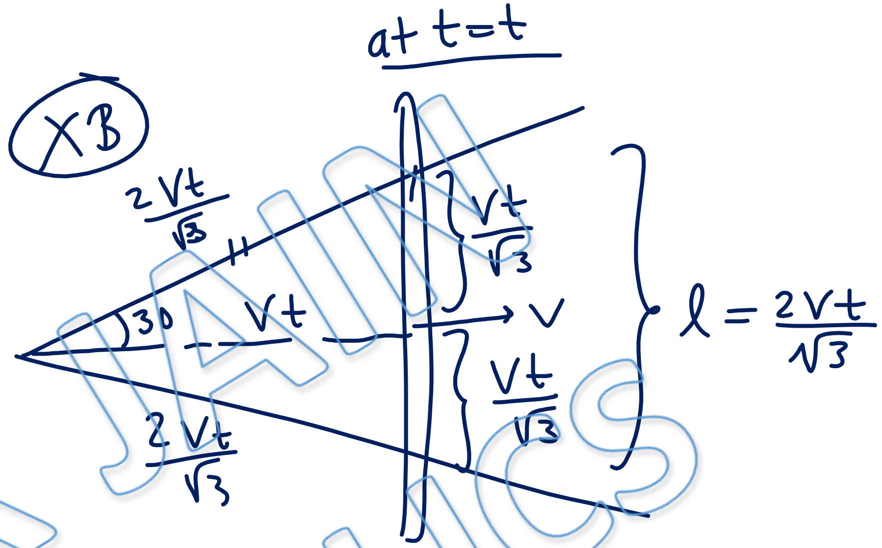


Comprehension(Q.9 TO Q.11)

The mobile side of the equilateral triangular conducting frame shown in the figure is sliding at uniform speed of v = 0.1 m/s along the other two side. This horizontal frame is in a vertical homogeneous magnetic field with an induction of B = 0.4 T. Resistance per unit length is 1 ohm/m. Initially at t = 0 sliding rod was at O.



Q.9) How induced emf vary with time ?



(a) Increase with time

(b) Decrease with time

(c) Remain constant

(d) Initially increase, then decrease

$$\mathcal{E} = BVl$$

$$= BV \times \frac{2Vt}{\sqrt{3}}$$

Q.10) Induced current in frame is –

$$R = (1\ \Omega/m)\left(\frac{6vt}{\sqrt{3}}\right)$$

(a)increasing with time

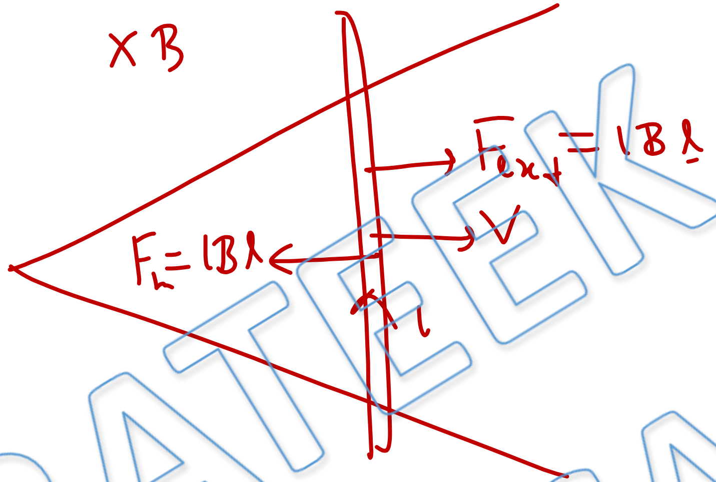
(b) decreasing with time

(c) remain constant

(d) initially increase then decrease

$$I = \frac{\varepsilon}{R} = \frac{2BV^2 t\sqrt{3}}{\sqrt{3} \times 6Vt} = \frac{BV}{3}$$

Q.11) Work required for sliding –



Since KE of Rod is Constant work done by external agent converts in to Heat

(a) Is equal to joule heating

(b) Is greater than joule heating

(c) Is less than joule heating

(d) none of these

Q.12) A conducting rod of length l is moved at constant velocity 'v_0' on two parallel, conducting, smooth, fixed rails, that are placed in a uniform constant magnetic field B perpendicular to the plane of the rails as shown in figure. A resistance R is connected between the two ends of the rail. Then which of the following is/are correct :

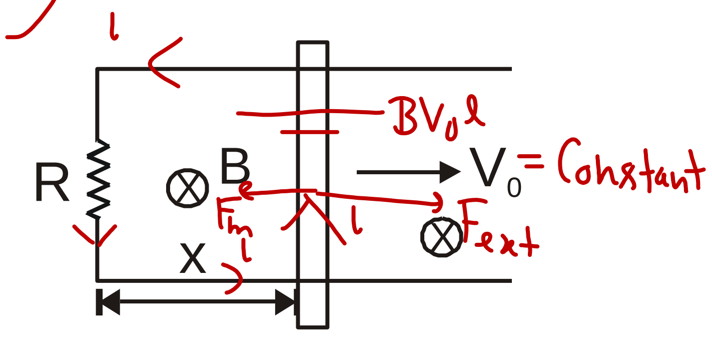
(a) The thermal power dissipated in the resistor is equal to rate of work done by external person pulling the rod.

by Conservation of energy

(b) If applied external force is doubled than a part of external power increases the velocity of rod.

(c) Lenz's Law is not satisfied if the rod is accelerated by external force

(d) If resistance R is doubled then power required to maintain the constant velocity v_0 becomes half.



$F_{ext} = F_m = IBl$

R is doubled.
ε is same
⇒ I is halved
⇒ F_m is halved

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