CPP-05
SS JEE(M) &
ADVANCED

Physics

Chapterwise Practise Problems (CPP) for JEE (Main & Advanced)

Chapter - Electromagnetic Induction

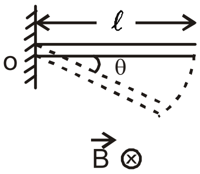
Level-1

SECTION - A

Straight Objective Type

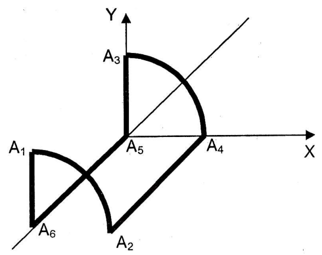
This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

1. A conducting rod of length ℓ is hinged at point O. It is free to rotate in vertical plane. There exists a uniform magnetic field $\vec{B}$ in horizontal direction. The rod is released from position shown in the figure. Potential difference between two ends of the rod is proportional to



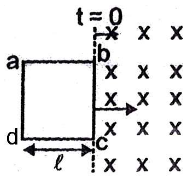
(A) $\ell^{3/2}$ (B) ℓ^2
(C) $\sin \theta/2$ (D) $\sin \theta$

2. A time varying magnetic field $B = B_0 t\hat{k}$ is confined in a cylindrical region, cutting the XY plane on a circle of radius $x^2+y^2=4$. We have placed a wire frame as shown. Segment A_1A_2 and A_3A_4 are identical quarter circles. The net emf induced in the wire frame is equal to



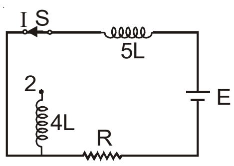
(A) Zero (B) $2B_0$
(C) $4B_0$ (D) B_0

3. A conducting square wire frame abcd of side length ℓ is pulled by horizontal force so that it moves with constant velocity V. A uniform magnetic field of strength B is existing perpendicular to the plane of wire. The resistance per unit length of wire is λ and negligible self inductance. At t = 0, frame is just at the boundary of magnetic field. Potential difference across bc at time $t = \dfrac{\ell}{2V}$ is



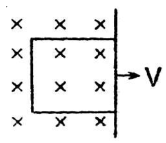
(A) $\dfrac{BV\ell}{4}$ (B) $BV\ell$
(C) $\dfrac{3BV\ell}{4}$ (D) None of these

4. In the circuit shown the switch S is shifted to position 2 from position 1 at t = 0, having been in position 1 for a long time. The current in the circuit just after shifting of switch will be (battery and both the inductors are ideal)



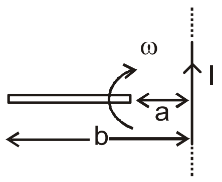
(A) $\dfrac{4}{5}\cdot\dfrac{E}{R}$ (B) $\dfrac{5}{4}\cdot\dfrac{E}{R}$
(C) $\dfrac{5}{9}\cdot\dfrac{E}{R}$ (D) $\dfrac{E}{R}$

5. A square loop of area 2.5×10^{-3} m^2 and total resistance of 100 Ω is moved out of a uniform magnetic field of 0.40 T perpendicular to the magnetic field in 1 sec with a constant velocity as shown in the figure. Work done, in the pulling the loop by the external agent is



(A) 0.01 μJ (B) 50 μJ
(C) 200 μJ (D) 500 μJ

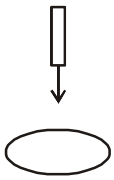
6. A copper rod moves with a constant angular velocity ω, about a long straight wire carrying a current I. If the ends of the rod from the wire are at distances a and b, then the e.m.f. induced in the rod is



(A) $\frac{\mu_0 i(\omega a)}{2\pi} \ln\left(\frac{b}{a}\right)$ (B) $\frac{\mu_0 i(\omega b)}{2\pi} \ln\left(\frac{b}{a}\right)$

(C) Zero (D) $\frac{\mu_0 i\omega(a+b)}{4\pi} \ln\left(\frac{b}{a}\right)$

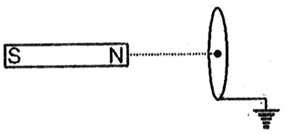
7. A rod of negligible dimensions carrying a charge q falls into a conducting loop of resistance R and radius a through a height h. The current flowing through the loop will be



(A) Zero (B) $q\left(\frac{g}{h}\right)$

(C) $\frac{q}{\sqrt{g}\,h}$ (D) $\frac{q^2}{gh}$

8. A circular conducting ring having resistance R fixed vertically in a gravity free space and one point of the ring is earthed. Now a magnet is placed along horizontal axis of the ring at a distance from its centre such that the nearer pole is north pole as shown in figure. A sharp impulse is applied on the magnet so that it starts to move towards the right. Then,



(A) Initially magnet experiences an acceleration and then it retards to come to an instantaneous rest

(B) The magnet will oscillate about centre of the ring

(C) The magnet retards continuously and come to rest finally, if it is crossing the ring.

(D) The magnet retards and come to rest finally, if it is not crossing the ring

9. Two tightly magnetically coupled coils have a mutual inductance of 32 mH. Calculate the inductance of each coil if one coil has twice the number of turns and twice the length of the other with same cross section (neglect any leakage)

(A) $16\sqrt{2}$ mH, $32\sqrt{2}$ mH

(B) $16\sqrt{2}$ mH each

(C) $12\sqrt{2}$ mH, $24\sqrt{2}$ mH

(D) $32\sqrt{2}$ mH each

SECTION - B

Multiple Correct Answer Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

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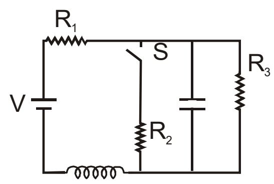
10. The circuit shown in figure is in a steady state with the switch open. When the switch is closed, which is/are of the following will not change immediately?(All of them eventually change, but few of them stay same for an instant).



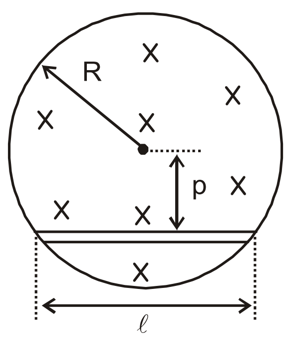
(A) The potential difference around the capacitor C

(B) The current through the inductor L

(C) The potential difference around the resistor R_1

(D) The current through the resistor R_3

11. A uniform magnetic field B fills a cylindrical volume of radius R. A metal rod of length ℓ is placed as shown. If B is changing at the rate of dB/dt, the emf that is induced in the rod by the changing magnetic field is ξ. Then



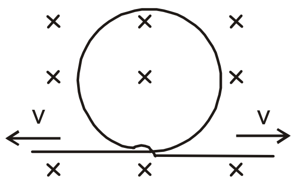
(A) The magnitude of the electric field induced along the length of the rod is $\frac{1}{2}p\frac{dB}{dt}$ at all positions

(B) The magnitude of the electric field component along the length of the rod is $\frac{1}{2}p\frac{dB}{dt}$ at any end of the rod

(C) The magnitude of the electric field component perpendicular to the rod is zero

(D) The induced emf across the ends of the rod is $\frac{1}{2}\ell p\frac{dB}{dt}$

12. A circular conducting loop of radius r_0 and having resistance per unit length λ as shown in the figure is placed in a magnetic field B which is constant in space and time. The ends of the loop are crossed and pulled in opposite directions with a velocity v such that the loop always remains circular and the radius of the loop goes on decreasing, then



(A) Radius of the loop changes with time as $r = r_0 - vt/\pi$

(B) EMF induced in the loop as a function of time is $e = 2Bv[r_0 - vt/\pi]$

(C) Current induced in the loop is $I = \frac{Bv}{2\pi\lambda}$

(D) Current induced in the loop is $I = \frac{Bv}{\pi\lambda}$

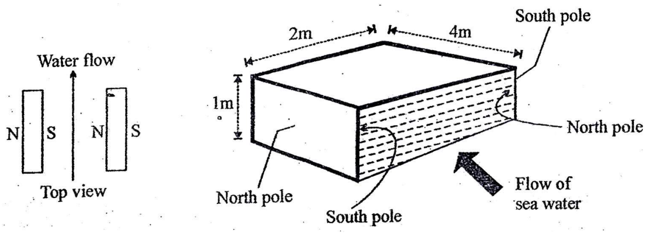
SECTION - C

Linked Comprehension Type

This section contains paragraph. Based upon this paragraph, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/are correct.

Paragraph for Question Nos. 13 to 15

The dead-quiet "caterpillar drive" for submarines in the movie "The Hunt for Red October" is based on a magnetohydrodynamic (MHD) drive ; as the submarines moves forward, seawater flows through multiple channels in a structure built around the rear of the hull. Figure shows the essentials of a channel. Magnets, positioned along opposite sides of the channel with opposite poles facing each other, create a magnetic field within the channel. Electrodes (not shown) create an electric field across the channel. The electric field derives a current across the channel and through the water ; the magnetic force on the current propels the water toward the rear of the channel, thus propelling the submarines forward.



13. In figure what should be the direction of electric field ?

(A) Upward (B) Downward

(C) Left ward (D) Right ward

14. If the value of magnetic field is 100T and current flowing is 50 A what is the force acting on the water ?

(A) 500 N (B) 5000 N

(C) 10000 N (D) 20000 N

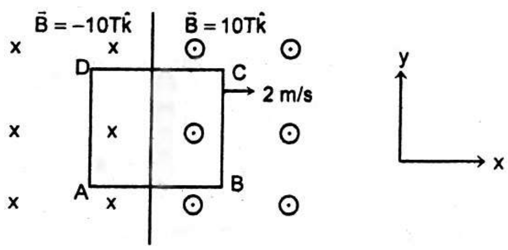
15. What should be the value of electric field to achieve the 50 A current given that resistivity of sea water is 8 Ω-m

(A) 25 V/m (B) 50 V/m

(C) 100 V/m (D) 200 V/m

Paragraph for Questions 16 and 17

There is a square loop of side ℓ = 10 cm. The resistance of loop is 0.5 Ω/cm. The loop is moved with constant velocity $2\hat{i}$ m/s in two uniform magnetic fields as shown in the figure. The magnitude of magnetic field is 10T in both regions



16. The potential difference across the points

(A) A and B is 1V (B) B and C is zero

(C) C and D is zero (D) D and A is 2V

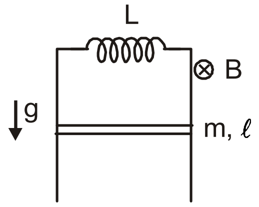
17. A cut is made in loop such that effective resistance of the loop becomes infinity the electric field in wire (in given state) :

(A) AB is zero (B) BC is $20\hat{j}$

(C) CD is zero (D) DA is $-20\hat{j}$

Paragraph for Question Nos. 18 to 20

A coil inductance L connects the upper end of two vertical copper bars separated by a distance ℓ. A horizontal conducting connector of mass m starts falling with zero initial velocity along the bars without losing contact with them. The whole system is located in uniform, magnetic field with induction B perpendicular to the plane of the bars



18. What is maximum velocity of connector ?

(A) $\frac{2g}{\ell B}\sqrt{mL}$ (B) $\frac{g}{\ell B}\sqrt{mL}$

(C) $\frac{g}{3\ell B}\sqrt{mL}$ (D) $\frac{4g}{\ell B}\sqrt{mL}$

19. What is maximum displacement of connector ?

(A) $\frac{gmL}{B^2\ell^2}$ (B) $\frac{4gmL}{B^2\ell^2}$

(C) $\frac{2gmL}{B^2\ell^2}$ (D) $\frac{3gmL}{B^2\ell^2}$

20. What is maximum current in inductor ?

(A) $\frac{mg}{B\ell}$ (B) $\frac{2mg}{B\ell}$

(C) $\frac{4mg}{B\ell}$ (D) $\frac{3mg}{B\ell}$

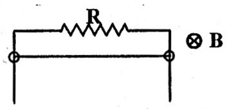
SECTION-D

Matrix-Match Type

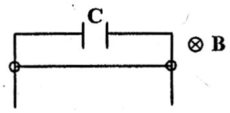
This **Section D** have "match the following" type question. Question contains two columns, **Col-I** and **Col-II**. Match the entries in **Col-I** with the entries in **Col-II**. One or more entries in **Col-I** may match with one or more entries in **Col-II**.

21. In the figure all the surfaces are frictionless, all the rods, wires and sliders are resistanceless. System is in vertical plane. All the elements are fixed except slider. A horizontal uniform magnetic field exist in space perpendicular to plane of circuit. Slider is released from rest. For subsequent motion under gravity match the following

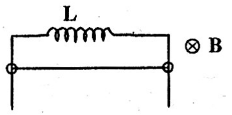
Column I **Column II**

(A) 

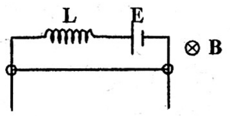
(p) Motion of the rod is oscillatory

(B) 

(q) Motion of rod is SHM

(C) 

(r) Velocity of rod varies simple harmonically

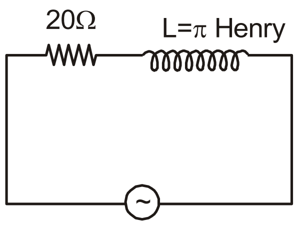
(D) 

(s) Slider will get a terminal velocity after long time

(t) Velocity of rod monotonically increases

22. In column-I certain situations are shown. Column-II has different values of phase difference. Match them [Take $\pi^2 = 10$ wherever required]

Column I	**Column II**
(A) Phase difference between current through circuit and voltage across source	(p) $\frac{\pi}{3}$
(B) Two pendulum of length 1 m and 4 m start oscillating in same phase. The phase difference between them after 1 sec is	(q) $\frac{\pi}{4}$
(C) A progressive wave of frequency 100 Hz is travelling in a taut string with tension 100 N and mass/length 10 gm/m. The phase difference between two points at a distance of 0.5 m	(r) $\frac{\pi}{2}$
	(s) π



V= 100 sin (2πt)

SECTION-E

Integer Answer Type

This section contains Integer type questions. The answer to each of the questions is an integer.

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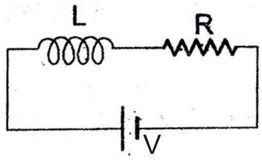
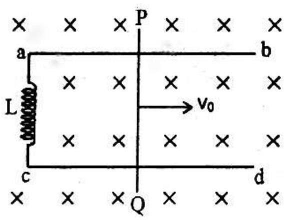
23. In the circuit shown steady state is already reached. EMF of the cell V = 12 volt. Now the inductance is suddenly doubled. The potential difference in volt across 'R' just after this is



24. In a uniform constant magnetic field of induction B, two long conducting wires ab and cd are kept parallel to each other at distance ℓ with their plane perpendicular to B. The ends a and c are connected together by an ideal inductor of inductance L. A conducting slider wire PQ of mass m is imparted speed v_0 at time t = 0. The situation is as shown in the figure. At time $t = \frac{\pi\sqrt{mL}}{4B\ell}$, the value of current through the wire PQ is $\sqrt{\frac{mv_0^2}{\alpha L}}$. Here α is integer. Find α (Ignore any resistance electrical as well as mechanical)

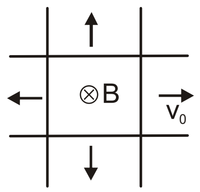


SECTION - A

Straight Objective Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

1. Two parallel long straight conductors lies on a smooth plane surface. Two other long parallel conductors rest on them at right angles so as to form a square of side a. A uniform magnetic field B exists at right angle to the plane containing conductors. Now conductors start moving outward with a constant velocity v_0 at t = 0. Then induced current in the loop at any time t is (λ is resistance per unit length of conductors)



(A) $\frac{aBv_0}{\lambda(a+v_0t)}$ (B) $\frac{aBv_0}{2\lambda}$

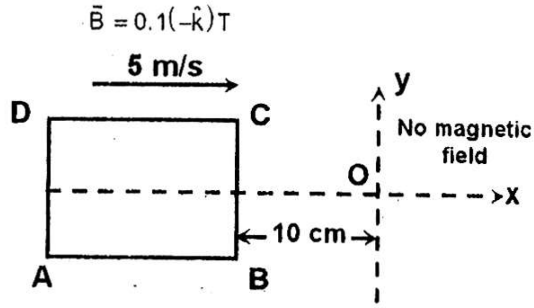
(C) $\frac{Bv_0}{\lambda}$ (D) $\frac{Bv_0}{2\lambda}$

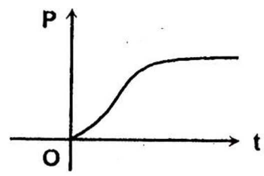
2. A metallic horizontal ring of mass m and radius r falling under gravity in a region having a magnetic field. If z is the vertical direction, the z-component of magnetic field is $B_z = B_0(1 + \lambda z)$ where B_0 and λ are constants. If R is the resistance of the ring, the terminal velocity of the ring is

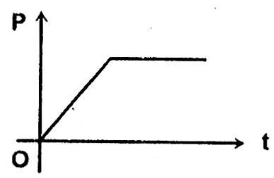
(A) $\left(\frac{mgR}{\pi r^2 \lambda B_0}\right)$ (B) $\frac{mgR}{\left(2\pi r^2 \lambda B_0\right)}$

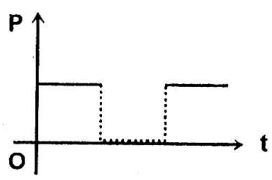
(C) $\frac{mgR}{\left(\pi r^2 B_0\right)^2}$ (D) $\frac{mgR}{\left(\pi r^2 \lambda B_0\right)^2}$

3. A uniform magnetic field $\vec{B} = 0.1(-\hat{k})T$ exists on the left side of plane x = 0. A rectangular wire frame ABCD whose sides are 40 cm and 10 cm respectively, starts moving towards positive x-axis with uniform velocity 5 m/s due to presence of variable external force $\vec{F}$ at t = 0 sec shown in the figure. The graph between power generated by external force versus time will be



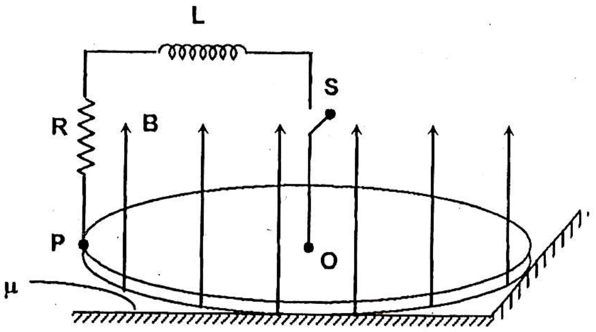
(A)


(B)


(C)


(D) None of these

4. A circular disc of mass m and radius r is rotating with an angular velocity ω on a rough horizontal plane. A uniform and constant magnetic field B is applied perpendicular and into the plane. An inductor L and an external resistance R are connected through a switch S between centre of the disc O and point P. The point P always touches the circumference of the disc. Initially the switch S is open. Take coefficient of friction between the plane and disc as μ. (Assuming the disc has no resistance)



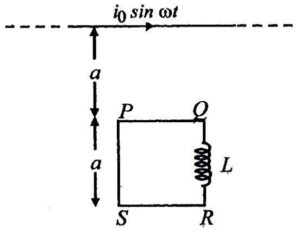
(A) The induced emf across the terminals of the switch is $B\omega r^2$ when disc has angular speed ω.

(B) The switch is closed at t = 0, the torque required about the centre of the disc is $(1/4)B^2r^4\omega^2 + \frac{\mu mgr}{4}$ (to maintain the constant angular speed ω at steady state)

(C) The current in the circuit as a function of time will be given as $\frac{Br^2\omega}{2R}\left(1-e^{\frac{R}{L}t}\right)$, when disc has a constant angular speed ω

(D) The switch is closed at t = 0, the torque required is $(1/2)B^2r^4\omega^2 + (2/3)\mu mgr$ (to maintain the constant angular speed ω at steady state)

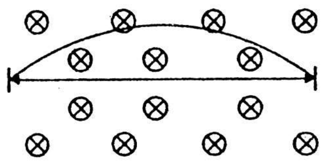
5. A conducting square loop PQRS of zero resistance but containing an inductor of inductance L is placed near a long wire carrying current $i_0 \sin\omega t$, as shown in the figure. The peak value of induced current in the loop is



(A) $\frac{\mu_0 a i_0 (\ln 2)}{\omega L}$ (B) $\frac{\mu_0 a i_0 (\ln 2)}{2\pi L}$

(C) $\frac{\mu_0 a i_0 (\ln 2)}{2\pi\omega L}$ (D) $\frac{2\mu_0 i_0 (\ln 2)}{\pi L}$

6. A conducting wire fixed at both end is vibrating in it's fundamental mode in the plane of paper. A constant magnetic filed (B) is switched on as shown. Find the emf induced in wire at an instant it is passing through mean position. Here 'a' is maximum amplitude of the standing wave, ω is angular frequency of wave of which standing wave is formed and length of wire is ℓ



(A) $\frac{Ba\omega\ell}{\pi}$

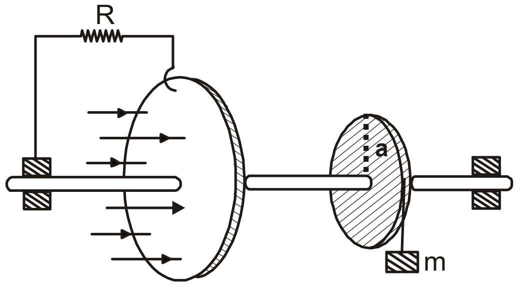
(B) $Ba\omega\ell$

(C) $\frac{Ba\omega\ell}{2\pi}$

(D) $\frac{2Ba\omega\ell}{\pi}$

7. A metallic disc of radius r is made of a material of negligible resistance and can rotate about a conducting horizontal shaft. A smaller non conducting disc of radius 'a' is fixed onto the same shaft and has a massless cord wrapped around it, which is attached to a small object of mass m as shown. Two ends of a resistor of resistance R are connected to the perimeter of the disc and to the shaft by sliding contacts. The system is then placed into a uniform horizontal magnetic field B and the mass m is released. Find the terminal angular velocity with which the disc will rotate finally.

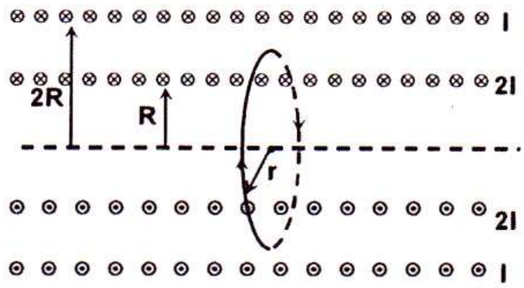
(Take r = 10cm, a = 2cm, R = $\frac{1}{100}\Omega$, B = 0.2 T, m = 50 gm, g = 10 m/s2)



(A) 200 rad/s (B) 300 rad/s

(C) 100 rad/s (D) 10 rad/s

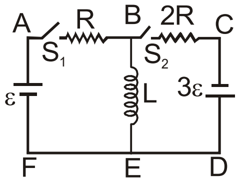
8. A long solenoid of radius 2R contains another co-axial solenoid of radius R. The coils have the same number of turns per unit length and initially both carry zero current. At time, t = 0, current start increasing linearly with time in both solenoids. At any moment the current flowing in the inner coil is twice as large as that in the outer one and their directions are same. A charged particle, initially at rest between the two solenoids, start moving along the circular trajectory due to increasing current in the solenoid as shown in the figure. What is the radius of the circle? (Assume magnetic field due to each solenoid remains uniform over its cross-section.)



(A) $\sqrt{2}R$ (B) $\sqrt{3}R$

(C) $\frac{3}{2}R$ (D) None of these

9. In the figure shown switch S_1 remains connected for a long time and the switch S_2 remains open. Now the switch S_2 is closed. Assuming ε=10V and L = 1H. Find the magnitude of rate of change of current in inductor (in A/s) just after the switch S_2 is closed



(A) 5 (B) 10

(C) 20 (D) None of these

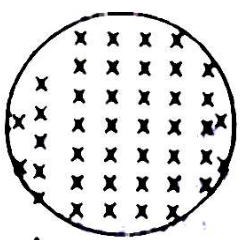
10. A non-conducting ring of radius R and mass m having charge q uniformly distributed over its circumference is placed on a rough horizontal surface. A vertical time varying uniform magnetic field B = $4t^2$ is switched on at time t = 0. The coefficient of friction between the ring and the table, if the ring starts rotating at t = 2sec, is

(A) $\frac{4qmR}{g}$

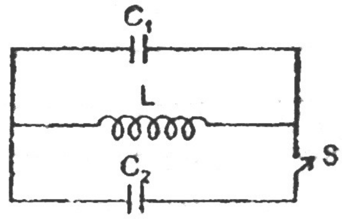
(B) $\frac{2qmR}{g}$

(C) $\frac{8qR}{mg}$

(D) $\frac{qR}{2mg}$



11. A moment (t = 0) when the charge on capacitor C_1 is zero, the switch is closed. If I_0 be the current through inductor at t = 0, for t > 0 (initially C_2 uncharged)



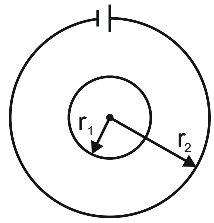
(A) Maximum current through inductor equals $I_0/2$

(B) Maximum current through inductor equals $\frac{C_1 I_0}{C_1 + C_2}$

(C) Maximum charge on $C_1 = \frac{C_1 I_0 \sqrt{LC_2}}{C_1 + C_2}$

(D) Maximum charge on C_1 = $C_1 I_0 \sqrt{\frac{L}{C_1 + C_2}}$

12. Two concentric coplanar circular loops have diameters 20 cm and 2 m and resistance of unit length of the wire = 10^{-4} Ω/m. A time-dependent voltage ε = (4 + 2.5 t) volts (t in sec) is applied to the larger as shown. The current in the smaller loop is



(A) 0.5 A

(B) 0.75 A

(C) 1 A

(D) 1.25A

13. A uniform conducting rod of mass M and length ℓ oscillates in a vertical plane about a fixed horizontal axis passing through its one end with angular amplitude θ. There exists a constant and uniform horizontal magnetic field of induction B perpendicular to the plane of oscillation. The maximum e.m.f. induced in the rod is

(A) $\frac{B}{8}\sqrt{27\ell^3 g(1-\cos\theta)}$ (B) $\frac{B}{8}\sqrt{27\ell^3 g(1+\cos\theta)}$

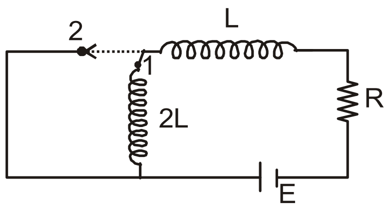
(C) $B\sqrt{\frac{3\ell^3 g(1-\cos\theta)}{4}}$ (D) $B\sqrt{\frac{3\ell^3 g(1+\cos\theta)}{4}}$

14. In a region at a distance r from z-axis magnetic field $\vec{B} = B_0 rt\hat{k}$ is present where B_o is constant and t is time. Then the induced electric field at a distance r from z-axis is given by

(A) $\frac{r}{2}B_0$ (B) $\frac{r^2}{2}B_0$

(C) $\frac{r^2}{3}B_0$ (D) None of these

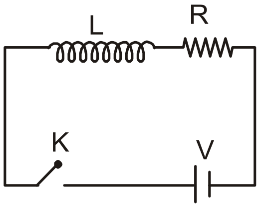
15. In the circuit shown switch is connected to 1 for a very long time. At a particular instant t = 0, switch is shifted to 2, the current in the circuit after a time gap of $\frac{L}{R}$ is

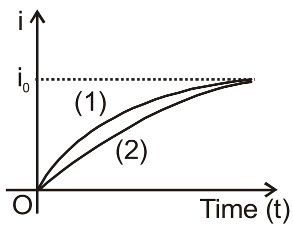


(A) $\frac{\varepsilon}{2Re}$ (B) $\frac{2\varepsilon}{R}$

(C) $\frac{3\varepsilon}{Re}$ (D) $1.73\frac{\varepsilon}{R}$

16. Refer to the circuit diagram and the corresponding graphs, the current rises when key K is pressed. With $R = R_1$ and $L = L_1$ the rise of current is shown by curve (1), while curve (2) shows the rise of current when $R = R_2$ and $L = L_2$. The maximum current is same for both curves, then





(A) $R_1 = R_2, L_1 > L_2$

(B) $R_1 > R_2, L_1 = L_2$

(C) $R_1 > R_2, L_1 < L_2$

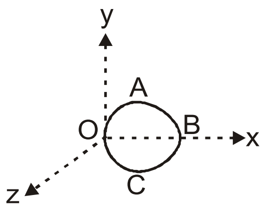
(D) $R_1 = R_2, L_1 < L_2$

17. Consider a long solenoid of radius R which has n turns per unit length. A time dependent current $I = I_0 \sin \omega t$ flows in solenoid then magnitude of electric field at a perpendicular distance r < R, from the axis of symmetry of solenoid will be :

(A) Zero (B) $\frac{1}{2}\omega\mu_0 n I_0 R^2 \cos\omega t$

(C) $\omega\mu_0 n I_0 r \sin\omega t$ (D) $\frac{1}{2}\omega\mu_0 n I_0 r \cos\omega t$

18. A circular loop is bent so that half of the loop (OAB) lies in xy-plane and the other half (OCB) lie in xz-plane. A time varying magnetic field exists here given by $\vec{B} = \alpha(t\hat{j} - 2t\hat{k})$ where α is a positive constant. What will be the direction of induced current ?



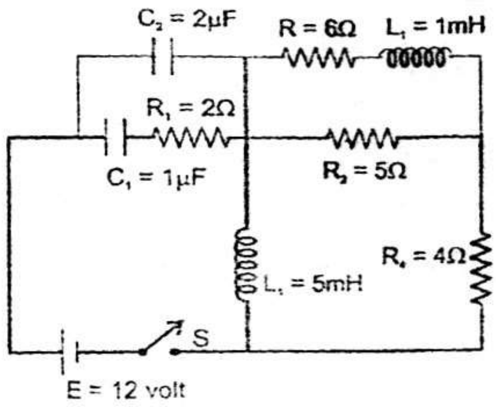
(A) OCBAO

(B) OABCO

(C) BAO in one part and BCO in the other part

(D) induced current will be zero

19. Find current through the battery just after switch S is closed. Initially all the capacitors are uncharged

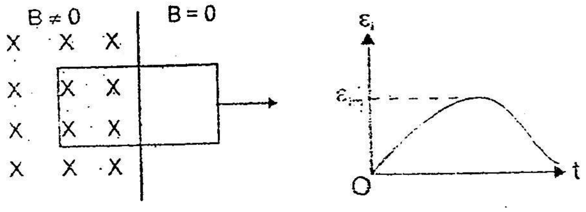


(A) $\frac{4}{3}A$ (B) $\frac{5}{3}A$

(C) $\frac{3}{4}A$ (D) $\frac{3}{5}A$

20. Plane rectangular loop is placed in a magnetic field. The emf induced in the loop due to this field is ε_1 whose maximum value is ε_{im}. The loop was pulled out of the magnetic field at a variable velocity. Assume the $\vec{B}$ is uniform and constant.

ε_1 is plotted against time t as shown in the graph. Which of the following are/is correct statement(s) :



(A) ε_{im} is independent of rate of removal of loop from the field.

(B) The total charge that passes through any cross-section of the wire of the loop in the process of complete removal of the loop does not depend on velocity of removal.

(C) The total area under the curve (ε_1 vs t) is independent of rate of removal of coil from the field.

(D) The area under the curve is dependent on the rate of removal of the coil.

21. Using a wire-drawing machine, you make a wire of uniform cross section out of a lump of a metal of resistivity 'ρ' and volume v. You then form the wire into a rectangular loop of side ratio 3:2 which you place in a uniform magnetic field B whose direction is parallel to the axis of the loop. When the magnetic field is turned off the charge Q passing through any imaginary cross-section through the wire is

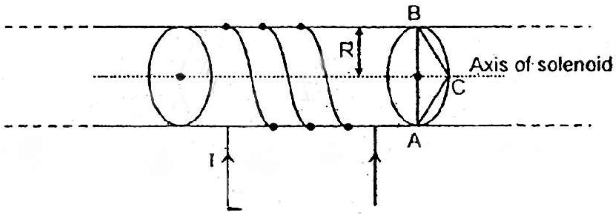
(A) $\dfrac{3Bv}{100\rho}$

(B) $\dfrac{3Bv}{50\rho}$

(C) $\dfrac{6Bv}{25\rho}$

(D) $\dfrac{6Bv}{5\rho}$

22. In a very long solenoid of radius 2 meter a circuit with three conducting rods AB, BC, AC is constructed in which AC = BC as shown in the figure. If the magnetic field 'B' along the axis of the solenoid changes at the rate of 1 Tesla/sec. Then (Plane of the triangle ABC is perpendicular to the axis of solenoid and AB is a diameter)



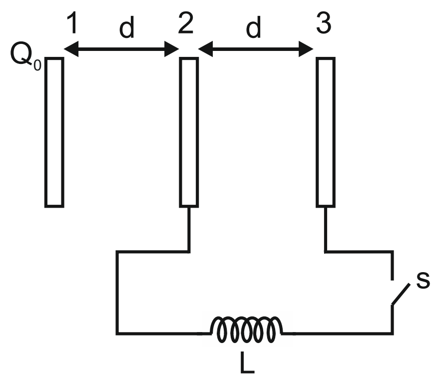
(A) Induced EMF for the circuit ABC is 2 volts

(B) Induced EMF for the circuit ABC is 0 volts

(C) Induced EMF between the ends of length AC; if AB and BC were removed from the circuit is 2 volts

(D) Induced EMF between the ends of length AC; if AB and BC were removed from the circuit is 4 volts

23. Three identical large parallel plates are fixed at separation d from each other as shown. The area of each plate is A. Plate 1 is given charge $+Q_0$, while plates 2 and 3 are neutral and are connected to each other through coil of inductance L and switch S. If resistance of all connecting wires is neglected then the maximum current that will flow through coil after closing switch is (take $C=\varepsilon_0 A/d$ and neglect fringe effect)



(A) $\dfrac{Q_0}{\sqrt{LC}}$

(B) $\dfrac{Q_0}{\sqrt{2LC}}$

(C) $\dfrac{3Q_0}{2\sqrt{LC}}$

(D) $\dfrac{Q_0}{2\sqrt{LC}}$

SECTION - B

Multiple Correct Answer Type

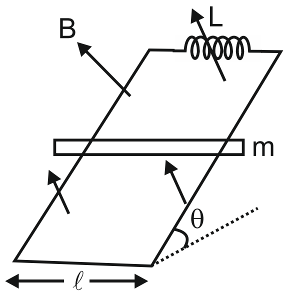
This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

24. Two different coils have self inductances $L_1 = 8$ mH and $L_2 = 2$ mH. The current in one coil is increased at a constant rate. The current in the second coil is also increased at the same constant rate. At a certain instant of time, the power given to the two coils is the same. At this time the current, the induced voltage and the energy stored in the first coil are i_1, V_1 and U_1 respectively. Corresponding values for the second coil at the same instant are i_2, V_2 and U_2 respectively. Then

(A) $\frac{i_1}{i_2} = \frac{1}{4}$ (B) $\frac{i_1}{i_2} = 4$

(C) $\frac{U_2}{U_1} = 4$ (D) $\frac{V_2}{V_1} = \frac{1}{4}$

25. A uniform magnetic field B is normal to the surface generated by the track of width ℓ and inclined at an angle θ with horizontal. An inductor of inductance L, connects the top ends as shown in the figure. A frictionless conducting rod of mass m is released from rest. There is no resistance anywhere. The rod is found to execute SHM. Then



(A) amplitude of oscillation is $\frac{mgL\sin\theta}{B^2\ell^2}$

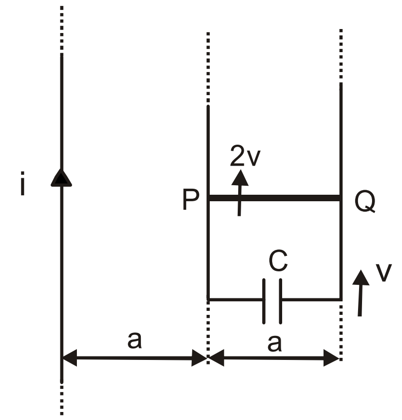
(B) time period of oscillation is $2\pi\sqrt{\frac{mL}{B^2\ell^2}}$

(C) The current in the rod is directly proportional to the square of distance x travelled by the rod on track. (x = 0 being the initial position).

(D) The equation of motion is

$$x = \frac{mgL}{B^2\ell^2}\cos\left(\sqrt{\frac{B^2\ell^2}{2mL}}\right)t$$

26. A U-shaped ideal conducting frame and a sliding rod PQ of resistance R, start moving with the velocities v and 2v respectively parallel to a long wire carrying steady current I, as shown in the figure.



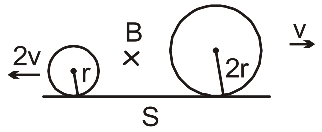
(A) Charge on the capacitor at time t is q = $\frac{C\mu_0 iv\ln 2}{2\pi}\left(1-e^{-t/RC}\right)$

(B) Charge on the capacitor at time t is q = $\frac{C\mu_0 iv\ln 2}{\pi}\left(1-e^{-t/RC}\right)$

(C) Current passing through the resistor at time t is $\frac{\mu_0 iv\ln 2}{2\pi R}\left(e^{-t/RC}\right)$

(D) Current passing through the capacitor at time t is $\frac{\mu_0 iv\ln 2}{\pi R}\left(e^{-t/RC}\right)$

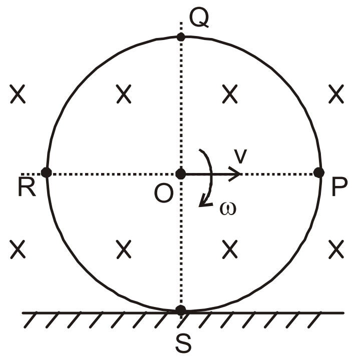
27. Two conducting rings of radii r and 2r move in opposite directions with velocities 2v and v respectively on a conducting surface S. There is a uniform magnetic field of magnitude B perpendicular to the plane of the rings. The potential difference between the highest points of the two rings is



(A) Zero (B) 2rvB

(C) 4rvB (D) 8rvB

28. A disc of radius r is rolling without sliding on a horizontal surface with a velocity of centre of mass v and angular velocity ω, in a uniform magnetic field B which is perpendicular to the plane of disc as shown in figure. O is the centre of disc and P, Q, R and S are the four points on disc



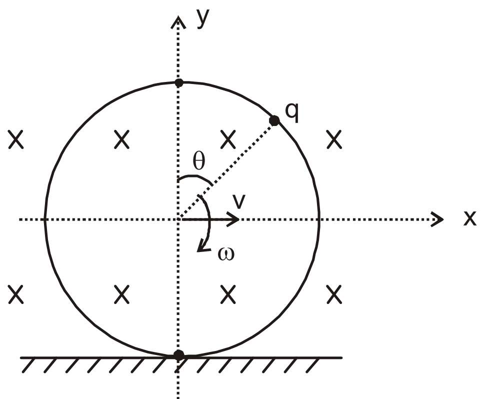
(A) Due to translation induced emf across PS = Bvr

(B) Due to rotation induced emf across QS = 0

(C) Due to translation induced emf across RO = 0

(D) Due to rotation induced emf across OQ = Bvr

29. A ring of mass m and radius R is set-into pure rolling on horizontal rough surface, in a uniform magnetic field of strength B as shown in the figure. A point charge of negligible mass is attached to rolling ring. Friction is sufficient so that it does not slip at any point of its motion (θ is measured in clockwise from positive y-axis)



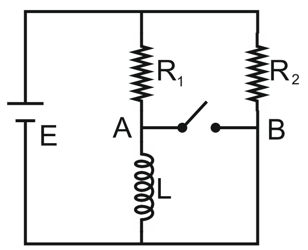
(A) Ring will continue to move with constant velocity

(B) The value of friction acting on ring is Bqv cos θ

(C) The value of friction acting on ring is Bqv sin θ

(D) Ring will lose contact with ground if v is greater than $\left(\frac{mg}{2qB}\right)$

30. In the circuit shown below the switch between A and B is closed at t = 0, then choose the correct options. (Consider circuit to be in steady state at t < 0)



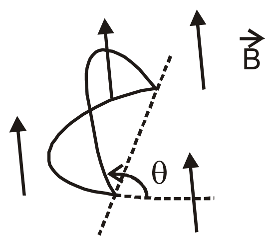
(A) Current through R_1 and R_2 will not change just after the switch is closed

(B) Current through R_1 and R_2 will change just after switch is closed

(C) Current through R_2 will be same at t < 0 and $t \to \infty$

(D) None of these

31. A uniform circular loop of radius "a" and resistance "R" is placed perpendicular to a uniform magnetic field B. One half of the loop is rotated about the diameter with angular velocity ω as shown. Then, the current in the loop is



(A) zero, when θ is zero

(B) $\frac{\pi a^2 B\omega}{2R}$, when θ is zero

(C) zero, when $\theta = \pi/2$

(D) $\frac{\pi a^2 B\omega}{2R}$, when $\theta = \pi/2$

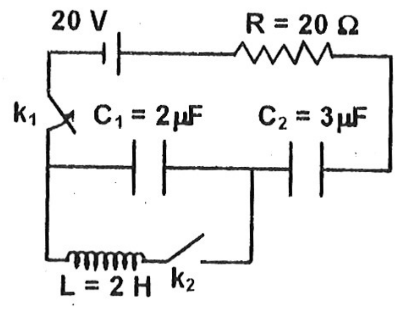
SECTION - C

Linked Comprehension Type

This section contains paragraph. Based upon this paragraph, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/are correct.

Paragraph for Question Nos. 32 to 34

A circuit shown in the figure in which k_1 is closed and k_2 is open. Inductor L can be connected in series to capacitor C_1 by closing switch k_2 and opening k_1.



32. Let switch k_1 be closed and k_2 is open for a long time. The charge on capacitor C_2 will be

(A) 60 μC (B) 12 μC

(C) 24 μC (D) 8 μC

33. At t = 0, when capacitors are fully charged, switch k_1 is opened and switch k_2 is closed, so that inductor is connected in series with capacitor C_1. The maximum charge will appear on capacitor C_1 at time t is

(A) $\frac{\pi}{2000}$ sec (B) $\frac{\pi}{1000}$ sec

(C) $\frac{\pi}{500}$ sec (D) $\frac{\pi}{1500}$ sec

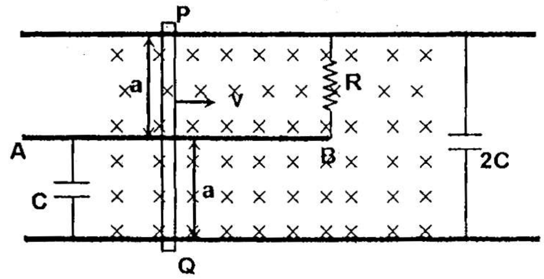
34. The maximum energy across inductor will be (after t = 0, where k_1 is opened and k_2 closed simultaneously at t = 0)

(A) 0.144 mJ (B) 0.288 mJ

(C) 0.072 mJ (D) 0.576 mJ

Paragraph for Question Nos. 35 and 36

Three conducting rails are fixed on a horizontal surface. The ends of rails are connected to two capacitors of capacitance C and 2C and a resistor of resistance R as shown. A conducting rod PQ of length 2a is moved on these rails with constant velocity v by an external agent, while maintaining contact with all the rails. Magnetic field is B_0 and uniform, friction is absent.



35. The power of external agent to maintain the velocity will be

(A) $\frac{B^2a^2v^2}{R}$ (B) $\frac{4B^2a^2v^2}{R}$

(C) $\frac{B^2a^2v^2}{2R}$ (D) $\frac{2B^2a^2v^2}{R}$

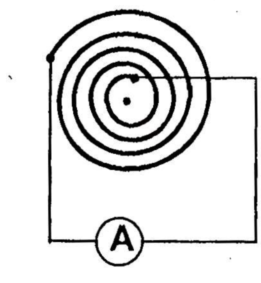
36. At t = 0 suddenly the rod is lifted. The current through resistance R as function of time is given as

(A) $i = \frac{Bav}{R}e^{-\frac{3t}{2CR}}$ (B) $i = \frac{2Bav}{R}e^{-\frac{2t}{3CR}}$

(C) $i = \frac{2Bav}{R}e^{-\frac{3t}{2CR}}$ (D) $i = \frac{Bav}{R}e^{-\frac{t}{CR}}$

Paragraph for Question Nos. 37 and 38

A plane spiral coil is made of conducting wire of resistance R and has N turns. The inside and outside radii are a and b respectively. The coil is kept in a magnetic field which varies with time t = 0 to t = T according to law $B = B_0 \sin\left(\frac{2\pi}{T}t\right)$ and is directed perpendicular to the plane of the coil. If the inner and outer ends of the coil is joined with an ammeter.



37. The maximum emf induced in the coil will be

(A) $\frac{2}{3}\frac{\pi^2 NB_0(a^2+ab+b^2)}{T}$

(B) $\frac{\pi^2 NB_0(a^2+ab+b^2)}{T}$

(C) $\frac{1}{3}\frac{\pi^2 NB_0(a^2+ab+b^2)}{T}$

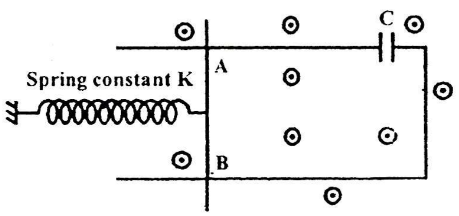
(D) $\frac{2}{3}\frac{\pi^2 NB_0(a^2+b^2)}{T}$

38. The value of time when the current reverse its sign for the first time will be

(A) T/2 (B) T/4
(C) T/6 (D) T/8

Paragraph for Question Nos. 39 and 40

In the arrangement shown in the figure, uniform magnetic field B is outward to the plane of paper. Connecter AB is smooth and conducting, having mass m and length l. Initially spring has extension X_0. Spring is non- conducting. Connector is released at t = 0. Answer the following two questions for this arrangement :



39. Maximum charge on the capacitor during subsequent motion is

(A) $X_0\sqrt{\frac{KC}{1+\frac{B^2l^2C}{m}}}$ (B) $X_0\sqrt{\frac{KC}{1+\frac{m}{B^2l^2C}}}$

(C) $\sqrt{\frac{KC}{2+\frac{B^2l^2C}{m}}}$ (D) $\sqrt{\frac{4KC}{1+\frac{B^2l^2C}{2m}}}$

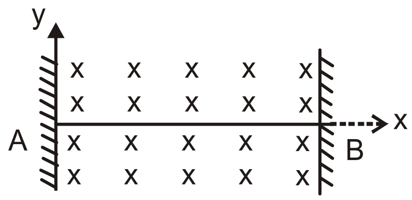
40. Charge on the capacitor during subsequent motion will be maximum for the first time at t equals to:

(A) $\frac{\pi}{2}\sqrt{\frac{B^2l^2C+m}{K}}$ (B) $\frac{\pi}{2}\sqrt{\frac{B^2l^2C-m}{K}}$

(C) $\frac{\pi}{2}\sqrt{\frac{K}{B^2l^2C-m}}$ (D) $\pi\sqrt{\frac{B^2l^2C-m}{K}}$

Paragraph for Question Nos. 41 to 43

Read the paragraph carefully and answer the following questions :



A standing wave y = 2A sinkx cosωt is setup in the conducting wire AB fixed at both ends by two vertical walls (see the figure). The region between the wall contains a constant magnetic field B. Now answer the following questions

41. The wire is found to vibrate in the 3rd harmonic. The maximum emf induced across the ends of wire is

(A) $\frac{4AB\omega}{k}$ (B) $\frac{3AB\omega}{k}$

(C) $\frac{2AB\omega}{k}$ (D) $\frac{AB\omega}{k}$

42. In the above question, the time when the emf becomes maximum for the first time is

(A) $\frac{2\pi}{\omega}$ (B) $\frac{\pi}{\omega}$

(C) $\frac{\pi}{2\omega}$ (D) $\frac{\pi}{4\omega}$

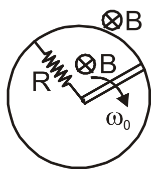
43. In which of the following modes the emf induced in AB is always zero ?

(A) Fundamental mode (B) Second harmonic
(C) Second overtone (D) Fourth overtone

Paragraph for Question Nos. 44 to 46

A circular ring of metallic wire is fixed on a horizontal surface, radius of ring is ℓ. A metal rod of mass m and length ℓ has one end fixed at centre of the ring and rod is free to move in plane of ring touching circumference. Centre of ring and circumference is joined by a resistance R (ignore other resistances). At t = 0 rod is given angular velocity ω_0. It is found that after moving through 180° rod stops. There is no friction anywhere.

[A uniform magnetic field B exists into the plane of ring]

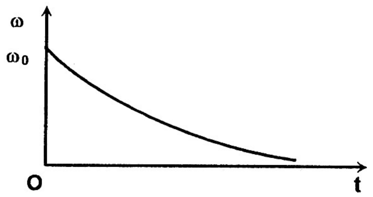


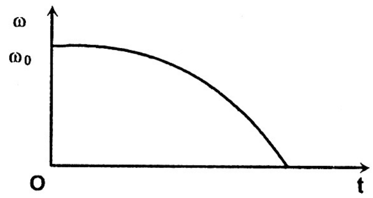
44. ω_0 is

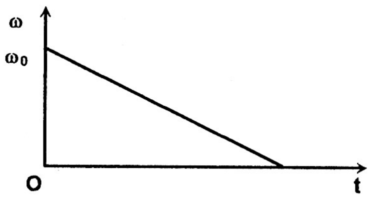
(A) $\frac{3\ell^2B^2\pi}{4mR}$ (B) $\frac{\ell^2B^2\pi}{4mR}$

(C) $\frac{\ell^2B^2\pi}{mR}$ (D) $\frac{\ell^2B^2\pi}{5mR}$

45. Plot ω angular velocity of rod against time.

(A)


(B)


(C)


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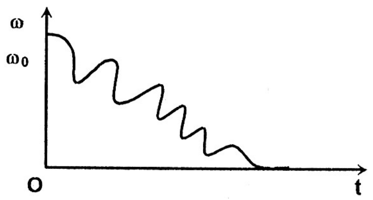


46. Suppose thermal energy produced is absorbed completely by the system uniformly whose heat capacity is C. Rise in temperature is

(A) $\frac{m\ell^2\omega_0^2}{C}$ (B) $\frac{m\ell^2\omega_0^2}{2C}$

(C) $\frac{3m\ell^2\omega_0^2}{4C}$ (D) $\frac{m\ell^2\omega_0^2}{6C}$

Paragraph for Question Nos. 47 to 49

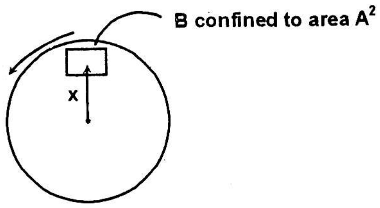
A metallic disc of radius R, thickness d and mass M is attached to a light, narrow conducting axle, which passes through the disc's centre. The disc is free to rotate and is totally inside in a uniform constant magnetic field B which is perpendicular to the plane of the disc.

47. Two electrical brushes are in contact with the axle and the rim of the disc. What potential difference must be applied across the terminals connected to the two brushes so that the rotational kinetic energy of the disc becomes T at the steady state? Assume that the disc is initially at rest.

(A) $BR\sqrt{\frac{T}{M}}$ (B) $BR\sqrt{\frac{T}{2M}}$

(C) $BR\sqrt{\frac{2T}{M}}$ (D) $2BR\sqrt{\frac{T}{M}}$

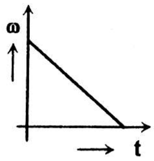
48. Consider the case where the magnetic field B is confined to a small square area of size A^2 and average distance x(x<R) from the disc's axis as shown in the figure. If the disc's electrical conductivity is σ, find an expression for the torque on the disc when it has rotation kinetic energy of T.

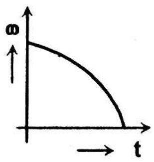


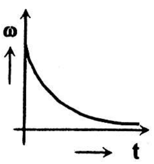
(A) $\frac{B^2A^2x^2\sigma d}{R}\sqrt{\frac{T}{M}}$ (B) $\frac{B^2A^2x^2\sigma d}{2R}\sqrt{\frac{T}{M}}$

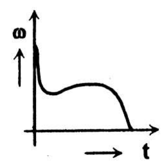
(C) $\frac{2B^2A^2x^2\sigma d}{R}\sqrt{\frac{T}{M}}$ (D) $\frac{B^2A^2x^2\sigma d}{2R}\sqrt{\frac{T}{M}}$

49. The disk has an initial angular velocity ω. Magnetic field is confined to a square path of area A^2. The disk is free to rotate about axle and retards due to magnetic field. Which of the following graph best represents the angular velocity of the disk as a function of time?

(A)


(B)


(C)


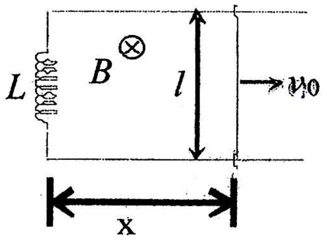
(D)


Paragraph for Question Nos. 50 and 51

Whenever the flux of magnetic field through the area bounded by a closed conducting loop changes, an emf is induced in the loop. The emf is given by

$\varepsilon = -\dfrac{d\phi}{dt}$, where $\phi = \int \vec{B} \cdot d\vec{s}$ is the flux of the magnetic field through the area.

Now consider a loop as shown in the figure. The loop comprises two parallel rails connected by an ideal inductor L and a slider of mass m and length l. A uniform external magnetic field B is directed into the plane of the loop. At t = 0 the slider (which was just next to the inductor) is imparted a velocity v_0 (as shown).



From the given information answer the following questions

50. The current in the circuit as a function of distance (x) travelled by the slider is

(A) $i = \left(\dfrac{Bl}{Lm}\right)x$ (B) $i = \left(\dfrac{Bl}{L}\right)x$

(C) $i = \left(\dfrac{Bl}{L}\right)x^2$ (D) $i = \left(\dfrac{Bl}{m}\right)x$

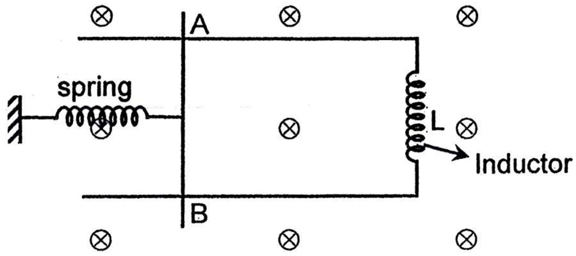
51. The time period of oscillation of the slider is

(A) $T = 2\pi\sqrt{\dfrac{Lm}{B^2l^2}}$ (B) $T = 2\pi\sqrt{\dfrac{Lm}{Bl}}$

(C) $T = 2\pi\sqrt{\dfrac{m}{B^2l^2}}$ (D) $T = 2\pi\sqrt{\dfrac{Lm}{Bl^2}}$

Paragraph for Question Nos 52 and 53

In the arrangement shown in the figure, uniform magnetic field B exists directed into the plane of the paper, connector AB is smooth, has mass m and there exist no friction between connector AB & conducting rails. Separation between rails is ℓ. Self inductance of inductor is L. Spring is ideal, perfectly non-conducting and spring constant is K. Neglect self inductance of everything else except inductor. Initially spring has compression X_0 and then released at t = 0. Answer the following two questions.



52. Maximum current in the circuit during the motion is

(A) $\dfrac{2KX_0B\ell}{KL+B^2\ell^2}$ (B) $\dfrac{KX_0B\ell}{2\left(KL+B^2\ell^2\right)}$

(C) $\dfrac{KX_0B\ell}{KL+B^2\ell^2}$ (D) $\dfrac{KX_0B\ell}{2KL+B^2\ell^2}$

53. Maximum speed of connector is

(A) $KX_0\sqrt{\dfrac{L}{m\left(KL+B^2\ell^2\right)}}$ (B) $2KX_0\sqrt{\dfrac{L}{m\left(KL+B^2\ell^2\right)}}$

(C) $KX_0\sqrt{\dfrac{2L}{m\left(KL+B^2\ell^2\right)}}$ (D) $KX_0\sqrt{\dfrac{L}{2m\left(KL+B^2\ell^2\right)}}$

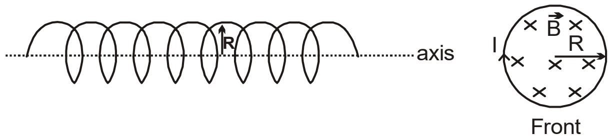
Paragraph for Question Nos. 54 to 58

A capacitor can be used to produce a desired electric field. We considered the parallel plate arrangement as a basic type of capacitor. Similarly, an inductor (symbol) can be used to produce a desired magnetic field. We shall consider a long solenoid (more specifically, a short length near the middle of a long solenoid) as our basic type of inductor.

If we establish a current i in the winding (or turns) of an inductor (a solenoid) the current produces a magnetic field ϕ_B through the central region of the inductor. The inductance of the inductor is then

$\left[L = \dfrac{N\phi_B}{i}\right]$ (inductance defined)

where N is the number of turns. The windings of the inductor are said to be linked by the shared flux, and the product $N\phi_B$ is called the magnetic flux linkage. The inductance L is thus a measure of flux produced by the inductor per unit of current. Now, consider a special type of inductor whose radius of turn is R as shown in the adjacent figure and total number of turns is N.



This special type of solenoid produces a magnetic field $|\vec{B}| = \frac{\mu_0 I r^2}{R^3}$ uniformly along the axis of the solenoid as shown in figure. r is the distance from the axis of solenoid

54. The value of total flux linkages when current I flows through this special type of inductor is given by

(A) $\frac{\pi}{2}\mu_0 NIR^1$ (B) $4\pi\mu_0 NIR^1$

(C) $2\pi\mu_0 NI$ (D) $\frac{2\pi}{3}\mu_0 NI^2R^{-1}$

55. Value of self inductance of this inductor is given by

(A) $\frac{4\pi}{3}\mu_0 NI$ (B) $\frac{2\pi}{3}\mu_0 N$

(C) $\frac{2\pi}{3}\mu_0 NIR^{-1}$ (D) $\frac{\pi\mu_0 NR}{2}$

56. If an external magnetic field $\vec{B}$ perpendicular to the axis of the solenoid is applied, then total flux linkage will

(A) Change

(B) Will not change

(C) Depend on the strength of magnetic field

(D) Cannot say

57. If it is given that total flux linkage through the inductor is KIL^2 (where L is the inductance), then its inductance is given by

(A) 1/K (B) K^2

(C) 5K (D) $1/K^2$

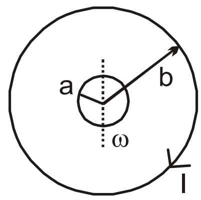
58. Adjust the value of 'K' such that inductance becomes twice of the previous value

(A) 4K (B) 3K

(C) 5K (D) K/2

Paragraph for Question Nos. 59 to 61

A very small circular loop of radius a is initially coplanar and concentric with a much large circular loop of radius b (>> a). A constant current I is passed in the large loop which is kept fixed in space and the small loop is rotated with angular velocity ω about a diameter. The resistance of the small loop is R and its self inductance is negligible.



59. Find the current in the small loop as a function of time

(A) $\frac{\pi a^2\mu_0 I\omega\sin\omega t}{2bR}$ (B) $\frac{\pi a^2\mu_0 I\omega\cos\omega t}{2bR}$

(C) $\frac{\pi b^2\mu_0 I\omega\sin\omega t}{2aR}$ (D) $\frac{\pi b^2\mu_0 I\omega\cos\omega t}{2aR}$

60. Calculate how much torque must be exerted on the small loop to rotate it?

(A) $\frac{\omega}{R}\left(\frac{\pi a^2\mu_0 I}{2b}\right)^2 \sin\omega t$

(B) $\frac{\omega}{R}\left(\frac{\pi b^2\mu_0 I}{2b}\right)^2 \sin\omega t\cos\omega t$

(C) $\frac{\omega}{R}\left(\frac{\pi a^2\mu_0 I\sin\omega t}{2b}\right)^2$

(D) None of these

61. At the moment both the loops are in the same plane

(A) The induced current in small loop is zero

(B) The induced current in small loop is clockwise

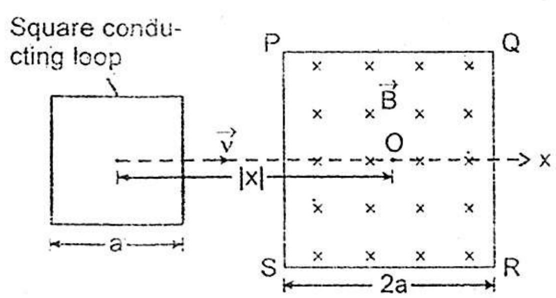
(C) The induced current in small loop is in anticlockwise direction

(D) The induced current is clockwise or anticlockwise depending on sense of angular velocity vector

Paragraph for Question 62 to 64

PQRS is a square region of side '2a' in the plane of paper.

A uniform magnetic field $\vec{B}$, directed perpendicular to the plane of paper and into its plane, is confined to this square region. A square loop of side 'a' and made of conducting wire of resistance 'R' is moved at a constant velocity $\vec{v}$ from left to right in the plane of paper as shown. Obviously, the square loop will enter the magnetic field at some time and then leave it after some time. During the motion of loop, whenever magnetic flux through it changes , emf will be induced resulting in induced current. Left the motion of the square loop be along x-axis and let us measure-x coordinate from the centre of the square magnetic field region (taken as origin) to the centre of square loop. Thus, x coordinate will be positive if the center of square loop is to the right of the origin O (centre of magnetic field).



62. For $x = -\frac{9}{5}a$, magnitude of induced current and its direction as seen from above will be :

(A) Bav, clockwise (B) $\frac{Bav}{R}$, clockwise

(C) Zero (D) $\frac{Bav}{R}$, anticlockwise

63. External force required to maintain constant velocity of the loop for $x = \frac{-9}{5}a$ will be:

(A) $B^2a^2v^2$ to the right (B) $\frac{B^2a^2v^2}{R}$ to the right

(C) $\frac{B^2a^2v^2}{R}$ to the left (D) Zero

64. For $x = -\frac{a}{4}$, (i) magnetic flux through the loop, (ii) induced current in the loop and (iii) external force required to maintain constant velocity of the loop, will be :

(A) (i) Ba^2 (ii) $\frac{Bav}{2R}$ (iii) $\frac{B^2a^2v^2}{4R^2}$

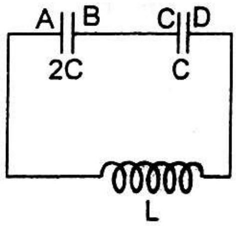
(B) (i) Ba^2 (ii) zero (iii) zero

(C) (i) Ba^2 (ii) $\frac{Bav}{2R}$ (iii) zero

(D) (i) zero (ii) zero (iii) zero

Paragraph for Questions 65 and 66

Two capacitors of capacitances 2C and C are connected in series with an inductor of inductance L. Initially capacitors have charge such that $V_B - V_A = 4V_0$ and $V_C - V_D = V_0$. Initial current in the circuit is zero. Assume inductor coil and connecting wires have negligible resistance.



65. Current flowing through inductor coil satisfies relation :

(A) $\frac{d^2i}{dt^2} = -\frac{2LC}{3}i$ (B) $\frac{d^2i}{dt^2} = 0$

(C) $\frac{d^2i}{dt^2} = \text{constant}$ (D) $\frac{d^2i}{dt^2} = -\frac{3}{2LC}i$

66. Select correct Alternatives :

(A) Maximum current that will flow in the circuit is $V_0\sqrt{\frac{6C}{L}}$

(B) Maximum current that will flow in the circuit is $V_0\sqrt{\frac{3C}{L}}$

(C) Potential difference across capacitor of capacitance 2C when current in the circuit is maximum is $3V_0$

(D) Potential difference across capacitor of capacitance C when current in the circuit is maximum is $3V_0$

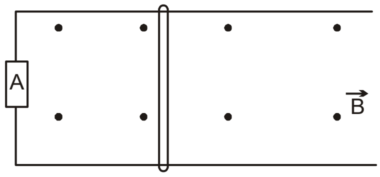
SECTION-D

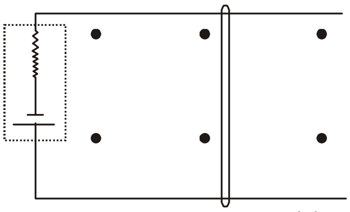
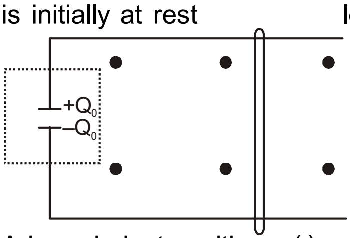
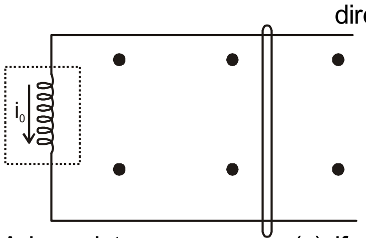
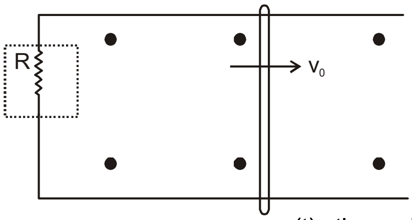
Matrix-Match Type

This **Section D** have "match the following" type question. Question contains two columns, **Col-I** and **Col-II**. Match the entries in **Col-I** with the entries in **Col-II**. One or more entries in **Col-I** may match with one or more entries in **Col-II**.

67. A homogeneous magnetic field B is perpendicular to a sufficiently long track of width l which is horizontal. A frinctionless conducting resistanceless rod of mass m straddles the two rails of the track as shown in the figure. Entire arrangement lies in horizontal plane. For the situation suggested in

column-II match the appropriate entries in column-I. The rails are also resistanceless. Box A can contain any electrical component as shown in column I.



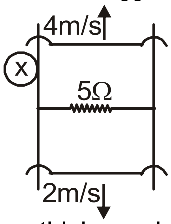
Column I	Column II
(A) A is a battery of emf V and internal resistance R. The rod is initially at rest	(p) energy is dissipated during the motion
	
(B) A is charged capacitor. The system has no resistance. The rod is initially at rest	(q) the rod moves with a constant velocity after a long time
	
(C) A is an inductor with initial current i_0. It is having no resistance	(r) after a certain time interval rod will change its direction of motion
	
(D) A is resistance. The rod is projected to the right with a velocity v_0	(s) if a constant force is applied on the rod to the right, it can move with a constant velocity
	
	(t) the rod stops after some time in absence of an external force

SECTION-E

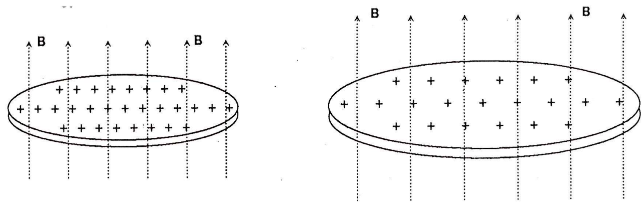
Integer Answer Type

This section contains Integer type questions. The answer to each of the questions is an integer.

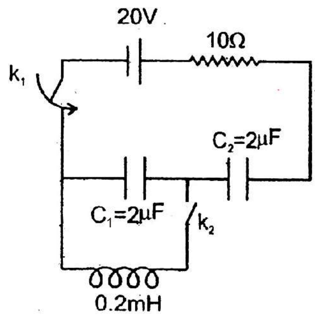
68. Two parallel rails with negligible resistance are 10 cm long. They are connected by a 5.0 Ω resistor. The circuit also contains two metal rods having resistance of 10 Ω and 15 Ω along the rails. The rod are pulled with constant speed 4.00 m/s and 2 m/s. A uniform magnetic field of magnitude 0.01T is applied perpendicular to the plane of the rails. The current in the 5Ω resistor is $\frac{k}{55}$ mA. Find k.



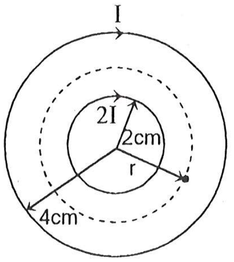
69. Two discs of same thickness but of radius R and 2R are made up of same insulating material. Both have uniform charge density σ on one surface. Both the discs are rotated about centrodial axis with constant angular velocity ω in uniform magnetic field B. If E_1 and E_2 are the work done by external agent to provide this rotational energy to the discs. Calculate $\frac{E_2}{2E_1}$.



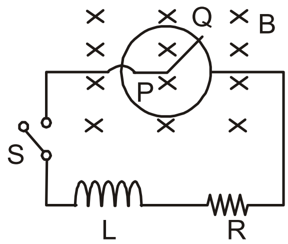
70. In the circuit shown in figure, the key k_1, was closed for long time and k_2 was open. At t = 0, key k_1 is opened and k_2 is closed. If the charge on capacitor C_1 is $\frac{N}{2}\sqrt{3}$ μC, at the instant, the energy stored in it is three times of energy stored in inductor. Then $\frac{N}{4}$ is



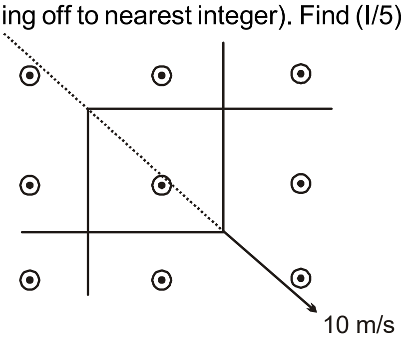
71. Two long coaxial solenoids of radius 2 cm and 4 cm respectively, have same number of turns per unit length and carry initially no currents. Current starts flowing in same direction in both solenoid simultaneously, such that both currents increases linearly with time. Instantaneous current in inner solenoid is double the current in outer solenoid. As a result of increasing currents in solenoids, a charged particle initially at rest between solenoids starts moving along a circular path of radius r. Find r^2 (in cm^2)



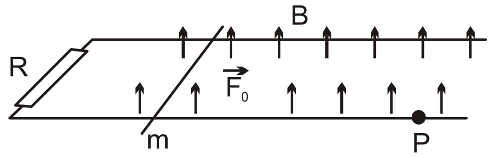
72. The diagram shows a circuit having a coil of resistance R = 10 Ω and inductance L connected to a conducting rod PQ which can slide on a perfectly conducting circular ring of radius 10 cm with its centre at P. Assume that friction and gravity are absent and a constant uniform magnetic field of 5T exists as shown in figure. At t = 0, the circuit is switched on and simultaneously a time varying external torque is applied on the rod so that it rotates about P with a constant angular velocity 40 rad/s. The magnitude of this torque (in μNm) when current reaches half of its maximum value is T. Find T/250. Neglect the self inductance of the loop formed by the circuit.



73. The L-shaped conductor as shown in figure moves with a velocity 10 m/s across a stationary L shaped conductor in a 0.10 T magnetic field. The two vertices overlap so that the enclosed area is zero at t = 0. The conductor has resistance of 0.010 ohms per meter. Current (in Amp.) at t = 0.10 sec is I. (After rounding off to nearest integer). Find (I/5)

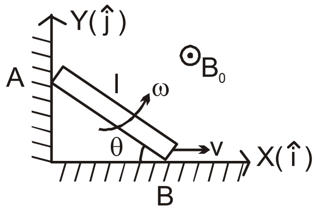


74. The long, horizontal pair of rails shown in the figure is connected using resistance R. The distance between the rails is l, the electrical resistance of the rails is negligible. A conducting wire of mass m and length l can slide without friction on the pair of rails, in a vertical, homogeneous magnetic field of induction B.

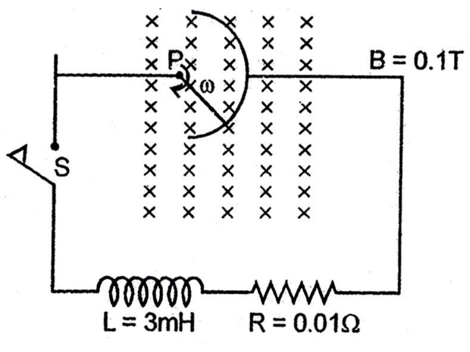


A force of magnitude F_0 is exerted for sufficiently long time onto the conducting wire, so that the speed of the wire becomes nearly constant. The force F_0 is now removed at a certain point P. The distance (in m) does the conducting wire cover on rails from point P before stopping is D. Find D/64. (Given : F_0 = 20 N, m = 1.6 gm, R = 0.01 Ω, l = 10 cm, B = 0.1 T)

75. A thin conducting rod of length l = 5m is moved such that its end B moves along the X-axis while end A moves along the Y-axis. A uniform magnetic field B = $6\hat{k}$ T exists in the region. At some instant, velocity of end B is 3 m/s and the rod makes an angle of θ = 37° with the X-axis as shown in the figure. Then, at this instant the emf induced (in volt) in the rod is V. Find V/3



76. The circuit shows a resistance $R = 0.01\Omega$ and inductance L = 3mH connected to a conducting rod PQ of length l= 2m which can slide on a perfectly conducting circular arc of radius ℓ with its centre at P. Assume that friction and gravity are absent and a constant uniform magnetic field B = 0.1T exists as shown in the figure. At t = 0, the circuit is switched on and simultaneously an external torque is applied on the rod so that it rotates about P with a constant angular velocity ω = 2 rad/sec. Find the magnitude of this torque (in N-m), at t = (0.3 ln2) second.



ANSWERS

LEVEL-1

1. (A)	2. (A)	3. (C)	4. (C)	5. (A)	6. (C)
7. (A)	8. (D)	9. (A)	10. (A,B,C,D)	11. (A,B,D)	12. (A,B,D)
13. (B)	14. (B)	15. (B)	16. (C)	17. (A,B,C,D)	18. (B)
19. (C)	20. (B)	21. (A-s,t, B-t ,C-p,q,r D-r)		22. (A-q, B-r ,C-s)	23. (6)
24. (2)					

LEVEL-2

1. (C)	2. (D)	3. (D)	4. (C)	5. (B)	6. (D)
7. (A)	8. (A)	9. (B)	10. (C)	11. (D)	12. (D)
13. (C)	14. (C)	15. (D)	16. (D)	17. (D)	18. (A)
19. (A)	20. (B,C)	21. (B)	22. (C)	23. (D)	24. (A,C,D)
25. (A,B)	26. (A,C)	27. (D)	28. (A,B,C)	29. (A,C,D)	30. (A,C)
31. (A,D)	32 (C)	33. (C)	34. (A)	35. (A)	36. (A)
37. (A)	38. (B)	39. (B)	40. (A)	41. (A)	42. (C)
43. (B)	44. (A)	45. (A)	46. (D)	47. (A)	48. (C)
49. (C)	50. (B)	51. (A)	52. (A)	53. (A)	54. (A)
55. (D)	56. (B)	57. (A)	58. (D)	59. (A)	60. (C)
61. (A)	62. (C)	63. (D)	64. (B)	65. (D)	66. (A,C)
67. (A-p,q, B-p,q ,C-r, D-p,s,t)		68. (8)	69. (8)	70. (5)	71. (8)
72. (5)	73. (7)	74. (5)	75. (7)	76. (4)	

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