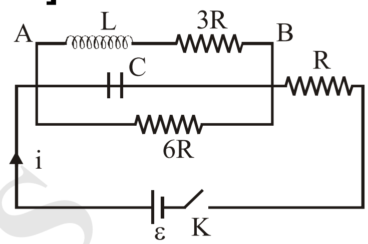
CLASS : CC (ADVANCED) **EMI & AC** **M.M. 73** **TEST NO. 6**

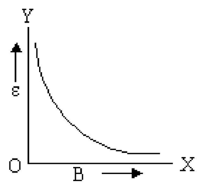
[SINGLE CORRECT CHOICE TYPE]

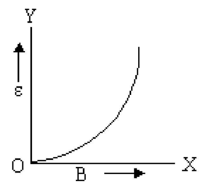
Q.1 In the given circuit diagram, the key K is switched on at $t = 0$. The ratio of the current i through the cell at $t = 0$ and $t = \infty$ will be **[3]**

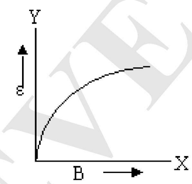


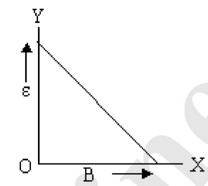
(A) 3 : 1 (B) 1 : 3
(C) 1 : 2 (D) 2 : 1

Q.2 Let B and ε denotes magnetic induction and magnetic field energy density at mid point of a long solenoid carrying current i. The graph between ε and B will be **[3]**

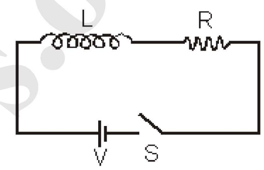
(A) 

(B) 

(C) 

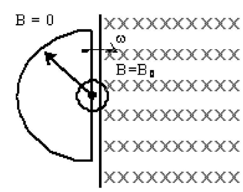
(D) 

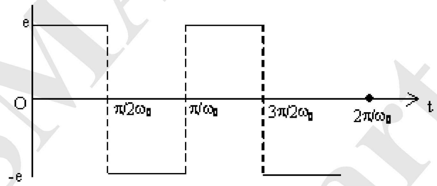
Q.3 An inductor of inductance $L = \frac{\tau R}{2}$ and a resistor of resistance R is connected to a battery of emf V as shown in the figure. The potential difference across the resistance at a time, $t = \tau \ln 2$ after the switch S is closed is (τ is constant) **[3]**

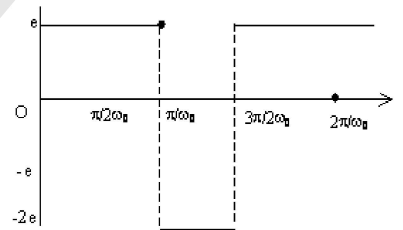


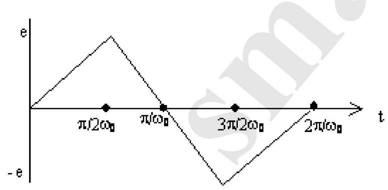
(A) $\frac{V}{4}$ (B) $\frac{3V}{4}$
(C) $\frac{V}{2}$ (D) $\frac{2V}{3}$

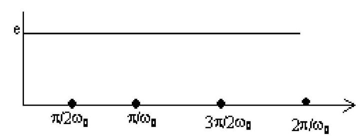
Q.4 A semicircular loop of radius r is being rotated about an axis normal to the plane of loop such that when loop is going inside the field $\omega = \omega_0$ and and when loop is coming out of the field $\omega = 2\omega_0$. Which of the following best represents the emf(e) induced as function of time with anticlockwise sense of rotation as +ve. **[3]**



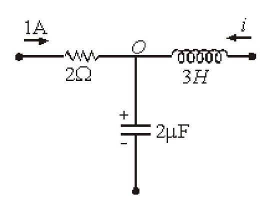
(A) 

(B) 

(C) 

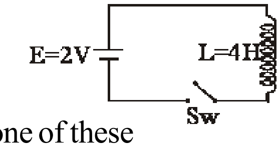
(D) 

Q.5 The potential difference V across the 2μF capacitor increases with time, as $\frac{dV}{dt} = 1 Vs^{-1}$ and $\frac{d^2V}{dt^2} = 2Vs^{-2}$ at particular instant. The p.d. across the 3H inductor is **[3]**



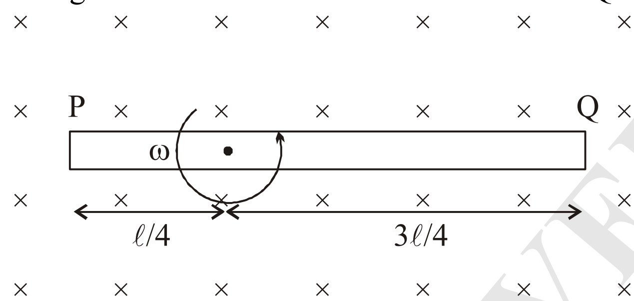
(A) 6 μ V (B) 12 μ V (C) 6V (D) none of these

Q.6 In the circuit shown, the cell is ideal. The coil has inductance of 4H and zero resistance. The switch is closed at t=0. The rate of energy supplied by the cell in the circuit at t=2 s is **[3]**



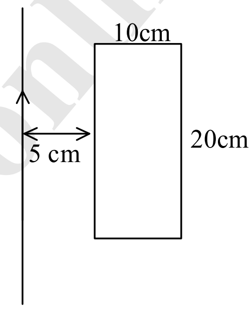
(A) 1 watt (B) 2 watt (C) zero (D) none of these

Q.7 A conductor of length l is rotating with constant angular velocity ω about an axis in a uniform magnetic field B as shown in figure. The emf induced between ends P and Q will be **[3]**



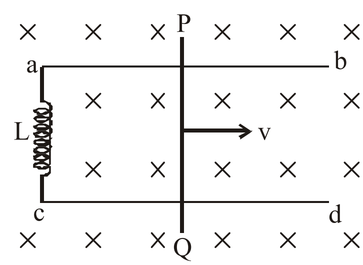
(A) $\frac{1}{4}B\omega l^2$ (B) $\frac{5}{10}B\omega l^2$ (C) Zero (D) $\frac{1}{2}B\omega l^2$

Q.8 A current of 20 A flowing in a long straight wire situated near a fixed rectangular loop as shown in figure falls to zero in 0.02 second. The average of emf induced in the loop: **[3]**



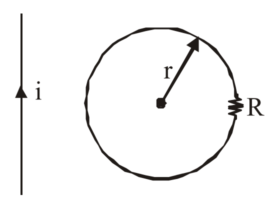
(A) 22 ln3μV (B) 66μV
(C) 40 ln3μV (D) 60μV

Q.9 In a uniform and 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 a 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 (Ignore any resistance, electrical as well as mechanical) **[3]**



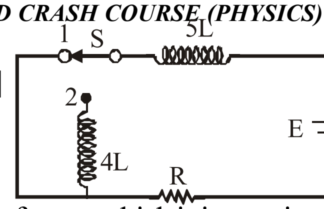
(A) $\sqrt{\frac{mv_0^2}{L}}$ (B) $\sqrt{\frac{mv_0^2}{2L}}$ (C) $\sqrt{\frac{mv_0^2}{4L}}$ (D) zero

Q.10 In the given figure, the mutual inductance of coil and the very long straight wire is M, the coil has resistance R and the self inductance L. The wire lies in the same plane as that of the coil. The current in the wire varies according to the law i = at, where a is a constant and t is the time, the time dependence of current in the coil is **[3]**



(A) $\frac{M}{aR}$ (B) $MaR\,e^{-Rt/L}$ (C) $\frac{M}{R}e^{-tR/L}$ (D) $\frac{Ma}{R}(1-e^{-tR/L})$

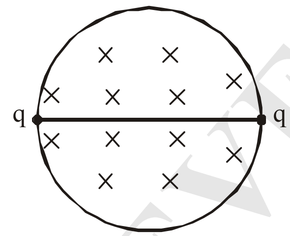
Q.11 In the circuit shown the switch S is shifted to position 2 from position 1 at t = 0, having been in position 1 for a long time. The current in the circuit just



after shifting of switch will be (battery and both the inductors are ideal) **[3]**

(A) $\frac{4}{5}\cdot\frac{\varepsilon}{R}$ (B) $\frac{5}{4}\cdot\frac{\varepsilon}{R}$ (C) $\frac{5}{9}\frac{\varepsilon}{R}$ (D) $\frac{\varepsilon}{R}$

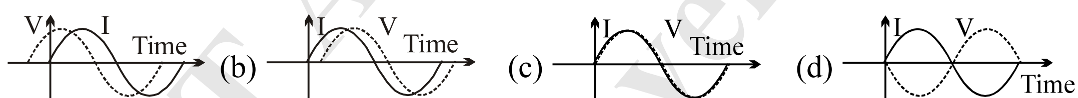
Q.12 A cylindrical region of uniform magnetic field exists perpendicular to plane of paper which is increasing at a constant rate $\frac{dB}{dt}=\alpha$. The diameter of cylindrical region is ℓ. A non-conducting rigid rod, of length ℓ and mass m with two massless charged particles each having charges q is fixed at the ends of the rod, is placed on the diameter of cylindrical region as shown. The angular acceleration of the rod is **[3]**



(A) $\frac{q\alpha}{2m}$ (B) $\frac{3q\alpha}{2m}$ (C) $\frac{3q\alpha}{m}$ (D) $\frac{3q\alpha}{4m}$

[MULTIPLE CORRECT CHOICE TYPE]

Q.13 The diagram shows the variation of V and I in an AC circuit. The circuit only be a series RC or series RL or series LC or series RLC. Consider the four different combinations of V and I graphs. Pick the correct combination/combinations for each graph. Solid curves represent I and broken curves represent V. **[4]**



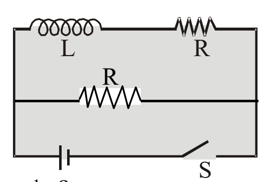
(a) Phase difference between V & I is $\pi/4$ (b) Phase difference between V & I is $\pi/4$. (c) V and I are in the same phase (d) V and I have a phase difference of π

Take the angular frequency of the AC voltage source to be 100 rad/s.

(I) : $R = 1k\Omega$, $L = 1H$ and $C = 100\mu F$ (II) : $R = 1\Omega$ and $L = 10^{-2}H$
(III) : $R = 100\Omega$ and $C = 10^{+2}\mu F$ (IV) : $L = 1H$ and $C = 100\mu F$, $R = 1\Omega$

(A) a $\rightarrow$ II ; d $\rightarrow$ I, IV ; (B) c $\rightarrow$ I ; d $\rightarrow$ none
(C) b $\rightarrow$ III ; c $\rightarrow$ IV (D) a $\rightarrow$ II,III ; b $\rightarrow$ II,III

Q.14 In the circuit shown in figure switch S is closed at time t = 0. Which statement is true after one time constant? **[4]**



(A) Flux linked with Inductor $\frac{2L\varepsilon}{R}(1-e^{-1})$ (B) Current through battery $\frac{\varepsilon}{2R}(1-e^{-1})$

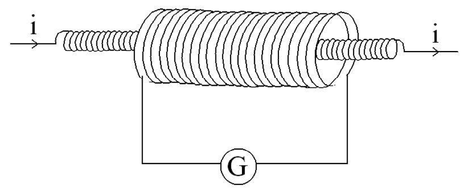
(C) Flux linked with Inductor $\frac{L\varepsilon}{R}(1-e^{-1})$ (D) Current through battery $\frac{2\varepsilon}{R}$

Q.15 Resonance occurs in a series L-C-R circuit when the frequency of the applied emf is 1000 Hz. Then : **[4]**
(A) when f = 900 Hz, the circuit behaves as a capacitative circuit
(B) the impedance of the circuit is maximum at f = 1000 Hz

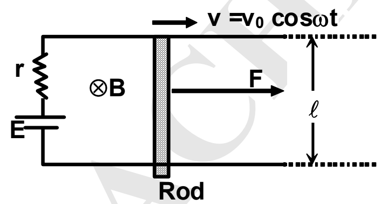
(C) at resonance the voltage accross L and voltage accross C differ in phase by 180°
(D) if the value of C is doubled resonance occurs at f = 2000 Hz

[SUBJECTIVE TYPE]

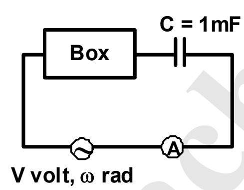
Q.16 A long solenoid of radius 2 cm has 100 turns/cm and is surrounded by a 100–turn coil of radius 4 cm having a total resistance of 20 Ω. The coil is connected to a galvanometer as shown in figure. If the current in the solenoid is changed from 5 A in one direction to 5 A in the opposite direction, find the charge which flows through the galvanometer. **[5]**



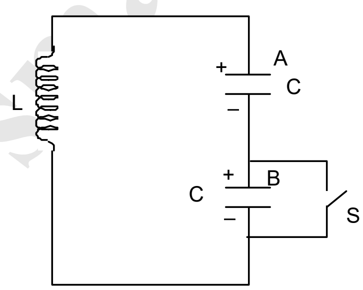
Q.17 Two parallel conducting rails are connected to a source of emf E and internal resistance r. Another conducting rod of length ℓ having negligible resistance lies at rest, initially, and can slide without friction over the rails. A uniform magnetic field of induction B is applied perpendicular to the plane of the rails.
At time t = 0, the sliding rod is pulled along the rails by applying a force F.
The velocity of the rod is observed to be $v = v_0 \cos\omega t$.
(a) Find the force F as a function of time and its maximum magnitude.
(b) Find the power spent by the force over 1 cycle. (time = $2\pi/\omega$) **[5]**



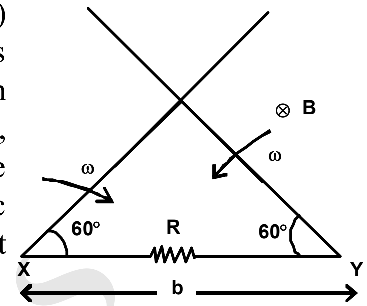
Q.18 As shown in the figure ammeter reading is 3 amp and power factor of circuit is 1. Find the power factor of the box (V = 90 volt, ω = 25 rad/sec). **[5]**



Q.19 Two identical capacitors A and B of capacitance C and each charged to voltage V are connected in series to coil of inductance L at t = 0. At t = 't_0' switch S is closed, find the maximum charge on capacitor A after this instant. **[5]**



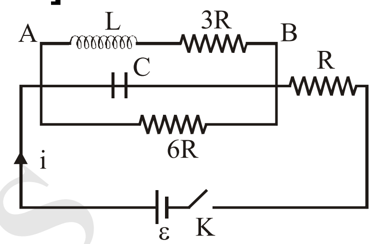
Q.20 Two long conducting rods are hinged to the conducting supports (X,Y) having distance b between them. A resistive wire of resistance R is connected between the supports. Constant magnetic field B exists in the region. Now both rods are rotated with constant angular velocity ω, such that one rod slides over other and two rods and resistive wire make an isosceles triangle at any instant. Find the induced magnetic field at the centroid of the equilateral triangle formed by the rods at that instant, due to current in the loop. **[5]**



CLASS : CC (ADVANCED) **EMI & AC** **M.M. 73** **TEST NO. 6**

[SINGLE CORRECT CHOICE TYPE]

Q.1 In the given circuit diagram, the key K is switched on at t = 0. The ratio of the current i through the cell at t = 0 and t = ∞ will be **[3]**



(A*) 3 : 1 (B) 1 : 3
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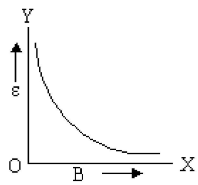
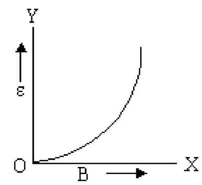
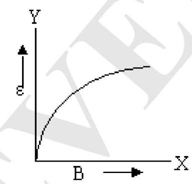
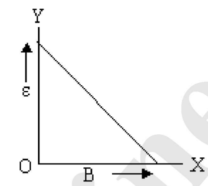
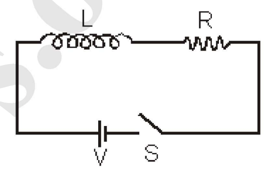
Q.2 Let B and ε denotes magnetic induction and magnetic field energy density at mid point of a long solenoid carrying current i. The graph between ε and B will be **[3]**

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

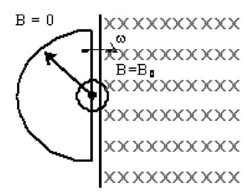
Q.3 An inductor of inductance $L = \frac{\tau R}{2}$ and a resistor of resistance R is connected to a battery of emf V as shown in the figure. The potential difference across the resistance at a time, $t = \tau \ln 2$ after the switch S is closed is (τ is constant) **[3]**

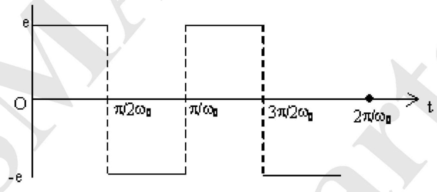


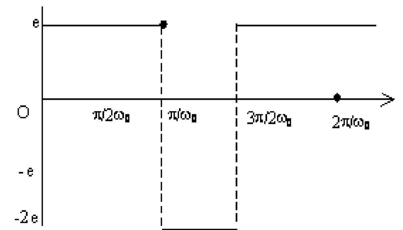
(A) $\frac{V}{4}$ (B*) $\frac{3V}{4}$

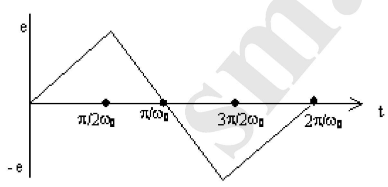
(C) $\frac{V}{2}$ (D) $\frac{2V}{3}$

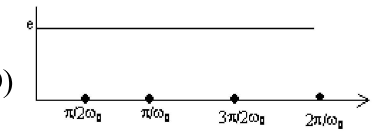
Q.4 A semicircular loop of radius r is being rotated about an axis normal to the plane of loop such that when loop is going inside the field $\omega = \omega_0$ and and when loop is coming out of the field $\omega = 2\omega_0$. Which of the following best represents the emf(e) induced as function of time with anticlockwise sense of rotation as +ve. **[3]**



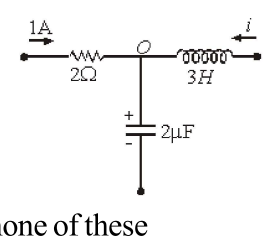
(A) 

(B*) 

(C) 

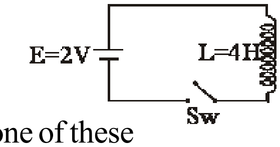
(D) 

Q.5 The potential difference V across the 2μF capacitor increases with time, as $\frac{dV}{dt} = 1Vs^{-1}$ and $\frac{d^2V}{dt^2} = 2Vs^{-2}$ at particular instant. The p.d. across the 3H inductor is **[3]**



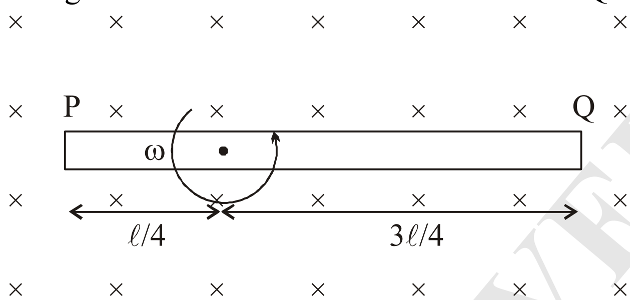
(A) 6 μ V (B*) 12 μ V (C) 6V (D) none of these

Q.6 In the circuit shown, the cell is ideal. The coil has inductance of 4H and zero resistance. The switch is closed at t=0. The rate of energy supplied by the cell in the circuit at t=2 s is **[3]**



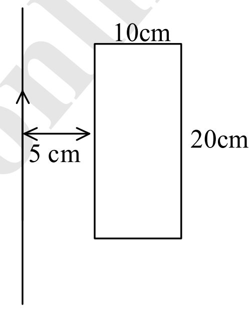
(A) 1 watt (B*) 2 watt (C) zero (D) none of these

Q.7 A conductor of length l is rotating with constant angular velocity ω about an axis in a uniform magnetic field B as shown in figure. The emf induced between ends P and Q will be **[3]**



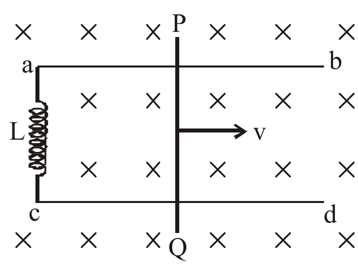
(A*) $\frac{1}{4}B\omega l^2$ (B) $\frac{5}{10}B\omega l^2$ (C) Zero (D) $\frac{1}{2}B\omega l^2$

Q.8 A current of 20 A flowing in a long straight wire situated near a fixed rectangular loop as shown in figure falls to zero in 0.02 second. The average of emf induced in the loop: **[3]**



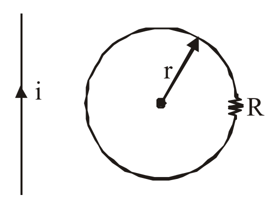
(A) $22 \ln 3 \mu V$ (B) $66 \mu V$
(C*) $40 \ln 3 \mu V$ (D) $60 \mu V$

Q.9 In a uniform and 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 a 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 (Ignore any resistance, electrical as well as mechanical) **[3]**



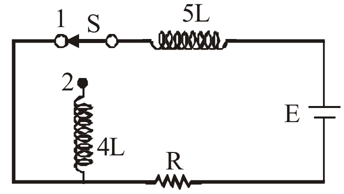
(A) $\sqrt{\frac{mv_0^2}{L}}$ (B*) $\sqrt{\frac{mv_0^2}{2L}}$ (C) $\sqrt{\frac{mv_0^2}{4L}}$ (D) zero

Q.10 In the given figure, the mutual inductance of coil and the very long straight wire is M, the coil has resistance R and the self inductance L. The wire lies in the same plane as that of the coil. The current in the wire varies according to the law i = at, where a is a constant and t is the time, the time dependence of current in the coil is **[3]**



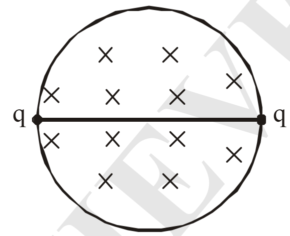
(A) $\frac{M}{aR}$ (B) $MaR\,e^{-Rt/L}$ (C) $\frac{M}{R}e^{-tR/L}$ (D*) $\frac{Ma}{R}(1-e^{-tR/L})$

Q.11 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) **[3]**



(A) $\frac{4}{5}.\frac{\varepsilon}{R}$ (B) $\frac{5}{4}.\frac{\varepsilon}{R}$ (C*) $\frac{5}{9}\frac{\varepsilon}{R}$ (D) $\frac{\varepsilon}{R}$

Q.12 A cylindrical region of uniform magnetic field exists perpendicular to plane of paper which is increasing at a constant rate $\frac{dB}{dt} = \alpha$. The diameter of cylindrical region is ℓ. A non-conducting rigid rod, of length ℓ and mass m with two massless charged particles each having charges q is fixed at the ends of the rod, is placed on the diameter of cylindrical region as shown. The angular acceleration of the rod is **[3]**

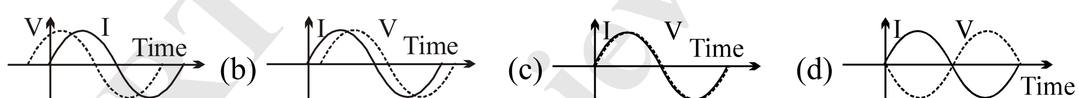


(A) $\frac{q\alpha}{2m}$ (B) $\frac{3q\alpha}{2m}$ (C*) $\frac{3q\alpha}{m}$ (D) $\frac{3q\alpha}{4m}$

[MULTIPLE CORRECT CHOICE TYPE]

Q.13 The diagram shows the variation of V and I in an AC circuit. The circuit only be a series RC or series RL or series LC or series RLC. Consider the four different combinations of V and I graphs. Pick the correct combination/combinations for each graph. Solid curves represent I and broken curves represent V. **[4]**

(a) (b) (c) (d)



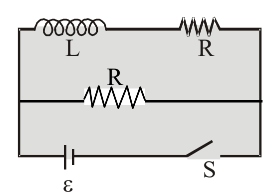
(a) Phase difference between V & I is $\pi/4$
(b) Phase difference between V & I is $\pi/4$.
(c) V and I are in the same phase
(d) V and I have a phase difference of π

Take the angular frequency of the AC voltage source to be 100 rad/s.

(I) : R = 1kΩ, L = 1H and C = 100μF
(II) : R = 1Ω and L = 10^{-2}H
(III) : R = 100Ω and C = 10^{+2}μF
(IV) : L = 1H and C = 100μF, R = 1Ω

(A) a → II ; d → I, IV ;
(B*) c → I ; d → none
(C*) b → III ; c → IV
(D) a → II,III ; b → II,III

Q.14 In the circuit shown in figure switch S is closed at time t = 0. Which statement is true after one time constant ? **[4]**

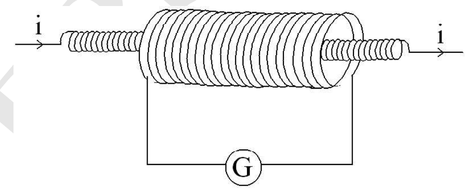


(A) Flux linked with Inductor $\frac{2L\varepsilon}{R}(1-e^{-1})$
(B) Current through battery $\frac{\varepsilon}{2R}(1-e^{-1})$
(C*) Flux linked with Inductor $\frac{L\varepsilon}{R}(1-e^{-1})$
(D) Current through battery $\frac{2\varepsilon}{R}$

Q.15 Resonance occurs in a series L-C-R circuit when the frequency of the applied emf is 1000 Hz. Then :**[4]**
(A*) when f = 900 Hz, the circuit behaves as a capacitative circuit
(B) the impedance of the circuit is maximum at f = 1000 Hz
(C*) at resonance the voltage accross L and voltage accross C differ in phase by 180°
(D) if the value of C is doubled resonance occurs at f = 2000 Hz

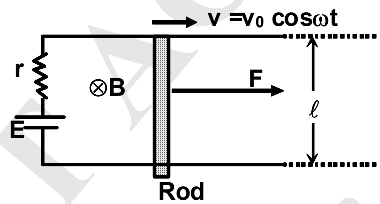
[SUBJECTIVE TYPE]

Q.16 A long solenoid of radius 2 cm has 100 turns/cm and is surrounded by a 100–turn coil of radius 4 cm having a total resistance of 20 Ω. The coil is connected to a galvanometer as shown in figure. If the current in the solenoid is changed from 5 A in one direction to 5 A in the opposite direction, find the charge which flows through the galvanometer. **[5]**



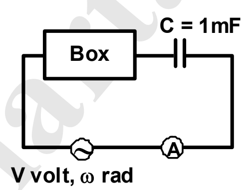
[Ans. 800 μC]

Q.17 Two parallel conducting rails are connected to a source of emf E and internal resistance r. Another conducting rod of length ℓ having negligible resistance lies at rest, initially, and can slide without friction over the rails. A uniform magnetic field of induction B is applied perpendicular to the plane of the rails. At time t = 0, the sliding rod is pulled along the rails by applying a force F.
The velocity of the rod is observed to be $v = v_0 \cos\omega t$.
(a) Find the force F as a function of time and its maximum magnitude.
(b) Find the power spent by the force over 1 cycle. (time = $2\pi/\omega$) **[5]**



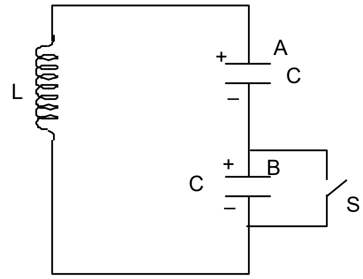
[Ans. (a) $v_0\sqrt{(m\omega)^2 + \left(\frac{B^2\ell^2}{r}\right)^2} + \frac{B\ell E}{r}$ (b) $\frac{B^2\ell^2 v_0^2}{2r}$]

Q.18 As shown in the figure ammeter reading is 3 amp and power factor of circuit is 1. Find the power factor of the box (V = 90 volt, ω = 25 rad/sec). **[5]**



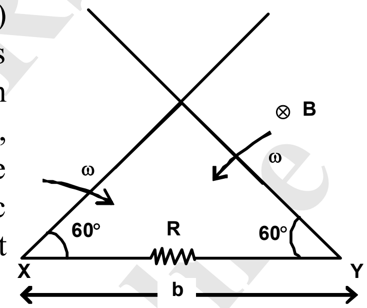
[Ans. 50Ω]

Q.19 Two identical capacitors A and B of capacitance C and each charged to voltage V are connected in series to coil of inductance L at t = 0. At t = 't_0' switch S is closed, find the maximum charge on capacitor A after this instant. **[5]**



[Ans. $CV\sqrt{[2-\cos^2\omega t_0]}$]

Q.20 Two long conducting rods are hinged to the conducting supports (X,Y) having distance b between them. A resistive wire of resistance R is connected between the supports. Constant magnetic field B exists in the region. Now both rods are rotated with constant angular velocity ω, such that one rod slides over other and two rods and resistive wire make an isosceles triangle at any instant. Find the induced magnetic field at the centroid of the equilateral triangle formed by the rods at that instant, due to current in the loop. **[5]**



[Ans. $\frac{B_0 b^2\omega}{R}$]