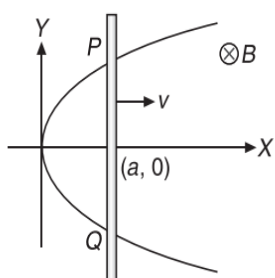


7. The dimensional formula for the ratio of electric flux to magnetic flux is same as that of

(A) $\frac{1}{\mu_0 \epsilon_0}$ (B) $\mu_0 \epsilon_0$
 (C) $\frac{1}{\sqrt{\mu_0 \epsilon_0}}$ (D) $\sqrt{\mu_0 \epsilon_0}$

8. A rod PQ slides with constant velocity v on a wire that is shaped like a parabola $y^2 = 4ax$. At the instant the rod crosses the point $(a, 0)$, the induced emf in the rod is



(A) Bva (B) $2Bav$
 (C) $3Bav$ (D) $4Bav$

9. A constant voltage is applied to a series R - L circuit by closing the switch. The voltage across inductor ($L = 2$ H) is 20 V at $t = 0$ and drops to 5 V at 20 ms. The value of R in Ω is

(A) $100 \ln 2 \Omega$ (B) $100(1 - \ln 2) \Omega$
 (C) $100 \ln 4 \Omega$ (D) $100(1 - \ln 4) \Omega$

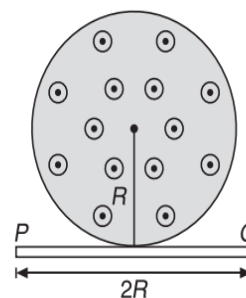
10. A coil of cross-sectional area 400 cm^2 having 30 turns is making 1800 revmin^{-1} in a magnetic field of 1 T. The peak value of the induced emf is

(A) 113 V (B) 226 V
 (C) 339 V (D) 452 V

11. In a gravity free space, a smooth insulating ring of radius R , with a bead having charge q is placed horizontally in a uniform magnetic field of induction B_0 and perpendicular to the plane of ring. Starting from $t = 0$, the magnetic field is varying with time as $B(t) = B_0 + \alpha t$, where α is a positive constant. The contact force between the ring and bead as a function of time is

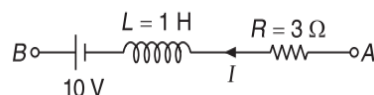
(A) $\frac{\alpha q^2 R t}{m} (2B_0 + \alpha t)$ (B) $\frac{\alpha q^2 R t}{4m} (2B_0 + \alpha t)$
 (C) $\frac{\alpha q^2 R t}{4m} (B_0 + \alpha t)$ (D) $\frac{4\alpha q^2 R t}{m} (2B_0 + \alpha t)$

12. Magnetic field in a cylindrical region is given by $B = \alpha t$. Find emf across rod PQ as shown in Figure.



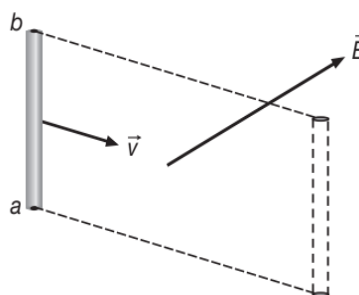
(A) αR^3 (B) $\pi \alpha R^2$
 (C) $\frac{\pi}{2} \alpha R^2$ (D) $\frac{\pi}{4} \alpha R^2$

13. In the given branch AB of a circuit a current, $I = (10t + 5)$ A is flowing, where t is time in second. At $t = 0$, the potential difference between points A and B ($V_A - V_B$) is



(A) 15 V (B) -5 V
 (C) -15 V (D) 5 V

14. A straight wire of length \vec{L} moves with constant velocity \vec{v} (no rotation) through a uniform magnetic field \vec{B} as shown in Figure.



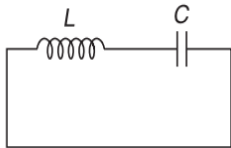
\vec{L} is a vector directed from a to b . ξ_i is the induced emf in the process.

(A) $\xi_i = 0$ (B) $\xi_i = \vec{B} \cdot (\vec{v} \times \vec{L})$
 (C) $\xi_i = \vec{L} \cdot (\vec{B} \times \vec{v})$ (D) $\xi_i = \vec{B} \cdot (\vec{L} \times \vec{v})$

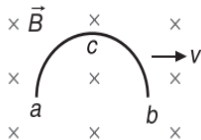
15. Two conducting rings of radius R and r ($r \ll R$) have a common axis. The distance between them is x . If the smaller ring carries current I , then the mutual inductance of bigger ring due to smaller ring is

- (A) $\frac{\mu_0 \pi R^2 r^2}{(R^2 + x^2)^{\frac{3}{2}}}$ (B) $\frac{\mu_0 \pi R^2 r^2}{4(R^2 + x^2)^{\frac{3}{2}}}$
 (C) $\frac{\mu_0 \pi R^2 r^2}{16(R^2 + x^2)^{\frac{3}{2}}}$ (D) $\frac{\mu_0 \pi R^2 r^2}{2(R^2 + x^2)^{\frac{3}{2}}}$

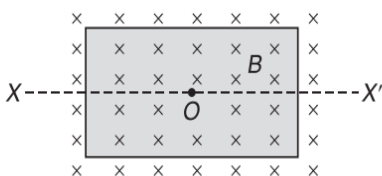
16. Identify the incorrect statement. Induced electric field
 (A) is produced by varying magnetic field
 (B) is non-conservative in nature
 (C) cannot exist in a region not occupied by magnetic field
 (D) None of these
17. In an LC circuit, the capacitor has maximum charge q_0 . The maximum value of rate of change of current is



- (A) $\frac{q_0}{LC}$ (B) $\frac{q_0}{\sqrt{LC}}$
 (C) $\frac{q_0}{LC} - 1$ (D) $\frac{q_0}{LC} + 1$
18. A semi-circular conducting ring acb of radius R moves with constant speed v in a plane perpendicular to uniform magnetic field B as shown in Figure. Identify the correct statement.

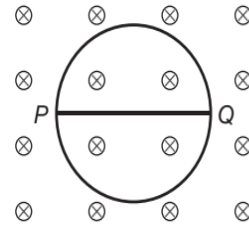


- (A) $V_a - V_c = BRv$ (B) $V_b - V_c = BRv$
 (C) $V_a - V_b = 0$ (D) None of these
19. A rectangular coil is placed in a region having a uniform magnetic field B perpendicular to the plane of the coil. An emf will not be induced in the coil if the



- (A) magnetic field is increased uniformly
 (B) magnetic field is switched off
 (C) coil is rotated about the axis XX'
 (D) coil is rotated about an axis perpendicular to the plane of the coil and passing through its centre O

20. A circular conducting loop of radius R and resistance per unit length λ is placed in a magnetic field decreasing at a constant rate α . Two points lying at the diametric ends are connected through a wire PQ . If I be the current in PQ then

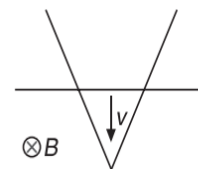


- (A) $I = \frac{R\alpha}{2\lambda}$ from P to Q
 (B) $I = \frac{R\alpha}{2\lambda}$ from Q to P
 (C) $I = \frac{2R\alpha}{\lambda}$ from P to Q
 (D) $I = 0$

21. A metal disc of radius R rotates with an axis perpendicular to its plane passing through its centre in a magnetic field of induction B acting perpendicular to the plane of the disc. The induced emf between the rim and the axis of the disc is

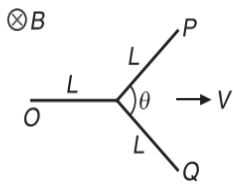
- (A) $-B\pi R^2$ (B) $-\frac{2B\pi^2 R^2}{\omega}$
 (C) $-B\pi R^2 \omega$ (D) $-\frac{BR^2 \omega}{2}$

22. A wire is bent in the form of a V shape and placed in a horizontal plane. There exists a uniform magnetic field B perpendicular to the plane of the wire. A uniform conducting rod starts sliding over the V shaped wire with a constant speed v as shown in Figure.



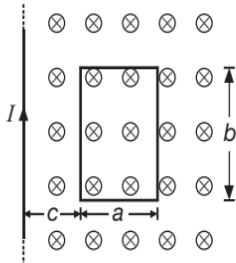
- If the wire has no resistance, the current in rod will
 (A) increase with time (B) decrease with time
 (C) remain constant (D) always be zero

23. A conducting wire in the shape of Y with each side of length L is moving in a uniform field B with uniform speed V . The induced emf between P and Q of the wire will be



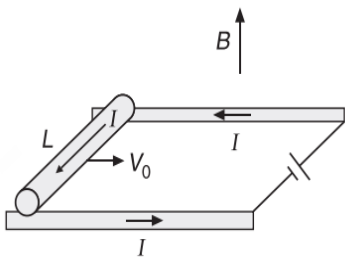
- (A) ZERO (B) $2BLV$
 (C) $2BLV \sin\left(\frac{\theta}{2}\right)$ (D) $2BLV \sin\theta$

24. A rectangular loop of width a , length b is located at a distance c from a long straight wire carrying a current I . The wire is parallel to the long side of the loop. The magnetic flux through the loop is ϕ .



- (A) $\phi = 0$ (B) $\phi = \frac{\mu_0 I b}{2\pi} \ln\left(\frac{a}{c}\right)$
 (C) $\phi = \frac{\mu_0 I b}{2\pi} \ln\left(\frac{a+c}{c}\right)$ (D) $\phi = \frac{\mu_0 I c}{2\pi} \ln\left(\frac{a+b}{b}\right)$

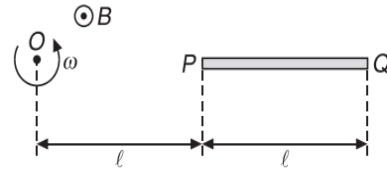
25. A constant current I flows through a metal rod of length L and mass m that slides on frictionless rails as shown in Figure.



If the initial speed of the rod is V_0 and a magnetic field B acts vertically up, find the total distance moved by the rod before coming to a stop

- (A) $\frac{mV_0^2}{BIL}$ (B) $\frac{mV_0^2}{2BIL}$
 (C) $\frac{BLV_0}{m}$ (D) $\frac{BILV_0 m}{2}$

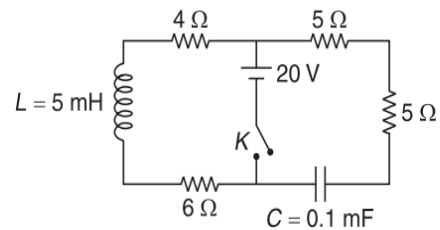
26. A rod of length l is rotating about an axis at distance l from one end as shown in Figure.



If angular speed of rod is ω and magnetic field is B_0 out of the page, find emf developed between end points of rod.

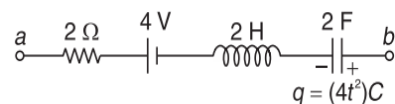
- (A) $\frac{1}{2}B\omega l^2$ (B) $B\omega l^2$
 (C) $\frac{3}{2}B\omega l^2$ (D) ZERO

27. In the circuit shown, key (K) is closed at $t=0$. The current through the key at the instant $t = 10^{-3} \ln 2$ s is



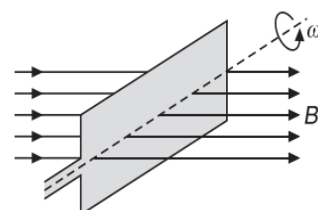
- (A) 2 A (B) 3.5 A
 (C) 2.5 A (D) 0

28. In the Figure shown, V_{ab} at $t = 1$ s is



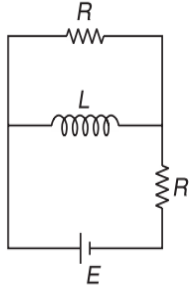
- (A) 30 V (B) -30 V
 (C) 20 V (D) -20 V

29. A rectangular coil of single turn, having area A , rotates in a uniform magnetic field B with an angular velocity ω about an axis perpendicular to the field. If initially the plane of the coil is perpendicular to the field, then the average induced emf when it has rotated through 90° is



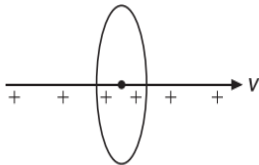
- (A) $\frac{\omega BA}{\pi}$ (B) $\frac{\omega BA}{2\pi}$
 (C) $\frac{\omega BA}{4\pi}$ (D) $\frac{2\omega BA}{\pi}$

30. The Figure shows an L - R circuit, the time constant for the circuit is



- (A) $\frac{L}{2R}$ (B) $\frac{2L}{R}$
 (C) $\frac{2R}{L}$ (D) $\frac{R}{2L}$

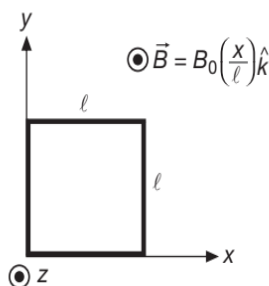
31. A very long uniformly charged non-conducting rod (linear charge density = λ) is moving with a constant velocity v through the centre of a circular conducting loop as shown. If radius of the loop is r , then induced emf in loop is



- (A) $\frac{\mu_0 \lambda v r}{4}$ (B) $\frac{\mu_0 \lambda v r^2}{4}$
 (C) $\frac{\mu_0 \lambda v r}{2}$ (D) ZERO

32. The magnetic field in a region is given by $\vec{B} = B_0 \left(\frac{x}{l} \right) \hat{k}$.

A square loop of side l is placed with its edges along the x and y axis. The loop is moved with a constant velocity $\vec{v} = v_0 \hat{i}$. The emf induced in the loop is

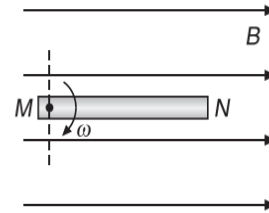


- (A) $B_0 l v_0$ (B) $2B_0 l v_0$
 (C) $\frac{1}{2}(B_0 l v_0)$ (D) $\frac{1}{4}(B_0 l v_0)$

33. In a uniform magnetic field of induction B , a wire in the form of a semicircle of radius r rotates about the diameter of the circle with angular frequency ω . The axis of rotation is perpendicular to the field. If the total resistance of the circuit is R , the mean power generated per period of rotation is

- (A) $\frac{B\pi r^2 \omega}{2R}$ (B) $\frac{(B\pi r^2 \omega)^2}{8R}$
 (C) $\frac{(B\pi r \omega)^2}{2R}$ (D) $\frac{(B\pi r \omega^2)^2}{8R}$

34. A metallic rod of length l is hinged at the point M and is rotating about an axis perpendicular to the plane of paper with a constant angular velocity ω . A uniform magnetic field of intensity B is acting in the region (as shown in Figure) parallel to the plane of paper. The potential difference between the points M and N

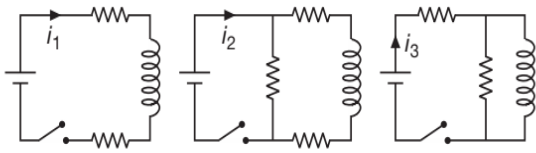


- (A) is always zero
 (B) varies between $\frac{1}{2} B \omega l^2$ to 0
 (C) is always $\frac{1}{2} B \omega l^2$
 (D) is always $B \omega l^2$

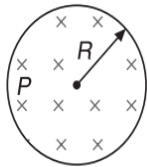
35. In a region of space, magnetic field exists in a cylindrical region of radius a centred at origin with magnetic field along negative z -direction. The field is given by $\vec{B} = -(B_0 t) \hat{k}$. The force experienced by a stationary charge q placed at $(r, 0, 0)$, where $r > a$, is

- (A) qB_0 (B) $\frac{qB_0 a^2}{2r}$
 (C) $\frac{qB_0 r}{2}$ (D) ZERO

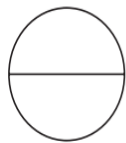
36. A magnet is taken towards a conducting ring in such a way that a constant current of 10 mA is induced in it. The total resistance of the ring is 0.5Ω . In 5 s, the magnetic flux through the ring changes by
 (A) 0.25 mWb (B) 25 mWb
 (C) 50 mWb (D) 15 mWb
37. Figure shows three circuits with identical batteries, inductors and resistors. Rank the circuits according to the currents through the battery just after the switch is closed, greatest first.



- (A) $i_2 > i_3 > i_1$ (B) $i_2 > i_1 > i_3$
 (C) $i_1 > i_2 > i_3$ (D) $i_1 > i_3 > i_2$
38. The Figure shows a circular region of radius R occupied by a time varying magnetic field $\vec{B}(t)$ such that $\frac{dB}{dt} < 0$. The magnitude of induced electric field at the point P at a distance $r < R$ is



- (A) decreasing with r (B) increasing with r
 (C) not varying with r (D) varying as r^{-2}
39. A wire loop consists of two parts as shown in Figure.



It is placed in a magnetic field directed into the plane of the paper and increases with time. Which of the following shows the induced current correctly?

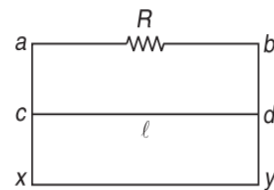
- (A) (B)
 (C) (D)

40. A non-conducting ring of radius r has charge q . A magnetic field perpendicular to the plane of the ring changes at the rate $\frac{dB}{dt}$. The torque experienced by the ring is
 (A) ZERO (B) $qr^2 \frac{dB}{dt}$
 (C) $\frac{1}{2}qr^2 \frac{dB}{dt}$ (D) $\pi qr^2 \frac{dB}{dt}$

41. A ring of radius r is spun about its axis with an angular velocity ω in a horizontal plane. A uniform magnetic field of magnitude B exists in the region in vertical direction. The emf induced in the ring is
 (A) ZERO (B) $\pi r^2 \omega B$
 (C) $\left(\frac{1}{2}\right)Br^2 \omega$ (D) $Br^2 \omega$

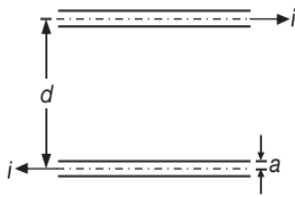
42. A magnetic flux through a stationary loop with a resistance R varies during the time interval τ as $\phi = at(\tau - t)$. Find the amount of heat generated in the loop during that time
 (A) $\frac{a\tau^2}{2R}$ (B) $\frac{a^2\tau^3}{3R}$
 (C) $\frac{2a^2\tau^3}{3R}$ (D) $\frac{a\tau}{3R}$

43. A wire cd of length l and mass m is sliding without friction on conducting rails ax and by as shown in Figure.



The vertical rails are connected to each other with a resistance R between a and b . A uniform magnetic field B is applied perpendicular to the plane $abcd$ such that cd moves with a constant velocity of

- (A) $\frac{mgR}{Bl}$ (B) $\frac{mgR}{B^2 l^2}$
 (C) $\frac{mgR}{B^2 l^3}$ (D) $\frac{mgR}{B^2 l}$
44. Two long parallel wires have radii equal to a and are at distance d measured between their centres as shown in Figure.

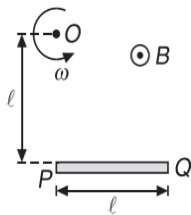


Their far ends are connected together so that the wires form two sides of the same loop. For a section far from the ends, if the flux within the wires is neglected, then the self-inductance per meter is

(A) $L = \frac{\mu_0}{\pi} \ln\left(\frac{d-a}{a}\right)$ (B) $L = \frac{\mu_0}{\pi} \ln\left(\frac{a}{d-a}\right)$

(C) $L = \frac{\mu_0}{\pi} \ln\left(\frac{d+a}{a}\right)$ (D) $L = \frac{\mu_0}{\pi} \ln\left(\frac{a}{d+a}\right)$

45. A rod of length l is rotating about an axis at P distance l from one end as shown in Figure.



If angular speed of rod is ω and magnetic field is B_0 out of the page, find emf developed between end points of rod.

(A) $\frac{1}{2}B\omega l^2$ (B) $B\omega l^2$

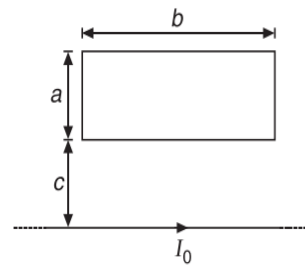
(C) $\frac{3}{2}B\omega l^2$ (D) ZERO

46. In the steady state condition, the rate of heat produced in a choke coil is P . The time constant of the choke coil is τ . If now the choke coil is short-circuited, then the total heat dissipated in the coil is

(A) $P\tau$ (B) $\frac{1}{2}P\tau$

(C) $\frac{P\tau}{\ln 2}$ (D) $P\tau \ln 2$

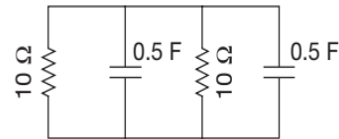
47. A rectangular loop of side a and b has a resistance R and lies at a distance c from an infinite straight wire carrying current I_0 . The current decreases to zero in time t_0 . $I(t) = I_0 \left[\frac{t_0 - t}{t_0} \right]$, $0 < t < t_0$. The charge flowing through the rectangular loop is



(A) $\mu_0 I_0 t_0$ (B) $\mu_0 I_0 \frac{ab}{c^2} t_0$

(C) $\frac{\mu_0 b I_0}{2\pi R} \ln\left(\frac{a+c}{c}\right)$ (D) $\frac{\mu_0 I t_0}{R} \ln\left(\frac{ab}{c^2}\right)$

48. The time constant of the circuit shown in Figure is



(A) 5 s (B) 10 s

(C) $\frac{1}{5}$ s (D) 0.1 s

49. A copper ring is held horizontally and bar magnet is dropped through the ring with its length along the axis of the ring. The acceleration of the falling magnet is

- (A) equal to that due to gravity
 (B) less than that due to gravity
 (C) more than that due to gravity
 (D) depends on the diameter of the ring and the length of the magnet

50. A non-conducting ring of mass m , radius R , having charge q uniformly distributed over its circumference is placed on a rough horizontal surface. A vertical time varying magnetic field $B = 8t^2$ is switched on at time $t = 0$. After 3 s, the ring starts rotating. The coefficient of friction between the ring and the table is

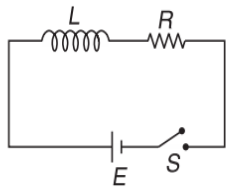
(A) $\frac{1}{24} \left(\frac{qR}{mg} \right)$ (B) $\frac{qR}{16mg}$

(C) $\frac{16qR}{mg}$ (D) $\frac{24qR}{mg}$

51. When a wheel with metal spokes, 1 m long, is rotated in a magnetic field of flux density $5 \times 10^{-4} \text{ Wbm}^{-2}$ normal to the plane of the wheel, an emf of 0.01 V is induced between the rim and the axle. The frequency of rotation of the wheel is

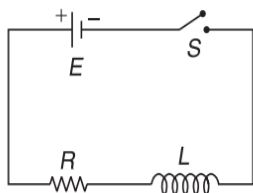
- (A) 10π revolutions per second
- (B) $\frac{20}{\pi}$ revolutions per second
- (C) $\frac{10}{\pi}$ revolutions per second
- (D) 20π revolutions per second

52. In the circuit shown in Figure, $L=10\text{ H}$, $R=5\ \Omega$, $E=15\text{ V}$. The switch S is closed at $t=0$. At $t=2\text{ s}$, the current in the circuit is



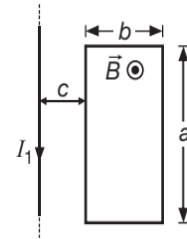
- (A) $3\left(1-\frac{1}{e}\right)\text{ A}$
- (B) $3\left(1-\frac{1}{e^2}\right)\text{ A}$
- (C) $3\left(\frac{1}{e}\right)\text{ A}$
- (D) $3\left(\frac{1}{e^2}\right)\text{ A}$

53. Switch S of the circuit shown in Figure is closed at $t=0$. If ξ denotes the induced emf in L and I the current flowing through the circuit at time t , then which of the following graphs is correct?



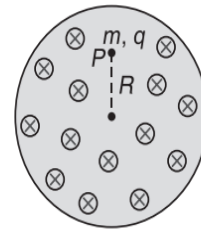
- (A)
- (B)
- (C)
- (D)

54. The mutual inductance between the rectangular loop and the long straight wire as shown in Figure is M .



- (A) $M = \text{ZERO}$
- (B) $M = \frac{\mu_0 a}{2\pi} \ln\left(1 + \frac{c}{b}\right)$
- (C) $M = \frac{\mu_0 b}{2\pi} \ln\left(\frac{a+c}{b}\right)$
- (D) $M = \frac{\mu_0 a}{2\pi} \ln\left(1 + \frac{b}{c}\right)$

55. A charge q , mass m is lying in a cylindrical region of magnetic field at point P . If magnetic field in the region is given by B_0 and P is at distance R from centre of region, find speed of charge if the magnetic field is suddenly switched off

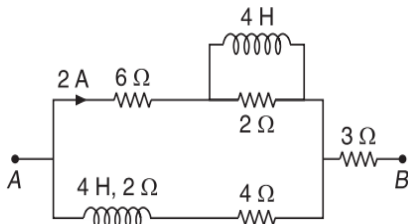


- (A) $\frac{qRB_0}{m}$
- (B) $\frac{2qRB_0}{3m}$
- (C) $\frac{qRB_0}{2m}$
- (D) $\frac{qRB_0}{3m}$

56. A flat circular coil of n turns, area A and resistance R is placed in a uniform magnetic field B . The plane of coil is initially perpendicular to B . When the coil is rotated through an angle of 180° about one of its diameter, a charge Q_1 flows through the coil. When the same coil after being brought to its initial position, is rotated through an angle of 360° about the same axis a charge Q_2 flows through it. Then, $\frac{Q_2}{Q_1}$ is

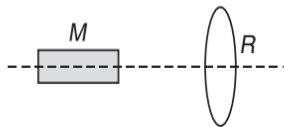
- (A) 1
- (B) 2
- (C) $\frac{1}{2}$
- (D) 0

57. Find $V_A - V_B$ in steady state



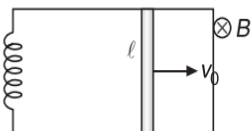
- (A) 8 V (B) 16 V
(C) 24 V (D) Data is insufficient

58. A conducting ring R is placed on the axis of a bar magnet M . The plane of R is perpendicular to this axis. M can move along this axis. Then,



- (A) M will repel R when it is moving towards R
(B) M will attract R when it is moving towards R
(C) M will repel R when moving towards as well as away from R
(D) M will attract R when moving towards as well as away from R

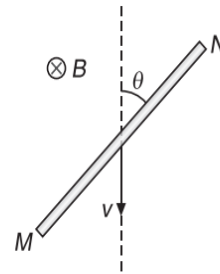
59. Two ends of an inductor of inductance L are connected to two parallel conducting wires. A rod of length l and mass m is given velocity v_0 as shown in Figure.



The whole system is placed in perpendicular magnetic field B . The maximum current in the inductor is (Neglect gravity and friction)

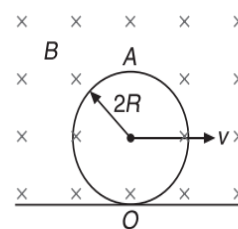
- (A) $\frac{mv_0}{L}$ (B) $\sqrt{\frac{m}{L}}v_0$
(C) $\frac{mv_0^2}{L}$ (D) $2\sqrt{\frac{m}{L}}v_0$

60. A conducting rod MN of length $2l$ moves through a uniform magnetic field of induction B , acting into the plane of the paper. The rod makes an angle θ with the vertical while it falls with a uniform linear velocity v . The potential difference between the two ends of the rod equals



- (A) ZERO (B) $2Bvl \sin \theta$
(C) $2Bvl$ (D) Bvl

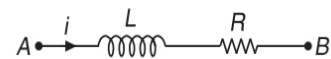
61. A conducting ring of radius $2R$ rolls on a smooth horizontal conducting surface as shown in Figure.



A uniform horizontal magnetic field B is perpendicular to the plane of the ring. The potential of A with respect to O is

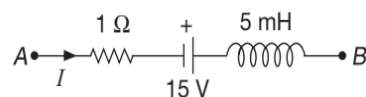
- (A) $2BvR$ (B) $\frac{1}{2}BvR$
(C) $8BvR$ (D) $4BvR$

62. In a part of circuit shown in Figure, $R = 0.2 \Omega$. At the instant shown, $V_A - V_B = 0.5 \text{ V}$, $i = 0.5 \text{ A}$, $\frac{di}{dt} = 8 \text{ As}^{-1}$. Then inductance L is



- (A) 0.01 H (B) 0.02 H
(C) 0.05 H (D) 0.5 H

63. The network shown in Figure is part of a complete circuit. If at a certain instant, the current I is 5 A and it is decreasing at a rate of 10^3 As^{-1} then $V_B - V_A$ equals

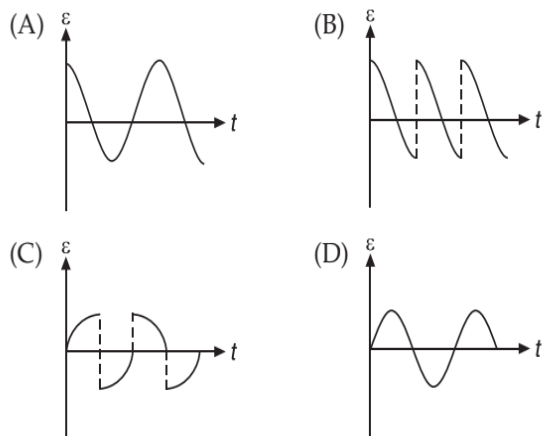
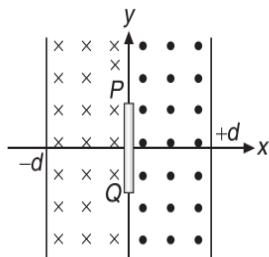


- (A) 20 V (B) 15 V
(C) 10 V (D) 5 V

64. In PROBLEM 63, if I is reversed in direction, then $V_B - V_A$ equals

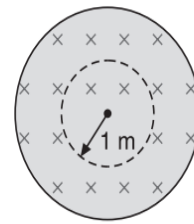
- (A) 5 V (B) 10 V
(C) 15 V (D) 20 V

65. A straight conducting rod PQ is executing SHM in xy plane from $x = -d$ to $x = +d$. Its mean position is $x = 0$ and its length is along y -axis. There exists a uniform magnetic field B from $x = -d$ to $x = 0$ pointing inward normal to the paper and from $x = 0$ to $x = +d$ there exists another uniform magnetic field of same magnitude B but pointing outward normal to the plane of the paper. At the instant $t = 0$, the rod is at $x = 0$ and moving to the right. The variation of induced EMF across the rod PQ with time is best represented as



66. An LR circuit is connected to a battery at time $t = 0$. The energy stored in the inductor reaches half its maximum value at time
- (A) $\frac{L}{R} \ln\left(\frac{\sqrt{2}}{\sqrt{2}-1}\right)$ (B) $\frac{L}{R} \ln\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$
- (C) $\frac{R}{L} \ln\left(\frac{\sqrt{2}}{\sqrt{2}-1}\right)$ (D) $\frac{R}{L} \ln\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$

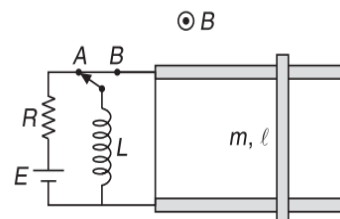
67. A uniform but time varying magnetic field exists in a cylindrical region as shown in Figure. The direction of magnetic field is into the plane of the paper and its magnitude is decreasing at a constant rate of $2 \times 10^{-3} \text{ Ts}^{-1}$. A particle of charge $1 \mu\text{C}$ is moved slowly along a circle of radius 1 m by an external force as shown in Figure.



The plane of the circle lies in the plane of the paper and it is concentric with the cylindrical region. The work done by the external force in moving this charge along the circle will be

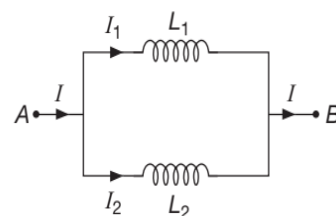
- (A) ZERO (B) $2\pi \times 10^{-9} \text{ J}$
- (C) $\pi \times 10^{-9} \text{ J}$ (D) $4\pi \times 10^{-6} \text{ J}$

68. Switch is in position A for a long time. It is suddenly switched to the side B . Mass of rod is m and length is l . Maximum speed of rod will be

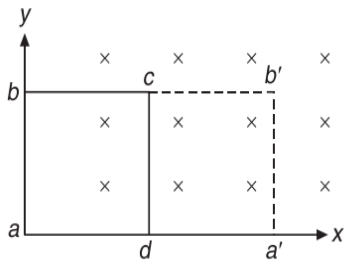


- (A) $\left(\frac{E}{R}\right)\sqrt{\frac{L}{m}}$ (B) $\left(\frac{E}{R}\right)\sqrt{\frac{m}{L}}$
- (C) $2\left(\frac{E}{R}\right)\sqrt{\frac{L}{m}}$ (D) $2\left(\frac{E}{R}\right)\sqrt{\frac{m}{L}}$

69. The parallel combination of the inductors shown is connected across a battery that delivers a current I to the combination. If I_1 and I_2 be the currents in the branches containing L_1 and L_2 , then

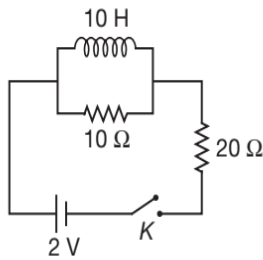


- (A) $\frac{I_1}{I_2} = \frac{L_2}{L_1}$ (B) $\frac{I_1}{I_2} = \sqrt{\frac{L_2}{L_1}}$
- (C) $\frac{I_1}{I_2} = \frac{L_1}{L_2}$ (D) $\frac{I_1}{I_2} = \frac{L_1}{L_1 + L_2}$



- (A) ZERO (B) $2B_0l^3$
 (C) $3B_0l^3$ (D) B_0l^3

79. Two resistors of $10\ \Omega$ and $20\ \Omega$ and an ideal inductor of $10\ \text{H}$ are connected to a $2\ \text{V}$ battery as shown in Figure.



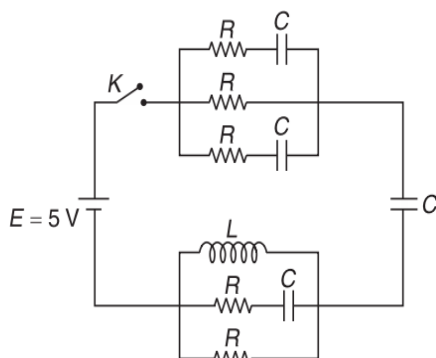
The key K is inserted at time $t = 0$. The initial ($t = 0$) and final ($t \rightarrow \infty$) currents through battery are

- (A) $\frac{1}{15}\ \text{A}, \frac{1}{10}\ \text{A}$ (B) $\frac{1}{10}\ \text{A}, \frac{1}{15}\ \text{A}$
 (C) $\frac{2}{15}\ \text{A}, \frac{1}{10}\ \text{A}$ (D) $\frac{1}{15}\ \text{A}, \frac{2}{25}\ \text{A}$

80. An inductor L and a resistor R are connected in series with a direct current source of emf E . The maximum rate at which energy is stored in the magnetic field is

- (A) $\frac{E^2}{4R}$ (B) $\frac{E^2}{R}$
 (C) $\frac{4E^2}{R}$ (D) $\frac{2E^2}{R}$

81. In the circuit shown, initially all the capacitors are uncharged. Given that $R = 6\ \Omega$ and $C = 4\ \mu\text{F}$, the current passing through battery immediately after key (K) is closed is

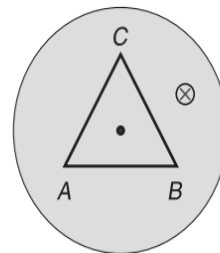


- (A) 1 A (B) 5 A
 (C) 3 A (D) 2 A

82. A thin circular ring of area A is held perpendicular to a uniform magnetic field B . A small cut is made in the ring and a galvanometer is connected across the ends such that the total resistance of the circuit is R . When the ring is suddenly squeezed to zero area, the charge flowing through the galvanometer is

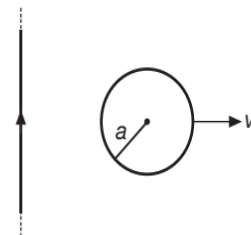
- (A) $\frac{B^2A}{R^2}$ (B) ABR
 (C) $\frac{AB}{R}$ (D) $\frac{A^2B^2}{R}$

83. A triangular wire frame having each side equal to $2\ \text{m}$ is placed in a region of time varying magnetic field having $\frac{dB}{dt} = \sqrt{3}\ \text{Ts}^{-1}$. The magnetic field is perpendicular to the plane of the triangle as shown in Figure. The base of the triangle AB has a resistance $1\ \Omega$ while the other two sides have resistance $2\ \Omega$ each. The magnitude of potential difference between the points A and B will be



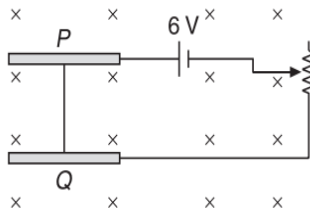
- (A) 0.4 V (B) 0.6 V
 (C) 1.2 V (D) None of these

84. A circular loop of radius a is placed in the same plane as a long straight wire carrying a current I . The centre of the loop is at a distance r from the wire where $r \gg a$. The loop is moved away from the wire with a constant velocity v . The induced emf in the loop is



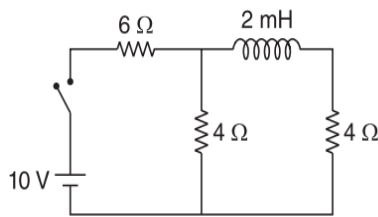
- (A) $\xi = \frac{\mu_0 I v}{2\pi}$ (B) $\xi = \frac{\mu_0 I a^2 v}{2\pi r^2}$
 (C) $\xi = \frac{\mu_0 I a^2 v}{2r^2}$ (D) $\xi = \frac{\mu_0 I a^3 v}{2r^3}$

85. A metal wire PQ having a mass of 10 g and length 4.9 cm lies at rest on the metal rails as shown in Figure.

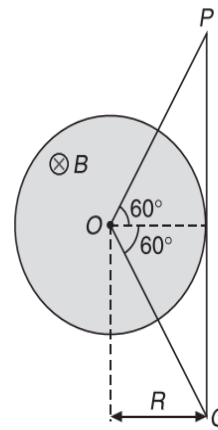


A vertically downward magnetic field of magnitude 0.8 T exists in the space. The resistance of the circuit is slowly decreased and it is found that when the resistance goes below 20Ω , the wire starts sliding on the rails. The coefficient of friction is

- (A) 0.25 (B) 0.31
(C) 0.43 (D) 0.12
86. When a loop moves towards a stationary magnet with speed v , the induced emf in the loop is E . If the magnet also moves away from the loop with the same speed, then the emf induced in the loop is
- (A) E (B) $2E$
(C) $\frac{E}{2}$ (D) ZERO
87. In the given circuit, find the ratio of i_1 and i_2 , where i_1 is the initial (at $t = 0$) current and i_2 is steady state (at $t = \infty$) current through the battery is

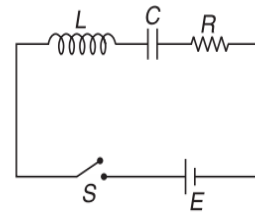


- (A) 1.0 (B) 0.8
(C) 1.2 (D) 1.5
88. The time constant of an inductance coil is 2×10^{-3} s. When a 90Ω resistance is joined in series, the same constant becomes 0.5×10^{-3} s. The inductance and resistance of the coil are
- (A) 30 mH; 30Ω (B) 30 mH; 60Ω
(C) 60 mH; 30Ω (D) 60 mH; 60Ω
89. In a cylindrical region having radius R , magnetic field varies with time as $B = a + bt$. OPQ is a triangular loop made of wire having resistance per unit length λ . Current induced in the loop is

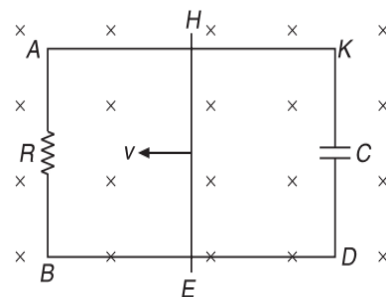


- (A) $\frac{\pi Rb(2 - \sqrt{3})}{6\lambda}$ (B) $\frac{\sqrt{3}Rb}{2\lambda(2 + \sqrt{3})}$
(C) $\frac{\pi Rb\sqrt{3}}{6\lambda(2 + \sqrt{3})}$ (D) $\frac{\pi Rb(2 + \sqrt{3})}{6\lambda}$

90. When the switch S is closed at $t = 0$, identify the correct statement just after closing the switch as shown in Figure.

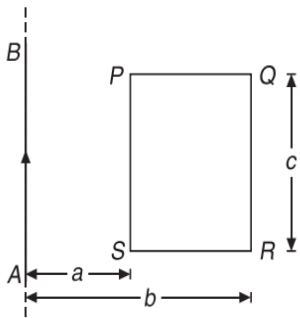


- (A) The current in the circuit is maximum
(B) Equal and opposite voltages are dropped across inductor and resistor
(C) The entire voltage is dropped across inductor
(D) All of these
91. In the circuit shown in Figure, a conducting wire HE is moved with a constant speed v towards left. The complete circuit is placed in a uniform magnetic field \vec{B} perpendicular to the plane of circuit inwards. The current in $HKDE$ after a long time is



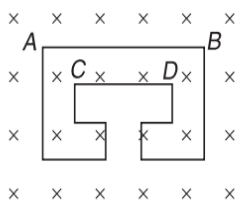
- (A) clockwise (B) anticlockwise
(C) alternating (D) zero

92. AB is an infinitely long wire placed in the plane of rectangular coil of dimensions as shown in Figure.

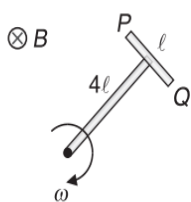


Calculate the mutual inductance of wire AB and coil $PQRS$

- (A) $\frac{\mu_0 b}{2\pi} \ln \frac{a}{b}$ (B) $\frac{\mu_0 c}{2\pi} \ln \frac{b}{a}$
 (C) $\frac{\mu_0 abc}{2\pi(b-a)^2}$ (D) None of these
93. A wire is bent to form a double loop shown in Figure. There is a uniform magnetic field directed into the plane of the loop. If the magnitude of this field is decreasing, current will flow from.

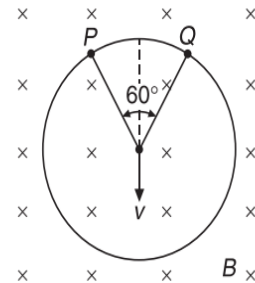


- (A) A to B and C to D
 (B) B to A and D to C
 (C) A to B and D to C
 (D) B to A and C to D
94. In the Figure shown, a T shaped conductor moves with constant angular velocity ω in a plane perpendicular to uniform magnetic field \vec{B} . The potential difference $V_P - V_Q$ is

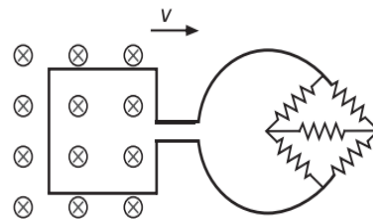


- (A) ZERO (B) $\frac{1}{2} B\omega l^2$
 (C) $2B\omega l^2$ (D) $B\omega l^2$

95. A conducting ring of radius a falls vertically downward with a velocity v in a magnetic field B . The potential difference between two points P and Q located symmetrically on both sides of the vertical has the value

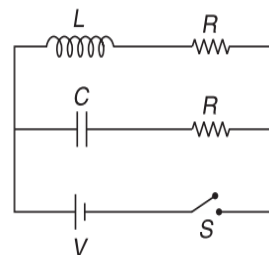


- (A) ZERO (B) $\frac{Bva}{2}$
 (C) $\frac{\sqrt{3}}{2} Bva$ (D) Bva
96. A square metal loop of side 10 cm and resistance 1Ω is moved with a constant velocity partly inside a magnetic field of 2 Wbm^{-2} , directed into the paper, as shown in Figure.



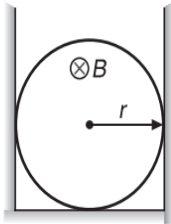
This loop is connected to a network of five resistors each of value 3Ω . If a steady current of 1 mA flows in the loop, then the speed of the loop is

- (A) 0.5 cms^{-1} (B) 1 cms^{-1}
 (C) 2 cms^{-1} (D) 4 cms^{-1}
97. In the circuit shown in Figure, $R = \sqrt{\frac{L}{C}}$. Switch S is closed at time $t = 0$. The current through C and L would be equal after a time t equal to



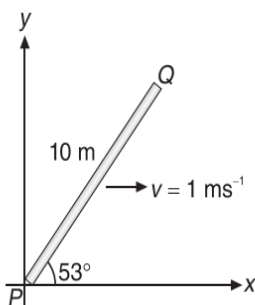
- (A) CR (B) $CR \ln(2)$
 (C) $\frac{L}{R \ln(2)}$ (D) LR

98. An inductance of 2 H carries a current of 2 A. To prevent sparking when the circuit is broken a capacitor of $4 \mu\text{F}$ is connected across the inductance. The voltage rating of the capacitor is of the order of
- (A) 10^3 V (B) 10 V
(C) 10^5 V (D) 10^6 V
99. A uniformly charged, insulating ring of charge Q , mass m and radius r is placed as shown in Figure.

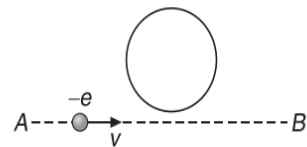


Vertical surfaces are smooth and the coefficient of friction between horizontal surface and ring is μ . Uniform magnetic field is present, in the perpendicular direction of the plane of ring. If magnetic field changes at the rate $\frac{dB}{dt} = kt$, ($k = 1 \text{ Tsec}^{-2}$), the time after which ring starts motion is

- (A) $\frac{\mu mg}{3rQ}$ (B) $\frac{2\mu mg}{rQ}$
(C) $\frac{\mu mg}{rQ}$ (D) $\frac{3\mu mg}{rQ}$
100. A coil has an inductance of 50 mH and a resistance of 0.3Ω . If a 12 V emf is applied across the coil, the energy stored in the magnetic field after the current has built up to its steady state value is
- (A) 40 J (B) 40 mJ
(C) 20 J (D) 20 mJ
101. A conducting rod PQ of length 10 m oriented as shown in Figure is moving with velocity $1 \hat{i} \text{ ms}^{-1}$ without any rotation in a uniform magnetic induction of $(3\hat{j} + 4\hat{k}) \text{ T}$. The emf induced across the rod is



- (A) 32 V (B) 40 V
(C) 50 V (D) 64 V
102. A rectangular coil of single turn, having area A , rotates in a uniform magnetic field B with an angular velocity ω about an axis perpendicular to the field. If initially the plane of coil is perpendicular to the field, then the average induced emf when it has rotated through 90° is
- (A) $\frac{\omega BA}{\pi}$ (B) $\frac{\omega BA}{2\pi}$
(C) $\frac{\omega BA}{4\pi}$ (D) $\frac{2\omega BA}{\pi}$
103. A circuit contains an inductance L , a resistance R and a battery of emf E . The circuit is switched on at $t = 0$. The charge flown through the battery in one time constant (τ) is
- (A) $\frac{2E\tau}{Re}$ (B) $\frac{E\tau}{2Re}$
(C) $\frac{E\tau}{Re}$ (D) ZERO
104. An electron moves along the line AB which lies in the same plane as a circular loop of conducting wire as shown in Figure.

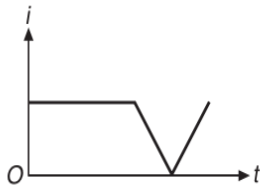


What will be the direction of the current induced in the loop?

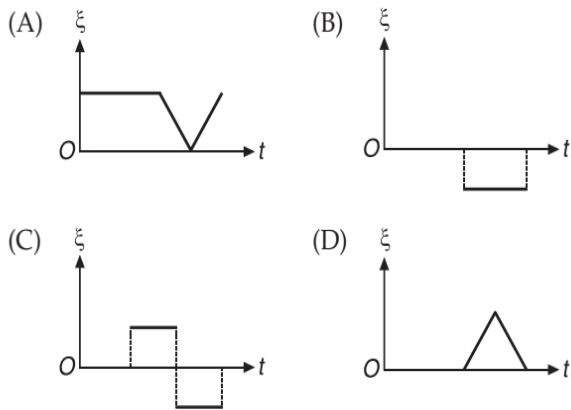
- (A) No current will be induced
(B) The current will be clockwise
(C) The current will anticlockwise
(D) The current will change direction as the electron passes by
105. When the number of turns in the two circular coils closely wound are doubled (in both), their mutual inductance becomes
- (A) four times (B) two times
(C) remains same (D) sixteen times
106. In a DC motor, if E is the applied emf and e is the back emf, then the efficiency is

- (A) $\frac{(E - e)}{E}$ (B) $\frac{e}{E}$
(C) $\left\{ \frac{(E - e)}{E} \right\}^2$ (D) $\left(\frac{e}{E} \right)^2$

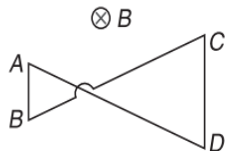
107. The current i in an induction coil varies with time t according to the graph shown in Figure.



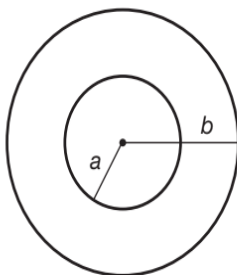
Which of the following graphs shows the induced emf (ξ) in the coil with time?



108. A conducting wire frame is placed in a magnetic field, which is directed into the paper. The magnetic field is increasing at a constant rate. The directions of induced currents in wires AB and CD are

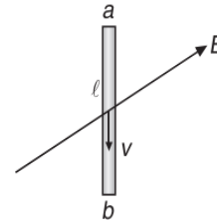


- (A) A to B and C to D
 (B) B to A and C to D
 (C) A to B and D to C
 (D) B to A and D to C
109. Two concentric and coplanar circular coils have radii a and b ($b \gg a$) as shown in Figure. Resistance of the inner coil is R . Current in the outer coil is increased from zero to I . The total charge circulating the inner coil is Q . Then Q equals



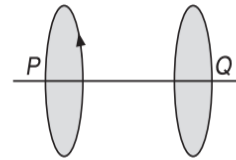
- (A) $\frac{\mu_0 I a b}{2R}$ (B) $\frac{\mu_0 I a^2}{2R b}$
 (C) $\frac{\mu_0 \pi I b^2}{2aR}$ (D) $\frac{\mu_0 \pi I a^2}{2bR}$

110. A conducting rod of length l falls vertically under gravity in a region of uniform magnetic field \vec{B} . The field vectors are inclined at an angle θ with the horizontal as shown in Figure.



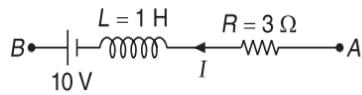
If the instantaneous velocity of the rod is v , the induced emf in the rod ab is

- (A) Blv (B) $Blv \cos \theta$
 (C) $Blv \sin \theta$ (D) ZERO
111. Two circular loops P and Q are placed with their planes parallel to each other. A current is flowing through P . If this current is increased, then



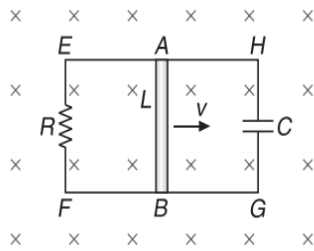
- (A) the loops will attract each other
 (B) the loops will repel each other
 (C) the loops will neither attract nor repel each other
 (D) loop Q will start rotating
112. A capacitor of capacitance $2 \mu\text{F}$ is first charged and then discharged through a resistance of $5 \times 10^4 \Omega$. The time in which the charge on the capacitor will fall to 36.8% of its initial value is
- (A) 0.0001 second (B) 0.001 second
 (C) 0.01 second (D) 0.1 second
113. A short magnet is allowed to fall from rest along the axis of a horizontal conducting ring. The distance fallen by the magnet in one second may be
- (A) 5 m (B) 6 m
 (C) 4 m (D) 7 m

114. In the given branch AB of a circuit, a current $I = (10t + 5)$ A is flowing, where t is time in second. At $t = 0$, the potential difference between points A and B i.e. $(V_A - V_B)$ is



- (A) 15 V (B) -5 V
(C) -15 V (D) 5 V

115. A conducting rod is moving with a constant velocity v over the parallel conducting rails which are connected at the ends through a resistor R and capacitor C as shown in Figure.



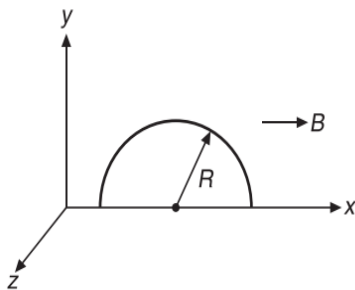
Magnetic field B is into the plane. Consider the following statements.

- (i) Current in loop $AEFBA$ is anti-clockwise.
(ii) Current in loop $AEFBA$ is clockwise.
(iii) Current through the capacitor is zero.
(iv) Energy stored in the capacitor is $\frac{1}{2}CB^2L^2v^2$.

Which of the following options is correct?

- (A) Statements (i) and (iii) are correct
(B) Statements (ii) and (iv) are correct
(C) Statements (i), (iii) and (iv) are correct
(D) None of these

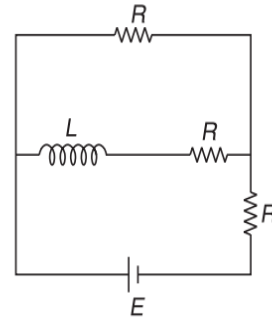
116. A semi-circular conducting loop of radius R is placed in the xy plane, as shown in Figure.



A uniform magnetic field is set up along the x -axis. No emf will be induced in the ring, if

- (A) it moves along the x -axis/ y -axis
(B) it moves along the y -axis/ z -axis
(C) it remains stationary
(D) All of these

117. The Figure shows a specific LR circuit, the time constant for this circuit is



- (A) $\frac{L}{2R}$ (B) $\frac{2L}{R}$
(C) $\frac{3L}{2R}$ (D) $\frac{2L}{3R}$

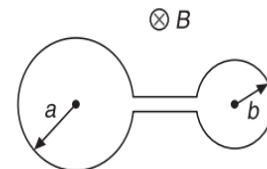
118. A toroidal solenoid with an air core has an average radius of 15 cm, area of cross-section 12 cm^2 and 1200 turns. Ignoring the field variation across the cross-section of the toroid, the self-inductance of the toroid is

- (A) 4.6 mH (B) 6.9 mH
(C) 2.3 mH (D) 9.2 mH

119. A toroidal solenoid with an air core has an average radius of 15 cm, area of cross-section 12 cm^2 and 1200 turns. A second coil of 300 turns is wound closely on this toroid. If the current in the toroid is increased from zero to 2.0 A in 0.05 s, the emf induced in the second coil is

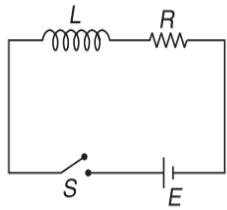
- (A) 0.046 V (B) 0.069 V
(C) 0.023 V (D) 0.092 V

120. Figure shows two circular rings of radii a and b ($a > b$) joined together by wire of negligible resistance. If the arrangement is placed in a time varying magnetic field, $\frac{dB}{dt} = k$ and if the resistance per unit length of wire is λ , then induced current is

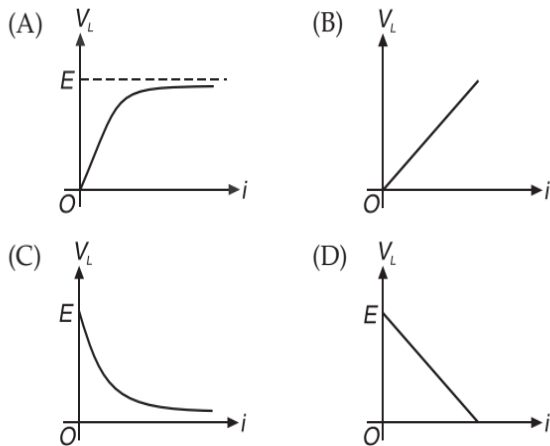


- (A) $\frac{k(a+b)}{2\lambda}$ (B) $\frac{k(a-b)}{2\lambda}$
(C) $\frac{k(a^2+b^2)}{2\lambda(a-b)}$ (D) $\frac{k(a^2+b^2)}{2\lambda(a+b)}$

121. The switch S is closed at $t=0$ in the circuit shown in Figure.



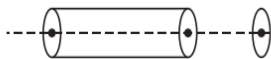
If V_L is the voltage induced across the inductor and i is the instantaneous current, the correct variation of V_L versus i is given by



122. Two coils P and S have 2000 turns and 5000 turns respectively. A current of 1 A in coil P causes a flux per turn of 0.8×10^{-3} weber to link with P and 0.4×10^{-3} weber through S . The ratio of coefficient of self-inductance of P and the coefficient of mutual inductance of P and S is

- (A) $\left(\frac{2}{3}\right)$ (B) $\left(\frac{3}{4}\right)$
 (C) $\left(\frac{4}{5}\right)$ (D) $\left(\frac{5}{4}\right)$

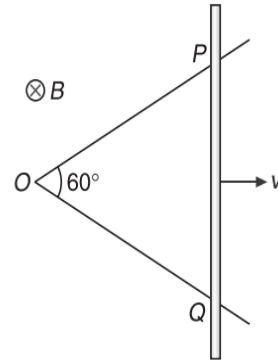
123. A solenoid carries a time varying current given by $I = I_0 t$. At the axis of this solenoid, a ring is placed as shown in Figure.



The mutual inductance of the ring and the solenoid is M and the self-inductance of the ring is L . If the resistance of the ring is R then maximum current which can flow through the ring is

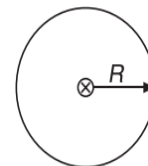
- (A) $\frac{(2M+L)I_0}{R}$ (B) $\frac{MI_0}{R}$
 (C) $\frac{(2M-L)I_0}{R}$ (D) $\frac{(M+L)I_0}{R}$

124. A rod PQ slides on a V-shaped wire with speed v as shown such that at any time $OP = OQ = l$. Magnetic field in the region is perpendicular into the paper and has strength B . Induced emf in the rod is



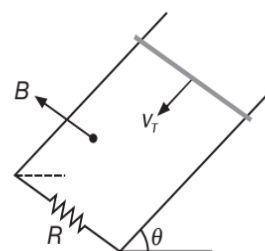
- (A) Bvl (B) $\frac{Bvl}{2}$
 (C) $\frac{\sqrt{3}Bvl}{2}$ (D) ZERO

125. A circuit consists of a circular loop of radius R kept in the plane of paper and an infinitely long current carrying wire kept perpendicular to the plane of paper and passing through the centre of loop. The mutual inductance of wire and loop will be



- (A) $\frac{\mu_0 \pi R}{2}$ (B) 0
 (C) $\mu_0 \pi R^2$ (D) $\frac{\mu_0 R^2}{2}$

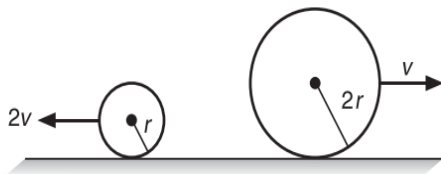
126. A copper rod of mass m slides under gravity on two smooth parallel rails l distance apart and set at an angle 30° to the horizontal. At the bottom, the rails are joined by a resistance R . There is a uniform magnetic field perpendicular to the plane of the rails. The terminal velocity of the rod is v_T . Then





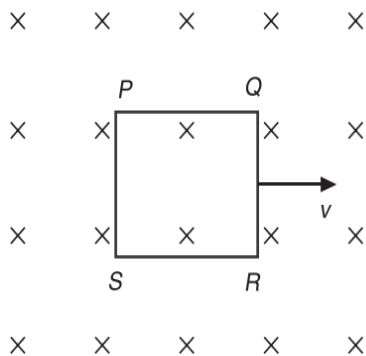
- (A) $v_T = \frac{\sqrt{3}mgR}{2B^2l^2}$ (B) $v_T = \frac{\sqrt{3}mgR}{B^2l^2}$
 (C) $v_T = \frac{mgR}{2B^2l^2}$ (D) $v_T = \frac{mgR}{\sqrt{3}B^2l^2}$

127. Two conducting rings of radii r and $2r$ rotate uniformly in opposite directions with centre of mass velocities $2v$ and v respectively on a conducting horizontal surface. 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) $4Bvr$
 (C) $8Bvr$ (D) $16Bvr$

128. A metallic square loop $PQRS$ is moving in its own plane with velocity v in a uniform magnetic field perpendicular to its plane as shown in Figure.



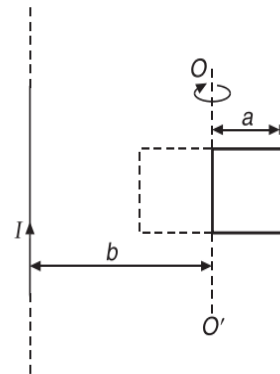
If V_P, V_Q, V_R and V_S are the potential of points P, Q, R and S , then incorrect statement is

- (A) $V_P = V_Q$ (B) $V_P > V_S$
 (C) $V_P > V_R$ (D) $V_S > V_R$

129. A coil of inductance 300 mH and resistance 2Ω is connected to a source of voltage 2 V . The current reaches half of its steady state value in

- (A) 0.15 s (B) 0.3 s
 (C) 0.05 s (D) 0.1 s

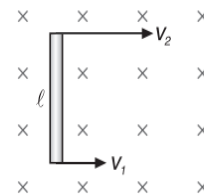
130. A square loop of side a and a straight long wire are placed in the same plane as shown in Figure.



The loop has a resistance R and inductance L . The frame is turned through 180° about the axis OO' . The charge that flows through the loop in this process is

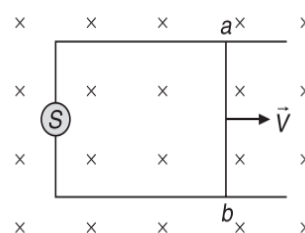
- (A) $\frac{\mu_0 I a}{2\pi R} \ln\left(\frac{2a+b}{b}\right)$ (B) $\frac{\mu_0 I a}{2\pi R} \ln\left(\frac{b}{b^2 - a^2}\right)$
 (C) $\frac{\mu_0 I a}{2\pi R} \ln\left(\frac{a+2b}{b}\right)$ (D) $\frac{\mu_0 I a}{2\pi R} \ln\left(\frac{b+a}{b-a}\right)$

131. In the Figure, magnetic field points into the plane of paper and the conducting rod of length l is moving in this field such that the lowest point has a velocity v_1 and the topmost point has the velocity v_2 ($v_2 > v_1$). The emf induced is given by



- (A) Bv_1l (B) Bv_2l
 (C) $\frac{1}{2}B(v_2 + v_1)l$ (D) $\frac{1}{2}B(v_2 - v_1)l$

132. The following diagram shows a wire ab of length l and resistance R sliding on a smooth pair of rails with a velocity v towards right. A uniform magnetic field of induction B acts normal to the plane containing the rails and the wire inwards. S is a current source providing a constant current I in the circuit. Then the potential difference between a and b is



- (A) Bvl (B) IR
 (C) $Bvl - IR$ (D) $Bvl + IR$

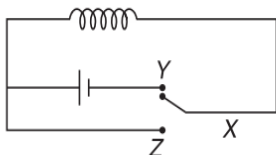
133. A uniformly wound long solenoid of inductance L and resistance R is cut into two equal parts. The two parts are then joined in parallel. Further this combination is joined to a cell of emf E . The time constant of the circuit is

- (A) $\frac{L}{4R}$ (B) $\frac{L}{2R}$
 (C) $\frac{2L}{R}$ (D) $\frac{L}{R}$

134. A uniformly wound long solenoid of inductance L and resistance R is cut into two equal parts. The two parts are then joined in parallel. Further this combination is joined to a cell of emf E . The steady-state current is

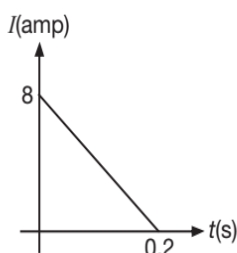
- (A) $\frac{2E}{R}$ (B) $\frac{4E}{R}$
 (C) $\frac{8E}{R}$ (D) $\frac{E}{R}$

135. In the circuit shown, the coil has inductance and resistance. When X is joined to Y , the time constant is τ during growth of current. When the steady state is reached, heat is produced in the coil at a rate P . X is now joined to Z . Then the total heat produced in the coil is



- (A) τP (B) $\frac{1}{2}\tau P$
 (C) $2\tau P$ (D) $\frac{1}{4}\tau P$

136. Some magnetic flux is changed from a coil of resistance 10Ω . As a result, an induced current is developed in it, which varies with time as shown in Figure. The magnitude of change in flux through the coil in weber is

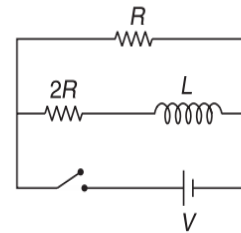


- (A) 2 (B) 4
 (C) 6 (D) 8

137. A loop of area 1 m^2 is placed in a magnetic field $B = 2T$, such that plane of the loop is parallel to the magnetic field. If the loop is rotated by 180° , the amount of net charge passing through any point of loop, if its resistance is 10Ω , is

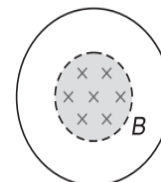
- (A) 0.4 C (B) 0.2 C
 (C) 0.8 C (D) 0 C

138. The ratio of time constants during current growth and current decay of the circuit shown in Figure is



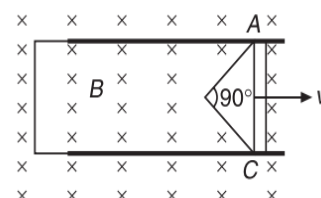
- (A) 1:1 (B) 3:2
 (C) 2:3 (D) 1:3

139. The Figure shows a conducting ring of radius R . A uniform steady magnetic field B lies perpendicular to the plane of the ring in a circular region of radius $r (< R)$. If the resistance per unit length of the ring is λ , then the current induced in the ring when its radius gets doubled is

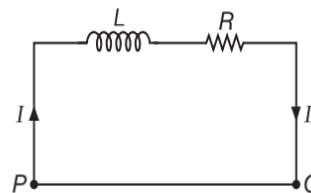


- (A) $\frac{BR}{\lambda}$ (B) $\frac{2BR}{\lambda}$
 (C) ZERO (D) $\frac{Br^2}{4R\lambda}$

140. Two parallel straight rails of negligible resistance are L apart. At one end, they are connected to each other by a wire of negligible resistance. An isosceles right-angled triangle ABC made of a uniform wire of resistance per unit length λ slides along the rail with a constant velocity v . Force required to pull it is



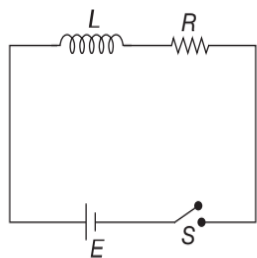
- (A) $\frac{B^2Lv(\sqrt{2}+1)}{\sqrt{2}\lambda}$ (B) $\frac{B^2Lv}{\lambda(\sqrt{2}+1)}$
 (C) $\frac{B^2Lv\sqrt{2}}{\lambda(\sqrt{2}+1)}$ (D) $\frac{B^2Lv}{\lambda}$



141. When a choke coil carrying a steady current is short-circuited, the current in it decreases to $\beta (> 1)$ times its initial value in a time T . The time constant of the choke coil is

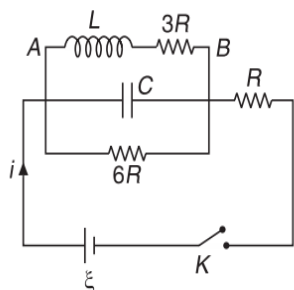
- (A) $\frac{T}{\beta}$ (B) $\frac{T}{\ln\left(\frac{1}{\beta}\right)}$
 (C) $\frac{T}{\ln\beta}$ (D) $T \ln\beta$

142. In the circuit shown in Figure switch S is closed at time $t = 0$. The charge which passes through the battery in one time constant is Q . Then



- (A) $Q = \frac{EL}{R^2} \left(1 - \frac{1}{e}\right)$ (B) $Q = \frac{EL}{R^2}$
 (C) $Q = \frac{EL}{eR^2}$ (D) $Q = \frac{EL}{R^2} \left(1 + \frac{1}{e}\right)$

143. 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



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

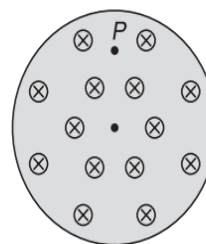
144. When the current in the portion of the circuit shown in Figure is 4 A and increasing at the rate of 4 As^{-1} , the measured potential difference $V_{PQ} = 16 \text{ V}$. However when the current is 2 A and decreasing at the rate of 1 As^{-1} , the measured potential difference $V_{PQ} = 5 \text{ V}$. Then

- (A) $L = 1 \text{ H}, R = 3 \Omega$ (B) $L = 2 \text{ H}, R = 4 \Omega$
 (C) $L = 3 \text{ H}, R = 1 \Omega$ (D) $L = 4 \text{ H}, R = 2 \Omega$

145. A magnet is moving towards the coil along the axis and the emf induced in the coil is ξ . If the coil also starts moving towards the magnet with the same speed, the induced emf will be

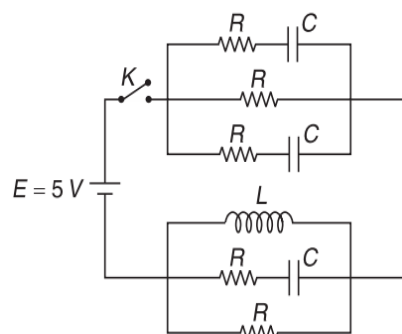
- (A) $\frac{\xi}{2}$ (B) ξ
 (C) 2ξ (D) 4ξ

146. A uniform but increasing with time magnetic field exists in a cylindrical region. The direction of force on an electron at P is



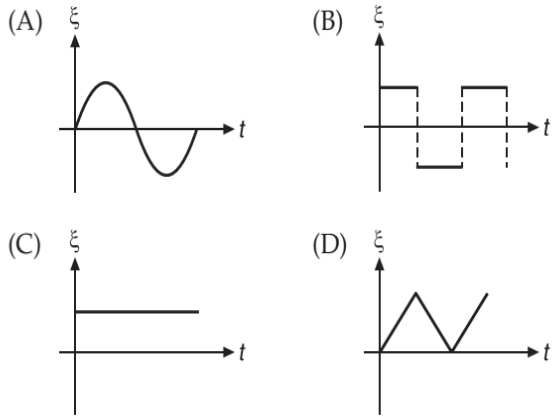
- (A) towards right
 (B) towards left
 (C) into the plane of paper
 (D) out of the plane of paper

147. In the circuit shown, initially all the capacitors are uncharged, $R = 6 \Omega$ and $C = 4 \mu\text{F}$. The current passing through the battery immediately after the key K is closed is i_1 and long time after the key K is closed is i_2 , then $\frac{i_1}{i_2}$ equals

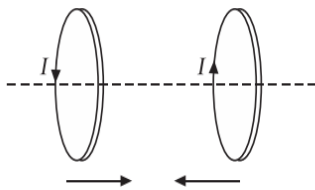


- (A) 1 (B) 5
 (C) 3 (D) 1.2

148. A conducting rod is rotated about one end in a plane perpendicular to a uniform magnetic field with constant angular velocity. The correct graph between the induced emf (ξ) across the rod and time (t) is

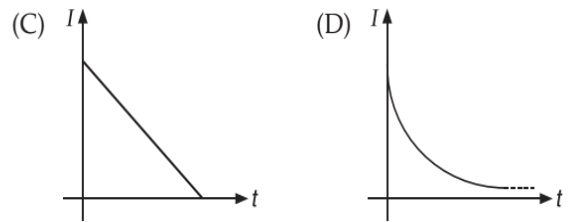
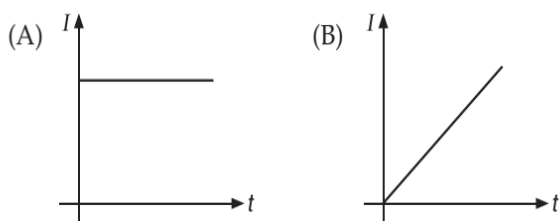
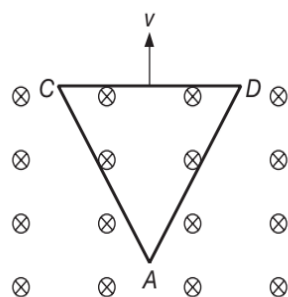


149. Two coils carrying current in opposite direction are placed co-axially with centres at some finite separation. If they are brought close to each other then, current flowing in them should

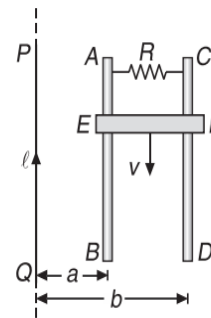


- (A) decrease
- (B) increase
- (C) remain same
- (D) become zero

150. An equilateral triangular loop ADC of side length $2a$, having resistance R is pulled with a constant velocity v out of a uniform magnetic field directed into the paper. At time $t=0$, side DC of the loop is at edge of the magnetic field. The induced current (I) versus time (t) graph will be as



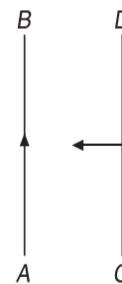
151. PQ is an infinite current carrying conductor. AB and CD are smooth conducting rods on which a conductor EF moves with constant velocity v as shown in Figure.



The force required to maintain constant speed of EF is

- (A) $\frac{1}{vR} \left[\frac{\mu_0 I v}{2\pi} \log_e \left(\frac{b}{a} \right) \right]^2$
- (B) $\frac{v}{R} \left[\frac{v_0 I v}{2\pi} \log_e \left(\frac{a}{b} \right) \right]^2$
- (C) $\frac{v}{R} \left[\frac{v_0 I v}{2\pi} \log_e \left(\frac{b}{a} \right) \right]^2$
- (D) $\frac{1}{vR} \left[\frac{\mu_0 I v}{2\pi} \log_e \left(\frac{a}{b} \right) \right]^2$

152. Two infinitely long straight wires AB and CD are placed side by side as shown in Figure. AB carries a current i . If CD is moved towards AB , then

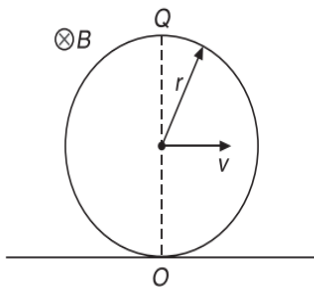


- (A) C will be at a higher potential
- (B) D will be at a higher potential
- (C) No emf is induced in CD
- (D) Force on CD will be away from AB

153. Two coils of inductances L_1 and L_2 are linked such that their mutual inductance is M .

- (A) $M = L_1 + L_2$
- (B) $M = \frac{1}{2}(L_1 + L_2)$
- (C) The maximum value of M is $\sqrt{L_1 L_2}$
- (D) The maximum value of M is $(L_1 + L_2)$

154. A conducting ring of radius r and resistance R rolls on a horizontal surface with constant velocity v . The magnetic field B is uniform normal to the plane of the loop.

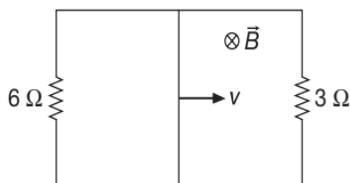


- (A) The induced emf between O and Q is $2Bvr$.
- (B) An induced current $I = \frac{2Bvr}{R}$ flows in the clockwise direction.
- (C) An induced current $I = \frac{2Bvr}{R}$ flows in the anti-clockwise direction.
- (D) None of these

155. The armature of a DC motor has 20Ω resistance. It draws a current of 1.5 A when run by 200 V DC supply. The value of back emf induced in it will be

- (A) 150 V (B) 170 V
- (C) 180 V (D) 190 V

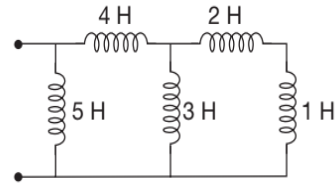
156. A rectangular loop with a sliding connector of length $l = 2 \text{ m}$ is situated in a uniform magnetic field $B = 2 \text{ T}$ perpendicular to the plane of loop. Resistance of connector is $r = 2 \Omega$. Two resistances of 6Ω and 3Ω are connected as shown in Figure.



The external force required to keep the connector moving with a constant velocity $v = 4 \text{ ms}^{-1}$ is

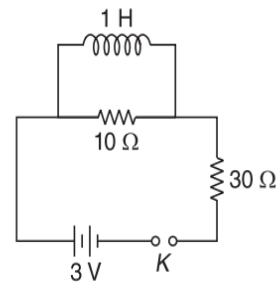
- (A) 4 N (B) 8 N
- (C) 16 N (D) 32 N

157. The equivalent inductance of the network shown here is



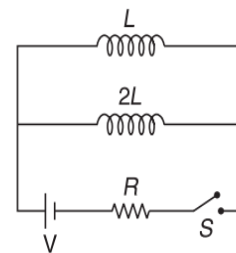
- (A) 2.619 H (B) 9.126 H
- (C) 6.219 H (D) 1.296 H

158. In Figure, final value of current in 10Ω resistor, when plug of key K is inserted is



- (A) $\frac{3}{10} \text{ A}$ (B) $\frac{3}{20} \text{ A}$
- (C) $\frac{3}{11} \text{ A}$ (D) ZERO

159. In the circuit shown in Figure, steady state current in the resistor R after the switch S is closed will be equal to



- (A) V/R (B) $2V/3R$
- (C) $V/3R$ (D) $V/2R$

160. The current through an inductor of 1 H is given by $I = 3t \sin t$. The voltage across the inductor of 1 H is

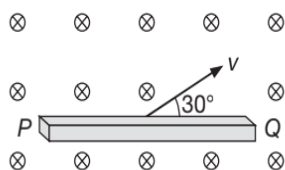
- (A) $3 \sin t + 3 \cos t$ (B) $3 \sin t + 3t \cos t$
- (C) $3 \cos t + t \sin t$ (D) $3t \cos t + \sin t$

161. A Player with 3 m long iron rod runs towards east with a speed of 30 kmhr^{-1} . Horizontal component of earth's magnetic field is $4 \times 10^{-5} \text{ Wbm}^{-2}$. If he is running with rod in horizontal and vertical positions,

then the potential difference induced between the two ends of the rod in two cases will be

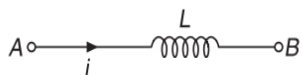
- (A) zero in vertical position and 10^{-3} V in horizontal position
- (B) 10^{-3} V in vertical position and zero in horizontal position
- (C) zero in both cases
- (D) 10^{-3} V in both cases

162. A conducting rod PQ of length $l = 2$ m is moving at a velocity $v = 8 \text{ ms}^{-1}$ making an angle 30° with its length. A uniform magnetic field $B = 3$ T exists in a direction perpendicular to the plane of motion. Then



- (A) $V_P - V_Q = 41.6$ V
- (B) $V_P - V_Q = 24$ V
- (C) $V_Q - V_P = 41.6$ V
- (D) $V_Q - V_P = 24$ V

163. In Figure, if the current i decreases at a rate α , then $V_A - V_B$ is



- (A) ZERO
- (B) $-\alpha L$
- (C) αL
- (D) No relation exists

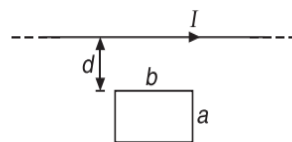
164. A rectangular loop of sides a and b is placed in xy plane. A uniform but time varying magnetic field of strength $\vec{B} = 20t\hat{i} + 10t^2\hat{j} + 50\hat{k}$ is present in the region. The magnitude of induced emf in the loop at time t is

- (A) $20 + 20t$
- (B) 20
- (C) $20t$
- (D) ZERO

165. The annular metallic disk of inner and outer radii a and b respectively is rotating with angular velocity ω in the uniform magnetic field of induction B normal to the plane. The induced emf between inner and outer edge of disk is

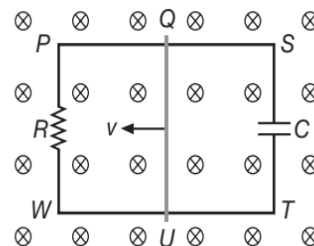
- (A) $\frac{B\omega}{2}(a^2 + b^2)$
- (B) $\frac{B\omega}{2}(b^2 - a^2)$
- (C) $B\omega(b - a)^2$
- (D) $B\omega(b + a)^2$

166. A long straight wire is parallel to one edge of a rectangular loop as shown in Figure. If the current in the long wire varies with time as $I = I_0 e^{-\frac{t}{\tau}}$, then the emf induced in the loop at $t = \tau$ is



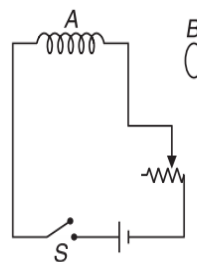
- (A) $\frac{\mu_0 b I}{\pi \tau} \ln\left(\frac{d+a}{d}\right)$
- (B) $\frac{\mu_0 b I}{2\pi \epsilon \tau} \ln\left(\frac{d+a}{d}\right)$
- (C) $\frac{2\mu_0 b I}{\pi \tau} \ln\left(\frac{d+a}{d}\right)$
- (D) $\frac{\mu_0 b I}{\pi \epsilon \tau} \ln\left(\frac{d}{d+a}\right)$

167. In the loop $PQSTUWP$ shown in Figure, a conducting wire QU of mass m , length l is moved with a constant velocity v towards left. The complete circuit is placed in a uniform inward magnetic field \vec{B} perpendicular to the plane of loop. The current in the branch $QSTU$ is



- (A) $\frac{Blv}{R}$, clockwise
- (B) $\frac{BlC}{R}$, anticlockwise
- (C) $\frac{BlCv}{R}$, clockwise
- (D) ZERO

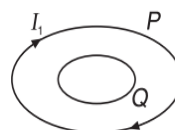
168. The ring B is coaxial with a solenoid A as shown in Figure.



As the switch S is closed at $t = 0$, the ring B

- (A) is attracted towards A
- (B) is repelled by A
- (C) is initially repelled and then attracted
- (D) is initially attracted and then repelled

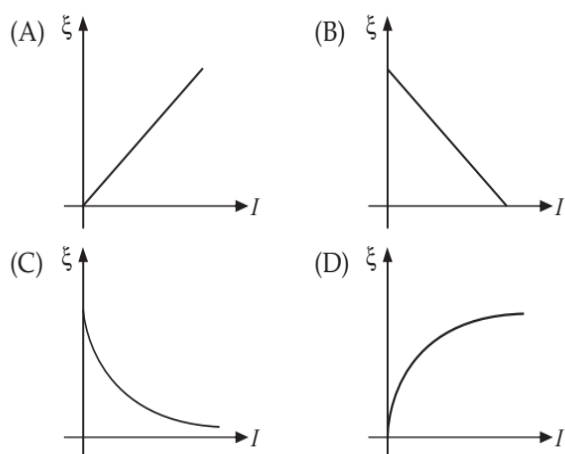
169. Two circular loops P and Q are concentric and coplanar as shown in Figure.



The loop Q is smaller than P . If the current I_1 flowing in loop P is decreasing with time, then the current I_2 in the loop Q

- (A) flows in the same direction as that of P
- (B) flows in the opposite direction as that of Q
- (C) is zero
- (D) None of these

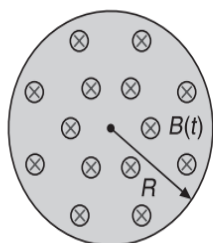
170. Consider a series LR combination connected to a battery of constant emf E and switch S in series. The switch S is closed at time $t = 0$. If ξ denotes the induced emf across inductor and I the current in the circuit at any time t . The graph showing the variation of ξ with I is



171. If the instantaneous magnetic flux and induced emf produced in a coil is ϕ and E respectively, then according to Faraday's law of electromagnetic induction

- (A) E must be zero if $\phi = 0$
- (B) $E \neq 0$ if $\phi = 0$
- (C) $E \neq 0$ but ϕ may or may not be zero
- (D) $E = 0$ then ϕ must be zero

172. A uniform but time varying magnetic field $B(t)$ exists in a circular region of radius R and is directed into the plane of the paper as shown. For the magnitude of induced electric field \vec{E} at a point at a distance r from centre, it can be said that

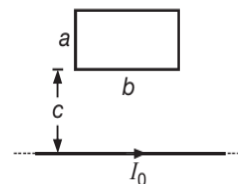


- (A) $\vec{E} = \vec{0}$ for $r > R$
- (B) $\vec{E} = \vec{0}$ for $r < R$
- (C) $|\vec{E}| \propto \frac{1}{r^2}$ for $r < R$
- (D) $|\vec{E}| \propto \frac{1}{r}$ for $r > R$

173. A rectangular loop of sides a and b , has a resistance R and lies at a distance c from an infinite straight wire carrying current I_0 . The current decreases to zero in time τ

$$I(t) = I_0 \frac{(\tau - t)}{\tau}, \quad 0 < t < \tau$$

The charge flowing through the rectangular loop is

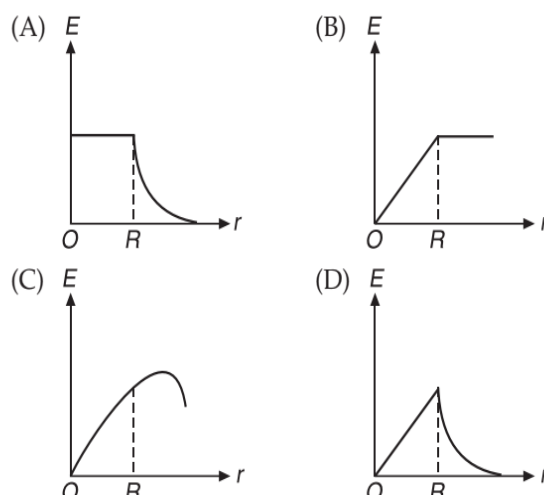
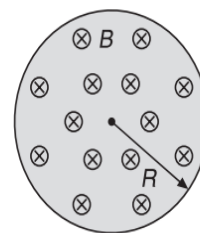


- (A) $\mu_0 I_0 \tau$
- (B) $\mu_0 I_0 \frac{ab}{c^2} \tau$
- (C) $\frac{1}{2} \frac{\mu_0 b I_0}{\pi R} \ln\left(\frac{c+a}{c}\right)$
- (D) $\frac{\mu_0 I \tau}{R} \frac{ba}{c^2}$

174. A conducting square loop is placed in a magnetic field B with its plane perpendicular to the field. Now the sides of the loop start shrinking at a constant rate α . The induced emf in the loop at an instant when its side is a , is

- (A) $2a\alpha B$
- (B) $a^2\alpha B$
- (C) $2a^2\alpha B$
- (D) $a\alpha B$

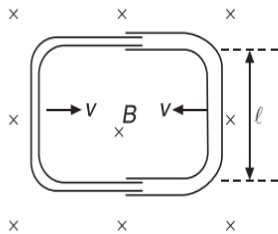
175. A uniform magnetic field is confined in a cylindrical region of radius R . Induction of magnetic field is increasing at a constant rate $\frac{dB}{dt} = \alpha$. Strength of induced electric field (E) varies with distance r from the axis of cylindrical region as



176. A small coil of radius r is placed at the centre of a large coil of radius R , where $R \gg r$. The coils are coplanar. The mutual induction between the coils is

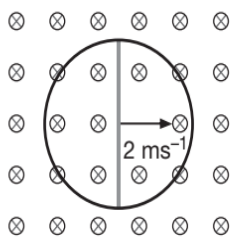
- (A) $\frac{\mu_0 \pi r}{2R}$ (B) $\frac{\mu_0 \pi r^2}{2R}$
 (C) $\frac{\mu_0 \pi r^2}{2R^2}$ (D) $\frac{\mu_0 \pi r}{2R^2}$

177. One conducting U tube can slide inside another as shown in Figure, maintaining electrical contacts between the tubes. The magnetic field B is perpendicular to the plane of the Figure. If each tube moves towards the other at a constant speed v , then the emf induced in the circuit in terms of B , l and v (l is the width of each tube) will be



- (A) ZERO (B) $2Blv$
 (C) Blv (D) $-Blv$

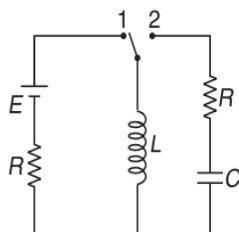
178. A circular loop of radius 2 m is kept in a magnetic field of strength $2T$ (plane of loop is perpendicular to the direction of magnetic field). Resistance of the loop wire is $\frac{2}{\pi} \Omega m^{-1}$. A conductor of length 4 m is sliding with a speed $2 ms^{-1}$ as shown in Figure.



Find the instantaneous force acting on the rod: Assuming the rod to have a negligible resistance, the instantaneous force acting on the rod is

- (A) 8 N (B) 16 N
 (C) 32 N (D) 64 N

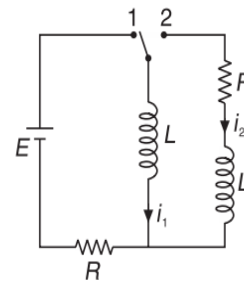
179. Initially, the switch is in position 1 for a long time and then shifted to position 2 at $t = 0$ as shown in Figure.



Just after closing the switch, the magnitude of current through the capacitor is

- (A) ZERO (B) $\frac{E}{2R}$
 (C) $\frac{E}{R}$ (D) None of these

180. In Figure, the switch is in the position 1 for a long time, then the switch is shifted to position 2 at $t = 0$. At this instant the value of i_1 and i_2 are



- (A) $\frac{E}{R}, 0$ (B) $\frac{E}{R}, -\frac{E}{R}$
 (C) $\frac{E}{2R}, -\frac{E}{2R}$ (D) None of these

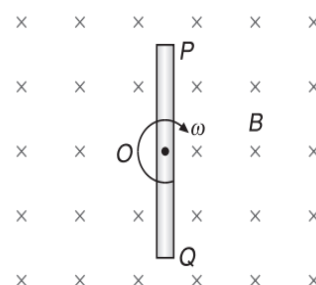
181. A coil is joined to a cell such that the current through the cell grows with a time constant τ . The current reaches 10% of its steady-state value in time t . Then

- (A) $t = \tau \ln(1.1)$ (B) $t = \tau \ln(0.1)$
 (C) $t = \tau \ln(0.9)$ (D) $t = 0.1\tau$

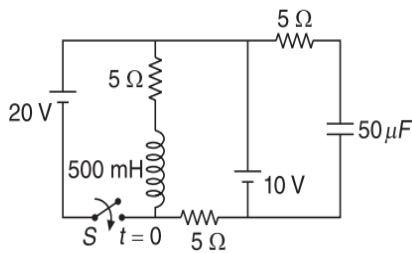
182. A coil is joined to a cell such that the current through the cell grows with a time constant τ . The current will be 10% less than its steady-state value after a time

- (A) $\tau \ln(9)$ (B) $\tau \ln(10)$
 (C) 0.9τ (D) $\tau \ln(0.9)$

183. A rod is rotating with a constant angular velocity ω about point O (its centre) in a magnetic field B as shown. Which of the following Figure correctly shows the distribution of charge inside the rod?

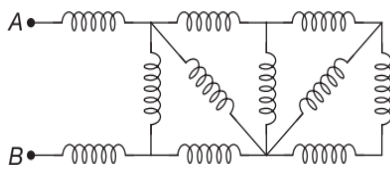


192. Switch S is closed at $t = 0$, in the circuit shown in Figure.

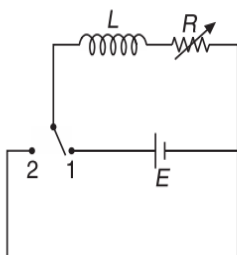


The change in flux in the inductor ($L = 500 \text{ mH}$) from $t = 0$ to an instant when it reaches steady state is

- (A) 2 Wb (B) 1.5 Wb
(C) 0 Wb (D) None of these
193. A network of inductances, each of value 1 H, is shown in Figure. The equivalent inductance of the circuit between points A and B is

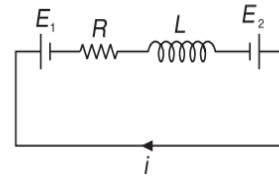


- (A) 6.218 H (B) 0.268 H
(C) 8.162 H (D) 2.618 H
194. In the circuit shown in Figure initially the switch is in position 1 for a long time, then suddenly at $t = 0$, the switch is shifted to position 2. It is required that a constant current should flow in the circuit, the value of resistance R in the circuit

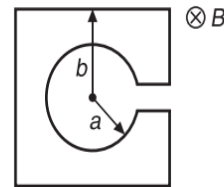


- (A) should be decreased at a constant rate
(B) should be increased at a constant rate
(C) should be maintained constant
(D) Not possible
195. A capacitor of capacitance $2 \mu\text{F}$ is first charged and then discharged through a resistance of $1 \text{ M}\Omega$. The time in which the charge on the capacitor will fall to 50% of its initial value is
- (A) 1.38 second (B) 1.04 second
(C) 0.35 second (D) 0.693 second

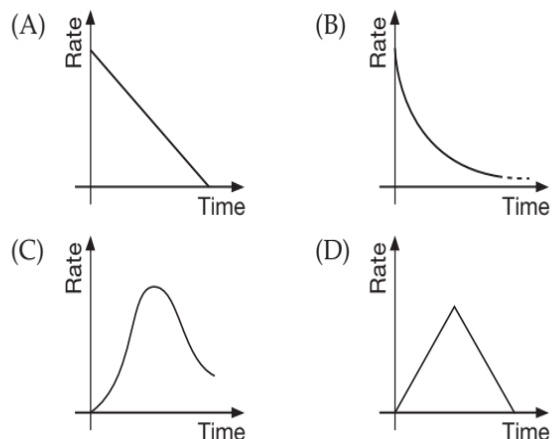
196. In the following loop, which one of the following is correct expression for Kirchhoff voltage law?



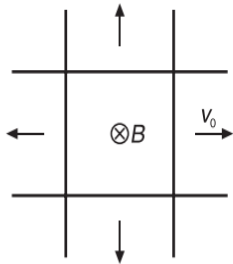
- (A) $E_1 - E_2 = iR + L \frac{di}{dt}$ (B) $E_2 - E_1 = iR + L \frac{di}{dt}$
(C) $L \frac{di}{dt} = iR + E_1 - E_2$ (D) $L \frac{di}{dt} = iR + E_2 - E_1$
197. A loop shown in Figure is immersed in the varying magnetic field $B = B_0 t$, directed into the page. If the total resistance of the loop is R , then the direction and magnitude of induced current in the inner circle is



- (A) clockwise $\frac{B_0(\pi a^2 - b^2)}{R}$
(B) anti-clockwise $\frac{B_0\pi(a^2 + b^2)}{R}$
(C) clockwise $\frac{B_0(\pi a^2 + 4b^2)}{R}$
(D) clockwise $\frac{B_0(4b^2 - \pi a^2)}{R}$
198. In a series LR circuit connected to a battery the rate at which energy is stored in the inductor is plotted against time during the growth of current in the circuit. Which of the following best represents the resulting curve?

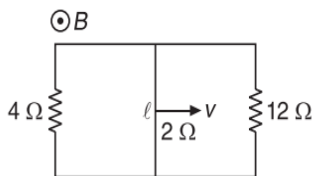


199. Two parallel long straight conductors lie on a smooth plane surface. Two other parallel conductors rest on them at right angles so as to form a square of side a . A uniform magnetic field B exists at right angles to the plane containing the conductors. Now, conductors start moving outward with a 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 the conductors)



- (A) $\frac{aBv_0}{\lambda(a+v_0t)}$ (B) $\frac{aBv_0}{2\lambda}$
 (C) $\frac{Bv_0}{\lambda}$ (D) $\frac{Bv_0}{2\lambda}$

200. A uniform magnetic field $|\vec{B}| = 0.5 \text{ T}$ is perpendicular to the plane of circuit as shown in Figure.



The sliding rod of length $l = 0.25 \text{ m}$ moves uniformly with constant speed $v = 4 \text{ ms}^{-1}$. If the resistance of the slides is 2Ω , then the current flowing through the sliding rod is

- (A) 0.1 A (B) 0.17 A
 (C) 0.08 A (D) 0.03 A

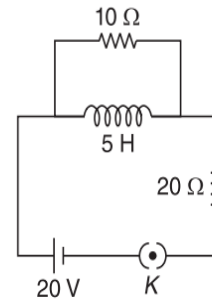
201. Initially an inductor of zero resistance is joined to a cell of emf E through a resistance. The current increases with a time constant τ . The potential difference across the coil after time t is

- (A) $E\left(1 - e^{-\frac{t}{\tau}}\right)$ (B) $\frac{Et}{\tau}$
 (C) $Ee^{-\frac{2t}{\tau}}$ (D) $Ee^{-\frac{t}{\tau}}$

202. Initially an inductor of zero resistance is joined to a cell of emf E through a resistance. The current increases with a time constant τ . The time after which the potential difference across the coil be equal to that across the resistance is

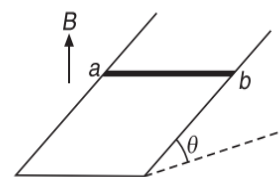
- (A) τ (B) $\tau(1 - \ln 2)$
 (C) $\tau \ln 2$ (D) $\frac{\tau}{\ln 2}$

203. Two resistances of 10Ω and 20Ω and an ideal inductor of inductance 5 H are connected to a 20 V battery through a key K , as shown in Figure. The key is closed at $t = 0$. What is the final value of current in the 10Ω resistor?



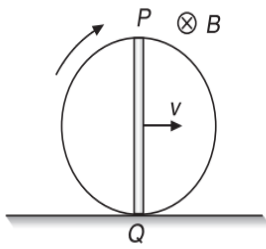
- (A) $\frac{2}{3} \text{ A}$ (B) $\frac{1}{3} \text{ A}$
 (C) $\frac{1}{6} \text{ A}$ (D) ZERO

204. A wire ab of length l , mass m and resistance R slides on a smooth thick pair of metallic rails joined at the bottom as shown in Figure. The plane of the rails makes an angle θ with the horizontal. A vertical magnetic field B exist in the region. If the wire slides on the rails at a constant speed v , then the value of B is



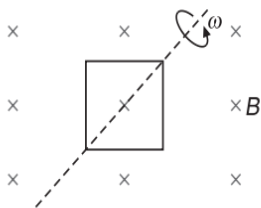
- (A) $\sqrt{\frac{mgR}{v l^2 \cos^2 \theta}}$ (B) $\sqrt{\frac{mgR \cos \theta}{v l^2 \sin^2 \theta}}$
 (C) $\sqrt{\frac{mgR}{v^2 l^2 \sin^2 \theta}}$ (D) $\sqrt{\frac{mgR \sin \theta}{v l^2 \cos^2 \theta}}$

205. A conducting straight rod PQ of length l is fixed along a diameter of a non-conducting ring as shown in Figure. The ring is given a pure rolling motion on a horizontal surface such that its centre of mass has a velocity v . There exists a uniform horizontal magnetic field B in horizontal direction perpendicular to the plane of ring. The magnitude of induced emf in the rod PQ at the position shown in Figure, will be



- (A) Bvl (B) $2Bvl$
 (C) $3Bvl/2$ (D) ZERO

206. A square loop of side b is rotated in a constant magnetic field B at angular frequency ω as shown in Figure.



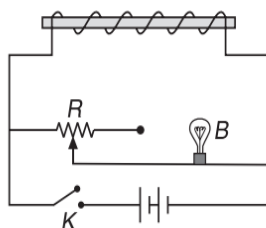
What is the emf induced in it?

- (A) $b^2B\omega\sin\omega t$ (B) $bB\omega\sin^2\omega t$
 (C) $bB^2\omega\cos\omega t$ (D) $b^2B\omega$

207. A uniformly wound long solenoid of inductance L and resistance R is cut into two parts in the ratio $\eta:1$, which are then connected in parallel. The combination is then connected to a cell of emf E . The time constant of the circuit is

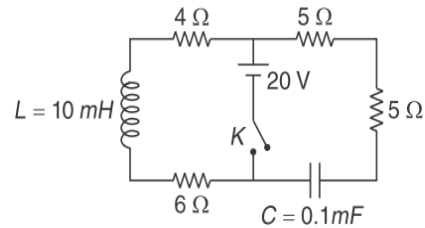
- (A) $\frac{L}{R}$ (B) $\frac{L}{(\eta+1)R}$
 (C) $\left(\frac{\eta}{\eta+1}\right)\frac{L}{R}$ (D) $\left(\frac{\eta+1}{\eta}\right)\frac{L}{R}$

208. Figure shows a solenoid connected to a resistance R , a bulb B and a source of emf. The resistance R is adjusted so that when K is closed, the bulb just glows. Then the switch K is suddenly opened. The bulb B will



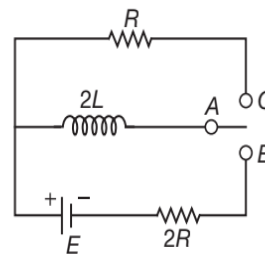
- (A) glow same as before
 (B) fuse
 (C) glow very brightly for a moment
 (D) None of these

209. In the circuit shown, the key (K) is closed at $t = 0$, the current through the key at the instant $t = 10^{-3} \ln 2$, is



- (A) 2 A (B) 8 A
 (C) 4 A (D) ZERO

210. In the circuit shown, A is joined to B for a long time, and then A is joined to C . The total heat produced in R is

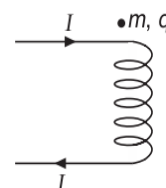


- (A) $\frac{LE^2}{R^2}$ (B) $\frac{LE^2}{2R^2}$
 (C) $\frac{LE^2}{4R^2}$ (D) $\frac{LE^2}{8R^2}$

211. A coil carrying a steady current is short-circuited. The current in it decreases α times in time t_0 . The time constant of the circuit is τ .

- (A) $\tau = t_0 \ln \alpha$ (B) $\tau = \frac{t_0}{\alpha}$
 (C) $\tau = \frac{t_0}{\ln \alpha}$ (D) $\tau = \frac{t_0}{\alpha - 1}$

212. A long solenoid carrying a current I is placed with its axis vertical as shown in Figure. A particle of mass m and charge q is released from the top of the solenoid. Its acceleration is (g being acceleration due to gravity).



- (A) greater than g (B) less than g
 (C) equal to g (D) None of these

213. A coil of inductance 2 H and negligible resistance is connected to a source of supply whose voltage, in volt, is given by $V = 4t$. If the voltage is applied when $t = 0$, then the energy stored in the coil in 4 s is

- (A) 144 J (B) 256 J
(C) 512 J (D) 1024 J

214. A solenoid having 2000 turns is wound over a length of 0.3 m. Its cross-sectional area is $1.2 \times 10^{-3} \text{ m}^2$. Around its central cross-section a coil of 300 turns is wound. If an initial current of 2 A flowing in the solenoid is reversed in 0.25 s, the emf induced in the coil is

- (A) 0.6 mV (B) 60 mV
(C) 0.48 mV (D) 48 mV

215. Two coils, X and Y, are linked such that emf E is induced in Y when the current in X is changing at the rate $\dot{I} \left(= \frac{dI}{dt} \right)$. If a current I_0 is now made to flow through Y, the flux linked with X will be

- (A) $E I_0 \dot{I}$ (B) $\left(\frac{E}{\dot{I}} \right) I_0$
(C) $(E \dot{I}) I_0$ (D) $\frac{I_0 \dot{I}}{E}$

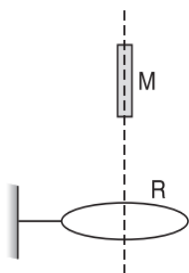
216. A metal disc of radius a rotates with a constant angular velocity ω about its axis. Assuming, m and e to be the mass and charge of electron, the potential difference between the centre and the rim of the disc is

- (A) $\frac{1}{2} \left(\frac{m \omega^2 a^2}{e} \right)$ (B) $\frac{m \omega^2 a^2}{e}$
(C) $\frac{2m \omega^2 a^2}{e}$ (D) $\frac{4m \omega^2 a^2}{e}$

MULTIPLE CORRECT CHOICE TYPE QUESTIONS

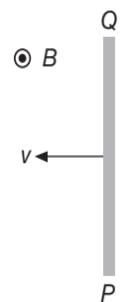
This section contains Multiple Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct.

1. A small magnet M is allowed to fall through a fixed horizontal conducting ring R . Let g be the acceleration due to gravity. The acceleration of M will be



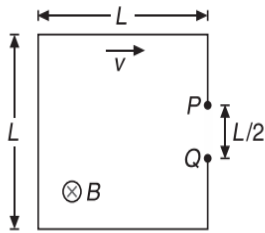
- (A) less than g when it is above R and moving towards R
(B) greater than g when it is above R and moving towards R
(C) less than g when it is below R and moving away R
(D) greater than g when it is below R and moving away R

2. The conductor PQ moves to the left in a uniform magnetic field directed out of the plane the paper.



- (A) The free electrons in PQ will move towards P
(B) Q will acquire a positive potential with respect to P
(C) If Q and P are joined by a conductor externally, a current will flow from P to Q in PQ
(D) The current in PQ flows from lower to higher potential

3. A loop is moving with a velocity v in a uniform magnetic field of magnitude B , directed into the paper as shown in Figure.

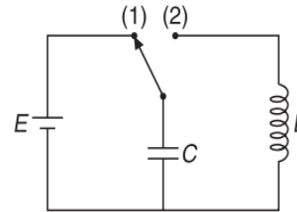


The potential difference between points P and Q is V . Select the correct statement(s)

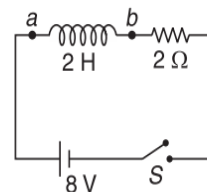
- (A) $V = \frac{1}{2}BLv$
 (B) $V = BLv$
 (C) P is positive with respect to Q
 (D) Q is positive with respect to P
4. A planar loop of wire of area A is placed in a region where the magnetic field is perpendicular to the plane of the loop. The magnitude of \vec{B} varies in time according to the expression $B = B_0 e^{-at}$, where a is a constant and B_0 is the value of field at $t = 0$. The induced emf
- (A) increases exponentially with time with minimum value aB_0A at $t = 0$.
 (B) decreases exponentially with time with maximum value aB_0A at $t = 0$
 (C) increases exponentially with time to a value $\frac{aB_0A}{e}$ at $t = \frac{1}{a}$
 (D) decreases exponentially with time to a value $\frac{aB_0A}{e}$ at $t = \frac{1}{a}$
5. A rectangular coil C having N turns, length $2l$, width l and resistance per unit length λ is placed in a uniform magnetic field of magnitude B . The plane of the coil is initially perpendicular to B . When the coil is rotated by an angle θ about the axis XY , a charge Q flows through it

- (A) $Q = \frac{NBl}{3\lambda}$, for $\theta = \frac{\pi}{2}$
 (B) $Q = \frac{2NBl}{3\lambda}$, for $\theta = \pi$
 (C) $Q = \frac{2NBl}{\lambda}$, for $\theta = \frac{3\pi}{2}$
 (D) $Q = \frac{NBl}{6\lambda}$, for $\theta = 2\pi$

6. In the circuit shown, the key is placed at position-1 till the capacitor gets fully charged. Now the key is shifted to position-2 at $t = 0$. The time(s) when equal energies are stored as electric and magnetic field is/are



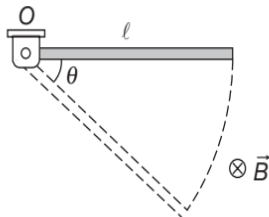
- (A) $\frac{\pi\sqrt{LC}}{4}$ (B) $\frac{\pi\sqrt{LC}}{2}$
 (C) $\frac{5\pi\sqrt{LC}}{4}$ (D) $\frac{5\pi\sqrt{LC}}{2}$
7. A magnetic flux ϕ linked with a closed coil produces an emf ξ .
- (A) ξ must be zero for $\phi = 0$
 (B) ξ may or may not be zero for $\phi \neq 0$
 (C) ξ is non-zero for $\phi \neq 0$
 (D) ξ is non-zero constant for ϕ varying linearly with time.
8. In the circuit shown in Figure the switch S is closed at time $t = 0$. At time $t = \ln(2)$ second, the



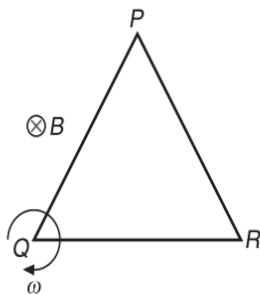
- (A) rate of energy supplied by the battery is 16 Js^{-1}
 (B) rate of heat dissipated across resistance is 8 Js^{-1}
 (C) rate of heat dissipated across resistance is 16 Js^{-1}
 (D) $V_a - V_b = 4 \text{ V}$
9. A conducting ring of radius r , charge Q , resistance R is placed in a magnetic field normal to its plane that changes at a rate B .
- (A) The emf induced in the ring is $\pi r^2 \frac{dB}{dt}$
 (B) The emf induced in the ring is $\pi r^2 B$
 (C) The potential difference between diametrically opposite points on the ring is half of the induced emf
 (D) All points on the ring are at the same potential



10. The magnetic flux ϕ_B linked with a closed coil depends on time t as $\phi = at^{n^2-1}$, where a is a positive constant and n is any real number. The emf induced in the coil is e .
- (A) $|e| = 0$ for $n = \pm 1$
 (B) $|e| = a$ for $n = \pm\sqrt{2}$
 (C) $|e|$ decreases with time for $-1 < n < 1$
 (D) $|e|$ increases with time for all values of n except those lying between -1 and 1
11. A conducting rod of mass m , length l , free to rotate in a vertical plane, is hinged at point O . There exists a uniform magnetic field \vec{B} in horizontal direction. The rod is released from the position shown. The potential difference between the two ends of the rod, when it reaches a position at an angle θ below the initial position, is proportional to



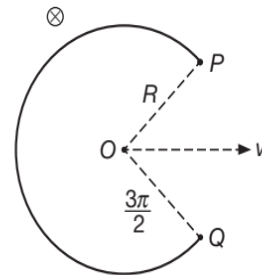
- (A) $\sqrt{\sin\theta}$ (B) l^2
 (C) B (D) $l^{3/2}$
12. An equilateral triangular conducting frame of side l is rotating with uniform angular velocity ω in a uniform magnetic field B directed inwards as shown in Figure.



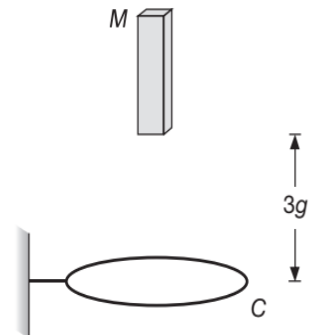
Select the correct option(s).

- (A) $V_P - V_R = 0$ (B) $V_P - V_R = \frac{B\omega l^2}{2}$
 (C) $V_P - V_Q = \frac{B\omega l^2}{2}$ (D) $V_R - V_Q = -\frac{B\omega l^2}{2}$

13. In an LR circuit, if an iron core is inserted inside the coil, then select the incorrect statements
 (A) steady state current will increase
 (B) steady state current will decrease
 (C) time constant will increase
 (D) time constant will decrease
14. A bar magnet is falling towards a fixed closed conducting loop of radius r . At $t = 2s$, the possible distance(s) moved by the magnet towards the loop is
 (A) 18 m (B) $21r$ m
 (C) 19 m (D) $20r$ m
15. The loop shown moves with a velocity v in a uniform magnetic field of magnitude B , directed into the paper. The potential difference between P and Q is ξ .

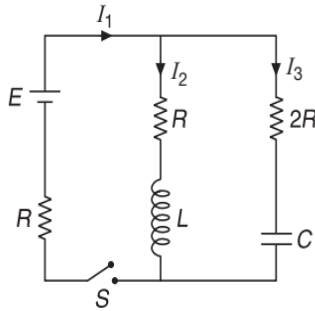


- (A) $\xi = BRv$ (B) $\xi = \sqrt{2}BRv$
 (C) $V_P > V_Q$ (D) $V_Q > V_P$
16. A coil of area 2 m^2 and resistance $4\ \Omega$ is placed perpendicular to a uniform magnetic field of 4 T . The loop is rotated by 90° in 0.1 second. Select the correct options.
 (A) Average induced emf in the coil is 8 V .
 (B) Average induced current in the circuit is 20 A .
 (C) $2C$ charge will flow in the coil in above period.
 (D) Heat produced in the coil in the above period cannot be determined from the given data.
17. A bar magnet M is allowed to fall towards a fixed conducting ring C . If g is the acceleration due to gravity, v is the velocity of the magnet at $t = 2\text{ s}$ and s is the distance travelled by it in the same time then,



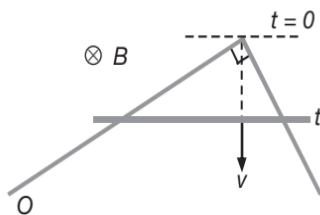
- (A) $v > 2g$ (B) $v < 2g$
 (C) $s > 2g$ (D) $s < 2g$

18. Consider the circuit shown. The switch is closed at $t = 0$. Currents in various branches are marked. Which of the following is correct?



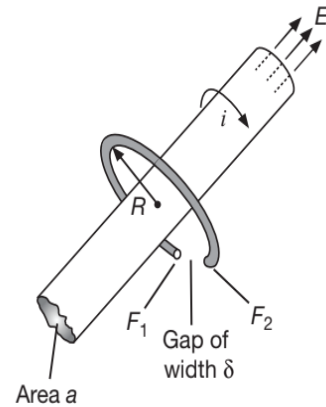
- (A) At $t = 0$, $I_1 = \frac{E}{3R}$, $I_2 = \frac{E}{6R}$, $I_3 = \frac{E}{3R}$
 (B) At $t = 0$, $I_1 = \frac{E}{3R}$, $I_3 = \frac{E}{3R}$
 (C) As $t \rightarrow \infty$, $I_1 = \frac{E}{2R}$, $I_2 = \frac{E}{4R}$, $I_3 = \frac{E}{4R}$
 (D) As $t \rightarrow \infty$, $I_1 = \frac{E}{2R}$, $I_2 = \frac{E}{2R}$

19. Two straight conducting rails form a right angle where their ends are joined. A long conducting bar in contact with the rails starts at the vertex at time $t = 0$ and moves with constant velocity v along them as shown in Figure. A magnetic field \vec{B} is directed into the page. The induced emf in the circuit at any time t is proportional to



- (A) t^2 (B) t
 (C) v^2 (D) v

20. A highly conducting ring of radius R is perpendicular to and concentric with the axis of a long solenoid, as shown. The ring has a narrow gap of width δ in its circumference. The cross-sectional area of the solenoid is a . The solenoid has a uniform internal field of magnitude $B(t) = B_0 + \beta t$, where $\beta > 0$. Assuming that no charge can flow across the gap, the face(s) accumulating an excess of positive charge is/are

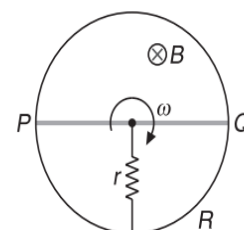


- (A) F_1
 (B) F_2
 (C) F_1 and F_2 both
 (D) difficult to conclude as data given is insufficient

21. In PROBLEM 20, the accumulation of the charge on the gap faces will cease when the total electric field within the ring becomes zero. For this to happen, the electric field in the gap is E_0 .

- (A) $E_0 = \frac{a\beta}{\delta}$
 (B) $E_0 = \frac{2a\beta}{\delta}$
 (C) E_0 is dependent on R for $R > \sqrt{\frac{a}{\pi}}$
 (D) E_0 is independent of R for $R > \sqrt{\frac{a}{\pi}}$

22. A fixed conducting ring R of negligible resistance and radius a has a uniform rod PQ of resistance r hinged at the centre of the ring and rotated about this point in clockwise direction with a uniform angular velocity ω . There exists a uniform magnetic field of strength B pointing inwards in this region. A fixed resistor of resistance r is connected between centre of ring and its circumference which does not hinder the path of rotating rod as shown in Figure. Select the correct statement(s).



- (A) The current through r is zero
- (B) The current through r is $\frac{2B\omega a^2}{5r}$
- (C) The direction of current in external r is from centre to circumference
- (D) The direction of current in external r is from circumference to centre

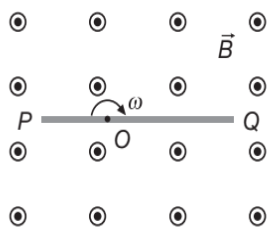
23. The magnetic field perpendicular to the plane of a conducting ring of radius a changes at the rate of α . Then,

- (A) all the points on the ring are at the same potential
- (B) the emf induced in the ring is $\pi a^2 \alpha$
- (C) electric field intensity E at any point on the ring is zero
- (D) $E = \frac{a\alpha}{2}$

24. A magnetic field B exists perpendicular to the plane of the paper in a cylindrical volume of radius R . If it is increasing at the rate $\frac{dB}{dt}$, then electric field at a distance r from its centre is

- (A) $E = -\frac{r}{2} \left(\frac{dB}{dt} \right)$ for $r < R$
- (B) $E = -\frac{r}{4} \left(\frac{dB}{dt} \right)$ for $r < R$
- (C) $E = -\frac{R^2}{2r} \frac{dB}{dt}$ for $r > R$
- (D) $E = -\frac{r^2}{2R} \frac{dB}{dt}$ for $r > R$

25. A conducting rod PQ of length $8l$ is rotated about a point O at distance $3l$ from P , in a uniform magnetic field \vec{B} directed into the paper. Then

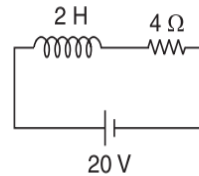


- (A) $V_P - V_O = \frac{B\omega l^2}{2}$
- (B) $V_O - V_Q = \frac{25}{2} B\omega l^2$
- (C) $V_P - V_Q = 8B\omega l^2$
- (D) $V_O - V_P = \frac{9}{2} B\omega l^2$

26. Select the correct option(s).

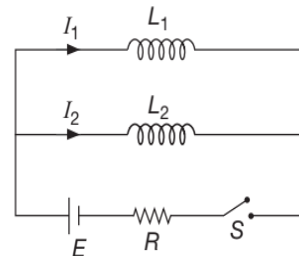
- (A) SI unit of magnetic flux is henry-ampere
- (B) SI unit of coefficient of self-inductance is JA^{-1}
- (C) SI unit of coefficient of self-inductance is $\frac{\text{volt-second}}{\text{ampere}}$
- (D) SI unit of magnetic induction is weber

27. In the LR circuit shown in Figure, potential difference across the resistance at some instant is 4 V. Then,



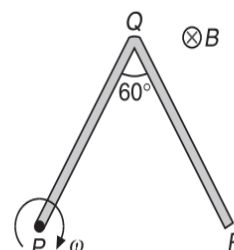
- (A) current is increasing at a rate of 8 As^{-1} at this instant
- (B) power supplied by the battery at this instant is 20 W
- (C) power stored in the magnetic field at this instant is 16 W
- (D) current in the circuit at this instant is 1 A

28. In the circuit shown in Figure. The steady state currents I_1 and I_2 in the coils after the switch S is closed are given by



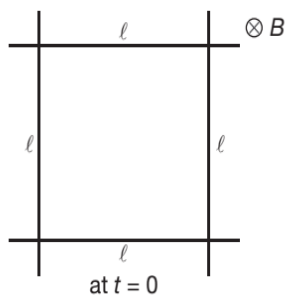
- (A) $I_1 = \frac{EL_2}{R(L_1 + L_2)}$
- (B) $I_1 = \frac{EL_1}{R(L_1 + L_2)}$
- (C) $I_2 = \frac{EL_2}{R\sqrt{L_1 L_2}}$
- (D) $I_2 = \frac{EL_1}{R(L_1 + L_2)}$

29. A bent rod PQR with $PQ = QR = l$ shown in Figure is rotating about its end P with a uniform angular velocity ω in a region of transverse magnetic field of induction B as shown in Figure. Select the correct statement(s).



- (A) No emf is induced across the rod PQ .
- (B) Induced emf across the rod PQ is $\frac{B\omega l^2}{2}$
- (C) Point P is at a lower potential with respect to point R .
- (D) Points Q and R are at the same potential.

30. Four long conductors having resistance per unit length λ , forming a square, capable of sliding smoothly on each other, are placed in a magnetic field B , as shown. At $t = 0$, the square formed by them has side length l . Now all the four conductors start moving outwards with a constant velocity v . The induced emf ξ and induced current I will vary with time t as

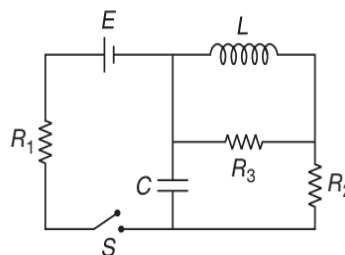


- (A)
- (B)
- (C)
- (D)

31. A conducting circular loop of radius a , resistance R , having resistance per unit length λ is kept on a horizontal plane. A vertical time varying magnetic field $B = 2t$ is switched on at time $t = 0$. If P is the power generated in the coil, $\frac{dq}{dt}$ is the rate of flow of charge from any section of the coil, Q is the total charge passing through coil from $t = 0$ to $t = 3$ s and ξ be the emf induced in the coil. Then

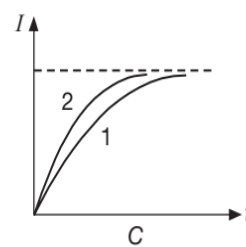
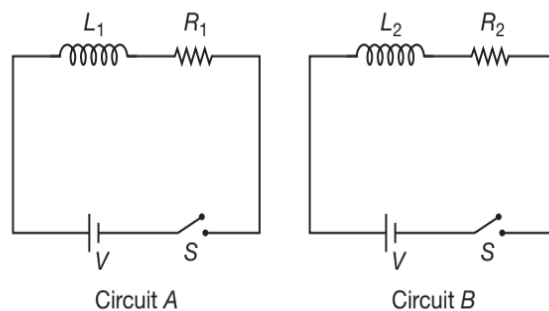
- (A) $\xi = 2\pi a^2$
- (B) $\frac{dq}{dt} = \frac{a}{\lambda}$
- (C) $Q = \frac{6\pi a^2}{R}$
- (D) $P = \frac{4\pi^2 a^4}{R}$

32. In the circuit shown, current in R_3

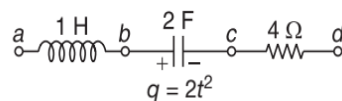


- (A) just after closing the switch is zero
- (B) long after closing the switch is zero
- (C) just after closing the switch is $\frac{E}{R_3}$
- (D) long after closing the switch is $\frac{E}{R_3}$

33. The growth of current in two series LR circuits A and B is shown in C . Let L_1, R_1 and L_2, R_2 be the corresponding inductor, resistor values in the two circuits. Then

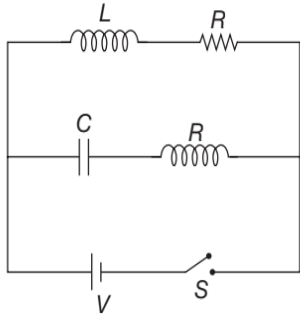


- (A) $R_1 > R_2$
 - (B) $R_1 = R_2$
 - (C) $L_1 > L_2$
 - (D) $L_1 < L_2$
34. In the setup shown in Figure, q is in coulomb and t in second. At time $t = 1$ s, we have

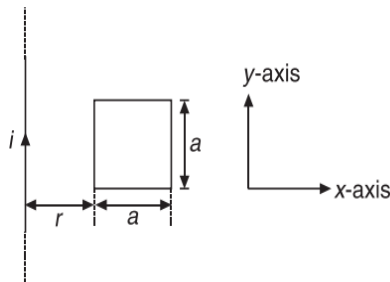


- (A) $V_a - V_b = 4$ V
- (B) $V_b - V_c = 1$ V
- (C) $V_c - V_d = 16$ V
- (D) $V_a - V_d = 20$ V

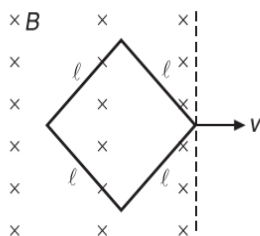
35. In the circuit shown, $R = \sqrt{\frac{L}{C}}$, the switch S is closed at time $t = 0$. Equal currents will flow through L and C at time t_0 . Then



- (A) $t_0 = RC$ (B) $t_0 = RC \ln(2)$
 (C) $t_0 = \frac{L \ln(2)}{R}$ (D) $t_0 = LR$
36. Figure shows a long straight conductor carrying current i . A square loop of side a is kept at a distance r from it. Which of the following is correct?

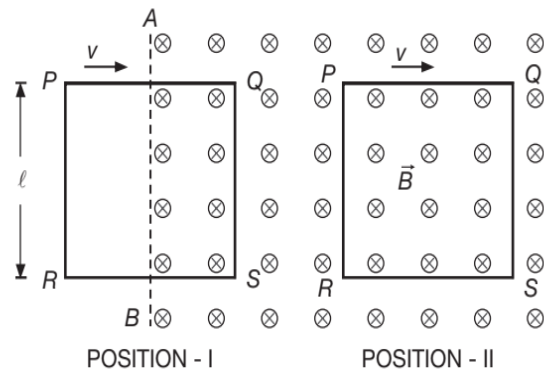


- (A) Mutual inductance $M = \frac{\mu_0 a}{2\pi} \ln\left(1 + \frac{a}{r}\right)$
 (B) If loop is pulled with constant speed v along x -axis, emf induced at the instant is $\frac{\mu_0 i a^2 v}{2\pi r(r+a)}$
 (C) If loop is pulled with constant speed v , no emf is induced
 (D) If i increases with time, the loop is repelled away from the straight conductor
37. Figure shows a square loop being pulled out with a constant speed out of a region of uniform magnetic field. The induced emf in the loop

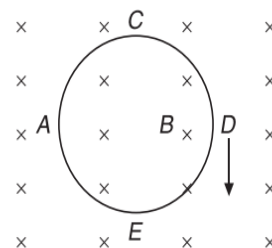


- (A) first increases, then decreases
 (B) first decreases, then increases
 (C) has a maximum value $Bvl\sqrt{2}$
 (D) has a maximum value $2Bvl$

38. A square loop $PQRS$ of edge l moves to the right with a velocity v , parallel to PQ . There is a uniform magnetic field of magnitude B , directed into the paper, in the region between AB and CD only. I, II and III are three positions of the loop.



- (A) In all the three positions, the emf induced in the loop has a magnitude Blv
 (B) In position I, the induced current is anticlockwise
 (C) In position II, the induced emf is zero
 (D) In position III, the induced current is clockwise
39. A vertical conducting ring of radius R falls vertically in a horizontal magnetic field of magnitude B . The direction of B is perpendicular to the plane of the ring. Then,

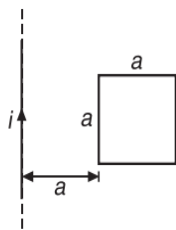


- (A) no current flows in the ring
- (B) A and D are at the same potential
- (C) C and E are at the same potential
- (D) the potential difference between A and D is $2BRv$, with D at a higher potential

40. An ideal inductor with initial current zero, a resistor and an ideal battery are connected in series at time $t=0$. At any time t , the battery supplies energy at the rate P_B , the resistor dissipates energy at the rate P_R and the inductor stores energy at the rate P_L then

- (A) at all instants of time, $P_B = P_R + P_L$
- (B) at all instants of time, $P_R < P_L$
- (C) in steady state, $P_L < P_R$
- (D) at the instant when the circuit is just closed, $P_R > P_L$

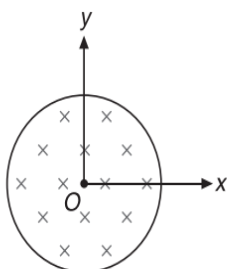
41. An infinitely long wire is placed near a square loop as shown in Figure.



Choose the correct statement(s)

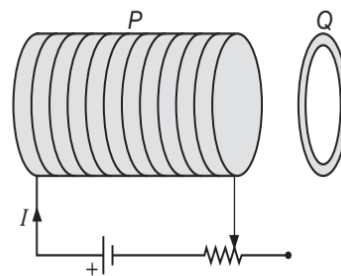
- (A) The mutual inductance between the two is $\frac{\mu_0 a}{2\pi} \ln(2)$.
- (B) The mutual inductance between the two is $\frac{\mu_0 a^2}{2\pi} \ln(2)$.
- (C) If a constant current is passed in the straight wire in upward direction and loop is brought close to the wire, then induced current in the loop is counter clockwise.
- (D) In the above condition, induced current in the loop is anti-clockwise.

42. Magnetic field in a cylindrical region of radius R , an inward magnetic field exists as shown in Figure.

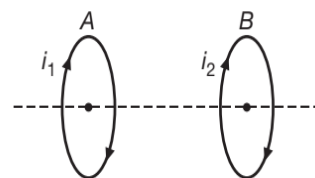


Select the correct statement(s).

- (A) An electron kept at $(2R, 0, 0)$ will experience no force if magnetic field increases with time.
 - (B) An electron kept at $(2R, 0, 0)$ will experience a force along negative y direction if the magnetic field increases with time.
 - (C) A proton kept at $(0, \frac{R}{2}, 0)$ will experience the force along positive x -direction if magnetic field is decreasing with time.
 - (D) A proton kept at $(-R, 0, 0)$ will experience force along negative y -direction if magnetic field is increasing with time.
43. In the arrangement shown, an aluminium ring Q faces an electromagnet P . The current I through P can be altered using a variable resistor. Then



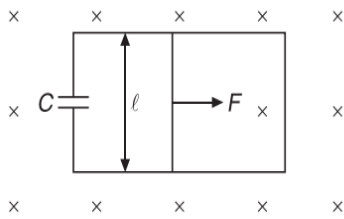
- (A) P repels Q , when I increases
 - (B) P attracts Q , when I increases
 - (C) P repels Q , when I decreases
 - (D) P attracts Q , when I decreases
44. Two circular coils are placed adjacent to each other. Their planes are parallel and currents through them i_1 and i_2 are in same direction. Select the correct statement(s).



- (A) When A is brought near B , current i_2 will decrease
 - (B) In the above process, current i_2 will increase
 - (C) When current i_1 is increased, current i_2 will decrease
 - (D) In the above process, current i_2 will increase
45. Which of the following statement(s) is/are correct regarding the nature of induced electric field produced by a changing magnetic field?

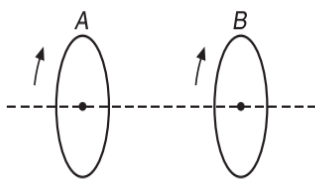
- (A) The lines of this field are closed curves
- (B) It is non-electrostatic in nature
- (C) A corresponding potential can be associated with this induced electric field
- (D) It is non-conservative in nature

46. A wire of mass m and length l can freely slide on a pair of smooth, horizontal rails placed in a vertical magnetic field B . The rails are connected by a capacitor of capacitance C . The electric resistance of the rails and wire is zero. If a constant force F acts on the wire and the resulting acceleration is a , then,



- (A) current in the circuit is $B l C a$
- (B) charge on the capacitor is $C B l a \sqrt{\frac{2l}{a}}$
- (C) acceleration $a = \frac{F}{m + B^2 l^2 C}$
- (D) acceleration $a = \frac{F}{m}$

47. Two circular coils A and B are arranged co-axially and the currents flowing in the direction of arrow are taken positive. Then,

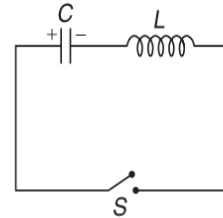


- (A) if A carries a steady positive current and A is moved towards B , a negative current is induced in B
- (B) if A carries a steady positive current and B is moved towards A , a negative current is induced in B
- (C) if both coils carry positive current, they attract each other
- (D) None of these

48. In LC oscillations, the quantities that are analogue to each other are

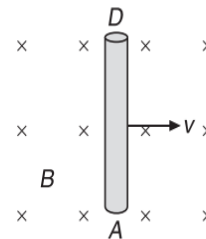
- (A) L and m
- (B) C and K
- (C) I and v
- (D) \dot{I} and \dot{v}

49. A capacitor is charged to a potential of V_0 . It is connected with an inductor through a switch S . The switch is closed at time $t = 0$. Which of the following statement(s) is/are correct?



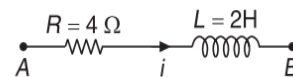
- (A) The maximum current in the circuit is $V_0 \sqrt{\frac{C}{L}}$
- (B) Potential across capacitor becomes zero for the first time at $t = \pi \sqrt{LC}$
- (C) Energy stored in the inductor at time $t = \frac{\pi}{2} \sqrt{LC}$ is $\frac{1}{2} C V_0^2$
- (D) Maximum energy stored in the inductor is $\frac{1}{2} C V_0^2$

50. The conductor AD moves to the right in a uniform magnetic field directed into the paper. Then,



- (A) the free electrons in AD will move towards A
- (B) D will acquire a positive potential with respect to A
- (C) if D and A are joined by a conductor externally, a current will flow from A to D in AD
- (D) the current in AD flows from lower to higher potential

51. In Figure shown the current in circuit is $i = 10e^{-4t}$ A. If V_L be the potential difference across the inductor and V_{AB} be the potential difference across the points A and B , then we have



- (A) $V_{AB} = 40e^{40t}$
- (B) $V_{AB} = -40e^{-40t}$
- (C) $V_L = -80e^{40t}$
- (D) $V_L = -80e^{-40t}$

REASONING BASED QUESTIONS

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

Bubble (A) If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.

Bubble (B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.

Bubble (C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.

Bubble (D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

1. **Statement-1:** The induced e.m.f. in a conducting loop of wire will be non-zero when it rotates in a uniform magnetic field.

Statement-2: The e.m.f. may be induced due to change in magnetic field.

2. **Statement-1:** If electric current, changes through a circuit, eddy currents are induced in nearby iron piece.

Statement-2: Due to change of electric current, the magnetic flux through iron piece changes, so eddy currents are induced in the iron piece.

3. **Statement-1:** The work done by a charge in a closed (induced) current carrying loop is non-zero.

Statement-2: Induced electric field is non-conservative in nature.

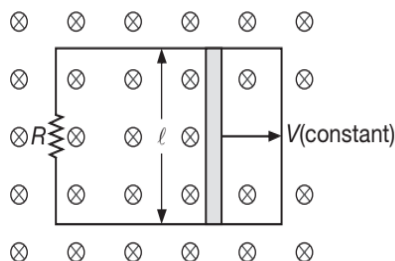
4. **Statement-1:** Lenz's Law violates the principle of conservation of energy.

Statement-2: Induced e.m.f. always opposes the change in magnetic flux responsible for its production.

5. **Statement-1:** The self-inductance (L) is given by the relation $\phi_B = LI$.

Statement-2: When current I is increased, self-inductance increases.

6. **Statement-1:** In the situation shown, a conductor can be moved with constant velocity by an external agent, that applies a force on it so that it moves with constant velocity.



Statement-2: As conductor is moved, a current is induced in the circuit as a result of which magnetic force acts on conductor opposite to its velocity.

7. **Statement-1:** An emf is induced in a long solenoid by a bar magnet that moves while totally inside it along the solenoid axis.

Statement-2: As the magnet moves inside the solenoid the flux through individual turns of the solenoid changes.

8. **Statement-1:** Time dependent magnetic field generates an induced electric field.

Statement-2: Direction of electric field generated from time variable magnetic field does not obey Lenz's Law.

9. **Statement-1:** If a coil is rotated in uniform magnetic field about an axis perpendicular to the field, e.m.f. induced in coil is maximum for orientation of coil in which magnetic flux through the coil is zero.

Statement-2: Work done to rotate the coil will get converted into electrical energy.

10. **Statement-1:** The direction of the induced electric field is always perpendicular to the direction of the (changing) magnetic field.

Statement-2: The induced electric field is a non-conservative field.

11. **Statement-1:** If a charged particle is released from rest in a time varying magnetic field, it moves in a circle.

Statement-2: In time varying magnetic field electric field is induced.

12. **Statement-1:** Varying magnetic field produces an electric field, which is non-conservative.

Statement-2: Charged particle(s) in motion produces only magnetic field.

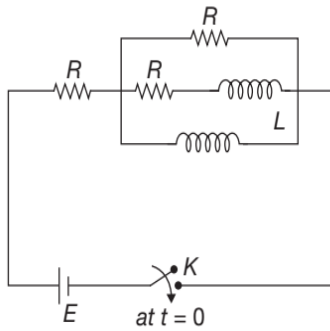
13. **Statement-1:** When two coils are wound on each other, the mutual induction between the coils is maximum.

Statement-2: Mutual induction does not depend on the orientation of the coils.

14. **Statement-1:** At $t = 0$, current through e.m.f. source $I = \frac{E}{2R}$ and at $t \rightarrow \infty$ the I (through e.m.f. source will

be) is $\frac{E}{R}$.

Statement-2: At $t = 0$, inductor will behave like open circuit and at $t \rightarrow \infty$, inductor will behave like short circuit.



15. **Statement-1:** The growth of current in LR circuit is uniform.
Statement-2: Inductor (L) opposes the growth of current.

16. **Statement-1:** The nature of induced e.m.f. is always such, so that it always opposes the change that causes it.
Statement-2: The direction of induced e.m.f. is given by Lenz's Law.
17. **Statement-1:** A system cannot have mutual inductance without having self-inductance.
Statement-2: If mutual inductance of system is zero, its self-inductance must be zero.
18. **Statement-1:** Two identical co-axial circular loops carry equal currents in same direction. When both loops start approaching each other, the current in both coils will decrease.
Statement-2: Current in a circuit is independent of any other circuit.

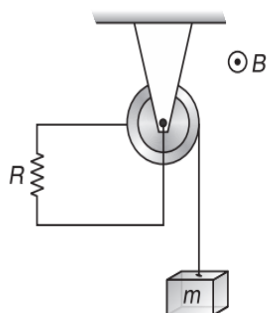
LINKED COMPREHENSION TYPE QUESTIONS

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct (For the sake of competitiveness there may be a few questions that may have more than one correct options).

Comprehension 1

A metal ring having three metallic spokes of length $r = 0.2$ m is in a vertical plane and can spin around a fixed horizontal axis in a homogeneous magnetic field of a magnetic induction $B = 0.5$ T. The lines of magnetic field are perpendicular to the plane of metal ring. Between the axis of the metal ring and its perimeter we connect a consumer of resistance of 0.15Ω with the help of two sliding contacts. We fix a thread of negligible mass to the rim of the ring and wind it several times around the ring and to its end we fix a body of a mass of 20 g. At a given moment we release the body of mass m . The friction is negligible everywhere, the resistance of the ring, the spokes and the connected wiring is also negligible. Based on the above facts, answer the following questions.

1. The torque exerted on the ring with spokes by the magnetic forces when the body of mass m is moving with a constant velocity is

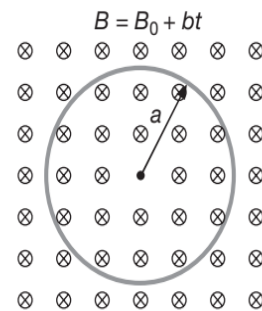


- (A) 0.02 Nm (B) 0.04 Nm
 (C) 0.06 Nm (D) 0.08 Nm

2. The current is flowing through the resistor when the velocity of the body of mass m is 3 ms^{-1}
 (A) 1 A (B) 3 A
 (C) 2 A (D) 4 A
3. The highest velocity of the body of mass m
 (A) 6 ms^{-1} (B) 7 ms^{-1}
 (C) 8 ms^{-1} (D) 12 ms^{-1}

Comprehension 2

A circular loop of wire of radius a , resistance per unit length λ is placed in a uniform magnetic field, with the plane of the loop perpendicular to the direction of the field, as shown in Figure.



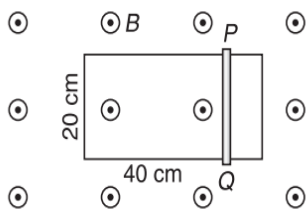
The magnetic field varies with time according to $B(t) = B_0 + bt$, where B_0 and b are positive constants.

4. The magnetic flux through the loop at $t = 0$ is
 (A) $\pi b a^2$ (B) $\pi B_0 a^2$
 (C) $\frac{\pi B_0 a^2}{2}$ (D) ZERO

5. The induced emf in the loop is
- (A) πba^2 (B) $\pi B_0 a^2$
 (C) $\frac{\pi ba^2}{2}$ (D) $\frac{\pi B_0 a^2}{2}$
6. The induced current and its direction of flow is
- (A) $\frac{ba}{\lambda}$, CW (B) $\frac{ba}{\lambda}$, CCW
 (C) $\frac{ba}{2\lambda}$, CW (D) $\frac{ba}{2\lambda}$, CCW
7. The power dissipated due to the resistance of the loop is
- (A) $\frac{\pi b^2 a^3}{\lambda}$ (B) $\frac{\pi b^3 a^2}{2\lambda}$
 (C) $\frac{\pi b^2 a^3}{2\lambda}$ (D) $\frac{\pi b^3 a^2}{\lambda}$

Comprehension 3

Figure shows a conducting rod PQ of negligible resistance that can slide on smooth U-shaped rail made of wire of resistance $1 \Omega \text{m}^{-1}$. Position of the conducting rod at $t = 0$ is shown. A time dependent magnetic field $B = 2t$ tesla is switched on at $t = 0$. Based on the above facts, answer the following questions.



8. The current in the loop at $t = 0$ due to induced emf is
- (A) 0.16 A, clockwise (B) 0.08 A, clockwise
 (C) 0.16 A, anti-clockwise (D) ZERO
9. At $t = 0$, when the magnetic field is switched on, the conducting rod is moved to the left at constant speed 5 cm s^{-1} by some external means. At $t = 2 \text{ s}$, net induced emf has magnitude
- (A) 0.12 V (B) 0.08 V
 (C) 0.04 V (D) 0.02 V
10. The magnitude of the force required at $t = 2 \text{ s}$ to move the conducting rod at a constant speed of 5 cm s^{-1} is
- (A) 0.096 N (B) 0.12 N
 (C) 0.08 N (D) 0.064 N

Comprehension 4

An induction furnace uses electromagnetic induction to produce eddy currents in a conductor, thereby raising the conductor's temperature. Commercial units operate at frequencies ranging from 60 Hz to about 1 MHz and deliver powers from a few watts to several megawatts. Induction heating can be used for welding in a vacuum enclosure, to avoid oxidation and contamination of the metal. At high frequencies, induced currents occur only near the surface of the conductor this is the "skin effect". By creating an induced current for a short time at an appropriately high frequency, one can heat a sample down to a controlled depth. For example, the surface of a farm tiller can be tempered to make it hard and brittle for effective cutting while keeping the interior metal soft and ductile to resist breakage.

To explore induction heating, consider a flat conducting disk of radius R , thickness b and resistivity ρ . A sinusoidal magnetic field $B_0 \cos(\omega t)$ is applied perpendicular to the disk. Assume that the frequency is so low that the skin effect is not important. Assume the eddy currents occur in circles concentric with the disk. Based on the above facts, answer the following questions.

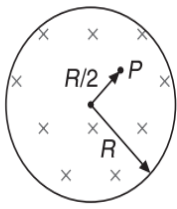
11. The average power delivered to disc is

(A) $\frac{1}{8} \left(\frac{\pi b B_0^2 R^4 \omega^2}{\rho} \right)$ (B) $\frac{1}{4} \left(\frac{\pi R B_0^3 b^4 \omega}{\rho} \right)$
 (C) $\frac{1}{8} \left(\frac{\pi b^2 B_0^2 R^3 \omega^4}{\rho} \right)$ (D) $\frac{1}{16} \left(\frac{\pi b B_0^2 R^4 \omega^2}{\rho} \right)$

12. The amplitude of the field is doubled (keeping others same), the factor by which the power changes is
- (A) 2 (B) 4
 (C) 16 (D) 8
13. The frequency of the field is doubled (keeping others same), then the factor by which the power changes is
- (A) 2 (B) 4
 (C) 8 (D) 16
14. The radius of the disc is doubled (keeping others same), then the factor by which the power changes is
- (A) 2 (B) 4
 (C) 8 (D) 16

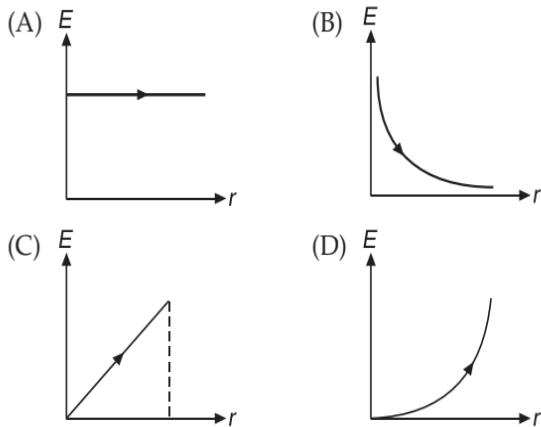
Comprehension 5

A uniform but time varying magnetic field $B = (2t^3 + 24t)$ T is present in a cylindrical region of radius $R = 2.5 \text{ cm}$ as shown in Figure.



Based on the above facts, answer the following questions.

15. The force on an electron at P at $t = 2$ s is
 (A) 96×10^{-21} N (B) 48×10^{-21} N
 (C) 24×10^{-21} N (D) ZERO
16. At any instant, the variation of induced electric field as a function of distance measured from the centre of cylindrical region is



17. At $t = 1$ s, the induced electric field is
 (A) clockwise (B) counter-clockwise
 (C) zero (D) vertically upwards

Comprehension 6

A circular wire loop of radius a and resistance R initially has a magnetic flux through it due to an external magnetic field. The external field then decreases to zero at a constant rate. A current is induced in the loop while the external field is changing. However, this current does not stop at the instant that the external field stops changing. The reason is that the current itself generates a magnetic field, which gives rise to a flux through the loop. If the current changes, the flux through the loop changes as well and an induced emf appears in the loop to oppose the change. Based on the information provided, answer the following questions.

18. Assuming that the field generated by the induced current I (say) is constant over the loop at all the points, the flux due to this field through the loop is

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

19. After the external field has stopped changing, the rate of fall of induced current is given by

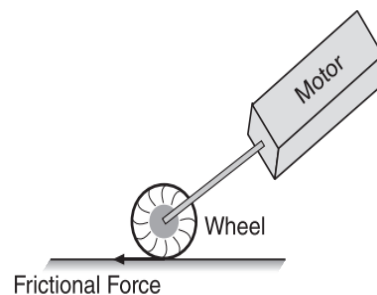
- (A) $\frac{2R}{\mu_0 \pi a}$ (B) $\frac{R}{2\mu_0 \pi a}$
 (C) $\left(\frac{2R}{\mu_0 \pi a}\right) I$ (D) $\left(\frac{R}{2\mu_0 \pi a}\right) I$

20. Designating the instant when the external field stops changing as $t = 0$ and assuming $I = I_0$ at $t = 0$, then

- (A) $I = I_0 + \left(\frac{2R}{\mu_0 \pi a}\right) t$ (B) $I = I_0 + \left(\frac{R}{2\mu_0 \pi a}\right) t$
 (C) $I = I_0 e^{-\left(\frac{R}{2\mu_0 \pi a}\right) t}$ (D) $I = I_0 e^{-\left(\frac{2R}{\mu_0 \pi a}\right) t}$

Comprehension 7

A small electric car overcomes a 250 N friction force between the road and its wheel when travelling at 30 kmh^{-1} . The electric motor is powered by ten 12 V batteries connected in series and is directly coupled to the wheels whose diameters are 50 cm. The $10 \text{ cm} \times 15 \text{ cm}$ rectangular motor coils have 300 turns and rotate in a 0.60 T magnetic field. You may assume that the geometry of the motor is such that the magnetic field is always parallel to the plane of the coils. Based on the above facts, answer the following questions.



21. The current that the motor draws to produce the required torque is

- (A) 2 A (B) 23.15 A
 (C) 13 A (D) 53 A

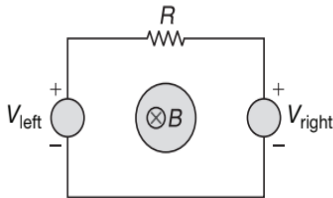
22. The back emf or induced emf generated in the coil is

- (A) 30 V (B) 20 V
 (C) 90 V (D) 50 V

23. The percentage of the input power used to drive the car is
- (A) 75% (B) 50%
(C) 95% (D) None of these

Comprehension 8

Two voltmeters V_{right} and V_{left} each with an internal resistance of $10^4 \Omega$ are in series with a resistor R of $5 \times 10^3 \Omega$. They are connected through wires of negligible resistances. The positive side of voltmeters is up as shown in Figure. A changing magnetic field is present in the region shown in Figure. At a particular moment in time V_{left} reads +0.1 volt. Based on the above facts, answer the following questions.



24. At that moment when reading of V_{left} is +0.1 Volt, the reading of V_{right} is
- (A) -0.1 Volt (B) -0.2 Volt
(C) -0.3 Volt (D) -0.4 Volt
25. At that moment current in ampere (magnitude and direction)
- (A) 10^{-4} A, clockwise
(B) 10^{-4} A, anticlockwise
(C) 10^{-5} A, clockwise
(D) 10^{-5} A, anticlockwise
26. At that moment induced emf is
- (A) 0.5 V (B) 0.25 V
(C) 0.75 V (D) 1 V

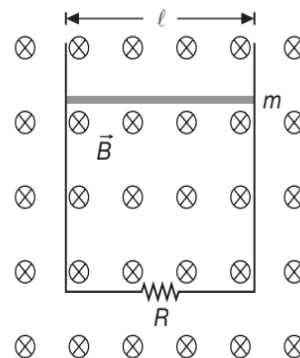
Comprehension 9

A thin non-conducting ring of mass m , radius a , carrying a charge q can rotate freely about its own axis which is vertical. Initially, the ring was at rest in horizontal position and no magnetic field was present. At instant $t = 0$, a uniform magnetic field is switched on which is vertically downward and increases with time as $B = B_0 t$, where B_0 is a positive constant. Neglecting magnetism induced due to rotational motion of ring, answer the following questions.

27. The magnitude of emf induced on the closed surface of ring is
- (A) $\pi a^2 B_0$ (B) $2a^2 B_0$
(C) ZERO (D) $\frac{1}{2} \pi a^2 B_0$
28. The magnitude of electric field at the circumference of the ring is
- (A) $a B_0$ (B) $2a B_0$
(C) $\frac{1}{2} a B_0$ (D) ZERO
29. Angular acceleration of ring is
- (A) $\frac{q B_0}{2m}$ (B) $\frac{q B_0}{4m}$
(C) $\frac{q B_0}{m}$ (D) $\frac{2q B_0}{m}$
30. The instantaneous power developed by electric force acting on the ring at $t = 1$ s is
- (A) $\frac{2q^2 B_0^2 a^2}{14m}$ (B) $\frac{q^2 B_0^2 a^2}{8m}$
(C) $\frac{3q^2 B_0^2 a^2}{m}$ (D) $\frac{q^2 B_0^2 a^2}{4m}$

Comprehension 10

A horizontal wire is free to slide on the vertical rails of a conducting frame as shown in figure. The wire has a mass m and length l . Resistance of the circuit is R . A uniform magnetic field B is directed perpendicular to the frame. Based on the facts provided, answer the following questions.

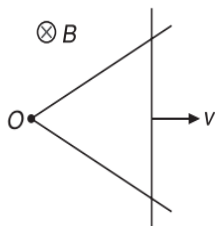


31. The terminal speed of the wire as it falls under the force of gravity is v_T . Then v_T equals
- (A) $\frac{mgR}{Bl}$ (B) $\frac{mgl}{BR}$
(C) $\frac{mgR}{B^2 l^2}$ (D) $\frac{B^2 l^2}{mgR}$

32. Assuming $m = 1 \text{ kg}$, $g = 10 \text{ ms}^{-2}$ and terminal velocity attained by it to be 4 ms^{-1} after falling through 1 m , the energy dissipated as heat till then is
- (A) 2 J (B) 8 J
(C) 10 J (D) 12 J
33. The rate at which energy is dissipated in resistor, once the terminal speed is attained is
- (A) $\frac{B^2 l^2 v_T^2}{2R}$ (B) $\frac{B^2 l^2 v_T^2}{R}$
(C) mgv_T (D) $\frac{1}{2}mgv_T$

Comprehension 11

The mobile side of the triangular conducting frame shown in Figure is sliding at uniform speed of $v = 0.1 \text{ ms}^{-1}$ along the other two side. This horizontal frame is in a vertical homogeneous magnetic field with an induction of $B = 0.4 \text{ T}$. Resistance per unit length is 1Ω . Initially at $t = 0$ sliding rod was at O . Based on the above facts, answer the following questions.

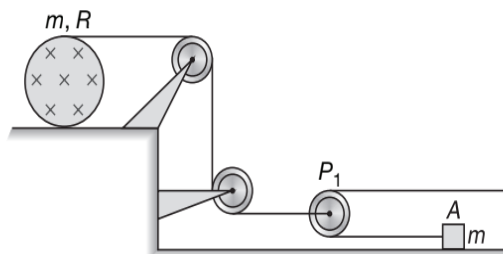


34. The induced emf
- (A) increases with time
(B) decreases with time
(C) remains constant
(D) initially increases, then decreases
35. Induced current in the frame is
- (A) increasing with time
(B) decreasing with time
(C) remain constant
(D) initially increase then decrease
36. Work done in sliding the rod in 10 seconds is
- (A) $3 \times 10^{-3} \text{ J}$ (B) $9 \times 10^{-3} \text{ J}$
(C) $12 \times 10^{-3} \text{ J}$ (D) $14 \times 10^{-3} \text{ J}$

Comprehension 12

A solid non-conducting disc of mass m and radius R has total charge Q is uniformly distributed on its surface. A light thin string is wound around the disc is connected to the light pulley P_1 as shown in Figure. A block of same

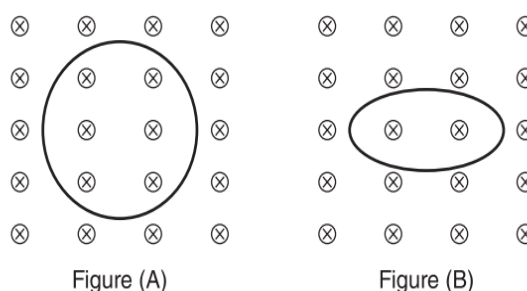
mass rest on smooth surface. Now uniform magnetic field given by $B = B_0 t$ perpendicular into the plane of paper is switched on. The surface on which disc lies is sufficiently rough to ensure pure rolling. Then



37. Tension in string wound around the disc is
- (A) $\frac{4QB_0R}{35}$ (B) $\frac{QB_0R}{35}$
(C) $\frac{4QB_0R}{70}$ (D) $\frac{QB_0R}{20}$
38. Angular acceleration of disc is
- (A) $\frac{QB_0}{m}$ (B) $\frac{4QB_0}{35m}$
(C) $\frac{QB_0}{70m}$ (D) $\frac{2QB_0}{35m}$
39. Acceleration of block
- (A) $\frac{2QB_0R}{35m}$ (B) $\frac{20QB_0R}{7m}$
(C) $\frac{4QB_0R}{41m}$ (D) $\frac{4QB_0R}{35m}$

Comprehension 13

Figure below shows a circular wire loop of radius $r = 0.1 \text{ m}$ with $N = 100$ turns and resistance $R = 2 \Omega$. The plane of the loop coincides with the plane of paper. There is a uniform magnetic field $B = 4 \text{ T}$ perpendicular to the plane of the paper and directed into page. Since the loop is flexible copper wire, you can grab it on opposite sides and pull it flat. Figure B shows the loop when you are in the middle of pulling it flat. You can assume that with no magnetic field, it would take almost no work to pull the loop flat. Figure C shows how the area enclosed by the loop changes with time. It starts at its initial area and drops linearly to zero in $\Delta t = 3 \text{ sec}$.



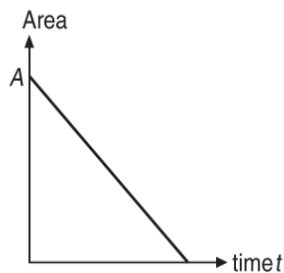
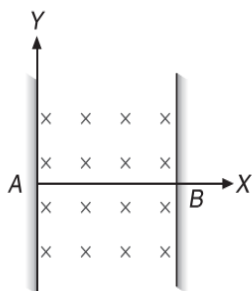


Figure (C)

40. While you are flattening the loop, there is an induced current in the loop. The
- (A) induced current is anticlockwise
 - (B) induced current will increase during flattening the loop
 - (C) induced current will decrease during flattening the loop
 - (D) induced current will remain same during flattening the loop
41. At $t = 2$ sec the magnitude of current is
- (A) 2.09 A
 - (B) 6.08 A
 - (C) 1.09 A
 - (D) 0.09 A
42. Average force required to flatten it
- (A) 111 N
 - (B) 231 N
 - (C) 350 N
 - (D) 160 N

Comprehension 14

A standing wave $y = 2A \sin(kx) \cos(\omega t)$ is set up in the wire AB fixed at both ends by two vertical walls. The region between the walls contains a constant magnetic field B . Now answer the following questions.

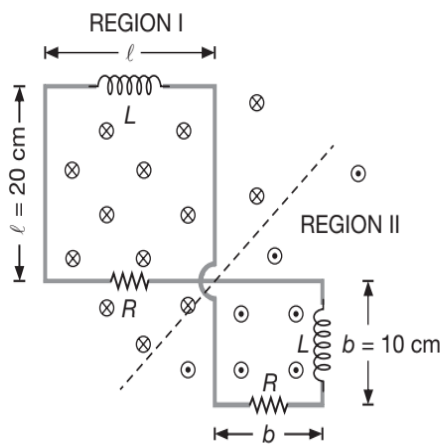


43. The wire is found to vibrate in the third harmonic. The maximum emf induced is
- (A) $\frac{4(AB)\omega}{k}$
 - (B) $\frac{3(AB)\omega}{k}$
 - (C) $\frac{2(AB)\omega}{k}$
 - (D) $\frac{(AB)\omega}{k}$

44. In the above problem, the instant 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) $\frac{\pi}{4\omega}$
45. In which of the following modes the emf induced in AB is always zero?
- (A) Fundamental mode
 - (B) Second harmonic
 - (C) Second overtone
 - (D) Forth overtone

Comprehension 15

Consider a frame consisting of two square loops having resistors and inductors as shown. This frame is placed in uniform but time varying magnetic field is such a way that the bigger loop is placed in Region I (above dotted line) having an inward, \otimes , field and other is placed in Region II (below the dotted line) having an outward, \odot , field. Both magnetic fields are perpendicular to the planes of loops. If the magnetic field is given by $B = (20 + 10t) \text{ Wbm}^{-2}$ in both regions, $l = 20 \text{ cm}$, $b = 10 \text{ cm}$, $R = 10 \Omega$ and $L = 10 \text{ H}$, then answer the following questions



46. The direction of induced current in bigger loop will be
- (A) clockwise
 - (B) counter clockwise
 - (C) first clockwise for some time then counter clockwise and so on
 - (D) first counter clockwise for some time then clockwise and so on
47. The induced emf in the frame is
- (A) 0.1 V
 - (B) 0.3 V
 - (C) 0.4 V
 - (D) 0.5 V

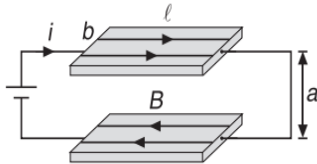


48. The current, in ampere, in the frame as a function of time will be

- (A) $\frac{1}{20}(1 - e^{-t})$ (B) $\frac{1}{40}(1 - e^{-t})$
 (C) $\frac{1}{20}e^{-t}$ (D) $\frac{1}{10}e^{-t}$

Comprehension 16

The system shown in Figure consists of two flat conducting strips of length l , width b (perpendicular to plane of diagram) separated by a small gap a (where $a \ll b$ and $a \ll l$). The right ends of the strips are shorted and a battery of voltage V_0 is connected across the left ends. The current is assumed to flow only parallel to the l -dimension of the strips. Neglect all resistances. Based on the above facts, answer the following questions.



49. The self-inductance of the circuit is

- (A) $\frac{\mu_0 l a}{b}$ (B) $\frac{\mu_0 b l}{a}$
 (C) $\frac{\mu_0 a l^2}{b^2}$ (D) $\frac{\mu_0 a^2 l}{b^2}$

50. The voltage across the strips as a function of the distance x from the shorted end (if L is the self-inductance) is

- (A) $\frac{\mu_0 x a V_0}{b L}$ (B) $\frac{\mu_0 a V_0}{x b L}$
 (C) $\frac{\mu_0 a x}{V_0 b L}$ (D) $\frac{\mu_0 a V_0 L}{b x}$

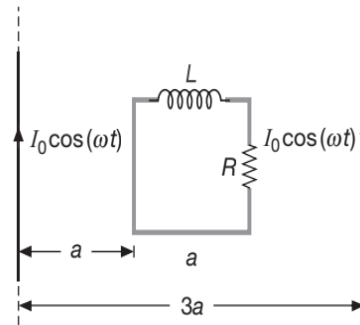
51. The rate of flow of energy down the system as a function of distance x from shorted end and the time t (if L is self-inductance) is

- (A) $\frac{\mu_0 x a}{b} \frac{V_0 t}{L}$ (B) $\frac{\mu_0 x a}{b} \frac{V_0^2 t}{L^2}$
 (C) $\frac{\mu_0 x a V_0^2 t}{b L}$ (D) ZERO

Comprehension 17

A square loop, consisting of an inductor L and a resistor R is placed between two long parallel wires each carrying time varying current of magnitude $I = I_0 \cos(\omega t)$ in

opposite directions, as shown. Based on the above facts, answer the following questions.



52. Total magnetic flux associated with the loop is

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

53. Magnitude of emf in this circuit only due to flux change associated with two long straight current carrying wires will be

- (A) $\frac{\mu_0 I_0 \omega a \log_e(2)}{\pi} \sin(\omega t)$
 (B) $\frac{2\mu_0 I_0 \omega a \log_e(2)}{\pi} \sin(\omega t)$
 (C) $\frac{\mu_0 I_0 \omega a \log_e(2)}{2\pi} \cos(\omega t)$
 (D) $\frac{\mu_0 I_0 \omega a \log_e(2)}{\pi} \cos(\omega t)$

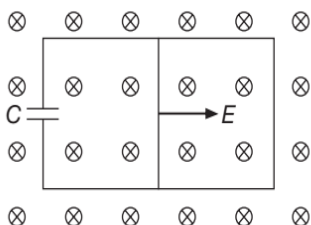
54. The instantaneous current in the circuit will be

- (A) $\frac{2\mu_0 I_0 \omega a \log_e(2)}{\pi \sqrt{R^2 + \omega^2 L^2}} \sin(\omega t - \phi)$
 (B) $\frac{2\mu_0 I_0 \omega a \log_e(2)}{\pi \sqrt{R^2 + \omega^2 L^2}} \sin(\omega t + \phi)$
 (C) $\frac{\mu_0 I_0 \omega a \log_e(2)}{\pi \sqrt{R^2 + \omega^2 L^2}} \sin(\omega t)$
 (D) $\frac{\mu_0 I_0 \omega a \log_e(2)}{\pi \sqrt{R^2 + \omega^2 L^2}} \sin(\omega t - \phi)$
 (where $\tan \phi = \frac{\omega L}{R}$)

Comprehension 18

A uniform wire of mass m and length l can slide freely on a pair of parallel, frictionless, horizontal rails placed in a vertical constant magnetic field B (as shown in figure).

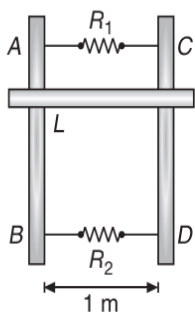
The rails are connected by a capacitor of capacitance C . The electric resistance of the circuit is zero. At $t = 0$, a constant horizontal force F acts on the middle point of wire and the wire was at rest initially. Based on the above facts, answer the following questions.



55. At $t = 0$, electric current in the circuit is
- (A) ZERO (B) $\frac{BICF}{(m + B^2l^2C)}$
- (C) $\frac{BICF}{m}$ (D) $\frac{Blv}{R}$
56. At $t = 0$, acceleration of wire is
- (A) $\frac{F}{m}$ (B) $\frac{F}{(m + B^2l^2C)}$
- (C) $\frac{F}{B^2l^2C}$ (D) $\frac{F}{2m}$

Comprehension 19

Two parallel vertical metallic rails AB and CD are separated by 1 m . They are connected at the two ends by resistances R_1 and R_2 as shown in Figure.

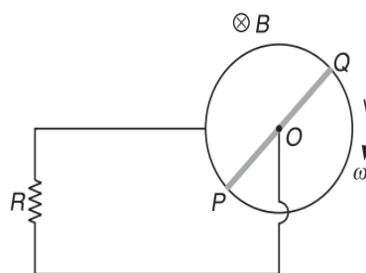


A horizontal metallic bar L of mass 0.2 kg slides without friction, vertically down the rails under the action of gravity. There is a uniform horizontal magnetic field of 0.6 T perpendicular to the plane of the rails. It is observed that when the terminal velocity is attained, the powers dissipated in R_1 and R_2 are 0.76 W and 1.2 W respectively ($g = 9.8\text{ ms}^{-2}$). Based on the above facts, answer the following questions.

57. The terminal velocity of the bar L will be
- (A) 2 ms^{-1} (B) 3 ms^{-1}
- (C) 1 ms^{-1} (D) None of these
58. The value of R_1 is
- (A) $0.47\ \Omega$ (B) $0.82\ \Omega$
- (C) $0.12\ \Omega$ (D) None of these
59. The value of R_2 is
- (A) $0.6\ \Omega$ (B) $0.5\ \Omega$
- (C) $0.4\ \Omega$ (D) $0.3\ \Omega$

Comprehension 20

A conducting rod PQ of mass M rotates without friction on a horizontal plane about O on circular rails of diameter l . The centre O and the periphery are connected by resistance R . The system is located in a uniform magnetic field perpendicular to the plane of the loop. At $t = 0$, PQ starts rotating clockwise with angular velocity ω_0 . Neglect the resistance of the rails and rod, as well as self-inductance.



Based on the above facts, answer the following questions.

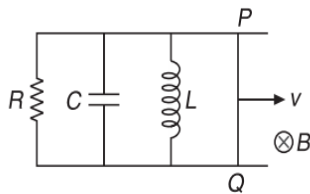
60. Magnitude of current as a function of time
- (A) $\frac{B\omega_0 l^2}{2R} e^{-at}$ (B) $\frac{B\omega_0 l^2}{16R} e^{-2at}$
- (C) $\frac{B\omega_0 l^2}{8R} e^{-at}$ (D) $\frac{B\omega_0 l^2}{8R} e^{-2at}$
- where $\alpha = \frac{3B^2 l^2}{8RM}$
61. Total charge flow through the resistance till rod PQ stops rotating is
- (A) $\frac{\omega_0 M}{8B}$ (B) $\frac{\omega_0 M}{3B}$
- (C) $\frac{\omega_0 M}{6B}$ (D) $\frac{\omega_0 M}{9B}$

62. Heat generated in the circuit by $t = \infty$

- (A) $\frac{Ml^2 \omega_0^2}{24}$ (B) $\frac{Ml^2 \omega_0^2}{8}$
 (C) $\frac{Ml^2 \omega_0^2}{3}$ (D) $\frac{Ml^2 \omega_0^2}{32}$

Comprehension 21

A conducting wire PQ of length $l = 1 \text{ m}$, is moved in a uniform magnetic field $B = 4 \text{ T}$ with constant velocity $v = 2 \text{ ms}^{-1}$ towards right as shown in Figure.



If $R = 2 \Omega$, $C = 1 \text{ F}$ and $L = 4 \text{ H}$ then, answer the following questions.

63. If V_P and V_Q are potentials of the point P and Q respectively, then
 (A) $V_P - V_Q = 0$ (B) $V_P - V_Q = -8 \text{ V}$
 (C) $V_Q - V_P = 4 \text{ V}$ (D) $V_Q - V_P = -8 \text{ V}$
64. The potential difference across the inductor is
 (A) 0 V (B) 2 V
 (C) 4 V (D) 8 V
65. The potential difference across the capacitor is
 (A) 0 V (B) 2 V
 (C) 4 V (D) 8 V
66. The potential difference across the resistor is
 (A) 0 V (B) 2 V
 (C) 4 V (D) 8 V
67. The rate of change of current in the inductor is
 (A) 8 As^{-1} (B) 4 As^{-1}
 (C) 2 As^{-1} (D) 1 As^{-1}
68. The current through capacitor at $t = 2 \text{ s}$ is
 (A) ZERO (B) 2 A
 (C) 4 A (D) 6 A
69. The current through resistor at $t = 2 \text{ s}$ is
 (A) ZERO (B) 2 A
 (C) 4 A (D) 6 A
70. The current through inductor at $t = 2 \text{ s}$ is
 (A) ZERO (B) 2 A
 (C) 4 A (D) 6 A
71. The current through wire PQ at $t = 2 \text{ s}$ is
 (A) 2 A (B) 4 A
 (C) 6 A (D) 8 A
72. The force required to move the wire with the given constant velocity of 2 ms^{-1} at $t = 2 \text{ s}$ is
 (A) 8 N (B) 16 N
 (C) 24 N (D) 32 N
73. The energy supplied per second by the source is
 (A) 16 W (B) 32 W
 (C) 64 W (D) 128 W
74. The total power generated by the applied external force is
 (A) 16 W (B) 32 W
 (C) 64 W (D) 128 W
75. The magnetic energy stored per second in inductor at $t = 2 \text{ s}$ is
 (A) 16 W (B) 32 W
 (C) 64 W (D) 128 W
76. The energy dissipated per second in the resistor at $t = 2 \text{ s}$ is
 (A) 16 W (B) 32 W
 (C) 64 W (D) 128 W
77. The electrostatic stored per second in capacitor at $t = 2 \text{ s}$ is
 (A) 0 W (B) 16 W
 (C) 32 W (D) 64 W

Comprehension 22

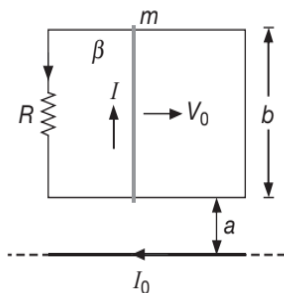
A fan operates at 200 volt (DC) consuming 1000 W when running at full speed. It's internal wiring has resistance 1Ω . When the fan runs at full speed, it's speed becomes constant. This is because the torque due to magnetic field inside the fan is balanced by the torque due to air resistance on the blades of the fan and torque due to friction between the fixed part and the shaft of the fan. The electrical power going into the fan is spent (i) in the internal resistance as heat, call it P_1 (ii) in doing work against internal friction and air resistance producing heat, sound etc. call it P_2 .

When the coil of fan rotates, an emf is also induced in the coil. This opposes the external emf applied to send the current into the fan. This emf is called back emf, call it ξ . Answer the following questions when the fan is running at full speed.

78. The current flowing into the fan and the value of back emf ξ is
 (A) 200 A, 5 volt (B) 5 A, 200 volt
 (C) 5 A, 195 volt (D) 1 A, 0 volt
79. The value of power P_1 is
 (A) 1000 W (B) 975 W
 (C) 25 W (D) 200 W
80. The value of power P_2 is
 (A) 1000 W (B) 975 W
 (C) 25 W (D) 200 W

Comprehension 23

A long straight wire carries a current I_0 . At distances a and b from it, there are two other wires, parallel to the former one, which are interconnected by a resistance R . A connector of mass m slides without friction along the wires with an initial velocity v_0 at time $t = 0$. Assume the resistances of the wires, the connector, the sliding contacts and the self-inductances of the frame to be negligible. Based on the above facts, answer the following questions.



81. The current I , induced in the circuit is
 (A) ZERO
 (B) $\frac{\mu_0 I_0 b v}{2\pi R}$, anticlockwise
 (C) $\frac{\mu_0 I_0 v_0}{2\pi R} \log_e \left(\frac{b}{a} \right)$, anticlockwise
 (D) $\frac{\mu_0 I_0 v_0}{2\pi R} \log_e \left(\frac{a}{b} \right)$, clockwise

82. The time after which velocity becomes half is

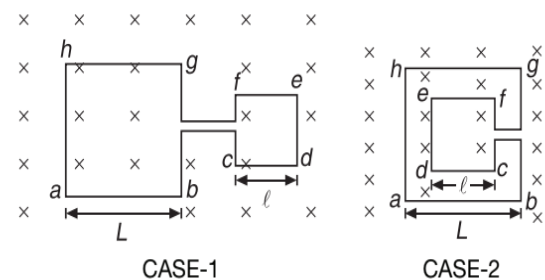
(A) $\frac{4\pi^2 m R \ln 2}{\mu_0^2 I_0^2 \left(\ln \left(\frac{b}{a} \right) \right)^2}$ (B) $\frac{2\pi^2 m R}{\mu_0^2 I_0^2 \left(\ln \left(\frac{b}{a} \right) \right)^2}$
 (C) $\frac{\pi^2 m R \log_e (2)}{\mu_0^2 I_0^2 \left(\ln \left(\frac{b}{a} \right) \right)^2}$ (D) infinity

83. The distance covered by the rod until it comes to rest is proportional to

(A) v_0 (B) $\sqrt{v_0}$
 (C) $\frac{1}{\sqrt{v_0}}$ (D) $v_0^{-\frac{2}{3}}$

Comprehension 24

Two different arrangements in which two square wire frames are placed in a uniform constantly decreasing magnetic field B are shown in Figure.



In both cases, length of larger square is L and that of the smaller square is l . Based on the above facts, answer the following questions.

84. The value of magnetic flux in CASE-1 and CASE-2, respectively are
 (A) $\phi = \pi(L^2 + l^2)B$, $\phi = \pi(L^2 - l^2)B$
 (B) $\phi = \pi(L^2 + l^2)B$, $\phi = \pi(L^2 + l^2)B$
 (C) $\phi = (L^2 + l^2)B$, $\phi = (L^2 + l^2)B$
 (D) $\phi = (L^2 + l^2)B$, $\phi = (L^2 - l^2)B$
85. The direction of induced current in the CASE-1 is
 (A) from a to b and from c to d
 (B) from a to b and from f to e
 (C) from b to a and from d to c
 (D) from b to a and from e to f



86. The direction of induced current in the CASE-2 is
 (A) from a to b and from c to d
 (B) from b to a and from f to e
 (C) from b to a and from c to d
 (D) from a to b and from d to c
87. If I_1 and I_2 are the magnitudes of induced current in the CASES-1 and 2 respectively, then,
 (A) $I_1 = I_2$ (B) $I_1 > I_2$
 (C) $I_1 < I_2$ (D) Nothing can be said

Comprehension 25

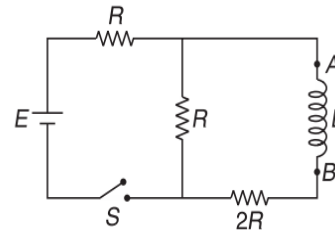
An LC circuit contains a 20 mH inductor and a 50 μF capacitor with an initial charge of 10 mC. The resistance of the circuit is negligible. Let the instant when the circuit is closed, be at $t = 0$. Based on the above facts, answer the following questions.

88. The total energy stored initially is and is during the LC oscillations. Then
 (A) 0.01 J, conserved (B) 0.1 J, not conserved
 (C) 1 J, conserved (D) 2 J, not conserved
89. The natural frequency of the circuit is
 (A) 50 Hz (B) 159 Hz
 (C) 259 Hz (D) 300 Hz
90. The times at which the energy stored is completely electrical i.e., stored in the capacitor are
 (A) $0, \frac{T}{2}, T, \frac{3T}{2}$ (B) $0, \frac{T}{4}, \frac{3T}{4}$
 (C) $\frac{T}{6}, \frac{T}{12}$ (D) $\frac{T}{4}, \frac{7T}{4}, \frac{9T}{4}$
91. The times at which the energy stored is completely magnetic i.e., stored in the inductor are
 (A) $0, \frac{T}{2}, T, \frac{3T}{2}$ (B) $0, \frac{T}{4}, \frac{7T}{4}, \frac{9T}{4}$
 (C) $\frac{T}{6}$ (D) $\frac{T}{4}, \frac{3T}{4}, \frac{5T}{4}$
92. The times at which the total energy is equally shared between the inductor and the capacitor are
 (A) $0, \frac{T}{2}, T, \frac{3T}{2}$ (B) $\frac{T}{4}, \frac{3T}{4}, \frac{5T}{4}$
 (C) $\frac{T}{8}, \frac{3T}{8}, \frac{5T}{8}$ (D) $\frac{T}{12}, \frac{3T}{12}, \frac{5T}{12}$

93. If a resistor is inserted in the circuit, how much energy is eventually dissipated as heat?
 (A) 0.01 J (B) 0.1 J
 (C) 1 J (D) 1.4 J

Comprehension 26

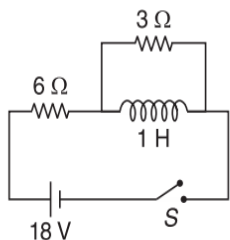
An inductor is connected to three resistors as shown in Figure. Assuming that the switch S is closed at $t = 0$, then answer the following questions.



94. The current flowing through the resistor $2R$ just when the switch is closed is
 (A) $\frac{E}{R}$ (B) $\frac{2E}{R}$
 (C) $\frac{E}{2R}$ (D) $\frac{E}{4R}$
95. The time constant of the circuit is
 (A) $\frac{5R}{2L}$ (B) $\frac{2R}{5L}$
 (C) $\frac{5L}{2R}$ (D) $\frac{2L}{5R}$
96. The open circuit voltage across the terminals of the inductor just when the switch is closed is
 (A) E (B) $\frac{E}{2}$
 (C) $\frac{E}{3}$ (D) $\frac{E}{4}$
97. The current through the inductor as a function of time is
 (A) $\frac{E}{5R} \left(1 - e^{-\frac{2Rt}{5L}}\right)$ (B) $\frac{E}{5R} \left(1 - e^{-\frac{5Rt}{2L}}\right)$
 (C) $\frac{5E}{R} \left(1 - e^{-\frac{5Rt}{2L}}\right)$ (D) $\frac{5E}{R} \left(1 - e^{-\frac{2Rt}{5L}}\right)$
98. The current supplied by the battery as a function of time is
 (A) $\frac{E}{2R} - \frac{E}{10R} \left(1 - e^{-\frac{5Rt}{2L}}\right)$ (B) $\frac{E}{R} + \frac{E}{10R} \left(1 - e^{-\frac{5Rt}{2L}}\right)$
 (C) $\frac{E}{2R} + \frac{E}{10R} \left(1 - e^{-\frac{5Rt}{2L}}\right)$ (D) $\frac{E}{R} - \frac{E}{10R} \left(1 - e^{-\frac{5Rt}{2L}}\right)$

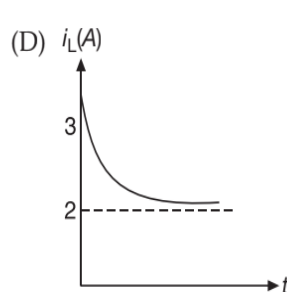
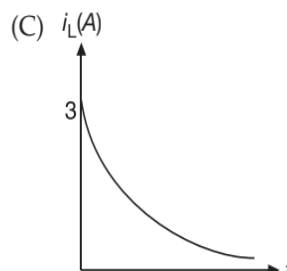
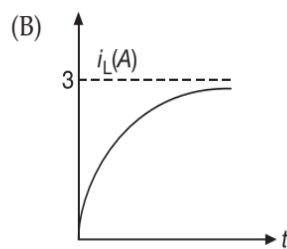
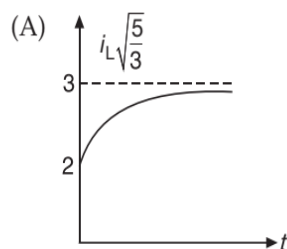
Comprehension 27

In LR circuits, the time constant of the circuit can be obtained by the expression $\tau = \frac{L}{R_{\text{net}}}$, where R_{net} is the net resistance across inductor after short circuiting the battery. In the circuit shown in Figure, switch S is closed at time $t = 0$. Based on the above facts, answer the following questions.



99. The potential difference across $3\ \Omega$ resistance at time t is given by
 (A) $9e^{-2t}$ (B) $6e^{-2t}$
 (C) $3e^{-2t}$ (D) $18\left(1 - e^{-\frac{t}{9}}\right)$
100. Current I from the battery at time t is given by
 (A) $3(1 - e^{-2t})$ (B) $3 + e^{-2t}$
 (C) $3\left(1 - e^{-\frac{t}{9}}\right)$ (D) $3 - e^{-2t}$
101. The time when the currents through $3\ \Omega$ resistance and $1\ \text{H}$ inductor are equal is
 (A) $\ln\sqrt{\frac{5}{3}}$ (B) $\ln\sqrt{\frac{3}{5}}$
 (C) $\ln\left(\frac{5}{3}\right)$ (D) $\ln\left(\frac{3}{5}\right)$

102. Taking left to right current through the inductor as positive current, current through inductor varies with time t as



MATRIX MATCH/COLUMN MATCH TYPE QUESTIONS

Each question in this section contains statements given in two columns, which have to be matched. The statements in COLUMN-I are labelled A, B, C and D, while the statements in COLUMN-II are labelled p, q, r, s (and t). Any given statement in COLUMN-I can have correct matching with ONE OR MORE statement(s) in COLUMN-II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

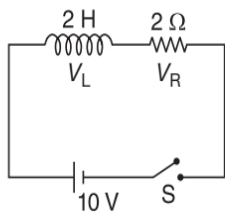
If the correct matches are $A \rightarrow p, s$ and t ; $B \rightarrow q$ and r ; $C \rightarrow p$ and q ; and $D \rightarrow s$ and t ; then the correct darkening of bubbles will look like the following:

	p	q	r	s	t
A	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
B	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

1. A uniform circular disc of mass M , radius R , having uniformly distributed charge Q is placed on a horizontal rough floor of coefficient of friction μ . A uniform, vertically downward magnetic field, varying with time t as $B = B_0 t^2$, is confined in a cylindrical region of radius $r (> R_0)$ coaxial with the disc. Assuming B_0 to be a positive constant, match quantities in **COLUMN-I** (given as a multiple of k) with their respective k values in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Rotation of disc begins at time $t_0 = k \left(\frac{\mu M g}{Q B_0 R} \right)$.	(p) $\frac{2}{3}$
(B) Torque due to friction at $t = 2$ s is $\tau_f = k(\mu M g R)$.	(q) $\frac{8}{9}$
(C) Torque due to magnetic field at time values $t = 0, t = t_0$ and $t = 3t_0$ are $k(\mu M g R)$, with multiple respective values of k to be selected from COLUMN-II .	(r) ZERO
(D) Angular velocity of disc at $t = 2t_0$ is $\omega = k \left(\frac{M \mu^2 g^2}{Q B_0 R^2} \right)$.	(s) $\frac{4}{3}$
	(t) 2

2. In the circuit shown in Figure, switch is closed at time $t = 0$. Match the contents of **COLUMN-I** with their values in **COLUMN-II**.



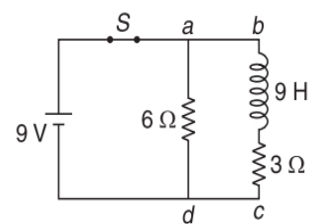
COLUMN-I	COLUMN-II
(A) V_L at $t = 0$	(p) zero
(B) V_R at $t = 0$	(q) 10 V

COLUMN-I	COLUMN-II
(C) V_L at $t = 1$ s	(r) $\frac{10}{e}$ V
(D) V_R at $t = 1$ s	(s) $10 \left(1 - \frac{1}{e} \right)$ V

3. Match the dimensional formulae with the corresponding units.

COLUMN-I	COLUMN-II
(A) $ML^2T^{-2}A^{-1}$	(p) farad
(B) $M^{-1}L^{-2}T^4A^2$	(q) weber
(C) $ML^2T^{-2}A^{-2}$	(r) ohm
(D) $ML^2T^{-3}A^{-2}$	(s) henry

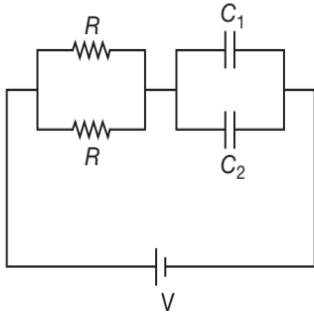
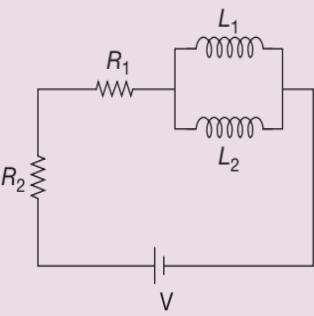
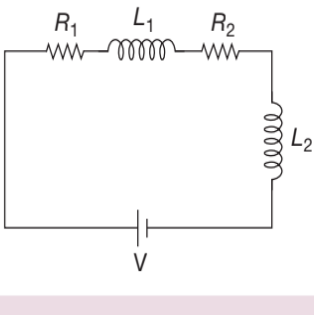
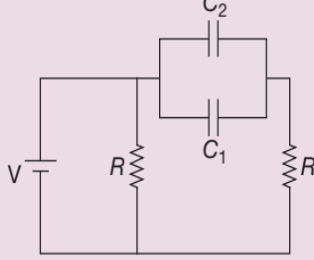
4. In the circuit shown in Figure, switch remains closed for long time. It is opened at time $t = 0$. Match the following two columns at $t = (\ln 2)$ second. Match the potential difference specified in **COLUMN-I** to the respective values given in **COLUMN-II**.



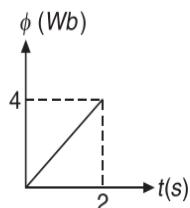
COLUMN-I	COLUMN-II
(A) Across inductor	(p) 9 V
(B) Across 3 Ω resistance	(q) 4.5 V
(C) Across 6 Ω resistance	(r) 6 V
(D) Between points b and c	(s) 13.5 V

(Continued)

5. Match the circuit with their respective time constants.

COLUMN-I	COLUMN-II
<p>(A) </p>	(p) $\frac{(L_1 + L_2)}{(R_1 + R_2)}$
<p>(B) </p>	(q) $\frac{R}{2}(C_1 + C_2)$
<p>(C) </p>	(r) $R(C_1 + C_2)$
<p>(D) </p>	(s) $\frac{\left(\frac{L_1 L_2}{L_1 + L_2}\right)}{R_1 + R_2}$

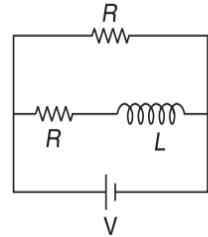
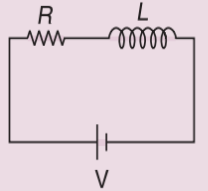
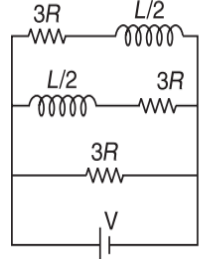
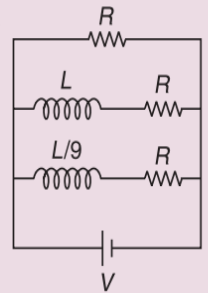
6. The variation of magnetic flux associated with a coil of resistance $2\ \Omega$ varies with time t as shown in Figure.



Match the quantities in COLUMN-I with their respective values (in SI units) in COLUMN-II.

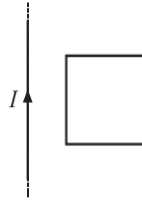
COLUMN-I	COLUMN-II
(A) Induced emf produced	(p) 4
(B) Induced current	(q) 1
(C) Charge flow in 2 s	(r) 8
(D) Heat generation in 2 s	(s) 2

7. Different LR circuits connected to a battery of potential difference V are shown in COLUMN-I. COLUMN-II shows the amount of current passing through inductor and magnetic energy stored in each inductor separately if there are two inductors in steady state. Match the situations in COLUMN-I with appropriate value in COLUMN-II.

COLUMN-I	COLUMN-II
<p>(A) </p>	(p) $\frac{V}{R}$
<p>(B) </p>	(q) $\frac{V}{3R}$
<p>(C) </p>	(r) $\frac{LV^2}{2R^2}$ Joule
<p>(D) </p>	(s) $\frac{LV^2}{36R^2}$ Joule
	(t) $\frac{LV^2}{18R^2}$ Joule



8. A square loop of perimeter $4l$, is placed near a long straight wire carrying a current I as shown. Match phenomenon in **COLUMN-I** with the consequences in **COLUMN-II**.

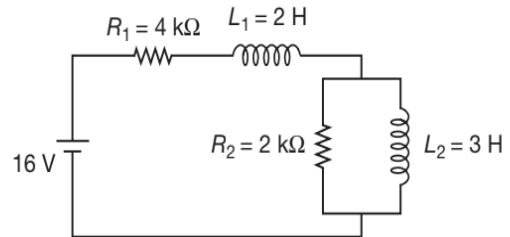


COLUMN-I	COLUMN-II
(A) I is increased	(p) Induced current in loop is clockwise
(B) I is decreased	(q) Induced current in loop is anticlockwise
(C) If loop is moved away from the wire	(r) wire will attract the loop
(D) If loop is moved towards the wire	(s) wire will repel the loop

9. **COLUMN-I** gives certain situations in which a straight metallic wire of resistance R is used and **COLUMN-II** gives some resulting effects. Match the statements in **COLUMN-I** with the statements in **COLUMN-II**.

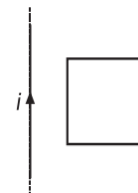
COLUMN-I	COLUMN-II
(A) A charged capacitor is connected to the ends of the wire.	(p) A constant current flow through the wire.
(B) The wire is moved perpendicular to its length with a constant velocity in a uniform magnetic field perpendicular to the plane of motion.	(q) Thermal energy is generated in the wire.
(C) The wire is placed in a constant electric field that has a direction along the length of the wire.	(r) A constant potential difference develops between the ends of the wire.
(D) A battery of constant emf is connected to the ends of the wire.	(s) Charges of constant magnitude appear at the ends of the wire.

10. In the circuit shown, $L_1 = 2 \text{ H}$, $L_2 = 3 \text{ H}$, $R_1 = 4 \text{ k}\Omega$ and $R_2 = 2 \text{ k}\Omega$. In steady state, match the items of **COLUMN-I** to the values in **COLUMN-II**.



COLUMN-I	COLUMN-II
(A) The current through inductor L_1 in mA .	(p) 16
(B) The voltage across inductor L_2 in volt.	(q) 10
(C) The energy stored in inductor L_1 in μJ .	(r) 4
(D) The energy stored in inductor L_2 in μJ .	(s) 0
	(t) 24

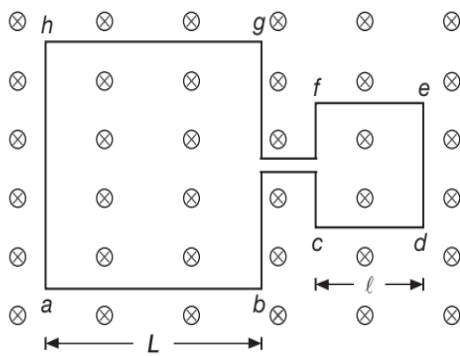
11. A square loop is placed near a long straight current carrying wire as shown in Figure.



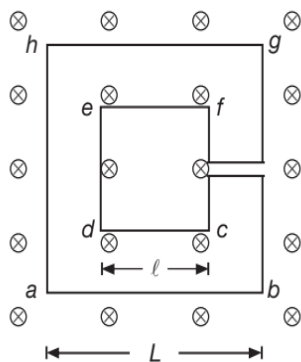
Match the following two **COLUMNS**.

COLUMN-I	COLUMN-II
(A) If current is increased	(p) induced current in loop is clockwise
(B) If current is decreased	(q) induced current in loop is anti-clockwise
(C) If loop is moved away from the wire	(r) wire will attract the loop
(D) If loop is moved towards the wire	(s) wire will repel the loop

12. The figure shows two different arrangements in which two square wire frames are placed in a uniform constantly decreasing magnetic field B .



FRAME I



FRAME II

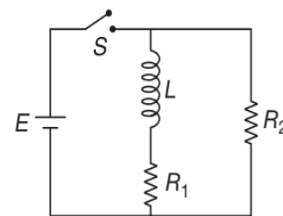
COLUMN-I	COLUMN-II
(A) Magnetic flux in wire frame I	(p) $(L^2 - l^2)B$
(B) Magnetic flux in wire frame II	(q) $(L^2 + l^2)B$
(C) Direction of induced current in wire frame I	(r) from b to a and from f to e
(D) Direction of induced current in wire frame II	(s) from b to a and from c to d
	(t) from b to a and from d to c

13. Consider an LC oscillating circuit and oscillations of a spring block system. Let Q and V be the initial charge and potential on the capacitor, I be the current in the circuit at time t , $\frac{dI}{dt}$ be the rate of change of current, U_C and U_L be the maximum energy across

the capacitor and the inductor. Further if mass of block is m , spring constant of spring is k , displacement of block or extension in the spring is x , acceleration of block at any instant is a , F be the restoring force, K be the kinetic energy of block and U be the potential energy of the spring, then match the pairs in COLUMN-I to those in COLUMN-II.

COLUMN-I	COLUMN-II
(A) L, C	(p) x, F
(B) $I, \frac{dI}{dt}$	(q) $m, \frac{1}{k}$
(C) Q, V	(r) U, K
(D) U_C, U_L	(s) v, a
	(t) K, U

14. In the circuit shown in Figure, $E = 18 \text{ V}$, $L = 2 \text{ H}$, $R_1 = 3 \Omega$, $R_2 = 6 \Omega$. Switch S is closed at $t = 0$. Match the following currents through a particular element (at an instant) in COLUMN-I with their respective values in COLUMN-II.

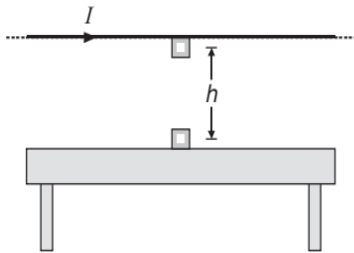


COLUMN-I	COLUMN-II
(A) R_1 at $t = 0$	(p) 6 A
(B) R_1 at $t \rightarrow \infty$	(q) 3 A
(C) R_2 at $t = 0$	(r) zero
(D) R_2 at $t \rightarrow \infty$	(s) Infinite

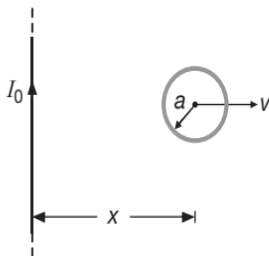
INTEGER/NUMERICAL ANSWER TYPE QUESTIONS

In this section, the answer to each question is a numerical value obtained after doing series of calculations based on the data given in the question(s).

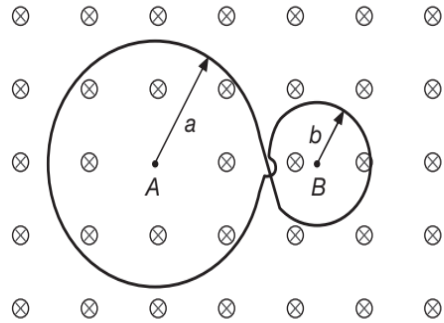
1. A small square washer of side 0.5 cm is held directly below a long, straight wire carrying a current of 10 A. The washer is located 0.5 m above the top of a table.



- (a) If the washer is dropped from rest, what is the magnitude of the average induced emf, in nano volt, in the washer from the time it is released to the moment it hits the table-top? Assume that the magnetic field is nearly constant over the area of the washer, and equal to the magnetic field at the center of the washer.
- (b) What is the direction of the induced current in the washer?
2. A small conducting loop of radius a and resistance per unit length λ , is pulled with velocity v perpendicular to a long straight conductor carrying a current I_0 . If a constant power P is dissipated in the loop, the variation of velocity of the loop as a function of x is $\frac{x^2}{\mu_0 I_0 a^2} \sqrt{k a \pi \lambda P}$, where k is an integer. {Given that $x \gg a$ }.

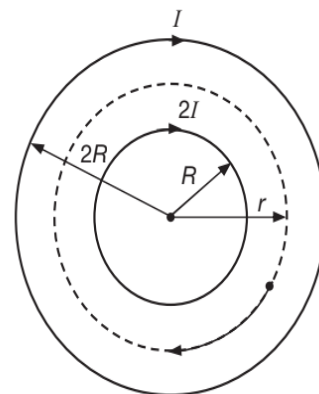


3. A plane loop is shaped in the form as shown in Figure with radii $a = 20$ cm and $b = 10$ cm and is placed in a uniform time varying magnetic field $B = B_0 \sin(\omega t)$ where $B_0 = 10$ mT and $\omega = 10$ rads $^{-1}$.



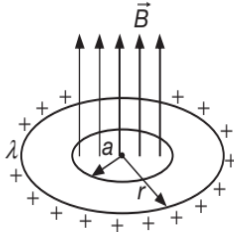
Find the amplitude of the induced current, in ampere, in the loop if its resistance per unit length $\lambda = 50 \times 10^{-3} \Omega \text{m}^{-1}$. The inductance of the loop is negligible.

4. Calculate the length of a thin wire in metre required to manufacture a solenoid of length 100 cm and inductance 1 mH. Assume that the solenoid's cross-sectional diameter is considerably less than its length.
5. A long solenoid of radius $2R$ contains another coaxial solenoid of half the radius. The coils have the same number of turns per unit length and initially both carry no current. At a same instant, the currents in both solenoids start increasing linearly with time. At any moment the current flowing in the inner coil is twice as large as that in the outer one and their directions are the same. Due the increasing currents, a charged particle, initially at rest between the solenoids, starts moving along a circular trajectory (see Figure) of radius $r = \sqrt{k}R$. Then find k .



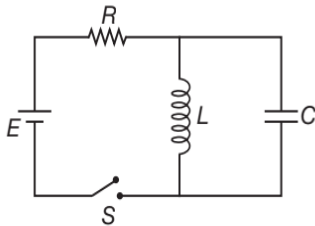
6. A ring of mass 4 kg is uniformly charged with $\lambda = 4$ cm $^{-1}$ and kept on rough horizontal surface with friction coefficient $\mu = \frac{\pi}{4}$. A time varying magnetic

field $B = B_0 t^2$ is applied in a circular region of radius a ($a < r$) perpendicular to the plane of ring as shown in Figure.

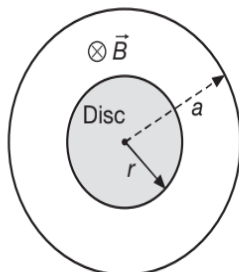


Find out the time when ring just starts to rotate on surface. (Take $a = 5$ cm and $g = 10$ ms⁻²) $\beta_0 = 125$ SI unit.

7. In the circuit of Figure, the battery emf is 50 V, the resistance is 250 Ω and the capacitance is 0.5 μ F. The switch S is closed for a long time and no voltage is measured across the capacitor. After the switch is opened, the potential difference across the capacitor reaches a maximum value of 150 V. Calculate the inductance, in mH, to the nearest three-digit integer.

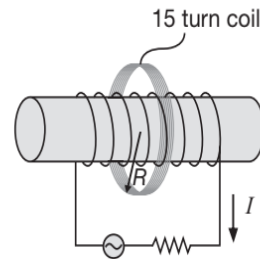


8. A uniform disc of radius r and mass m is charged uniformly with the charge q . This disc is placed flat on a rough horizontal surface having coefficient of friction μ . A uniform magnetic field is present in a circular region ($a > r$) but varying as kt^3 as shown in Figure.



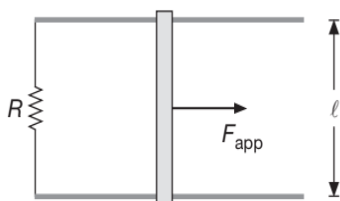
Find the time, in second, after which the disc begins to rotate. (Given $r = 1$ m, $m = 18$ kg, $q = 1$ C, $\mu = 0.1$, $K = 4$, $g = 10$ ms⁻²)

9. A coil formed by wrapping 50 turns of wire in the shape of a square is positioned in a magnetic field so that the normal to the plane of the coil makes an angle of 30° with the direction of the field. When the magnetic field is increased uniformly from 200 μ T to 600 μ T in 0.4 s, an emf of magnitude 80 mV is induced in the coil. Calculate the total length of the wire, in metre.
10. A coil of 15 turns and radius 10 cm surrounds a long solenoid of radius 2 cm and 1000 turns per metre as shown. The current in the solenoid changes as I (in ampere) = $4 \cos(250t)$. Find the induced peak emf, in millivolt, in the 15 turn coil as a function of time. (Take $\pi^2 = 10$)

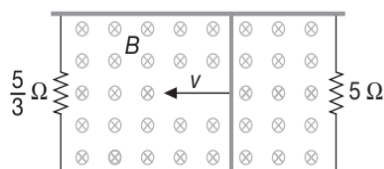


11. A thin charged ring of radius $a = 9$ cm rotates about its axis with an angular velocity $\omega = 100$ rads⁻¹. The ratio of volume energy densities of magnetic and electric field at the axis of the ring at a point lying on the axis of the ring at a distance equal to the radius of the ring is $(*) \times 10^{-16}$, where $*$ is not readable. Find $*$.
12. It has been observed that very large magnetic fields can be produced by adopting a method called **flux compression**. In this method a metallic cylindrical tube of radius R is placed coaxially in a long solenoid of somewhat larger radius. The space between the tube and the solenoid is filled with a highly explosive material. When the explosive is set off, it collapses the tube to a cylinder of radius $r < R$. If the collapse happens so rapidly that the induced current in tube maintains a nearly constant magnetic flux inside the tube. If the initial magnetic field in the solenoid is 2.5 T, and $\frac{R}{r} = 12$, what maximum value of magnetic field, in tesla, can be achieved?

13. Figure shows a top view of a bar of length $l = 1.2$ m that can slide without friction. The resistor is 6 Ω and a 2.5 T magnetic field is directed perpendicularly downward, into the paper.

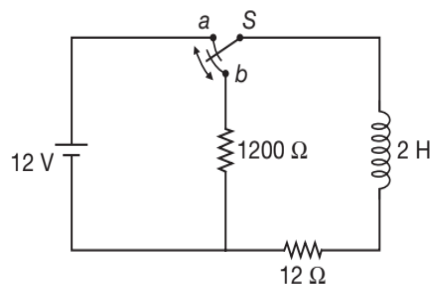


- (a) Calculate the applied force, in newton, required to move the bar to the right at a constant speed of 2 ms^{-1} .
- (b) At what rate, in SI units, is energy delivered to the resistor?
14. An iron core is inserted into a solenoid 0.5 m long with 4 turns per unit centimetre. The area of cross-section of the solenoid is 0.001 m^2 . If the magnetic flux associated with the cross-section of the solenoid is $1.6 \times 10^{-3} \text{ Wb}$, then calculate the relative permeability of the core when a current of 5 A flows through the solenoid and the inductance of the solenoid in mH .
15. A conducting rod of length $l = 50 \text{ cm}$ is free to slide on two parallel conducting bars as shown in Figure. Two resistors $R_1 = \frac{5}{3} \Omega$ and $R_2 = 5 \Omega$ are connected across the ends of the bars to form a loop. A constant magnetic field $B = 2.5 \text{ T}$ is directed perpendicularly into the page. An external agent pulls the rod to the left with a constant speed of $v = 8 \text{ ms}^{-1}$. Find (in SI units)

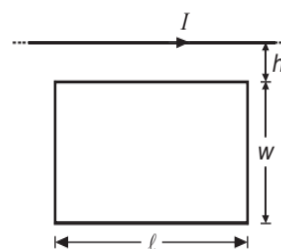


- (a) the current in both resistors and the rod.
- (b) the total power delivered to the resistance of the circuit, and
- (c) the magnitude of the applied force required to move the rod with this constant velocity.
16. The magnetic flux through a metal ring varies with time t according to $\phi_B = 3(at^3 - bt^2) \text{ Tm}^2$, with $a = 2 \text{ s}^{-3}$ and $b = 6 \text{ s}^{-2}$. The resistance of the ring is 3Ω . Determine the maximum current induced in the ring during the interval from $t = 0$ to $t = 2 \text{ s}$.
17. A 42 H inductor carries a current of 20 A . Calculate the amount of ice in gram at 0°C that could be melted by the energy stored as magnetic field in the inductor if the latent heat of ice is taken to be 80 calg^{-1} .
18. A $1 \mu\text{F}$ capacitor is charged by a 40 V power supply. The fully charged capacitor is then discharged through a 10 mH inductor. Find the maximum current in, mA , in the resulting oscillations.

19. For the circuit shown, answer the following questions.



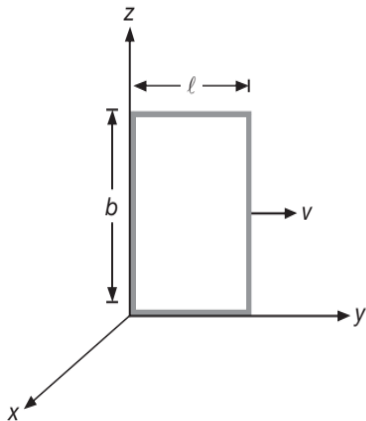
- (a) What is the current, in ampere, in the circuit a long time after the switch has been in position a ?
- (b) Now the switch is thrown quickly from a to b . Compute the initial voltage, in volt, across each resistor and across the inductor.
- (c) The time elapsed before the voltage across the inductor drops to 12 V is $x \times 10^{-4} \text{ s}$. Then find x . Take $\log_e(101) = 4.6$.
20. A relatively long straight conductor and a conducting rectangular loop lie in the same plane, as shown in Figure.



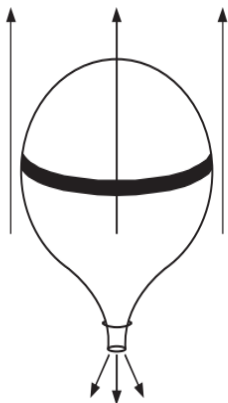
Taking $h = 0.4 \text{ mm}$, $w = 1.3 \text{ mm}$ and $l = 2.7 \text{ mm}$, find their mutual inductance, in pH (picohenry).

21. A series RL circuit with $L = 3 \text{ H}$ and a series RC circuit with $C = 3 \mu\text{F}$ have equal time constants. The two circuits contain the same resistance R . Find the value of R , in $\text{k}\Omega$ and the time constant, in millisecond.
22. Assuming the magnetic field in the space surrounding the earth to be varying according to the expression $B = \frac{B_0 R^2}{r^2}$ where B_0 is the field close to the surface of earth, R is the radius of the earth and r is the radial distance from its centre. Take $B_0 = 50 \mu\text{T}$ and $R = 6 \times 10^6 \text{ m}$, find the energy associated with this magnetic field surrounding the earth. Assume all other fields to be absent or negligible in comparison to B_0 . Give your answer in peta joule.
23. A solenoid has an inductance of 20 H and a resistance of 2Ω . It is connected to a 10 V battery through a switch S . Calculate the time taken (in second) for the magnetic energy to reach one fourth of its maximum value. Take $\ln(2) \approx 0.7$

24. A rectangular loop $l \times b$, where $l = 2$ m and $b = 5$ m is moved through a region in which the magnetic field is given by $B_y = B_z = 0$, $B_x = (6 - y)T$. Find the induced emf, in volt, in the loop, at $t = 1$ s, if at $t = 0$, the loop starts moving from rest, from the position (shown in Figure)
- (a) at constant velocity $v = 3 \text{ ms}^{-1}$
- (b) at constant acceleration of 2 ms^{-2} .



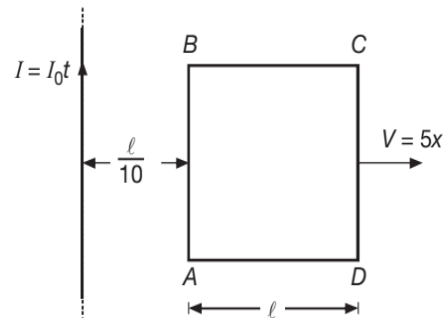
25. An elasticized conducting band is wrapped around a spherical balloon. Its plane passes through the centre of the balloon. A uniform magnetic field of magnitude 0.04 T is directed perpendicular to the plane of the band. Air is let out of the balloon at $100 \text{ cm}^3 \text{ s}^{-1}$ at an instant when the radius of the balloon is 6 cm . What is the emf induced, in μV , in the band?



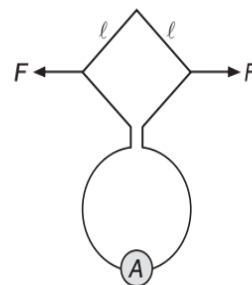
26. As shown in Figure a square shaped conducting loop having side length l and resistance $R = \frac{\mu_0 I_0 l}{2\pi}$ is moving away with a velocity $v = 5x$, where x is the separation between conductor and side AB of the loop at any instant, from an infinitely long current carrying conductor carrying a time dependent current given by $I = I_0 t$. At $t = 0$ the side AB is at a distance $\frac{l}{10}$ from

the conductor. Find the current, in milliamperes, to the nearest three digit integer, in the loop when the side AB is at a distance $10l$ from the conductor.

(Given: $\log_e(100) = 4.605$ and $\log_e(1.1) = 0.095$)



27. A 1 mH inductor and a $1 \mu\text{F}$ capacitor is connected in series. The current in the circuit is described by $I = 20t$, where t is in second and I is in ampere. The capacitor initially has no charge. Determine,
- (a) the voltage across the inductor at $t = 1$ s, in millivolt.
- (b) the voltage across the capacitor as a function of time at $t = 1$ ms, in volt.
- (c) the time, closest to two-digit integer, in microsecond, when the energy stored in the capacitor first exceeds that in the inductor.
28. A total charge of $5 \times 10^{-4} \text{ C}$ passes through a 100 turn coil of resistance 200Ω , cross-sectional area 40 cm^2 , when it is rotated in a uniform field from a position where the plane of the coil is perpendicular to the field to a position where the coil's plane is parallel to the field. Calculate B , in millitesla.
29. The plane of a square loop of wire with edge length $l = 0.2 \text{ m}$ is perpendicular to the Earth's magnetic field at a point where $B = 25 \mu\text{T}$, as shown in Figure.



The total resistance of the loop and the wires connecting it to a sensitive ammeter is 0.5Ω . If the loop is suddenly collapsed by horizontal forces as shown, what is the total charge, in μC , that passes through the ammeter?

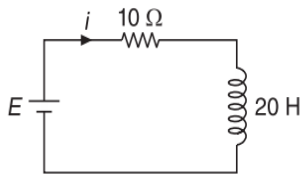
30. A small coil is introduced between the poles of an electromagnet so that its axis coincides with the magnetic field direction. The cross-sectional area of the coil is $A = 3 \text{ mm}^2$, the number of turns is $N = 30$. When the coil turns through 180° about its

diameter, a galvanometer connected to the coil indicates a charge $q = 4.5 \mu\text{C}$ flowing through it. Find the magnetic induction magnitude between the poles provided the total resistance of the electric circuit equals $R = 40 \Omega$.

ARCHIVE: JEE MAIN

1. [Online April 2019]

A 20 H inductor coil is connected to a 10Ω resistance in series as shown in Figure. The time at which rate of dissipation of energy (Joule's heat) across resistance is equal to the rate at which magnetic energy is stored in the inductor, is



- (A) $\frac{2}{\ln 2}$ (B) $2 \ln 2$
 (C) $\ln 2$ (D) $\frac{1}{2} \ln 2$

2. [Online April 2019]

The total number of turns and cross-section area in a solenoid is fixed. However, its length L is varied by adjusting the separation between windings. The inductance of solenoid will be proportional to

- (A) $\frac{1}{L}$ (B) L
 (C) $\frac{1}{L^2}$ (D) L^2

3. [Online April 2019]

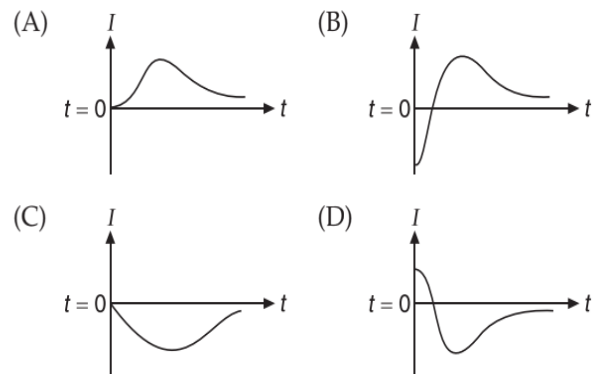
Two coils P and Q are separated by some distance. When a current of 3 A flows through coil P a magnetic flux of 10^{-3} Wb passes through Q . No current is passed through Q . When no current passes through P and a current of 2 A passes through Q , the flux through P is

- (A) $6.67 \times 10^{-3} \text{ Wb}$ (B) $6.67 \times 10^{-4} \text{ Wb}$
 (C) $3.67 \times 10^{-3} \text{ Wb}$ (D) $3.67 \times 10^{-4} \text{ Wb}$

4. [Online April 2019]

A very long solenoid of radius R is carrying current $I(t) = kte^{-at}$ ($k > 0$), as a function of time ($t \geq 0$). Counter clockwise current is taken to be positive. A circular conducting coil of radius $2R$ is placed in the equatorial plane of the solenoid and concentric

with the solenoid. The current induced in the outer coil is correctly depicted, as a function of time, by



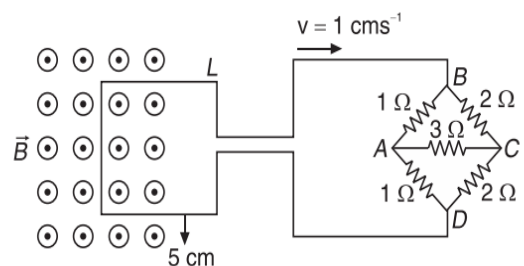
5. [Online April 2019]

A coil of self-inductance 10 mH and resistance 0.1Ω is connected through a switch to a battery of internal resistance 0.9Ω . After the switch is closed, the time taken for the current to attain 80% of the saturation value is [take $\ln 5 = 1.6$]

- (A) 0.002 s (B) 0.324 s
 (C) 0.103 s (D) 0.016 s

6. [Online April 2019]

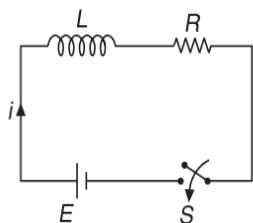
The figure shows a square loop L of side 5 cm which is connected to a network of resistances. The whole setup is moving towards right with a constant speed of 1 cm s^{-1} . At some instant, a part of L is in a uniform magnetic field of 1 T , perpendicular to the plane of the loop. If the resistance of L is 1.7Ω , the current in the loop at that instant will be close to



- (A) $170 \mu\text{A}$ (B) $60 \mu\text{A}$
 (C) $150 \mu\text{A}$ (D) $115 \mu\text{A}$

7. [Online April 2019]

Consider the LR circuit shown in Figure. If the switch S is closed at $t = 0$, then the amount of charge that passes through the battery between $t = 0$ and $t = \frac{L}{R}$ is



- (A) $\frac{2.7EL}{R^2}$ (B) $\frac{EL}{2.7R^2}$
 (C) $\frac{7.3EL}{R^2}$ (D) $\frac{EL}{7.3R^2}$

8. [Online January 2019]

A conducting circular loop made of a thin wire, has area $3.5 \times 10^{-3} \text{ m}^2$ and resistance 10Ω . It is placed perpendicular to a time dependent magnetic field $B(t) = (0.4T)\sin(50\pi t)$. The field is uniform in space. Then the net charge flowing through the loop during $t = 0 \text{ s}$ and $t = 10 \text{ ms}$ is close to

- (A) 7 mC (B) 21 mC
 (C) 6 mC (D) 14 mC

9. [Online January 2019]

A bar magnet is demagnetized by inserting it inside a solenoid of length 0.2 m, 100 turns and carrying a current of 5.2 A. The coercivity of the bar magnet is

- (A) 520 Am^{-1} (B) 2600 Am^{-1}
 (C) 1200 Am^{-1} (D) 285 Am^{-1}

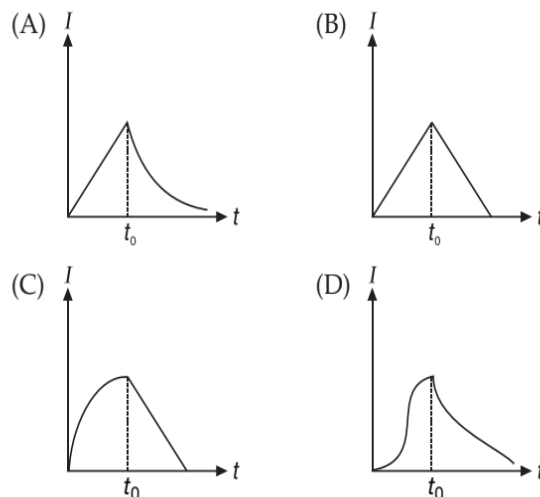
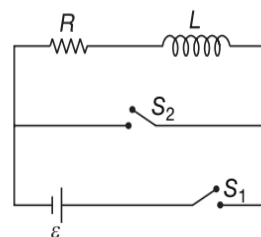
10. [Online January 2019]

The self-induced emf of a coil is 25 volts. When the current in it is changed at uniform rate from 10 A to 25 A in 1 s, the change in the energy of the inductance is

- (A) 437.5 J (B) 740 J
 (C) 637.5 J (D) 540 J

11. [Online January 2019]

In the circuit shown, the switch S_1 is closed at time $t = 0$ and the switch S_2 is kept open. At some later time (t_0), the switch S_1 is opened and S_2 is closed. The behaviour of the current I as a function of time t is given by


12. [Online January 2019]

There are two long co-axial solenoids of same length l . The inner and outer coils have radii r_1 and r_2 and number of turns per unit length n_1 and n_2 , respectively. The ratio of mutual inductance to the self-inductance of the inner-coil is

- (A) $\frac{n_2 r_2^2}{n_1 r_1^2}$ (B) $\frac{n_2}{n_1}$
 (C) $\frac{n_2 r_1}{n_1 r_2}$ (D) $\frac{n_1}{n_2}$

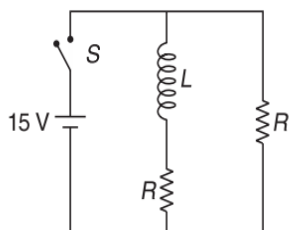
13. [Online January 2019]

A copper wire is wound on a wooden frame, whose shape is that of an equilateral triangle. If the linear dimension of each side of the frame is increased by a factor of 3, keeping the number of turns of the coil per unit length of the frame the same, then the self-inductance of the coil

- (A) Increases by a factor of 3
 (B) Decreases by a factor of $9\sqrt{3}$
 (C) Decreases by a factor of 9
 (D) Increases by a factor of 27

14. [Online January 2019]

In the Figure shown, a circuit contains two identical resistors with resistance $R = 5 \Omega$ and an inductance with $L = 2 \text{ mH}$. An ideal battery of 15 V is connected in the circuit. What will be the current through the battery long after the switch is closed?



- (A) 7.5 A (B) 3 A
(C) 6 A (D) 5.5 A

15. [Online January 2019]

A 10 m long horizontal wire extends from North East to South West. It is falling with a speed of 5.0 ms^{-1} , at right angles to the horizontal component of the earth's magnetic field, of $0.3 \times 10^{-4} \text{ Wbm}^{-2}$. The value of the induced emf in wire is

- (A) $1.1 \times 10^{-3} \text{ V}$ (B) $0.3 \times 10^{-3} \text{ V}$
(C) $2.5 \times 10^{-3} \text{ V}$ (D) $1.5 \times 10^{-3} \text{ V}$

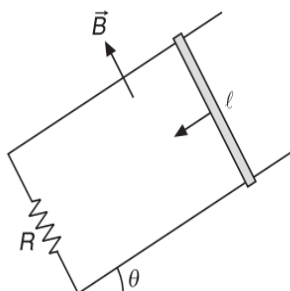
16. [Online 2018]

At the centre of a fixed large circular coil of radius R , a much smaller circular coil of radius r is placed. The two coils are concentric and are in the same plane. The larger coil carries a current I . The smaller coil is set to rotate with a constant angular velocity ω about an axis along their common diameter. Calculate the emf induced in the smaller coil after a time t of its start of rotation.

- (A) $\frac{\mu_0 I}{4R} \omega \pi r^2 \sin \omega t$ (B) $\frac{\mu_0 I}{4R} \omega r^2 \sin \omega t$
(C) $\frac{\mu_0 I}{2R} \omega r^2 \sin \omega t$ (D) $\frac{\mu_0 I}{2R} \omega \pi r^2 \sin \omega t$

17. [Online 2018]

A copper rod of mass m slides under gravity on two smooth parallel rails, with separation l and set an angle of θ with the horizontal. At the bottom, rails are joined by a resistance R . There is a uniform magnetic field B normal to the plane of the rails, as shown in Figure. The terminal speed of the copper rod is



- (A) $\frac{mgR \sin \theta}{B^2 l^2}$ (B) $\frac{mgR \cot \theta}{B^2 l^2}$
(C) $\frac{mgR \tan \theta}{B^2 l^2}$ (D) $\frac{mgR \cos \theta}{B^2 l^2}$

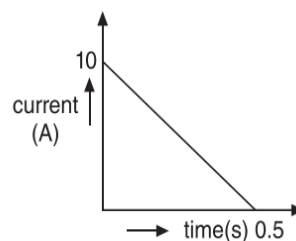
18. [Online 2018]

A coil of cross-sectional area A having n turns is placed in a uniform magnetic field B . When it is rotated with an angular velocity ω , the maximum e.m.f. induced in the coil will be

- (A) $\frac{3}{2} nBA\omega$ (B) $nBA\omega$
(C) $3nBA\omega$ (D) $\frac{1}{2} nBA\omega$

19. [2017]

In a coil of resistance 100Ω , a current is induced by changing the magnetic flux through it as shown in Figure. The magnitude of change in flux through the coil is



- (A) 200 Wb (B) 225 Wb
(C) 250 Wb (D) 275 Wb

20. [Online 2017]

A small circular loop of wire of radius a is located at the centre of a much larger circular wire loop of radius b . The two loops are in the same plane. The outer loop of radius b carries an alternating current $I = I_0 \cos(\omega t)$. The emf induced in the smaller inner loop is nearly

- (A) $\frac{\pi \mu_0 I_0 a^2}{2b} \omega \cos(\omega t)$ (B) $\frac{\pi \mu_0 I_0 b^2}{a} \omega \cos(\omega t)$
(C) $\frac{\pi \mu_0 I_0 a^2}{2b} \omega \sin(\omega t)$ (D) $\pi \mu_0 I_0 \frac{a^2}{b} \omega \sin(\omega t)$

21. [Online 2016]

A conducting metal circular-wire-loop of radius r is placed perpendicular to a magnetic field which varies with time as $B = B_0 e^{-\frac{t}{\tau}}$, where B_0 and τ are constants, at time $t = 0$. If the resistance of the loop is R then the heat generated in the loop after a long time ($t \rightarrow \infty$) is

- (A) $\frac{\pi^2 r^4 B_0^4}{2\tau R}$ (B) $\frac{\pi^2 r^4 B_0^2}{2\tau R}$
 (C) $\frac{\pi^2 r^4 B_0^2 R}{\tau}$ (D) $\frac{\pi^2 r^4 B_0^2}{\tau R}$

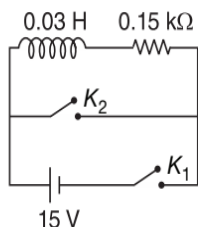
22. [Online 2016]

A fighter plane of length 20 m, wing span (distance from tip of one wing to the tip of the other wing) of 15 m and height 5 m is flying towards east over Delhi. Its speed is 240 ms^{-1} . The earth's magnetic field over Delhi is $5 \times 10^{-5} \text{ T}$ with the declination angle $\sim 0^\circ$ and dip of θ such that $\sin \theta = \frac{2}{3}$. If the voltage developed is V_B between the lower and upper side of the plane and V_W between the tips of the wings then V_B and V_W are close to

- (A) $V_B = 40 \text{ mV}$; $V_W = 135 \text{ mV}$ with left side of pilot at higher voltage
 (B) $V_B = 45 \text{ mV}$; $V_W = 120 \text{ mV}$ with right side of pilot at higher voltage
 (C) $V_B = 40 \text{ mV}$; $V_W = 135 \text{ mV}$ with right side of pilot at higher voltage
 (D) $V_B = 45 \text{ mV}$; $V_W = 120 \text{ mV}$ with left side of pilot at higher voltage.

23. [2015]

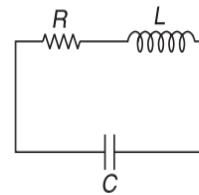
An inductor ($L = 0.03 \text{ H}$) and a resistor ($R = 0.15 \text{ k}\Omega$) are connected in series to a battery of 15 V emf in a circuit shown below. The key K_1 has been kept closed for a long time. Then at $t = 0$, K_1 is opened and key K_2 is closed simultaneously. At $t = 1 \text{ ms}$, the current in the circuit will be ($e^5 \cong 150$)



- (A) 6.7 mA (B) 0.67 mA
 (C) 100 mA (D) 67 mA

24. [2015]

An LCR circuit is equivalent to a damped pendulum. In an LCR circuit the capacitor is charged to Q_0 and then connected to the L and R as shown here.



If a student plots graphs of the square of maximum charge (Q_{max}^2) on capacitor with time (t) for two different values L_1 and L_2 ($L_1 > L_2$) of L then which of the following represents this graph correctly? (plots are schematic and not drawn to scale)

- (A) (B) (C) (D)

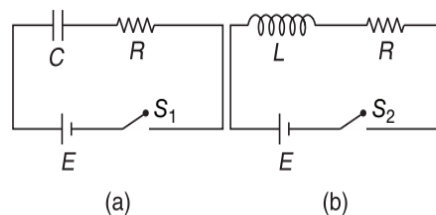
25. [Online 2015]

When current in a coil changes from 5 A to 2 A in 0.1 s, an average voltage of 50 V is produced. The self-inductance of the coil is

- (A) 0.67 H (B) 1.67 H
 (C) 3 H (D) 6 H

26. [Online 2015]

In the circuits (a) and (b) switches S_1 and S_2 are closed at $t = 0$ and are kept closed for a long time. The variation of currents in the two circuits for $t \geq 0$ are roughly shown by (figures are schematic and not drawn to scale)

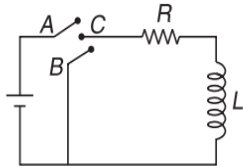


- (A) (B) (C) (D)



27. [2014]

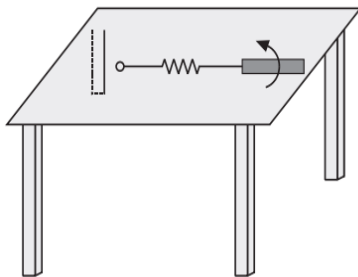
In the circuit shown here, the point C is kept connected to point A till the current flowing through the circuit becomes constant. Afterward, suddenly, point C is disconnected from point A and connected to point B at time $t = 0$. Ratio of the voltage across resistance and the inductor at $t = \frac{L}{R}$ will be equal to



- (A) $\frac{1-e}{e}$ (B) $\frac{e}{1-e}$
 (C) 1 (D) -1

28. [2013]

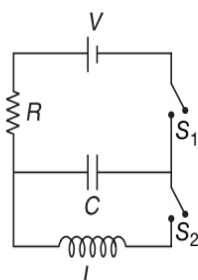
A metallic rod of length l is tied to a string of length $2l$ and made to rotate with angular speed ω on a horizontal table with one end of the string fixed. If there is a vertical magnetic field B in the region, the e.m.f. induced across the ends of the rod is



- (A) $\frac{5B\omega l^2}{2}$ (B) $\frac{2B\omega l^2}{2}$
 (C) $\frac{3B\omega l^2}{2}$ (D) $\frac{4B\omega l^2}{2}$

29. [2013]

In an LCR circuit as shown below both switches are open initially. Now switch S_1 is closed, S_2 kept open. (q is charge on the capacitor and $\tau = RC$ is capacitive time constant). Which of the following statement is correct?



- (A) At $t = \frac{\tau}{2}$, $q = CV(1 - e^{-1})$
 (B) Work done by the battery is half of the energy dissipated in the resistor
 (C) At $t = \tau$, $q = \frac{CV}{2}$
 (D) At $t = 2\tau$, $q = CV(1 - e^{-2})$

30. [2013]

A circular loop of radius 0.3 cm lies parallel to a much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm. If a current of 2.0 A flows through the smaller loop, then the flux linked with bigger loop is

- (A) 6.6×10^{-9} weber (B) 9.1×10^{-11} weber
 (C) 6×10^{-11} weber (D) 3.3×10^{-11} weber

31. [2011]

A boat is moving due east in a region where the earth's magnetic field is $5.0 \times 10^{-5} \text{ NA}^{-1}\text{m}^{-1}$ due north and horizontal. The boat carries a vertical aerial 2 m long. If the speed of the boat is 1.50 ms^{-1} , the magnitude of the induced emf in the wire of aerial is

- (A) 1 mV (B) 0.75 mV
 (C) 0.50 mV (D) 0.15 mV

32. [2011]

A resistor R and $2 \mu\text{F}$ capacitor in series is connected through a switch to 200 V direct supply. Across the capacitor is a neon bulb that lights up at 120 V. Calculate the value of R to make the bulb light up 5 s after the switch has been closed. ($\log_{10} 2.5 = 0.4$)

- (A) $1.3 \times 10^4 \Omega$ (B) $1.7 \times 10^5 \Omega$
 (C) $2.7 \times 10^6 \Omega$ (D) $3.3 \times 10^7 \Omega$

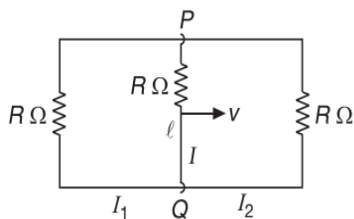
33. [2011]

A fully charged capacitor C with initial charge q_0 is connected to a coil of self-inductance L at $t = 0$. The time at which the energy is stored equally between the electric and the magnetic fields is

- (A) $\pi\sqrt{LC}$ (B) $\frac{\pi}{4}\sqrt{LC}$
 (C) $2\pi\sqrt{LC}$ (D) \sqrt{LC}

34. [2010]

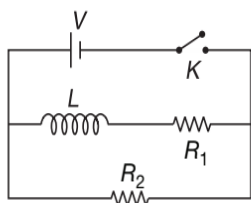
A rectangular loop has a sliding connector PQ of length l and resistance $R \Omega$ and it is moving with a speed v as shown. The set-up is placed in a uniform magnetic field going into the plane of the paper. The three currents I_1 , I_2 and I are



- (A) $I_1 = I_2 = \frac{Blv}{6R}, I = \frac{Blv}{3R}$
 (B) $I_1 = -I_2 = \frac{Blv}{R}, I = \frac{2Blv}{R}$
 (C) $I_1 = I_2 = \frac{Blv}{3R}, I = \frac{2Blv}{3R}$
 (D) $I_1 = I_2 = I = \frac{Blv}{R}$

35. [2010]

In the circuit shown below, the key K is closed at $t = 0$. The current through the battery is

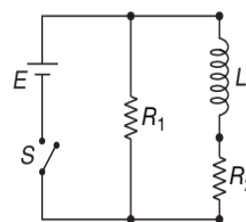


- (A) $\frac{V(R_1 + R_2)}{R_1 R_2}$ at $t = 0$ and $\frac{V}{R_2}$ at $t = \infty$
 (B) $\frac{VR_1 R_2}{\sqrt{R_1^2 + R_2^2}}$ at $t = 0$ and $\frac{V}{R_2}$ at $t = \infty$

- (C) $\frac{V}{R_2}$ at $t = 0$ and $\frac{V(R_1 + R_2)}{R_1 R_2}$ at $t = \infty$
 (D) $\frac{V}{R_2}$ at $t = 0$ and $\frac{VR_1 R_2}{\sqrt{R_1^2 + R_2^2}}$ at $t = \infty$

36. [2009]

An inductor of inductance $L = 400$ mH and resistors of resistances $R_1 = 2 \Omega$ and $R_2 = 2 \Omega$ are connected to a battery of emf 12 V as shown in Figure. The internal resistance of the battery is negligible. The switch S is closed at $t = 0$. The potential drop across L as a function of time is



- (A) $6e^{-5t}$ V
 (B) $\frac{12}{t}e^{-3t}$ V
 (C) $6\left(1 - e^{-\frac{t}{0.2}}\right)$ V
 (D) $12e^{-5t}$ V

ARCHIVE: JEE ADVANCED

Single Correct Choice Type Problems

This section contains Single Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct.

1. [IIT-JEE 2011]

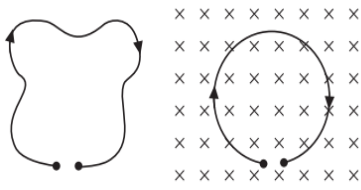
Which of the field patterns given in Figure is valid for electric field as well as for magnetic field?

- (A) (B)

- (C) (D)

2. [IIT-JEE 2010]

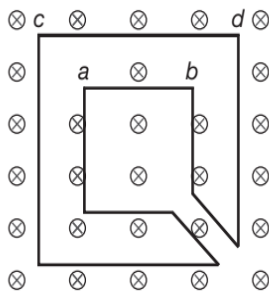
A thin flexible wire of length L is connected to two adjacent fixed points and carries a current I in the clockwise direction, as shown in Figure. When the system is put in a uniform magnetic field of strength B going into the plane of the paper, the wire takes the shape of a circle. The tension in the wire is



- (A) IBL (B) $\frac{IBL}{\pi}$
 (C) $\frac{IBL}{2\pi}$ (D) $\frac{IBL}{4\pi}$

3. [IIT-JEE 2009]

The Figure shows certain wire segments joined together to form a coplanar loop. The loop is placed in a perpendicular magnetic field in the direction going into the plane of the Figure. The magnitude of the field increases with time. I_1 and I_2 are the currents in the segments ab and cd . Then,



- (A) $I_1 > I_2$
 (B) $I_1 < I_2$
 (C) I_1 is in the direction ba and I_2 is in the direction cd
 (D) I_1 is in the direction ab and I_2 is in the direction dc

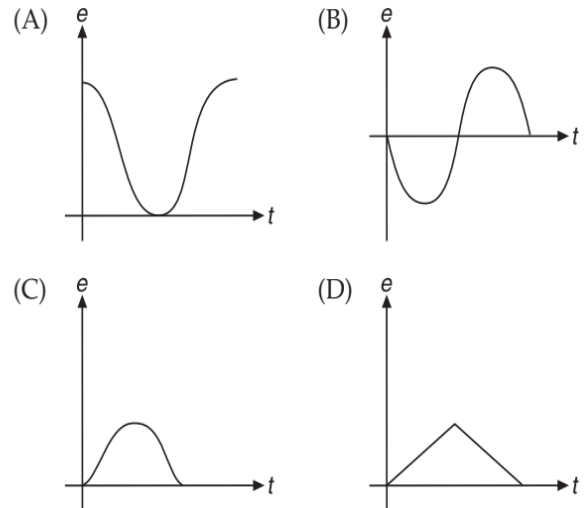
4. [IIT-JEE 2005]

An infinitely long cylinder is kept parallel to a uniform magnetic field B directed along positive z -axis. The direction of induced current as seen from the z -axis will be

- (A) clockwise of the +ve z -axis
 (B) anticlockwise of the +ve z -axis
 (C) ZERO
 (D) along the magnetic field

5. [IIT-JEE 2004]

The variation of induced emf (e) with time (t) in a coil if a short bar magnet is moved along its axis with a constant velocity is best represented as



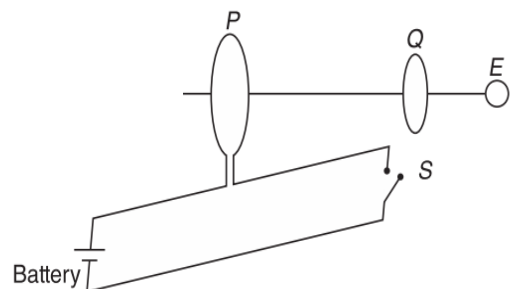
6. [IIT-JEE 2002]

A short-circuited coil is placed in a time varying magnetic field. Electrical power is dissipated due to the current induced in the coil. If the number of turns were to be quadrupled and the wire radius halved, the electrical power dissipated would be

- (A) halved (B) the same
 (C) doubled (D) quadrupled

7. [IIT-JEE 2002]

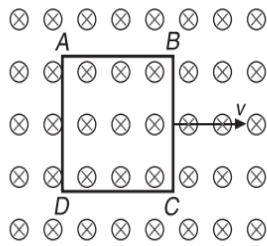
As shown in Figure, P and Q are two coaxial conducting loops separated by some distance. When the switch S is closed, a clockwise current I_P flows in P (as seen by E) and an induced current I_{Q1} flows in Q . The switch remains closed for a long time. When S is opened, a current I_{Q2} flows in Q . Then the directions of I_{Q1} and I_{Q2} (as seen by E) are



- (A) respectively clockwise and anti-clockwise.
 (B) both clockwise.
 (C) both anti-clockwise.
 (D) respectively anti-clockwise and clockwise.

8. [IIT-JEE 2001]

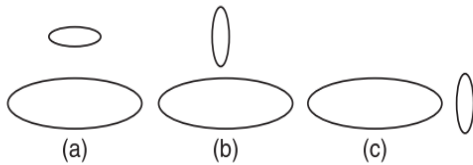
A metallic square loop $ABCD$ is moving in its own plane with velocity v in a uniform magnetic field perpendicular to its plane as shown in Figure. Electric field is induced



- (A) in AD , but not in BC
- (B) in BC , but not in AD
- (C) neither in AD nor in BC
- (D) in both AD and BC

9. [IIT-JEE 2001]

Two circular coils can be arranged in any of the three situations shown in Figure. Their mutual inductance will be



- (A) maximum in situation (a)
- (B) maximum in situation (b)
- (C) maximum in situation (c)
- (D) the same in all situations

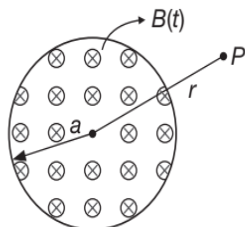
10. [IIT-JEE 2000]

A coil of wire having finite inductance and resistance has a conducting ring placed co-axially within it. The coil is connected to a battery at time $t = 0$, so that a time dependent current $I_1(t)$ starts flowing through the coil. If $I_2(t)$ is the current induced in the ring and $B(t)$ is the magnetic field at the axis of the coil due to $I_1(t)$, then as a function of time ($t > 0$), the product $I_2(t)B(t)$

- (A) increases with time
- (B) decreases with time
- (C) does not vary with time
- (D) passes through a maximum

11. [IIT-JEE 2000]

A uniform but time-varying magnetic field $B(t)$ exists in a circular region of radius a and is directed into the plane of the paper, as shown. The magnitude of the induced electric field at point P at a distance r from the centre of the circular region



- (A) is ZERO
- (B) decreases as $\frac{1}{r}$
- (C) increases as r
- (D) decreases as $\frac{1}{r^2}$

12. [IIT-JEE 1999]

A circular loop of radius R , carrying current I , lies in $x-y$ plane with its centre at origin. The total magnetic flux through $x-y$ plane is

- (A) directly proportional to I
- (B) directly proportional to R
- (C) inversely proportional to R
- (D) ZERO

13. [IIT-JEE 1999]

A coil of inductance 8.4 mH and resistance 6Ω is connected to a 12 V battery. The current in the coil is 1 A at approximately the time

- (A) 500 s
- (B) 20 ms
- (C) 35 ms
- (D) 1 ms

14. [IIT-JEE 1999]

Two identical circular loops of metal wire are lying on a table without touching each other. Loop A carries a current which increase with time. In response, the loop B

- (A) remains stationary
- (B) is attracted by the loop A
- (C) is repelled by the loop A
- (D) rotates about its CM , with CM fixed

15. [IIT-JEE 1998]

A small square loop of wire of side l is placed inside a large square loop of side $L (L \gg l)$. The loops are coplanar and their centres coincide. The mutual inductance of the system is proportional to

- (A) $\frac{l}{L}$
- (B) $\frac{l^2}{L}$
- (C) $\frac{L}{l}$
- (D) $\frac{L^2}{l}$

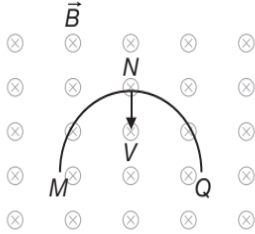
16. [IIT-JEE 1998]

A metal rod moves at a constant velocity in a direction perpendicular to its length. A constant uniform magnetic field exists in space in a direction perpendicular to the rod as well as its velocity. Select the correct statement(s) from the following

- (A) The entire rod is at same electric potential
- (B) There is an electric field in the rod
- (C) The electric potential is highest at the centre of the rod and decreases towards its ends
- (D) The electric potential is lowest at the centre of the rod and increases towards its ends

17. [IIT-JEE 1996]

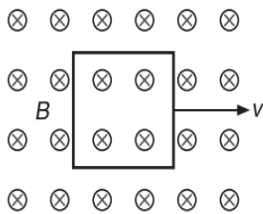
A thin semi-circular conducting ring of radius R is falling with its plane vertical in a horizontal magnetic induction \vec{B} . At the position MNQ the speed of the ring is V , and the potential difference developed across the ring is



- (A) ZERO
- (B) $\frac{BV\pi R^2}{2}$ and M is at a higher potential
- (C) πRBV and Q is at a higher potential
- (D) $2RBV$ and Q is at a higher potential

18. [IIT-JEE 1989]

A conducting square loop of side L is moving with uniform velocity v perpendicular to one of its sides. A magnetic induction B , constant in time and space, pointing perpendicular and into plane of the loop exists everywhere. Current induced in the loop is



- (A) $\frac{BLv}{R}$, clockwise
- (B) $\frac{BLv}{R}$, anticlockwise
- (C) $\frac{2BLv}{R}$, anticlockwise
- (D) ZERO

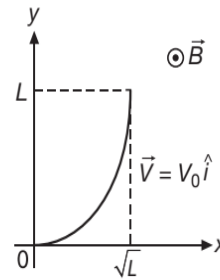
Multiple Correct Choice Type Problems

This section contains Multiple Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct.

1. [JEE (Advanced) 2019]

A conducting wire of parabolic shape, initially $y = x^2$, is moving with velocity $\vec{V} = V_0 \hat{i}$ in a non-uniform magnetic field $\vec{B} = B_0 \left(1 + \left(\frac{y}{L} \right)^\beta \right) \hat{k}$, as shown in Figure. If V_0, B_0, L and β are positive constants and

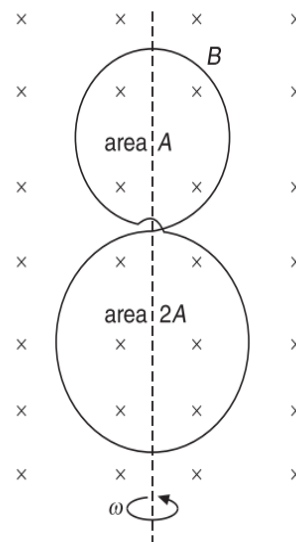
$\Delta\phi$ is the potential difference developed between the ends of the wire, then the correct statement(s) is/are



- (A) $|\Delta\phi| = \frac{1}{2} B_0 V_0 L$ for $\beta = 0$
- (B) $|\Delta\phi|$ remains the same if the parabolic wire is replaced by a straight wire, $y = x$ initially, of length $\sqrt{2}L$
- (C) $|\Delta\phi|$ is proportional to the length of the wire projected on the y -axis
- (D) $|\Delta\phi| = \frac{4}{3} B_0 V_0 L$ for $\beta = 2$

2. [JEE (Advanced) 2017]

A circular insulated copper wire loop is twisted to form two loops of area A and $2A$ as shown in Figure. At the point of crossing the wires remain electrically insulated from each other. The entire loop lies in the plane (of the paper). A uniform magnetic field \vec{B} points into the plane of the paper. At $t = 0$, the loop starts rotating about the common diameter as axis with a constant angular velocity ω in the magnetic field. Which of the following options is/are correct?

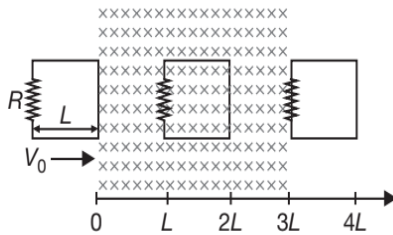


- (A) The emf induced in the loop is proportional to the sum of the areas of the two loops

- (B) The rate of change of the flux is maximum when the plane of the loops is perpendicular to plane of the paper
- (C) The net emf induced due to both the loops is proportional to $\cos \omega t$
- (D) The amplitude of the maximum net emf induced due to both the loops is equal to the amplitude of maximum emf induced in the smaller loop alone

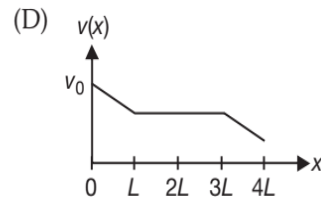
3. [JEE (Advanced) 2016]

A rigid wire loop of square shape having side of length L and resistance R is moving along the x -axis with a constant velocity v_0 in the plane of the paper. At $t = 0$, the right edge of the loop enters a region of length $3L$ where there is a uniform magnetic field B_0 into the plane of the paper, as shown in Figure. For sufficiently large v_0 , the loop eventually crosses the region. Let x be the location of the right edge of the loop. Let $v(x)$, $I(x)$ and $F(x)$ represent the velocity of the loop, current in the loop and force on the loop, respectively, as a function of x . Counter-clockwise current is taken as positive.

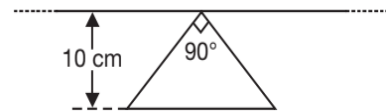


Which of the following schematic plot(s) is(are) correct? (Ignore gravity)

- (A)
- (B)
- (C)


4. [JEE (Advanced) 2016]

A conducting loop in the shape of a right angled isosceles triangle of height 10 cm is kept such that the 90° vertex is very close to an infinitely long conducting wire (see the Figure). The wire is electrically insulated from the loop. The hypotenuse of the triangle is parallel to the wire. The current in the triangular loop is in counter clockwise direction and increased at a constant rate of 10 As^{-1} . Which of the following statement(s) is(are) true?

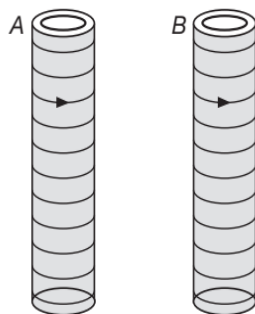


- (A) The magnitude of induced emf in the wire is $\left(\frac{\mu_0}{\pi}\right)$ volt
- (B) If the loop is rotated at a constant angular speed about the wire, an additional emf of $\left(\frac{\mu_0}{\pi}\right)$ volt is induced in the wire
- (C) The induced current in the wire is in opposite direction to the current along the hypotenuse
- (D) There is a repulsive force between the wire and the loop
- 5. [IIT-JEE 2012]**
- A current carrying infinitely long wire is kept along the diameter of a circular wire loop, without touching it. The correct statement(s) is (are)
- (A) The emf induced in the loop is zero if the current is constant
- (B) The emf induced in the loop is finite if the current is constant
- (C) The emf induced in the loop is zero if the current decreases at a steady rate
- (D) The emf induced in the loop is finite if the current decreases at a steady rate

6. [IIT-JEE 2009]

Two metallic rings A and B , identical in shape and size but having different resistivities ρ_A and ρ_B , are kept on top of two identical solenoids as shown in Figure. When current I is switched on in both the solenoids in identical manner, the rings A and B jump to heights h_A and h_B , respectively, with $h_A > h_B$.

The possible relation(s) between their resistivities and their masses m_A and m_B is (are)



- (A) $\rho_A > \rho_B$ and $m_A = m_B$
- (B) $\rho_A < \rho_B$ and $m_A = m_B$
- (C) $\rho_A > \rho_B$ and $m_A > m_B$
- (D) $\rho_A < \rho_B$ and $m_A < m_B$

7. [IIT-JEE 2006]

A field line is shown in Figure. This field cannot represent



- (A) magnetic field
- (B) electrostatic field
- (C) induced electric field
- (D) gravitational field

8. [IIT-JEE 1994]

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 that time the current, the induced voltage and the energy stored in the first coil are i_1 , v_1 and w_1 respectively. Corresponding values for the second coil at the same instant are i_2 , v_2 and w_2 respectively. Then,

- (A) $\frac{i_1}{i_2} = \frac{1}{4}$
- (B) $\frac{i_1}{i_2} = 4$
- (C) $\frac{w_2}{w_1} = 4$
- (D) $\frac{v_2}{v_1} = \frac{1}{4}$

Reasoning Based Questions

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

Bubble (A) If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.

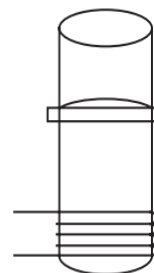
Bubble (B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.

Bubble (C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.

Bubble (D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

1. [IIT-JEE 2007]

Statement-1: A vertical iron rod has a coil of wire wound over it at the bottom end. An alternating current flow in the coil. The rod goes through a conducting ring as shown in Figure.



The ring can float at a certain height above the coil.

Statement-2: In the above situation, a current is induced in the ring which interacts with the horizontal component of the magnetic field to produce an average force in the upward direction.

Linked Comprehension Type Questions

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options)

Comprehension 1

Consider a simple RC circuit as shown in Figure 1.

Process 1: In the circuit, the switch S is closed at $t = 0$ and the capacitor is fully charged to voltage V_0 (i.e. charging continues for time $T \gg RC$). In the process, some dissipation (E_D) occurs across the resistance R . The amount of energy finally stored in the fully charged capacitor is E_c .

Process 2: In a different process the voltage is first set to $\frac{V_0}{3}$ and maintained for a charging time $T \gg RC$. Then, the voltage is raised to $\frac{2V_0}{3}$ without discharging the capacitor and again maintained for a time $T \gg RC$. The process is repeated one more time by raising the voltage to V_0 and the capacitor is charged to the same final voltage V_0 as in process 1. These two processes are depicted in Figure 2.

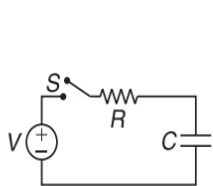


Figure 1

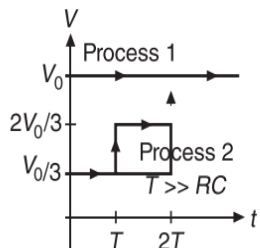


Figure 2

1. [JEE (Advanced) 2017]

In process 1, the energy stored in the capacitor E_C and heat dissipated across resistance E_D are related by

- (A) $E_C = E_D \ln 2$ (B) $E_C = E_D$
 (C) $E_C = 2E_D$ (D) $E_C = \frac{1}{2}E_D$

2. [JEE (Advanced) 2017]

In process 2, total energy dissipated across the resistance E_D is

- (A) $E_D = \frac{1}{3} \left(\frac{1}{2} CV_0^2 \right)$ (B) $E_D = 3 \left(\frac{1}{2} CV_0^2 \right)$
 (C) $E_D = 3CV_0^2$ (D) $E_D = \frac{1}{2} CV_0^2$

Comprehension 2

A point charge Q is moving in a circular orbit of radius R in the x - y plane with an angular velocity ω . This can be considered as equivalent to a loop carrying a steady current $\frac{Q\omega}{2\pi}$. A uniform magnetic field along the positive z -axis is now switched on, which increases at a constant rate from 0 to B in one second. Assume that the radius of the orbit remains constant. The applications of the magnetic field induces an emf in the orbit. The induced emf is defined as the work done by an induced electric field in moving a unit positive charge around a closed loop. It is known that, for an orbiting charge, the magnetic dipole moment is proportional to the angular momentum with a proportionality constant γ .

3. [JEE (Advanced) 2013]

The magnitude of the induced electric field in the orbit at any instant of time during the time interval of the magnetic field change is

- (A) $\frac{BR}{4}$ (B) $-\frac{BR}{2}$
 (C) BR (D) $2BR$

4. [JEE (Advanced) 2013]

The change in the magnetic dipole moment associated with the orbit, at the end of the time interval of the magnetic field change, is

- (A) γBQR^2 (B) $-\gamma \frac{BQR^2}{2}$
 (C) $\gamma \frac{BQR^2}{2}$ (D) γBQR^2

Comprehension 3

Modern trains are based on Maglev technology in which trains are magnetically levitated, which runs its EDS Maglev system. There are coils on both sides of wheels. Due to motion of train, current induces in the coil of track which levitate it. This is in accordance with Lenz's law. If trains lower down then due to Lenz's law a repulsive force increases due to which train gets uplifted and if it goes much high then there is a net downward force disc to gravity. The advantage of Maglev train is that there is no friction between the train and the track, thereby reducing power consumption and enabling the train to attain very high speeds.

Disadvantage of Maglev train is that as it slows down the electromagnetic forces decrease and it becomes difficult to keep it levitated and as it moves forward according to Lenz law there is an electromagnetic drag force. Based on the above facts, answer the following questions.

5. [IIT-JEE 2006]

What is the advantage of this system?

- (A) No friction hence no power consumption
 (B) No electric power is used
 (C) Gravitation force is zero
 (D) Electrostatic force draws the train

6. [IIT-JEE 2006]

What is the disadvantage of this system?

- (A) Train experiences upward force according to Lenz's law
 (B) Friction force create a drag on the train
 (C) Retardation
 (D) By Lenz's law train experience a drag



7. [IIT-JEE 2006]

Which force causes the train to elevate up?

- (A) Electrostatic force
- (B) Time varying electric field
- (C) Magnetic force
- (D) Induced electric field

Matrix Match/Column Match Type Questions

Each question in this section contains statements given in two columns, which have to be matched. The statements in **COLUMN-I** are labelled A, B, C and D, while the statements in **COLUMN-II** are labelled p, q, r, s (and t). Any given statement in **COLUMN-I** can have correct matching with **ONE OR MORE** statement(s) in **COLUMN-II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

If the correct matches are $A \rightarrow p, s$ and t ; $B \rightarrow q$ and r ; $C \rightarrow p$ and q ; and $D \rightarrow s$ and t ; then the correct darkening of bubbles will look like the following:

	<i>p</i>	<i>q</i>	<i>r</i>	<i>s</i>	<i>t</i>
A	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>
B	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
C	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
D	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>

1. [IIT-JEE 2006]

Match the following

COLUMN-I	COLUMN-II
(A) Dielectric ring uniformly charged	(p) Time independent electrostatic field out of system
(B) Dielectric ring uniformly charged rotating with angular velocity ω	(q) Magnetic field
(C) Constant current in ring i_0	(r) Induced electric field
(D) $i = i_0 \cos \omega t$	(s) Magnetic moment

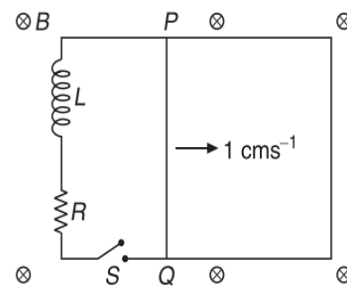
Integer/Numerical Answer Type Questions

In this section, the answer to each question is a numerical value obtained after series of calculations based on the data provided in the question(s).

1. [JEE (Advanced) 2019]

A 10 cm long perfectly conducting wire PQ is moving with a velocity 1 cms^{-1} on a pair of horizontal rails of zero resistance. One side of the rails is connected to an inductor $L = 1 \text{ mH}$ and a resistance $R = 1 \Omega$ as shown in Figure. The horizontal rails, L and R lie in the same plane with a uniform magnetic field $B = 1 \text{ T}$ perpendicular to the plane. If the key S is closed at certain instant, the current in the circuit after 1 milli-second is $x \times 10^{-3} \text{ A}$, where the value of x is

(Assume the velocity of wire PQ remains constant (1 cms^{-1}) after key S is closed. Given: $e^{-1} = 0.37$, where e is base of the natural logarithm)



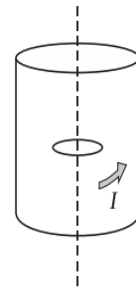
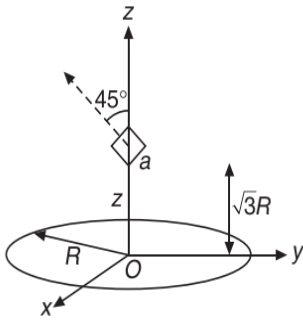
2. [IIT-JEE 2016]

Two inductors L_1 (inductance 1 mH , internal resistance 3Ω) and L_2 (inductance 2 mH , internal resistance 4Ω), and a resistor R (resistance 12Ω) are all connected in parallel across a 5 V battery. The circuit is switched on at time $t = 0$. The ratio of the maximum to the minimum current $\left(\frac{I_{\max}}{I_{\min}} \right)$ drawn from the battery is

3. [IIT-JEE 2012]

A circular wire loop of radius R is placed in the x - y plane centred at the origin O . A square loop of side a ($a \ll R$) having two turns is placed with its centre at $z = \sqrt{3}R$ along the axis of the circular wire loop, as shown in Figure. The plane of the square loop makes an angle of 45° with respect to the Z -axis. If the mutual inductance between the loops is given by

$$\frac{\mu_0 a^2}{2^2 R}, \text{ then the value of } p \text{ is}$$



4. [IIT-JEE 2011]

A long circular tube of length 10 m and radius 0.3 m carries a current I along its curved surface as shown. A wire-loop of resistance 0.005Ω and of radius 0.1 m is placed inside the tube with its axis coinciding with the axis of the tube.

The current varies as $I = I_0 \cos 300t$ where I_0 is constant. If the magnetic moment of the loop is $N\mu_0 I_0 \sin(300t)$, then N is

ANSWER KEYS—TEST YOUR CONCEPTS AND PRACTICE EXERCISES
Test Your Concepts-I (Based on Magnetic Flux, Faraday's Laws and Induced EMF)

- Negative
- No current is induced in the loop
- Clockwise
- (b) Zero
- (a) $2.54 \times 10^5 \text{ ms}^{-1}$
(b) 215 V
- (a) πar^2
(b) $-\pi br^2$
(c) $\frac{br}{2\lambda}$
(d) $\frac{\pi b^2 r^3}{2\lambda}$
- 1.6 mC
- 6.75 V
- $2a^2 B_0 v(2vt + a)$
- 62 mV
- 4.1 V
- $aAB_0 e^{-at}$
- 13.3 mA
- $(68)e^{-1.6t} \text{ mV}$, counterclockwise
- $27\pi \times 10^{-3} \text{ rads}^{-1}$
- $\frac{\mu_0 I a^2 v}{2\pi x(x+a)}$
- 0.5 A
- (a) $\pi a^2 CK$
(b) Upper
- (a) 3.7 A
(b) 54 μA
(c) Counterclockwise

Test Your Concepts-II (Based on Faraday's Laws: Motional EMF)

- (a) 0.5 A
(b) 2 W
(c) 2 W
- $\frac{MgR}{B^2 w^2}$

- $\frac{\mu_0 I v \ell}{2\pi r R}$
- $\frac{B\ell v}{\left(R + \frac{R_1 R_2}{R_1 + R_2}\right)}$
- $\frac{mgR \sin \alpha}{B^2 \ell^2}$
- 1 mV
- 0.02 ms^{-1} , clockwise
- (a) a to b
(b) $\frac{mgR \sin \phi}{B^2 \ell^2 \cos^2 \phi}$
(c) $\frac{mg \tan \phi}{B\ell}$
(d) $\frac{m^2 g^2 R \tan^2 \phi}{B^2 \ell^2}$
(e) $\frac{m^2 g^2 R \tan^2 \phi}{B^2 \ell^2}$
- $\frac{Bv}{\lambda(1+\sqrt{2})}$
- (a) $4Bv(\ell - 2vt)$
(b) $\frac{Bv}{\lambda}$
(c) $\frac{B^2 v}{\lambda}(\ell - 2vt)$
(d) $\frac{4B^2 v^2}{\lambda}(\ell - 2vt)$
(e) $\frac{4B^2 v^2(\ell - 2vt)}{\lambda}$
- (a) $\frac{N^2 B^2 w^2 v}{R}$, to the left
(b) 0
(c) $\frac{N^2 B^2 w^2 v}{R}$, to the left again
- 2.83 mV
- $\frac{7ak}{22\lambda}$, from P to S
 $\frac{ak}{22\lambda}$, from R to Q
 $\frac{3ak}{11\lambda}$, from U to T

15. $\frac{\mu_0 I v}{2\pi} \log_e \left(\frac{d+2r \cos \theta}{d-2r \cos \theta} \right)$

16. $\frac{MgR}{B^2 \ell^2} \left(1 - e^{-\frac{B^2 \ell^2 t}{R(M+m)}} \right), \frac{MgR}{B^2 \ell^2}$

Test Your Concepts-III (Based on Faraday's Laws: AC Generator)

1. $30.8 \cos(1000t)$ mV, 30.8 mV

2. (a) 36 V

(b) 0.6 Wbs^{-1}

(c) $18\sqrt{2}$ V

(d) 4.32 Nm

3. (a) $5 \cos(100\pi t)$

(b) 1.57 W

4. $\frac{\mu_0 L n d a^2 I_0 \omega \cos(\omega t)}{2\rho R}$

5. (a) $B \left(\frac{\pi r^2}{2} \cos(\omega t) + ab \right)$

(b) $\frac{\pi B r^2 \omega}{2} \sin(\omega t)$

(c) $\frac{\pi B r^2 \omega}{2R} \sin(\omega t)$

7. (a) 1.6 V

(b) 0

(c) Both remain unchanged

8. (a) $(8 \times 10^{-3}) \cos(377t)$ Tm²

(b) $3 \sin(377t)$ V

(c) $3 \sin(377t)$ A

(d) $9 \sin^2(377t)$ W

(e) $24 \times 10^{-3} \sin^2(377t)$ Nm

9. (a) 100 V

(b) 600 W

(c) 2 kW

Test Your Concepts-IV (Based on Faraday's Laws: Induced Electric Field)

1. $\left(\frac{\mu_0 n r \omega I_0}{2} \right) \cos(\omega t)$, clockwise

2. $1.8 \times 10^{-3} \text{ NC}^{-1}$

4. $E = \begin{cases} \frac{r\alpha}{2} & \text{for } r \leq R \\ \frac{\alpha R^2}{2r} & \text{for } r \geq R \end{cases}$

6. (a) $\frac{qB_0}{2m}, \left(\frac{qB_0}{2m} \right) t$

(b) $\frac{q^2 B_0^2 R^2 t}{4m}$

7. $\left(\frac{\mu_0 n I}{2} \right) r, \left(\frac{\mu_0 n I a^2}{2} \right) \frac{1}{r}$

9. $\frac{E - 18\pi r^2}{rR(3 + \pi)}$

Test Your Concepts-V (Based on Faraday's Laws: Self Induction)

1. (a) 360 mV

(b) 180 mV

(c) 3 s

2. $\frac{\xi_0}{k^2 L}$

3. (a) 1.62×10^{-2} V

(b) a is at higher potential.

4. 35 V

5. (a) 1.81×10^{-4} H

(b) 9.05 mV

6. $\frac{\mu_r \mu_0}{2\pi} N^2 a \ln \left(\frac{b+a}{a} \right)$

7. (a) 16 V

(b) 20 V

(c) 0 V

8. 64 mV, 32 μC

9. $\frac{\mu_0}{\pi} \ln(\eta)$

Test Your Concepts-VI (Based on Growth and Decay of Current in LR Circuits)

1. $3.6 \left(1 - e^{-\frac{t}{3 \times 10^{-4}}} \right)$

2. (a) 400 As⁻¹

(b) 148 As⁻¹

(c) 10 A

3. (a) 0.2 s
(b) 10 A
(c) 9.93 A
(d) 100 J
4. (a) $\frac{E}{r} e^{-\left(\frac{R+r}{L}\right)t}$
(b) $\frac{E^2 L}{2r(R+r)}$
5. Dies out slowly
6. $\frac{8}{3}$ A
7. $5\left(1 - e^{-\frac{2000t}{3}}\right)$ A
8. $\frac{V}{R}$
9. $\frac{1}{R} \left[E - (E - I_0 R) e^{-\frac{Rt}{L}} \right]$
10. $\frac{4}{3}(r_1 - r_2)$
11. $\frac{EL_2}{R(L_1 + L_2)}, \frac{EL_1}{R(L_1 + L_2)}$
12. $\frac{V}{R} - \left(\frac{VR_0}{R + R_0} \right) e^{-\frac{Rt}{L}}$
13. $10e^{-5t}$ V, $5e^{-10t}$ A (direction of current is from *c* to *d*)
14. $2.22(1 - e^{-2.7t})$ A

Test Your Concepts-VII (Based on Magnetic Energy and Magnetic Energy Density)

1. 180 H
2. $\frac{2\pi B_0^2 R^3}{\mu_0}$
3. $\frac{\mu_0 I^2}{4\pi} \ln 2$
4. $u_e = 44.25 \text{ nJm}^{-3}$, $u_m = 995 \text{ } \mu\text{Jm}^{-3}$
 $3 \times 10^8 \text{ ms}^{-1}$, velocity of light
5. $\frac{\mu_0 i^2 l}{4\pi} \ln\left(\frac{b}{a}\right)$
6. (a) 6.25×10^{-4} H
(b) 138 mJ, 210 mW

7. (a) $-Lk$
(b) $\frac{kt^2}{2C}$
(c) $2\sqrt{LC}$
8. 3.465 s

Test Your Concepts-VIII (Based on Faraday's Laws : Mutual Induction)

1. (a) 2 H
(b) 30 V
(c) 1 H
2. 3.125 mH, 937.5 mV
3. $M \approx 4 \times 10^{-4}$ H, $0.02 \text{ V} = 20 \text{ mV}$, $20 \times 10^{-3} \text{ Wbs}^{-1}$,
 $10^{-4} \text{ C} = 100 \text{ } \mu\text{C}$
4. $\frac{\mu_0 \pi (N_1 N_2) (R_1 R_2)^2}{2(x^2 + R_1^2)^{3/2}}$
5. 5×10^{-4} H
6. $\frac{\phi}{i} = \frac{\mu_0 \pi a^4}{2l^3}$
7. (a) 251 μH
(b) 25.1 μH
(c) 25.1 nC
8. 3.2×10^{-5} H
9. (a) $\frac{\mu_0 \omega \pi a^2 I}{2bR} \sin(\omega t)$
(b) $\frac{\mu_0^2 \omega \pi^2 a^4 I^2}{4b^2 R} \sin^2(\omega t)$
(c) $\frac{\mu_0^2 \pi^2 a^4 \omega^2 I}{4b^2} \cos(\omega t)$
10. $\frac{\mu_0 a}{2\pi} \log_e \left(1 + \frac{b}{c} \right)$
11. $L_s = \frac{L}{3} + \frac{L}{3} = \frac{2L}{3}$, $L_p = \frac{L}{6}$
12. $\frac{\mu_0 b}{2\pi h} \left[h - a \log_e \left(\frac{a+h}{a} \right) \right]$

Test Your Concepts-IX (Based on LC Oscillations)

1. (a) 503 Hz
(b) 12 μC

- (c) 38 mA
(d) 72 μJ
2. 20 V
3. $\frac{E\sqrt{LC}}{R}$
4. 10.5 μs
5. (a) 12.5 mV
(b) 8.33×10^{-4} A
(c) 3.125×10^{-8} J
(d) 4.33×10^{-6} C, 7.8×10^{-7} J
6. (a) $\frac{10^4}{\pi}$ Hz
(b) 20 A
7. $\frac{Q}{2N} \sqrt{\frac{3L}{C}}$
8. 0.5 A, $\frac{1}{\sqrt{3}}$ A
9. $\frac{9t^2}{\pi^2 C}$
10. (a) $6.28 \times 10^3 \text{ rads}^{-1}$, 10^{-3} s
(b) $10^{-4} \cos(6.28 \times 10^3 t)$
(c) 25 mH
(d) 0.4 A
11. $I_0 \sqrt{LC} \sin\left(\frac{t}{\sqrt{LC}}\right)$
12. $2\pi \sqrt{\frac{LC}{2}}$, $V \sqrt{\frac{C}{2L}}$
13. (a) 8.15 V
(b) 16.3 A, $\frac{20}{\pi}$ Hz
14. (a) 3.6×10^{-3} H
(b) 1.33 kHz
(c) 0.188 ms
15. (a) $q_0 \omega$, when $\omega t = \frac{\pi}{2}$
(b) $3V_0$, $3V_0$
(c) $q_0 \omega \sin(\omega t)$

Single Correct Choice Type Questions

1. C	2. D	3. C	4. C	5. C	6. D	7. C	8. D	9. C	10. B
11. B	12. D	13. A	14. D	15. D	16. C	17. A	18. C	19. D	20. D
21. D	22. C	23. C	24. C	25. B	26. C	27. C	28. B	29. D	30. B
31. D	32. A	33. B	34. A	35. B	36. B	37. A	38. B	39. D	40. C
41. A	42. B	43. B	44. A	45. A	46. B	47. C	48. A	49. B	50. D
51. B	52. A	53. C	54. D	55. C	56. D	57. C	58. A	59. B	60. B
61. D	62. C	63. B	64. C	65. B	66. A	67. B	68. A	69. A	70. D
71. A	72. D	73. A	74. A	75. D	76. B	77. B	78. B	79. A	80. A
81. A	82. C	83. A	84. C	85. D	86. D	87. B	88. C	89. A	90. C
91. D	92. B	93. C	94. A	95. D	96. C	97. B	98. A	99. B	100. A
101. A	102. D	103. C	104. D	105. A	106. B	107. C	108. D	109. D	110. D
111. B	112. D	113. C	114. A	115. C	116. D	117. D	118. C	119. C	120. D
121. D	122. C	123. B	124. A	125. B	126. C	127. D	128. D	129. D	130. D
131. C	132. C	133. D	134. B	135. B	136. D	137. A	138. B	139. C	140. A
141. C	142. C	143. A	144. A	145. C	146. A	147. D	148. C	149. B	150. C
151. A	152. A	153. C	154. A	155. B	156. D	157. A	158. D	159. A	160. B
161. B	162. B	163. B	164. D	165. B	166. B	167. D	168. B	169. A	170. B



171. C	172. D	173. C	174. A	175. D	176. B	177. B	178. D	179. C	180. B
181. A	182. B	183. A	184. C	185. A	186. C	187. B	188. C	189. C	190. D
191. D	192. B	193. D	194. D	195. A	196. B	197. D	198. C	199. C	200. A
201. D	202. C	203. D	204. D	205. A	206. A	207. A	208. C	209. A	210. C
211. C	212. C	213. B	214. D	215. B	216. A				

Multiple Correct Choice Type Questions

1. A, C	2. A, B, C, D	3. A, C	4. B, D	5. A, B
6. A, C	7. A, B, D	8. A, B, D	9. B, D	10. A, B
11. A, C, D	12. A, C	13. A, B, D	14. A, C	15. B, C
16. B, C, D	17. B, D	18. B, D	19. B, C	20. A
21. A, D	22. B, D	23. A, B, D	24. A, C	25. B, C, D
26. A, C	27. A, B, C, D	28. A, D	29. B, C, D	30. A, D
31. A, B, C, D	32. A, B	33. B, C	34. A, B, C	35. B, C
36. A, B, D	37. A, C	38. B, C, D	39. A, C, D	40. A, C
41. A, C	42. B, C, D	43. A, D	44. A, C	45. A, B, D
46. A, C	47. A, B, C	48. A, C, D	49. A, C, D	50. A, B, C, D
51. B, D				

Reasoning Based Questions

1. D	2. A	3. A	4. D	5. C	6. A	7. D	8. C	9. B	10. B
11. D	12. C	13. C	14. A	15. D	16. B	17. C	18. C		

Linked Comprehension Type Questions

1. B	2. A	3. D	4. B	5. A	6. D	7. C	8. A	9. B	10. C
11. D	12. B	13. B	14. D	15. B	16. C	17. B	18. A	19. C	20. D
21. B	22. C	23. A	24. A	25. D	26. B	27. A	28. C	29. A	30. D
31. C	32. A	33. B, C	34. A	35. C	36. A	37. A	38. C	39. A	40. D
41. A	42. B	43. A	44. C	45. B	46. B	47. D	48. B	49. A	50. A
51. B	52. A	53. A	54. D	55. B	56. B	57. C	58. A	59. D	60. C
61. B	62. A	63. D	64. D	65. D	66. D	67. C	68. A	69. C	70. C
71. D	72. D	73. C	74. C	75. B	76. B	77. A	78. C	79. C	80. B
81. C	82. A	83. A	84. D	85. C	86. B	87. B	88. C	89. B	90. A
91. D	92. C	93. C	94. D	95. C	96. B	97. B	98. C	99. B	100. D
101. A	102. B								

Matrix Match/Column Match Type Questions

1. A → (s)	B → (p)	C → (p, r, t)	D → (q)
2. A → (q)	B → (p)	C → (r)	D → (s)
3. A → (q)	B → (p)	C → (s)	D → (r)

4. $A \rightarrow (s)$	$B \rightarrow (q)$	$C \rightarrow (p)$	$D \rightarrow (p)$
5. $A \rightarrow (q)$	$B \rightarrow (s)$	$C \rightarrow (p)$	$D \rightarrow (r)$
6. $A \rightarrow (s)$	$B \rightarrow (q)$	$C \rightarrow (s)$	$D \rightarrow (p)$
7. $A \rightarrow (p, r)$	$B \rightarrow (p, r)$	$C \rightarrow (q, s)$	$D \rightarrow (p, r, t)$
8. $A \rightarrow (q, s)$	$B \rightarrow (p, r)$	$C \rightarrow (p, r)$	$D \rightarrow (q, s)$
9. $A \rightarrow (q)$	$B \rightarrow (r, s)$	$C \rightarrow (s)$	$D \rightarrow (p, q, r)$
10. $A \rightarrow (r)$	$B \rightarrow (s)$	$C \rightarrow (p)$	$D \rightarrow (t)$
11. $A \rightarrow (q, s)$	$B \rightarrow (p, r)$	$C \rightarrow (p, r)$	$D \rightarrow (q, s)$
12. $A \rightarrow (q)$	$B \rightarrow (p)$	$C \rightarrow (t)$	$D \rightarrow (r)$
13. $A \rightarrow (q)$	$B \rightarrow (s)$	$C \rightarrow (p)$	$D \rightarrow (r)$
14. $A \rightarrow (r)$	$B \rightarrow (p)$	$C \rightarrow (q)$	$D \rightarrow (q)$

Integer/Numerical Answer Type Questions

1. (a) 31, (b) clockwise	2. 8	3. 1	4. 100
5. 2	6. 4	7. 281	8. 2
10. 24	11. 9	12. 360	13. (a) 3, (b) 6
15. (a) 2, (b) 80, (c) 10	16. 6	17. 25	18. 400
19. (a) 1 (b) Voltage across 12Ω , 12Ω and L (in volt) is 12, 1200, 1212 (c) $x = 76$	20. 783		
21. 3	22. 2700	23. 7	24. (a) 30, (b) 20
26. 324	27. (a) 20, (b) 10, (c) 63	28. 250	29. 2
30. 1			

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1. B	2. A	3. B	4. B	5. D	6. A	7. B	8. *	9. B	10. A
11. *	12. B	13. A	14. C	15. A	16. D	17. A	18. B	19. C	20. C
21. B	22. D	23. B	24. C	25. B	26. A	27. D	28. A	29. D	30. B
31. D	32. C	33. B	34. C	35. C	36. D				

* No given option is correct

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Single Correct Choice Type Problems

1. C	2. C	3. D	4. C	5. B	6. B	7. D	8. D	9. A	10. D
11. B	12. D	13. D	14. C	15. B	16. B	17. D	18. D		

Multiple Correct Choice Type Problems

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

Reasoning Based Questions

1. A

**Linked Comprehension Type Questions**

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

Matrix Match/Column Match Type Questions

1. A \rightarrow (p) B \rightarrow (p, q, s) C \rightarrow (q, s) D \rightarrow (q, r, s)

Integer/Numerical Answer Type Questions

1. 0.63 2. 8 3. 7 4. 6