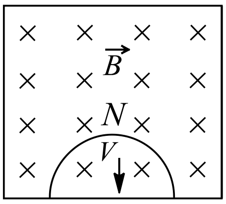
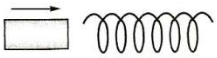
Single Correct Answer Type

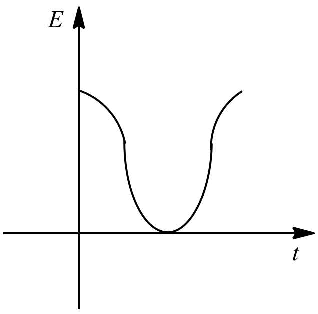
1. A thin semicircular conducting ring of radius R is falling with its plane vertical in horizontal magnetic induction $\vec{B}$. At the position MNQ the speed of the ring is V, and the potential difference developed across the ring is

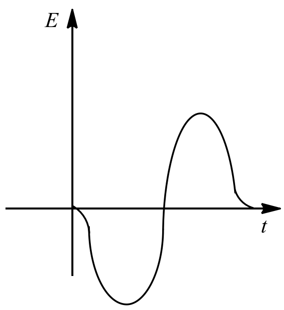


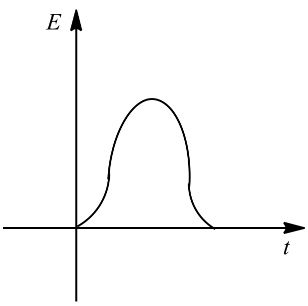
a) Zero
b) $BV\pi R^2/2$ and M is at higher potential
c) πRBV and Q is at higher potential
d) $2RBV$ and Q is at higher potential

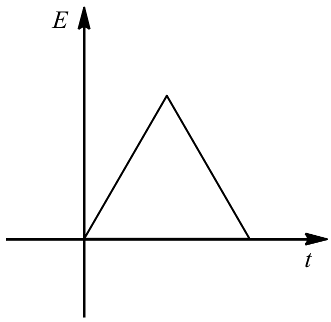
2. The variation of induced emf(ε) with time (t) in a coil if a short bar magnet is moved along its axis with a constant velocity is best represented as



a) 

b) 

c) 

d) 

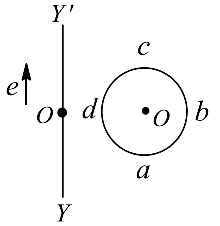
3. The coefficient of mutual inductance of two circuits A and B is 3 mH and their respective resistances are 10 and 4 Ω. How much current should change in 0.02 s in circuit A, so that the induced current in B should be 0.0060 A?

a) 0.24 A
b) 1.6 A
c) 0.18 A
d) 0.16 A

4. A current i_0 is flowing through an $L - R$ circuit of time constant t_0. The source of the current is switched off at time $t = 0$. Let r be the value of $(-di/dt)$ at time $t = 0$. Assuming this rate to be constant, the current will reduce to zero in a time interval of

a) t_0
b) et_0
c) $\frac{t_0}{e}$
d) $\left(1 - \frac{1}{e}\right) t_0$

5. An electron moves on a straight line path YY' as shown in figure. A coil is kept on the right such that YY' is in the plane of the coil. At the instant when the electron gets closest to the coil (neglect self-induction of the coil)



a) The current in the coil floes clockwise
b) The current in the coil flows anticlockwise
c) The current in the coil is zero
d) The current in the coil does not change the direction as the electron crosses point Q

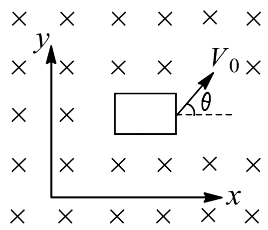
6. The time constant of an inductance coil is 2×10^{-3} s. When a 90 Ω resistance is joined in series, the same constant becomes 0.5×10^{-3} s. The inductance and resistance of the coil are

a) 30 mH; 30 Ω b) 60 mH; 30 Ω c) 30 mH; 60 Ω d) 60 mH; 60 Ω

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

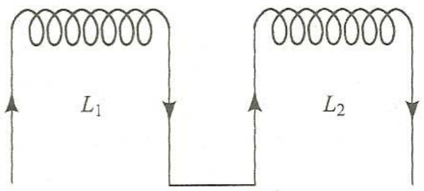
a) EI_0I' b) $\frac{I_0I'}{E}$ c) $(EI')I_0$ d) $\left(\frac{E}{I'}\right) I_0$

8. In the space shown a non-uniform magnetic filed$\vec{B} = B_0(1 + x)(-\hat{k})$ tesla is present. A closed loop of small resistance, placed in the xy plane is given velocityV_0. The force due to magnitude filed on the loop is



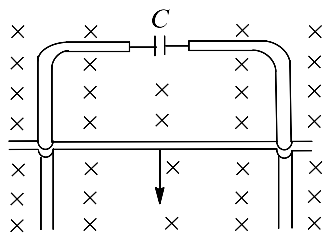
a) Zero b) A long $+x$ direction c) Along – x direction d) Along $+y$ direction

9. A circuit contains two inductors of self-inductance L_1 and L_2 in series. If M is the mutual inductance then the effective inductance of the circuit shown will be



a) $L_1 + L_2$ b) $L_1 + L_2 - 2\,M$ c) $L_1 + L_2 + \,M$ d) $L_1 + L_2 + 2\,M$

10. A conductor of length l and mass m can slide without any friction along the two vertical conductors connected at the top through a capacitor figure. A uniform magnetic filed B is set up ⊥ to the plane of paper. The acceleration of the conductor



a) Is constant b) Increases c) Decreases d) Cannot say

11. A metal disc of radius a rotates with a constant angular velocity ω about itsaxis. The potential difference between the centre and the rim of the disc is (m =mass of elelctron, e =charge on electron)

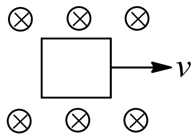
a) $\frac{m\omega^2 a^2}{e}$ b) $\frac{1}{2}\frac{m\omega^2 a^2}{e}$ c) $\frac{e\omega^2 a^2}{2m}$ d) $\frac{e\omega^2 a^2}{m}$

12. A 0.1 m long conductor carrying a current of 50 A is perpendicular to a magnetic field of 1.21 mT. The

mechanical power to move the conductor with a speed of 1 ms^{-1} is

a) 0.25 mW b) 6.25 mW c) 0.625 W d) 1 W

13. A conducting square loop of side L and resistance R moves in its plane with a uniform velocity v perpendicular to one of its sides. A magnetic induction B, constant in time and space, pointing perpendicular to and into the plane of the loop exists everywhere

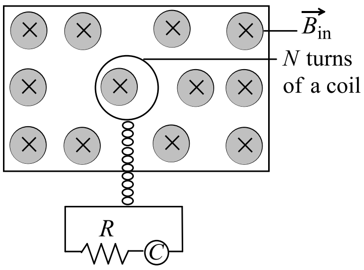


The current induced in the loop is

a) BLv/R clockwise b) BLv/R anticlockwise

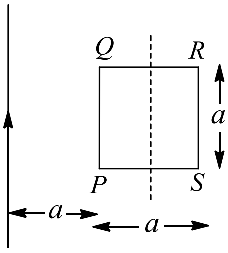
c) $2BLv/R$ anticlockwise d) Zero

14. A flip coil consists of N turns of circular coils which lie in a uniform magnetic field. Plane of the coils is perpendicular to the magnetic filed as shown in figure. The coil is connected to a current integrator which measures the total charge passing through it. The coil is turned 180° about the diameter. The charge passing through the coil is



a) $\frac{NBA}{R}$ b) $\frac{\sqrt{3}NBA}{2R}$ c) $\frac{NBA}{\sqrt{2}R}$ d) $\frac{2NBA}{R}$

15. In figure, a square loop $PQRS$ of side a and resistance r is placed near an infinitely long wire carrying a constant current I. The sides PQ and RS are parallel to the wire. The wire and the loop are in the same plane. The loop is rotated by 180° about an axis parallel to the long wire and passing through the mid-points of the sides $QR$and PS. The total amount of charge which passes through any point of the loop during rotation is



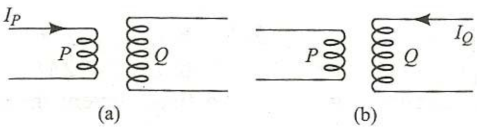
a) $\frac{\mu_0 Ia}{2\pi r}$In2

b) $\frac{\mu_0 Ia}{\pi r}$In2

c) $\frac{\mu_0 Ia^2}{2\pi r}$

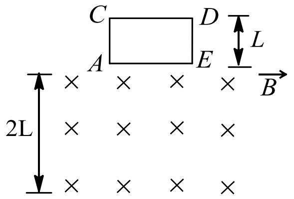
d) Cannot be found because time of rotation is not given

16. In Fig (a) and (b), two air-cored solenoids P and Q have been shown. They are placed near each other. In Fig (a) when I_P, the current in P, changes at the rate of 5 A s^{-1}, an e.m.f. of 2 mV in induced in Q. The current in P is then switched off, and the current changing at 2 A s^{-1} is fed through Q as shown in the fig. What e.m.f. will be induced in P?



a) 8×10^{-4} V b) 2×10^{-3} V c) 5×10^{-3} V d) 8×10^{-2} V

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

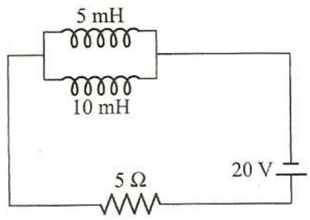


a) Less than g for all the time the loop crosses the magnetic field completely
b) Less than g when it enters the filed and greater than g when it comes out of the field
c) g all the time
d) Less than g when it enters and comes out of the field but equal to g when it is within the filed

18. A square conducting loop of side L is situated in gravity-free space. A small conducting circular loop of radius $r(r \ll L)$ is placed at the centre of the square loop, with its plane perpendicular to the plane of the square loop. The mutual inductance of the two coils is

a) $\frac{2\sqrt{2}\mu_0 I}{L} r^2$ b) $\frac{\sqrt{2}\mu_0 I_0}{L} r^2$ c) 0 d) None of these

19. In the gives circuit fig, current through the 5 mH inductor in steady state is

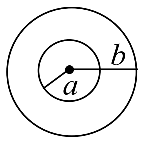


a) $\frac{2}{3}$ A b) $\frac{8}{3}$ A c) $\frac{1}{3}$ A d) $\frac{2}{3}$ A

20. Charge Q is uniformly distributed on a thin insulating ring of mass m which is initially at rest. To what angular velocity will the ring be accelerated when a magnetic field$B$, perpendicular to the plane of the ring, is switched on?

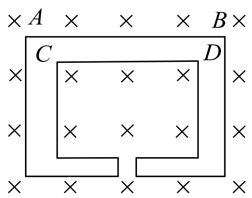
a) $\frac{QB}{2m}$ b) $\frac{3QB}{2m}$ c) $\frac{QB}{m}$ d) $\frac{QB}{4m}$

21. Two concentric and coplanar coils have radii a and $b(\gg a)$ as shown in fig. Resistance of the inner coil is R. Current in the outer is increased from 0 to i, then the total change circulating the inner coil is



a) $\frac{\mu_0 i a^2 \pi}{2Rb}$ b) $\frac{\mu_0 iab}{2R}$ c) $\frac{\mu_0 iab}{2a} \frac{\pi b^2}{R}$ d) $\frac{\mu_0 ib}{2\pi R}$

22. A wire is bent to form the double loop shown in figure. There is s uniform magnetic field directed into the plane of the loop. If the magnitude of this filed is decreasing, the current will flow from

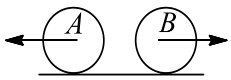


a) a to b and c to d b) b to a and d to c c) a to b and d to c d) b to a and c to d

23. A metallic wire is folded to form a square loop of side a. It carries a current i and is kept perpendicular to0 the region of uniform magnetic filed B. If the shape of the loop is changed from square to an equilateral triangle without changing the length of the wire and current, the amount of work done in doing so is

a) $Bia^2\left(1-\frac{4\sqrt{3}}{9}\right)$ b) $Bia^2\left(1-\frac{\sqrt{3}}{9}\right)$ c) $\frac{2}{3}Bia^2$ d) Zero

24. Two identical conducting rings A and B of radius R are rolling over a horizontal conducting plane with same speed v but in opposite direction. A constant magnetic filed B is present pointing into the plane of paper. Then the potential difference between the highest points of the two rings is



a) 0 b) $2BvR$ c) $4BvR$ d) None of these

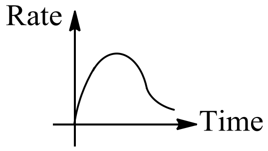
25. The capacitor of an oscillatory circuit of frequency 10,000 Hz is enclosed in a container. When the container is evacuated, the frequency changed by 50 Hz, the dielectric constant of the gas is

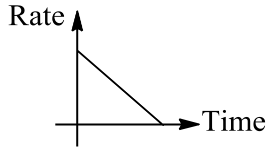
a) 1.1 b) 1.01 c) 1.001 d) 1.0001

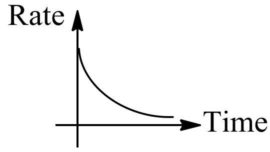
26. A small square loop of wire of side ℓ is placed inside a large square loop of wire of side $L(L \gg \ell)$. The loops are coplanar and their centres coincide. The mutual inductance of the system is proportional to

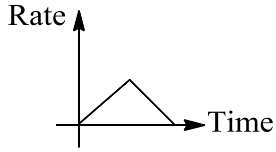
a) ℓ/L b) ℓ^2/L c) L/ℓ d) L^2/ℓ

27. In an 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?

a) 

b) 

c) 

d) 

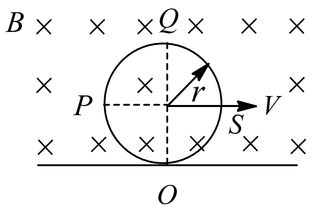
28. The inductance L of a solenoid of length l, whose windings are made of material of density D and resistivity ρ, is (the winding resistance is R)

a) $\frac{\mu_0}{4\pi l}\frac{Rm}{\rho D}$ b) $\frac{\mu_0}{4\pi R}\frac{lm}{\rho D}$ c) $\frac{\mu_0}{4\pi l}\frac{R^2m}{\rho D}$ d) $\frac{\mu_0}{2\pi R}\frac{lm}{\rho D}$

29. The magnitude flux density B us changing in magnitude at a constant rate dB/dt. A given mass m of copper, drawn into a wire of radius a and formed into a circular loop of radius r is placed perpendicular to the field B. The induced current in the loop is i. The resistivity of copper is ρ and density is d. The value of the induced current i is

a) $\frac{m}{2\pi\rho d}\frac{dB}{dt}$ b) $\frac{m}{2\pi a^2 r}\frac{dB}{dt}$ c) $\frac{m}{4\pi a d}\frac{dB}{dt}$ d) $\frac{m}{4\pi\rho d}\frac{dB}{dt}$

30. A conducting ring of radius r and resistance R rolls on a horizontal surface with constant velocity$v$. The magnitude filed B is uniform and is normal to the plane of the loop. Choose the correct option



a) The inclined emf between O and Q is Brv

b) An induced current $I=\frac{2Bvr}{R}$ flows in the clockwise direction

c) An included current $I=\frac{2Bvr}{R}$ flows in the anticlockwise direction

d) No current flows

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

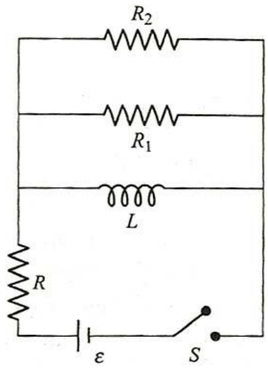
a) Remains stationary b) Is attached by the loop A

c) Is repelled by the loop A d) Rotates about its CM with CM fixed

32. A closed circuit consists of a resistor R; inductor of inductance L and a source of e.m.f. E are connected in series. If the inductance of the coil is abruptly decreased to $L/4$ (by removing its magnetic core), the new current immediately after this moment is (before decreasing the inductance the circuit is in steady state)

a) Zero　　b) $\frac{E}{R}$　　c) $4\frac{E}{R}$　　d) $\frac{E}{4R}$

33. In fig switch S is closed for a long time. At $t = 0$, if it is opened, then



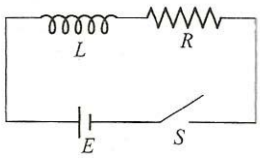
a) Total heat produced in resistor R after opening the switch is $\frac{1}{2}\frac{L\mathcal{E}}{R^2}$

b) Total heat produced in resistor R_1 after opening the switch is $\frac{1}{2}\frac{L\mathcal{E}^2}{R^2}\left(\frac{R_1}{R_1+R_2}\right)$

c) Heat produced in resistor R_1 after opening the switch is $\frac{1}{2}\frac{R_2 L\mathcal{E}^2}{(R_1+R_2)R^2}$

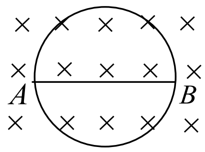
d) No heat will be produced in R_1

34. In the circuit shown in fig, switch S is closed at time $t = 0$. The charge that passes through the battery in one time constant is



a) $\frac{eR^2E}{L}$　　b) $E\left(\frac{L}{R}\right)$　　c) $\frac{EL}{eR^2}$　　d) $\frac{eL}{ER}$

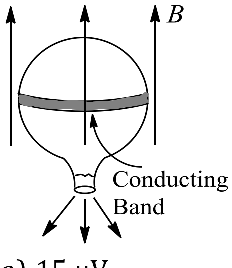
35. The radius of the circular conducting loop shown in figure is$R$. Magnetic field is decreasing at a constant rateα. Resistance per unit length of the loop is p



Then, the current in wire AB is (AB is one of the diameters)

a) $\frac{R\alpha}{2\rho}$ from A to B　　b) $\frac{R\alpha}{2\rho}$ from B to A　　c) $\frac{R\alpha}{\rho}$ from A to B　　d) 0

36. An elasticized conducting band is around a spherical balloon figure. Its plane passes through the centre of the balloon. A uniform magnitude field of magnitude 0.04 T is directed perpendicular to the plane of the band. Air is let out of the balloon at 100 cm^3/a at an instant when the radius of the balloon is 10 cm. The induced emf in the band is



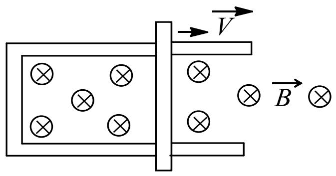
a) 15 μV　　b) 25 μV　　c) 10 μV　　d) 20 μV

37. Two identical cycle wheels (geometrically) have different number of spokes connected from centre to rim. One is having 20 spokes and the other having only 10 (the rim and the spokes are resistanceless). One resistance of value R is connected between centre and rim. The current in R will be

a) Double in the first wheel than in the second wheel

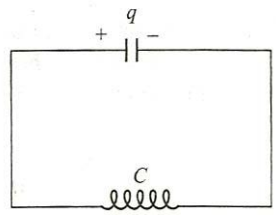
b) Four times in the first wheel than in the second wheel
c) Will be double in the second wheel than that of the first wheel
d) Will be equal in both these wheels

38. A rod lies across frictionless rails in a uniform magnetic field $\vec{B}$ as shown in figure. The rod moves to the right with speed$V$. In order to make the induced emf in the circuit to be zero, the magnitude filed should



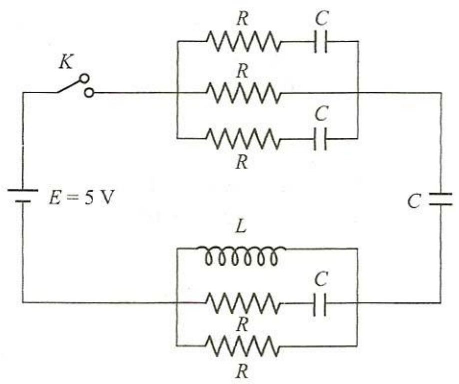
a) Not change
b) Increases linearly with time
c) Decreases linearly with time
d) Decrease nonlinearly with time

39. In an LC circuit shown in fig, $C = 1$ F, $L = 4$ H. At time $t = 0$, charge in the capacitor is 4 C and it is decreasing at the rate of $\sqrt{5}$ Cs^{-1}. Choose the correct statement



a) Maximum charge in the capacitor can be 6 C
b) Maximum charge in the capacitor can be 8 C
c) Charge in the capacitor will be maximum after time $3\sin^{-1}(2/3)$ s
d) None of these

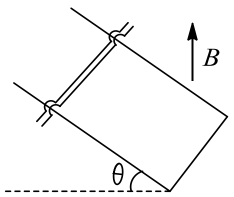
40. The current passing through the battery immediately after key (K) is closed [it is given that initially all the capacitors are uncharged (given that $R = 6\ \Omega$ and $C = 4\ \mu$F)] is



a) 1 A
b) 5 A
c) 3 A
d) 2 A

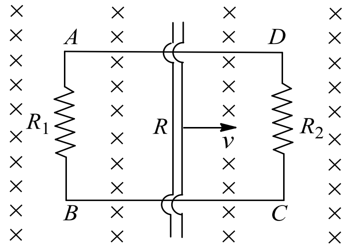
41. A uniform magnitude filed exists in a region given by $\vec{B} = 3\hat{\imath} + 4\hat{\jmath} + 5\hat{k}$. A rod of length 5 m along y-axis moves with a constant speed of 1 m/s along x axis. Then the induced emf in the rod will be
a) 0
b) 25 V
c) 20 V
d) 15 V

42. A wire of length$l$, mass m and resistance R slides without any friction down the parallel conducting rails of negligible resistance figure. The rails are connected to each other at the bottom by a resistanceless rail parallel to the wire so that the wire and the rails from a closed rectangular conducting loop. The plane of the rails makes an angle θ with the horizontal and a uniform vertical magnetic field of induction B exists throughout the region. Find the steady-state velocity of the wire



a) $\frac{mg}{R}\frac{\sin\theta}{B^2l^2\cos^2\theta}$ b) $\frac{mg}{R}\frac{\sin^2\theta}{B^2l^2\cos^2\theta}$ c) $\frac{mgR\sin\theta}{B^2l^2\cos^2\theta}$ d) $mgR\frac{\sin^2\theta}{B^2l^2\cos\theta}$

43. A rectangular loop with a sliding conductor of length l is located in a uniform magnetic field perpendicular to the plane of the loop figure. The magnetic induction is$B$. The conductor has a resistance$R$. The sides AB and CD have resistances $R_1$and R_2, respectively. Find the current through the conductor during its motion to the right with a constant velocity v

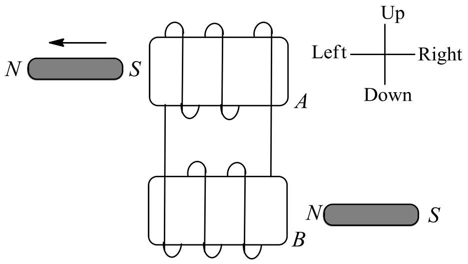


a) $\frac{Blv(R_1+R_2)}{R_1(R_1+R_2)}$ b) $\frac{Bl^2v}{R_1+R_1R_2}$ c) $\frac{Blv(R_1+R_2)}{R_1R_2+R(R_1+R_2)}$ d) $\frac{Bl^2v}{R_1R_2+R(R_1+R_2)}$

44. A conductor AB of length ℓ moves in xy plane with velocity $\vec{v}=v_0(\hat{\imath}-\hat{\jmath})$. A magnetic field $\vec{B}=B_0(\hat{\imath}+\hat{\jmath})$ exists in the region. The induced emf is

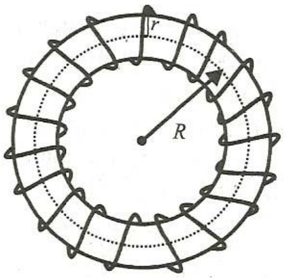
a) Zero b) $2B_0\ell v_0$ c) $B_0\ell v_0$ d) $\sqrt{2}B_0lv_0$

45. A bar magnet was pulled away from a hollow coil A as shown in fig. As the south pole came out of the coil, the bar magnet next to hollow coil B experienced a magnetic force



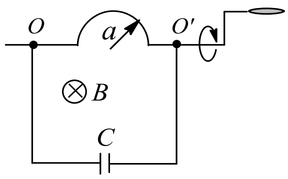
a) To the right b) To the left c) Upwards d) Equal to zero

46. A toroid is wound over a circular core. Radius of each turn is r and radius of toroid is $R(\gg r)$. The coefficient of self-inductance of the toroid is given by



a) $L=\frac{\mu_0Nr^2}{2R}$ b) $L=\frac{\mu_0Nr}{2R}$ c) $L=\frac{\mu_0Nr^2}{R}$ d) $L=\frac{\mu_0N^2r^2}{2R}$

47. A copper rod is bent into a semi-circle of radius a and at ends straight parts are bent along diameter of the semi-circle and are passed through fixed. Smooth and conducting ring O and O' as shown in figure. A capacitor having capacitance C is connected to the rings. The system is located in a uniform magnetic field of induction B such that axis of rotation OO' is perpendicular to the field direction. At initial moment of time($t=0$), plane of semi-circle was normal to the field direction and the semi-circle is set in rotation with constant angular velocityω. Neglect the resistance and inductance of the circuit. The current flowing through the circuit as function of time is



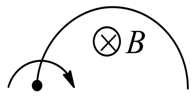
a) $\frac{1}{4}\pi\omega^2 a^2 CB \cos\omega t$

b) $\frac{1}{2}\pi\omega^2 a\ CB \cos\omega t$

c) $\frac{1}{4}\pi\omega^2 a^2 CB \sin\omega t$

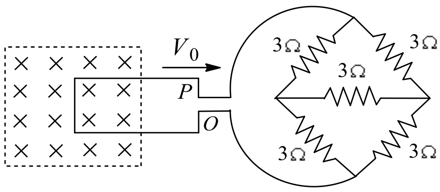
d) $\frac{1}{2}\pi\omega^2 a^2\ CB \sin\omega t$

48. A semicircular wire of radius R is rotated with constant angular velocity about an axis passing through one end and perpendicular to the plane of the wire. There is a uniform magnetic field of strength$B$. The induced emf between the ends is



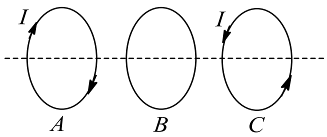
a) $B\omega R^2/2$ b) $2B\omega R^2$ c) Is variable d) None of these

49. A square metal wire loop of side 10 cm and resistance 1 Ω is moved with constant velocity v_0 in a uniform magnetic field of induction $B = 2\text{Wbm}^{-2}$, as shown in figure. The magnetic field lines are perpendicular to the plane of loop and directed into the paper. The loop is connected to the network of resistances, each of value 3 Ω. The resistance of the lead wires is negligible. The speed of the loop so as to have a steady current of 1 mA in the loop is



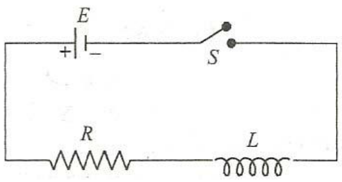
a) $2\ \text{ms}^{-1}$ b) $2\ \text{cms}^{-1}$ c) $10\ \text{ms}^{-1}$ d) $20\ \text{ms}^{-1}$

50. Three identical coils A, B and C carrying currents are placed coaxially with their planes parallel to one another. $A$and$C$ carry currents as shown in figure B is kept fixed, while A and C both are moved towards B with the same speed. Initially, B is equally separated from $A$and C. The direction of the inclined current in the coil B is

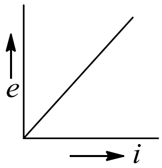


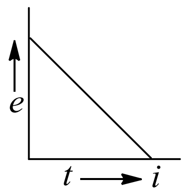
a) Same as that in coil A b) Same as that in coil c) Zero d) None of these

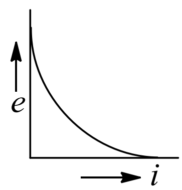
51. Switch S of the circuit shown in Fig is closed at $t = 0$

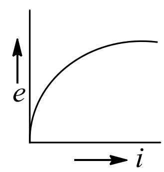


If e denotes the induced e.m.f. in L and i the current flowing through the circuit at time t, then which of the following graphs correctly represents the variation of e with i?

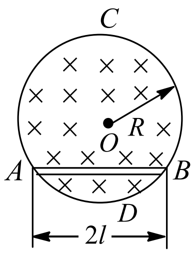
a) 

b) 

c) 

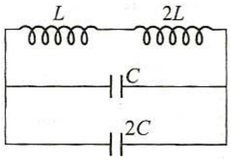
d) 

52. A uniform magnetic field of induction B fills a cylindrical volume of radius R. A rod AB of length $2l$ is placed as shown in figure. If B is changing at the rate dB/dt, the emf that is produced by the changing magnetic field and that acts between the ends of the rod is



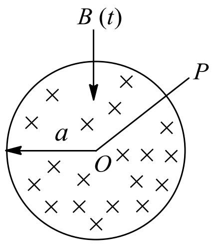
a) $\frac{dB}{dt} l\sqrt{R^2 - l^2}$ b) $\frac{dB}{dt} l\sqrt{R^2 + l^2}$ c) $\frac{1}{2}\frac{dB}{dt} l\sqrt{R^2 - l^2}$ d) $\frac{1}{2}\frac{dB}{dt} l\sqrt{R^2 + l^2}$

53. The frequency of oscillation of current in the inductance is



a) $\frac{1}{3\sqrt{LC}}$ b) $\frac{1}{6\pi\sqrt{LC}}$ c) $\frac{1}{\sqrt{LC}}$ d) $\frac{1}{2\pi\sqrt{LC}}$

54. 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 filed at point P at a distance r from the centre of the circular region



a) Is zero b) Decreases as $1/r$ c) Increases as r d) Decreases as $1/r^2$

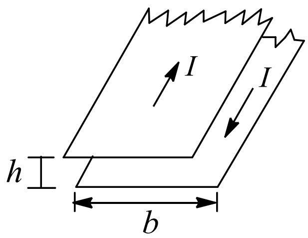
55. A wire of fixed length is wound on a solenoid of length ℓ and radius r. Its self-inductance is found to be L. Now, if the same wire is wound on a solenoid of length $\ell/2$ and radius $r/2$, then the self-inductance will be

a) $2L$ b) L c) $4L$ d) $8L$

56. An e.m.f of 15 V is applied in a circuit containing 5 H inductance and 10 Ω resistance. The ratio of the currents at time $t = \infty$ and $t = 1$ s is

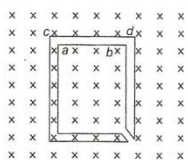
a) $\frac{e^{1/2}}{e^{1/2} - 1}$ b) $\frac{e^2}{e^2 - 1}$ c) $1 - e^{-1}$ d) e^{-1}

57. Calculate the inductance of a unit length of a double tape line as shown in fig, if the tapes are separated by a distance h which is considerably less than their width b



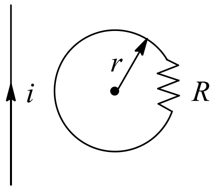
a) $\frac{\mu_0 h}{b}$ b) $\frac{\mu_0 h}{2b}$ c) $\frac{2\mu_0 h}{b}$ d) $\frac{\sqrt{2}\mu_0 h}{b}$

58. 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,



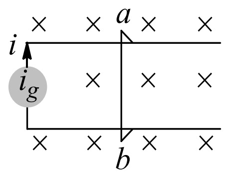
a) $I_1 > I_2$
b) $I_1 < I_2$
c) I_1 is in the direction ba and $I_2$is in the direction cd
d) I_1 is in the direction ab and $I_2$is in the direction dc

59. In fig, the mutual inductance of a coil and a very long straight wire is M, the coil has resistance R and self-inductance L. The current in the wire varies according to the law $i = at$, where a is a constant and t is the time, the time dependence of current in the coil is



a) $\frac{M}{aR}$ b) $MaRe^{-Rt/L}$ c) $\frac{M}{R}e^{-tR/L}$ d) $\frac{Ma}{R}(1 - e^{-tR/L})$

60. The current generator i_g, shown in figure, sends a constant current i through the circuit. The wire ab has a length ℓ and mass m slide on the smooth, horizontal rails connected to i_g. The entire system lies in a vertical magnetic field B. The velocity of the wire as a function of time is

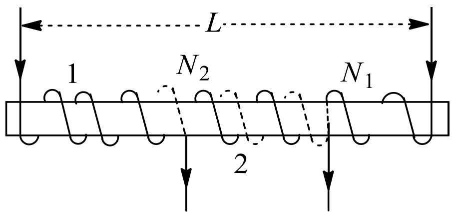


a) $\frac{i\ell Bt}{m}$ b) $\frac{i\ell Bt}{2m}$ c) $\frac{2i\ell Bt}{m}$ d) $\frac{i\ell Bt}{3m}$

61. An infinitely cylinder is kept parallel to an uniform magnetic field Bdirected along positive z axis. This direction of induced current as seen from the z axis will be

a) Clockwise of the +ve z axis
b) Anticlockwise +ve z axis
c) Zero
d) Along the magnetic field

62. A long solenoid of length L, cross section A having N_1 turns has wound about its centre a small coil of N_2 turns as shown in fig. The mutual inductance of two circuits is

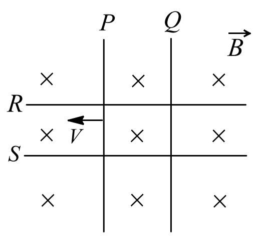


a) $\frac{\mu_0 A(N_1/N_2)}{L}$ b) $\frac{\mu_0 A(N_1 N_2)}{L}$ c) $\mu_0 A\, N_1 N_2 L$ d) $\frac{\mu_0 A\, N_1^2 N_2}{L}$

63. 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

a) $\tau = t_0 \text{ In } \alpha$ b) $\tau = \frac{t_0}{\text{In } \alpha}$ c) $\tau = \frac{t_0}{\alpha}$ d) $\tau = \frac{t_0}{\alpha - 1}$

64. Two identical conductors P and Q are placed on two frictionless rails R and S in a uniform magnetic field directed into the plane. If P is moved in the direction shown in figure with a constant speed, then rod Q

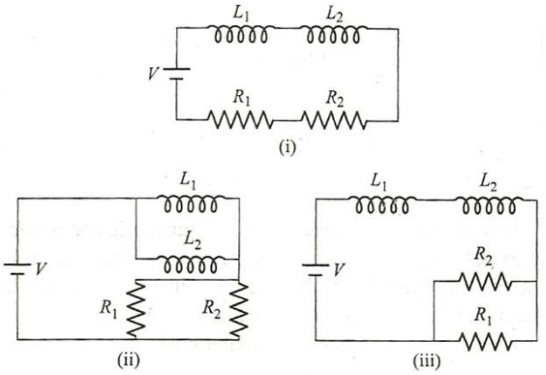


a) Will be attracted towards P
b) Will be repelled away from P

c) Will remain stationary

d) May be repelled away or attracted towards P

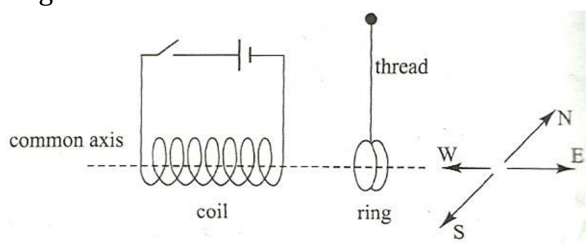
65. Given $L_1 = 1$ mH, $R_1 = 1\ \Omega$, $L_2 = 2$ mH, $R_2 = 2\ \Omega$



Neglecting mutual inductance, the time constants (in ms) for circuits (i), (ii) and (iii) are

a) $1,1,\frac{9}{2}$ b) $\frac{9}{4},1,1$ c) 1,1,1 d) $1,\frac{9}{4},1$

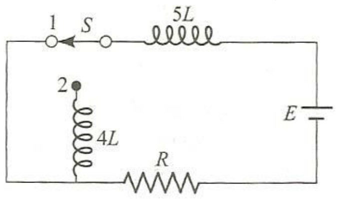
66. An aluminium ring hangs vertically from a thread with its axis pointing east-west. A coil is fixed near to the ring and coaxial with it



What is the initial motion of the aluminium ring when the current in the coil is switched on?

a) Moves towards E b) Moves towards W c) Moves towards N d) Moves towards S

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

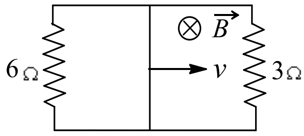


a) $\frac{4}{5}\frac{E}{R}$ b) $\frac{5}{4}\frac{E}{R}$ c) $\frac{5}{9}\frac{E}{R}$ d) $\frac{E}{R}$

68. A rectangular loop of slides 10 cm and 5 cm with cut is stationary between the pole pieces of an electromagnet. The magnetic field of the magnet is normal to the loop. The current feeding the electromagnet is reduced so that the field decreases from its initial value of 0.3 T at the rate of0.02 Ts^{-1}. If the cut is joined and the loop has a resistance of 2.0 Ω, the power dissipated by the loop as heat is

a) 5 nW b) 4 nW c) 3 nW d) 2 nW

69. A rectangular loop with a sliding connector of length $l = 1.0$ m is situated in a uniform magnetic field $B = 2$T perpendicular to the plane of loop. Resistance of connector is$r = 2\ \Omega$. Two resistances of 6 and 3 Ω are connected as shown in figure. The external force required to keep the connector moving with a constant velocity $v = 2m/s$ is



a) 6N b) 4N c) 2N d) 1N

70. A gold rod of length ℓ is accelerated in the horizontal direction with an acceleration a_0. The rod is held between two perfectly insulating clamps. Calculate the electric filed set up in the rod. Take the mass of

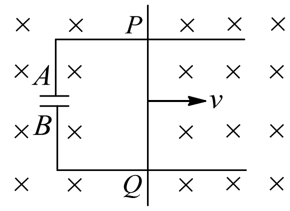
electron as m

a) $E=\frac{ma_0}{e}$ b) $E=ma_0\ell$ c) Zero d) None of these

71. The capacitance in an oscillatory LC circuit is increased by 1%. The change in inductance required to restore its frequency of oscillation is to

a) Decrease it by 0.5% b) Increase it by 1% c) Decrease it by 1% d) Decrease it by 2%

72. A conducting rod PQ of length $L=1.0$ m is moving with a uniform speed $v=2.0$ m/s in a uniform magnetic field $B=4.0$ T directed into the plane of the paper



A capacitor of capacity $C=10\ \mu F$ is connected as shown in figure, then

a) $q_A=+80\mu C$ and $q_B=-80\ \mu C$

b) $q_A=+80\mu C$ and $q_B=+80\ \mu C$

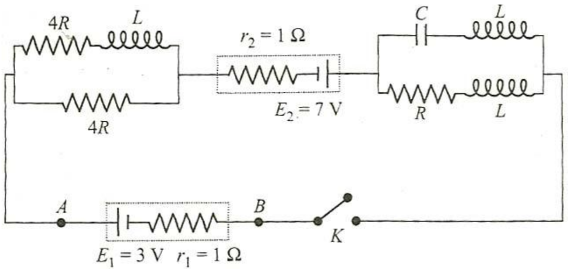
c) $q_A=0=q_B$

d) Charge stored in the capacitor increases exponentially with time

73. 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 magnitude filed is

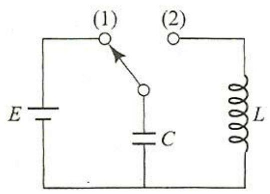
a) $\frac{E^2}{4R}$ b) $\frac{E^2}{R}$ c) $\frac{4E^2}{R}$ d) $\frac{2E^2}{R}$

74. In fig, key K is closed at $t=0$. After a long time, the potential difference between A and B is zero, the value of R will be [$r_1=r_2=1\Omega, E_1=3$ V and $E_2=7$ V, $C-2\ \mu F, L=4$ mH, where r_1 and r_2 are the internal resistance of cells E_1 and E_2, respectively]



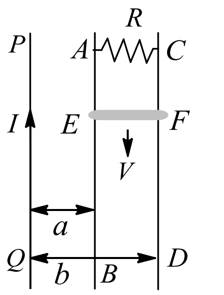
a) $\frac{4}{3}\Omega$ b) $\frac{4}{9}\Omega$ c) $\frac{2}{3}\Omega$ d) 4 Ω

75. In the following electrical network at $t<0$ fig, key is placed on (1) till the capacitor got fully charged. Key is placed on (2) at $t=0$. Time when the energy in both the capacitor and the inductor will be same for the first time is



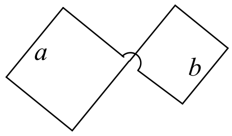
a) $\frac{\pi}{4}\sqrt{LC}$ b) $\frac{3\pi}{4}\sqrt{LC}$ c) $\frac{\pi}{3}\sqrt{LC}$ d) $\frac{2\pi}{3}\sqrt{LC}$

76. $PQ$is an infinite current-carrying conductor. ABandCD are smooth conducting rods on which a conductor EF moves with constat velocity V as shown in figure. The force needed to maintain constant speed of EF is



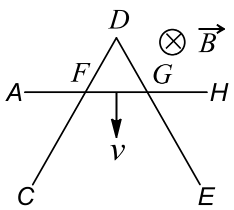
a) $\frac{1}{VR}\left[\frac{\mu_0 IV}{2\pi}\text{In}\left(\frac{b}{a}\right)\right]^2$ b) $\left[\frac{\mu_0 IV}{2\pi}\text{In}\left(\frac{b}{a}\right)\right]^2\frac{1}{VR}$ c) $\left[\frac{\mu_0 IV}{2\pi}\text{In}\left(\frac{b}{a}\right)\right]^2\frac{V}{R}$ d) $\frac{V}{R}\left[\frac{\mu_0 IV}{2\pi}\text{In}\left(\frac{b}{a}\right)\right]^2$

77. A plane loop, shaped as two squares of sides $a = 1$ m and $b = 04$ m is introduced into a uniform magnetic filed ⊥ to the plane of loop figure. The magnetic filed varies as$B = 10^{-3}\sin(100t)$. The amplitude of the current induced in the loop, if its resistance per unit length is $r = 5\ \text{m}\Omega/\text{m}$ is



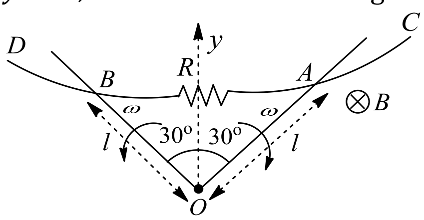
a) 2 A b) 3 A c) 4 A d) 5 A

78. A long conducting wire AH is moved over a conducting triangular wire CDE with a constant velocity v in a uniform magnetic filed$\vec{B}$ directed into the plane of the paper. Resistance per unit length of each wire isρ. Then



a) A constant clockwise induced current will flow in the closed loop
b) An increasing anticlockwise induced current will flow in the closed loop
c) A decreasing anticlockwise induced current will flow in the closed loop
d) A constant anticlockwise induced current will flow in the closed loop

79. In figure, there exists a uniform magnetic filed$B$ into the plane of paper. Wire CD is in the shapes of an arc and is fixed. OAandOB are the wires rotating with angular velocity ω as shown in figure in the same plane as that of the arc about point O. If at some instant, $OA = OB = l$ and each wires makes angle $\theta = 30°$with y-axis, then the current through resistance R is (wires OA and OB have no resistance)

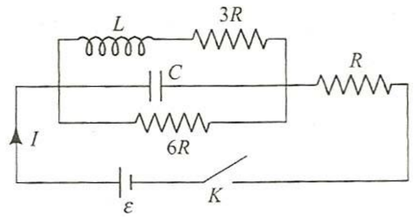


a) 0 b) $\frac{B\omega l^2}{R}$ c) $\frac{B\omega l^2}{2R}$ d) $\frac{B\omega l^2}{4R}$

80. 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

81. Current in a coil of self-inductance 2.0 H is increasing as $i = 2\sin t^2$. The amount of energy spent during the period when the current changes from 0 to 2 A is
a) 1 J b) 2 J c) 3 J d) 4 J

82. In the given circuit diagram fig, key K is switched on at $t = 0$. The ratio of current i through the cell at $t = 0$ to that at $t = \infty$ will be



a) 3 : 1 b) 1 : 3 c) 1 : 2 d) 2 : 1

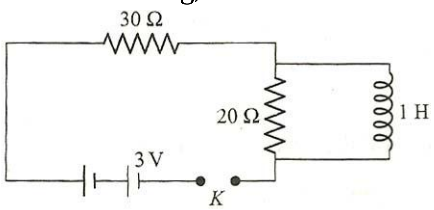
83. The length of a thin wire required to manufacture a solenoid of length $l = 100$ cm and inductance $L = 1$ mH, if the solenoid's cross-sectional diameter is considerably less than its length is

a) 1.0 km b) 0.10 km c) 0.010 km d) 10 km

84. A horizontal ring of radius $r = \frac{1}{2}$m is kept in a vertical constant magnetic field 1 T. The ring is collapsed from maximum area to zero area in 1 s. Then the e.m.f. induced in the ring is

a) 1 V b) $(\pi/4)$V c) $(\pi/2)$V d) π V

85. In the circuit fig, the final current through 30 Ω resistance when circuit is completed is

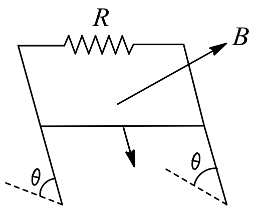


a) 3 A b) 0.1 A c) 5 A d) 0.5 A

86. The total heat produced in resistor R in an RL circuit when the current in the inductor decreases from I_0 to 0 is

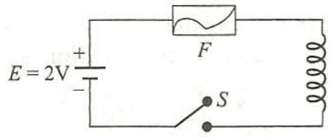
a) LI_0^2 b) $\frac{1}{2}LI_0^2$ c) $\frac{3}{2}LI_0^2$ d) $\frac{1}{3}LI_0^2$

87. A conducting wire of mass m slides down two smooth conducting bars, set at an angle θ to the horizontal as shown in figure. The separation between the bars is$l$. The system is located in the magnetic field B, perpendicular to the plane of the sliding wire and bars. The constant velocity of the wire is



a) $\frac{mgR\sin\theta}{B^2l^2}$ b) $\frac{mgR\sin\theta}{Bl^3}$ c) $\frac{mgR\theta}{B^2l^5}$ d) $\frac{mgR\sin\theta}{Bl^4}$

88. In the circuit shown fig, the cell is ideal. The coil has an inductance of 4 H and zero resistance. F is a fuse of zero resistance and will blow when the current through it reaches 5 A. The switch is closed at $t = 0$. The fuse will blow

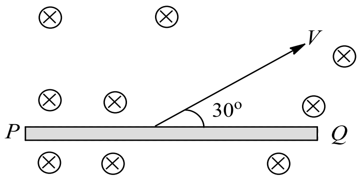


a) Almost at once b) After 2 s c) After 5 s d) After 10 s

89. A vertical ring of radius r and resistance R falls vertically. It is in contact with two vertical rails which are joined at the top. The rails are without friction and resistance. There is a horizontal uniform magnetic field of magnitude Bperpendicular to the plane of the ring and the rails. When the speed of the ring is v, the current in the top horizontal of the rails section is

a) 0 b) $\frac{2Brv}{R}$ c) $\frac{4Brv}{R}$ d) $\frac{8Brv}{R}$

90. A conducting rod PQ of length $\ell = 2$ m is moving at a speed of 2 ms^{-1} making an angle of 30° with its length. A uniform magnetic filed $B = 2$ T exists in a direction perpendicular to the plane of motion. Then

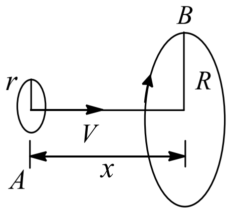


a) $V_P - V_Q = 8$ V b) $V_P - V_Q = 4$ V c) $V_Q - V_P = 8$ V d) $V_Q - V_P = 4$ V

91. There is a conducting ring of radius R. Another ring having current i and radius $r(r << R)$ is kept on the axis of bigger ring such that its centre lies on the axis of bigger ring at a distance x from the centre of bigger ring and its plane is perpendicular to that axis. The mutual inductance of the bigger ring due to the smaller ring is

a) $\frac{\mu_0 \pi R^2 r^2}{(R^2 + x^2)^{3/2}}$ b) $\frac{\mu_0 \pi R^2 r^2}{4(R^2 + x^2)^{3/2}}$ c) $\frac{\mu_0 \pi R^2 r^2}{16(R^2 + x^2)^{3/2}}$ d) $\frac{\mu_0 \pi R^2 r^2}{2(R^2 + x^2)^{3/2}}$

92. Loop A fo radius $r << R$ moves towards loop B with a constant velocity V in such a way that their planes are always parallel. What is the distance between the two loops (x) when the induced emf in loop A is maximum?



a) R b) $\frac{R}{\sqrt{2}}$ c) $\frac{R}{2}$ d) $R\left(1 - \frac{1}{\sqrt{2}}\right)$

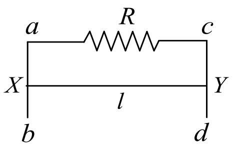
93. Find the inductance of a unit length of two parallel wires, each of radius a, whose centres are a distance d apart and carry equal currents in opposite directions. Neglect the flux within the wire

a) $\frac{\mu_0}{2\pi} \text{In}\left(\frac{d-a}{a}\right)$ b) $\frac{\mu_0}{\pi} \text{In}\left(\frac{d-a}{a}\right)$ c) $\frac{3\mu_0}{\pi} \text{In}\left(\frac{d-a}{a}\right)$ d) $\frac{\mu_0}{3\pi} \text{In}\left(\frac{d-a}{a}\right)$

94. A small coil of radius r is placed at the centre of a large coil of radius R, where $R \gg r$. The two coils are coplanar. The mutual inductance between the coils is proportional to

a) r/R b) r^2/R c) r^2/R^2 d) r/R^2

95. A conducting wire xy of length ℓ and mass$m$ is sliding without friction on vertical conduction rails ab and cd as shown in figure. A uniform magnetic field B exists perpendicular to the plane of the rails, $x$moves with a constant velocity of



a) $\frac{mgR}{B\ell}$ b) $\frac{mgR}{B\ell^2}$ c) $\frac{mgR}{B^2\ell^2}$ d) $\frac{mgR}{B^2\ell}$

96. A coil of wire having inductance and resistance has a conducting ring placed coaxially 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

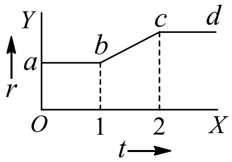
97. Magnetic flux linked with a stationary loop of resistance R varies with respect to time during the time period T as follows :

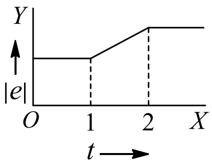
$\phi = at(T - t)$

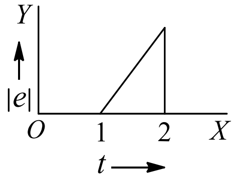
The amount of heat generated in the loop during that time (inductance of the coil is negligible) is

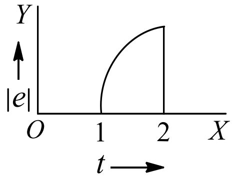
a) $\frac{aT}{3R}$ b) $\frac{a^2T^2}{3R}$ c) $\frac{a^2T^2}{R}$ d) $\frac{a^2T^3}{3R}$

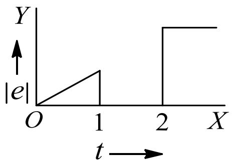
98. A flexible wire bent in the form of a circle is placein a uniform magnetic field perpendicularly to the plane of the coil.The radius of the coil changes as shown in figure. The graph of magnitude of induced emf in the coil is represented by



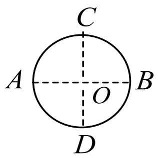
a) 

b) 

c) 

d) 

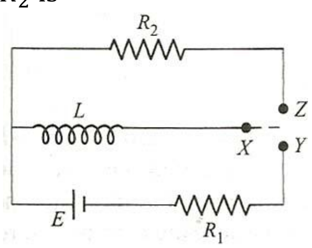
99. A vertical conducting ring of radius R falls vertically with a speed V in a horizontal uniform magnetic field B which is perpendicular to the plane of the ring. Which of the following statements is correct?



a) A and B are at same potential
b) C and D are at the same potential
c) Current flow in clockwise direction
d) Current flows in anticlockwise direction

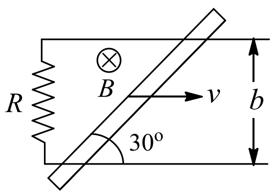
100. Two coils are at fixed locations. When coil 1 has no current and the current in coil 2 increases at the rate of 15.0 A/s, the e.m.f. in coil 1 is 25.0 mV, when coil 2 has no current and coil 1 has a current of 3.6 A, the flux linkage in coil 2 is
a) 16 mWb
b) 10 mWb
c) 4.00 mWb
d) 6.00 mWb

101. In the circuit shown fig, X is joined to Y for a long time and then X is joined to Z. The total heat produced in R_2 is



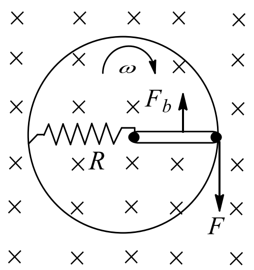
a) $\frac{LE^2}{2R_1^2}$
b) $\frac{LE^2}{2R_2^2}$
c) $\frac{LE^2}{2R_1R_2}$
d) $\frac{LE^2R_2}{2R_1^3}$

102. A wire is sliding as shown in figure. The angle between the acceleration and the velocity of the wire is



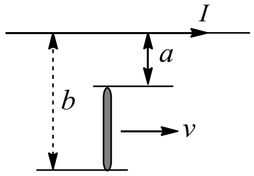
a) 30°
b) 40°
c) 120°
d) 90°

103. A metallic ring of radius r with a uniform metallic spoke of negligible mass and length r is rotated about its axis with angular velocity ω in a perpendicular uniform magnitude field B as shown in figure. The central end of the spoke is connected to the rim of the wheel through a resistor R as shown. The resistor does not rotate, its one end is always at the centre of the ring and the other end is always in contact with the ring. A force F as shown is needed to maintain constant angular velocity of the wheel. F is equal to (the ring and the spoke has zero resistance)



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

104. Figure shows a copper rod moving with velocity v parallel to a long straight wire carrying current =100 A. Calculate the induced emf in the rod, where $v = 5\ \text{ms}^{-1}, a = 1\ \text{cm}, b = 100\ \text{cm}$

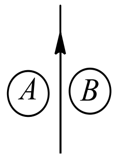


a) 0.23 mV b) 0.46 mV c) 0.16 mV d) 0.32 mV

105. A metal rod of resistance 20 Ω is fixed along a diameter of a conducting ring of radius 0.1 m and lies on $x - y$Plane. There is a magnetic field$\vec{B} = 50(\text{T})\hat{k}$. The ring rotates with an angular velocity $\omega = 20$ rad/s about its axis. An external resistance of 10 Ω is connected across the centre of the ring and rim. The current through external resistance is

a) $\frac{1}{4}$ b) $\frac{1}{2}$ c) $\frac{1}{3}$ d)

106. $A$and$B$ are two metallic rings placed at opposite sides of an infinitely long straight conducing wire as shown in figure. If current in the wire is slowly decreased, the direction of the induced current will be

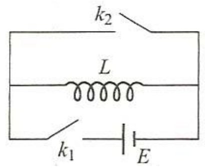


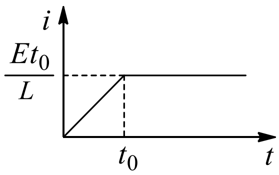
a) Clockwise in A and anticlockwise in B b) Anticlockwise in A and clockwise in B
c) Clockwise in both A and B d) Anticlockwise in both A and B

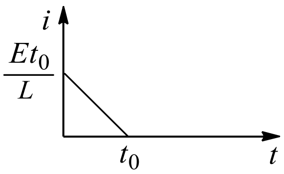
107. A straight solenoid of length 1 m has 5000 turns in the primary and 200 turns in the secondary. If the area of cross section is 4 cm^2, the mutual inductance will be

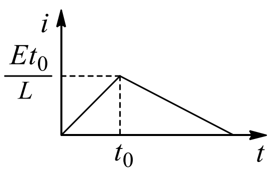
a) 503 H b) 503 mH c) 503 μH d) 5.03 H

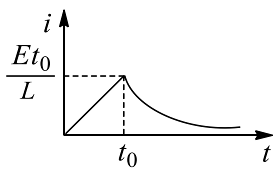
108. In the circuit shown, switch k_2 is open and switch k_1 is closed at $t = 0$. At time $t = t_0$, switch k_1 is opened and switch k_2 is simultaneously closed. The variation of inductor current with time is



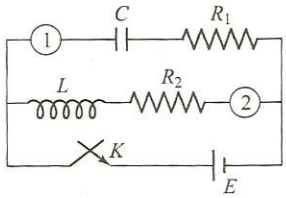
a) 

b) 

c) 

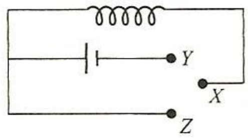
d) 

109. In the circuit of Fig (1) and (2) are ammeters. Just after key K is pressed to complete the circuit, the reading is



a) Maximum in both 1 and 2
b) Zero in both 1 and 2
c) Zero in 1, minimum in 2
d) Maximum in 1, zero in 2

110. In the circuit shown fig, the coil has inductance and resistance. When X is joined to Y, the time constant is t during the growth of current

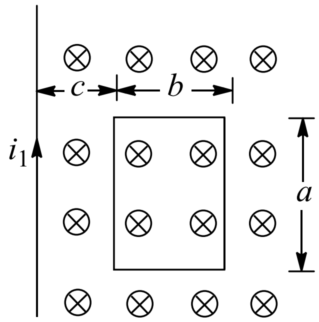


When the steady state is reached, heat is produced in the coil at a rate P. X is now joined to Z. After joining X and Z:
a) The total heat produced in the coil is $P\tau$
b) The total heat produced in the coil is $\frac{1}{2}\ P\tau$
c) The total heat produced in the coil is $2\ P\tau$
d) The data given are not sufficient to reach a conclusion

111. The length of a wire required to manufacture a solenoid of length l and self-induction L is (cross-sectional area is negligible)

a) $\sqrt{\frac{2\pi\ Ll}{\mu_0}}$
b) $\sqrt{\frac{\mu_0\ Ll}{4\pi}}$
c) $\sqrt{\frac{4\pi\ Ll}{\mu_0}}$
d) $\sqrt{\frac{\mu_0\ Ll}{2\pi}}$

112. Fig shows a rectangular coil near a long wire. The mutual inductance of the combination is

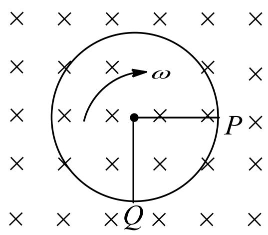


a) $\frac{\mu_0 a}{2\pi}\text{In}\left(1-\frac{b}{c}\right)$
b) $\frac{\mu_0 a}{2\pi}\text{In}\left(1+\frac{b}{c}\right)$
c) $\frac{\mu_0 a}{\pi}\text{In}\left(1+\frac{b}{c}\right)$
d) $\frac{\mu_0 a}{\sqrt{2}\pi}\text{In}\left(1+\frac{b}{c}\right)$

113. The magnitude field in a region is given by $\vec{B} = B_0\left(1+\frac{x}{a}\right)\hat{k}$. Asquare loop of edge length d is placed with its edge along the x-and y-axes. The loop is moved with a constant velocity$\vec{v} = v_0\hat{\imath}$. The emf induced in the loop is

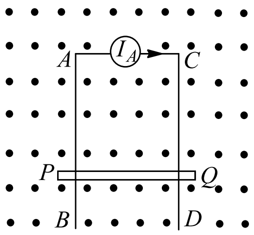
a) $\frac{v_0 B_0 d^2}{a}$
b) $\frac{v_0 B_0 d^3}{a^2}$
c) $v_0 B_0 d$
d) Zero

114. A conductor ring of radius r is rolling without slipping with a constant angular velocity ω figure. If the magnitude filed strength is B and is directed into the page then the emf induced across PQ is



a) $B\omega r^2$ b) $\frac{B\omega r^2}{2}$ c) $4B\omega r^2$ d) $\frac{\pi^2 r^2 B\omega}{8}$

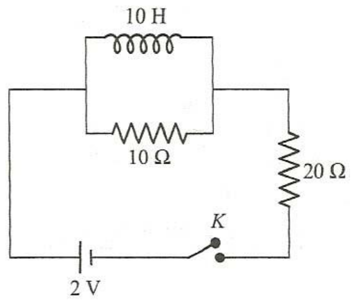
115. ABandCD are fixed conducting smooth rails placed in a vertical plane and joined by a constant source at its upper end. $PQ$is a conducting rod which is free to slide on the rails. A horizontal uniform magnitude field exists in space as shown. If the rod PQ is released from rest then,



a) The rod PQ will move downward with constant acceleration
b) The rod PQ will move upward with constant acceleration
c) The rod will remain at rest
d) Any of the above

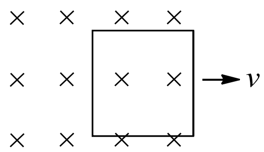
116. A metal rod moves at a constant velocity in a direction perpendicular to its length. A constant uniform magnetic field exists in space in a direction perpendicular to the rod as well as its velocity. Select the correct statements(s) from the following:
a) The entire rod is at the same electric potential
b) There is an electric field in the rod
c) The electric potential is highest at the centre of the rod and decrease towards its ends
d) The electric potential is lowest at the centre of the rod and increases towards its ends

117. Two resistors of 10 Ω and 20 Ω and an ideal inductor of 10 H are connected to a 2 V battery as shown. Key K is inserted at time $t = 0$. The initial $(t = 0)$ and final $(t \to \infty)$ current through the battery are



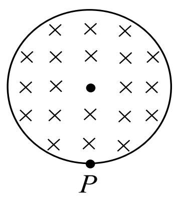
a) $\frac{1}{15}$ A, $\frac{1}{10}$ A b) $\frac{1}{10}$ A, $\frac{1}{15}$ A c) $\frac{2}{15}$ A, $\frac{1}{10}$ A d) $\frac{1}{15}$ A, $\frac{2}{25}$ A

118. Figure shows a square loop of side 0.5 m and resistance 10 Ω. The magnitude filed has a magnitude $B = 1.0$ T. The work done in pulling the loop out of the filed slowly and uniformly in 2.0 s is



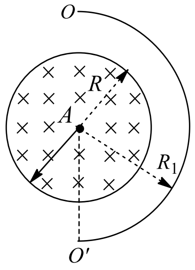
a) 3.125×10^{-3} J b) 6.25×10^{-4} J c) 1.25×10^{-2} J d) 5.0×10^{-4} J

119. A uniform magnitude field of induction B is confined to a cylindrical region of radius R. The magnitude field is increasing at a constant rate of dB/dt Ts^{-1}. An electron placed at the point P on the periphery of the field, experiences an acceleration



a) $\frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$ towards left b) $\frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$ towards right c) $\frac{eR}{m}\frac{dB}{dt}$ towards left d) Zero

120. There is a uniform magnetic filed$B$ in a circular region of radius R as shown in figure whose magnitude changes at the rate ofdB/dt. The e.m.f. induced across the ends of a circular concentric conducting arc of radius R_1 having an angle θ as shown($\angle OAO' = \theta$) is



a) $\frac{\theta}{2\pi} R_1^2 \frac{dB}{dt}$ b) $\frac{\theta}{2} R^2 \frac{dB}{dt}$ c) $\frac{\theta}{2\pi} R^2 \frac{dB}{dt}$ d) None of these

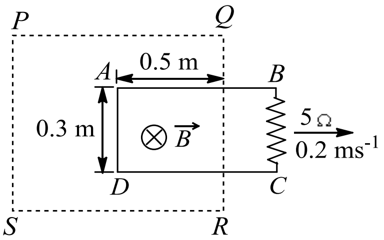
121. The approximate formula expressing the formula of mutual inductance of two thin co-axial loops of the same radius a when their centres are separated by a distance l with $l \gg a$ is

a) $\frac{1}{2} \frac{\mu_0 \pi a^4}{l^3}$ b) $\frac{1}{2} \frac{\mu_0 a^4}{l^2}$ c) $\frac{\mu_0}{4\pi} \frac{\pi a^4}{l^2}$ d) $\frac{\mu_0}{\pi} \frac{a^4}{l^3}$

122. A coil of inductance 8.4 mH and resistance 6 Ω is connected to a 12 V battery. The current in the coil is 1.0 A at approximately the time

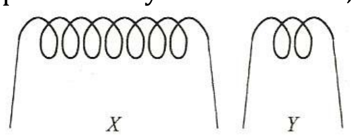
a) 500 s b) 25 s c) 35 ms d) 1 ms

123. A circuit $ABCD$ is held perpendicular to the uniform magnetic filed of $B = 5 \times 10^{-2}$ T extending over the region $PQRS$ and directed into the filed at a uniform speed of 0.2 ms^{-1} for 1.5 s. During this time, the current in the 5Ω resistor is



a) 0.6 mA from B to C b) 0.9 mA from C to B c) 0.9 mA from C to B d) 0.6 mA from C to B

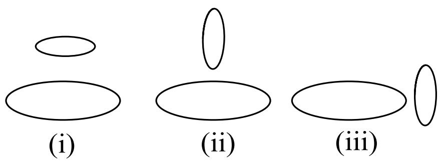
124. A mutual inductor consists of two coils X and Y as shown in fig in which one quarter of the magnetic flux produced by X links with. Y, giving a mutual inductance M



What will be the mutual inductance when Y is used as the primary?

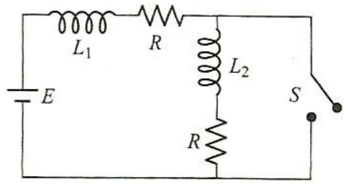
a) $M/4$ b) $M/2$ c) M d) $2M$

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



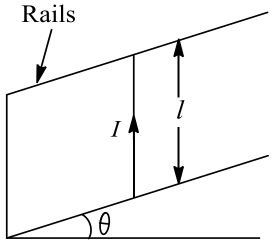
a) Maximum in situation (i) b) Maximum in situation (ii)
c) Maximum in situation (iii) d) The same in all situations

126. Switch S shown in fig is closed for $t < 0$ and is opened at $t = 0$. When currents through L_1 and L_2 are equal, their common value is



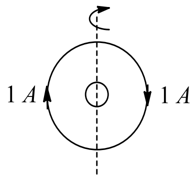
a) $\frac{E}{R}$ b) $\frac{E(L_2+L_1)}{RL_1}$ c) $\frac{EL_1}{R(L_1+L_2)}$ d) $\frac{E}{R}\frac{(L_1+L_2)}{L_2}$

127. A conducting wire of length ℓ and mass m is placed on two inclined rails as shown in figure. A current I is flowing in the wire in the direction shown. When no magnitude field is present in the region, the wire is just on the verge of sliding. When a vertical upwards magnitude field is switched on, the wire starts moving up the incline. The distance travelled by the wire as a function of time t will be



a) $\frac{1}{2}\left[\frac{IB\ell}{m}-2g\right]t^2$
b) $\frac{1}{2}\left[\frac{IB\ell}{m}\times\frac{1}{\cos\theta}-2g\sin\theta\right]t^2$
c) $\frac{1}{2}\left[\frac{IB\ell}{m}-2g\sin\theta\right]t^2$
d) $\frac{1}{2}\left[\frac{IB\ell}{m}\frac{\cos 2\theta}{\cos\theta}-2g\sin\theta\right]t^2$

128. The inner loop has an area of $5\times10^{-4}\text{m}^2$ and a resistance of 2Ω figure. The larger circular loop is fixed and has a radius of 0.1 m. Both the loops are concentric and coplanar. The smaller loop is rotated with an angular velocity ω rad s^{-1} about its diameter. The magnetic flux with the smaller loop is

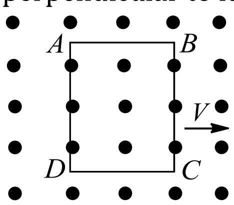


a) $2\pi\times10^{-6}$ weber
b) $\pi\times10^{-9}$ weber
c) $\pi\times10^{-9}\cos\omega t$ weber
d) Zero

129. A coil of inductance 0.20 H is connected in series with a switch and a cell of e.m.f. 1.6 V. The total resistance of the circuit is 4.0 Ω. What is the initial rate of growth of the current when the switch is closed?

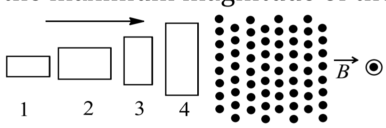
a) 0.050 As^{-1} b) 0.40 As^{-1} c) 0.13 As^{-1} d) 8.0 As^{-1}

130. 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 the figure. An electric filed 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

131. The four wire loops shown in figure have vertical edge lengths of either$L$, $2L$ or $3L$. They will move with the same speed into a region of uniform magnetic filed $\vec{B}$ directed out of the page. Rank them according to the maximum magnitude of the induced emf greatest to least

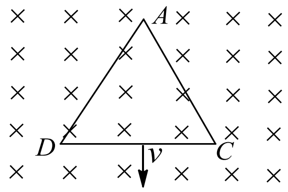


a) 1 and 2 tie, then 3 and 4 tie
b) 3 and 4 tie, then 1 and 2 tie
c) 4, 2, 3, 1
d) 4 then, 2 and 3 tie and then 1

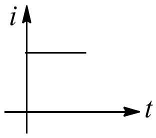
132. A thin circular ring of area A is held perpendicular to a uniform magnetic field of induction B. A small cut is made in the ring and a galvanometer is connected across the ends such that the total resistance of the circuit is R. When the ring is suddenly squeezed to zero area, the charge flowing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

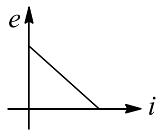
a) $\frac{BR}{A}$ b) $(AB)/R$ c) ABR d) $(E^2A)/R^2$

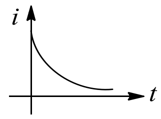
133. An equilateral triangular loop ADC having some resistance is pulled with a constant velocity v out of a uniform magnetic filed directed into the paper figure. At time $t=0$, side DC of the loop is at edge of the magnetic filed

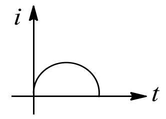


The induced current (i) versus time (t) graph will be as

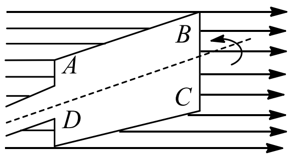
a) 

b) 

c) 

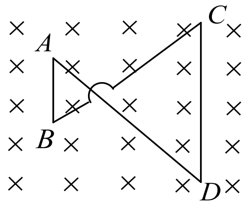
d) 

134. A rectangular coil $ABCD$ is rotated anticlockwise with a uniform angular velocity about the axis shown in figure. The axis of rotation of the coil as well as the magnetic field B is horizontal. The induced emf in the coil would be minimum when the plane of the coil



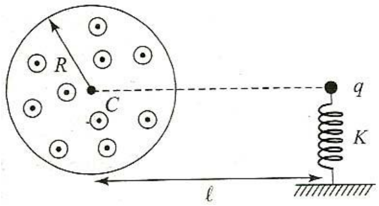
a) Is horizontal
b) Makes an angle of 45° with the direction of magnetic filed
c) Is at right angle to the magnetic field
d) Makes an angle of 30° with the magnetic filed

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



a) B to A and D to C b) A to B and C to D c) A to B and D to C d) B to A and C to D

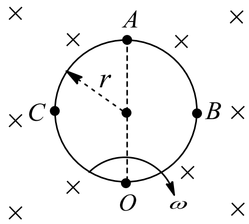
136. There is a horizontal cylindrical uniform but time-varying magnetic field increasing at a constant rate dB/dt as shown in figure. A charged particle having charge q and mass m is kept in equilibrium, at the top of a spring of spring constant K, in such a way that it is on the horizontal line passing through the centre of the magnetic field as shown in figure. The compression in the spring will be



a) $\frac{1}{K}\left[mg-\frac{qR^2}{2\ell}\frac{dB}{dt}\right]$ b) $\frac{1}{K}\left[mg+\frac{qR^2}{2\ell}\frac{dB}{dt}\right]$ c) $\frac{1}{K}\left[mg+\frac{2qR^2}{\ell}\frac{dB}{dt}\right]$ d) $\frac{1}{K}\left[mg+\frac{qR^2}{2\ell}\frac{dB}{dt}\right]$

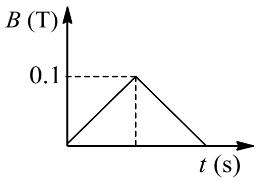
137. A horizontal straight conductor when placed along south-north direction falls under gravity; there is
a) an induced current from south-to-north direction
b) an induced current from north-to-south direction
c) no induced emf along the length of the conductor
d) an induced emf along the length of the conductor

138. In figure, there is a conducting ring having resistance R placed in the plane of paper in a uniform magnetic filedB_0. If the ring is rotating in the plane of paper about an axis passing through point O and perpendicular to the plane of paper with constant angular speed ω in clockwise direction, then



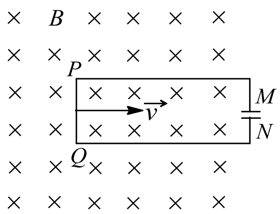
a) Point O will be at higher potential than A
b) The potential of point B and C will be different
c) The current in the ring will be zero
d) The current in the ring will be $2B_0\omega r^2/R$

139. A closed loop of cross-sectional area 10^{-2} m^{-2} which has inductance $L = 10$ mH and negligible resistance is placed in a time-varying magnetic field. Figure shows the variation of B with time for the interval 4 s. The field is perpendicular to the plane of the loop (give at $t = 0, B = 0, I = 0$). The value of the maximum current induced in the loop is



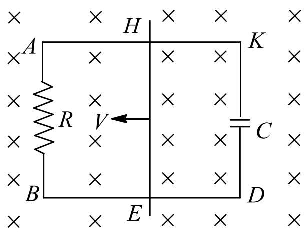
a) 0.1 mA
b) 10 mA
c) 100 mA
d) Data insufficient

140. A rod PQ is rotated to the capacitor plates. The rod is placed in a magnetic filed (B) directed downwards perpendicular to the plane of the paper. If the rod is pulled out of magnetic field with velocity$\vec{v}$ as shown in figure



a) Plate M will be positively charged
b) Plate N will be positively charged
c) Both plates will be similarly charged
d) No charge will be collected on plates

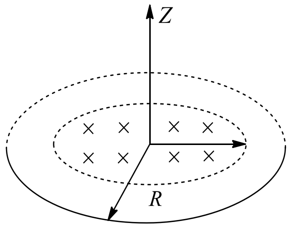
141. In the circuit shown in figure, a conducting wire HE is moved with a constant speed v towards left. The complete circuit is placed in a uniform magnetic filed$\vec{B}$perpendicular to the plane of the circuit inwards. The current in $HKDE$ is



a) Clockwise
b) Anticlockwise
c) Alternating
d) Zero

142. A line charge λ per unit length is passed uniformly on to the rim of a wheel of mass m and radius R. The

wheel has light non-conducing spokes and is free to rotate about a vertical axis as shown in figure. A uniform magnitic field extends over a radial region of radius r given by $B = -B_0\hat{k}(r \le a; a < R) = 0$ (otherwise). What is the angular velocity of the wheel when this field is suddenly switched off?



a) $\frac{-2B_0\pi a^2 r}{mR}\hat{k}$
b) $\frac{-B_0\pi a^2 r}{3mR}\hat{k}$
c) $\frac{B_0\pi a^2 \lambda}{mR}\hat{k}$
d) $\frac{-B_0\pi a^2 \lambda}{mR}\hat{k}$

143. A flexible wire loop in the shape of a circle has a radius that grows linearly with time. There is a magnetic filed perpendicular to the plane of the loop that has a magnitude inversely proportional to the distance from the centre of the loop, $B(r) \propto \frac{1}{r}$. How does the emf$E$ vary with time?

a) $E \propto t^2$
b) $E \propto t$
c) $E \propto \sqrt{t}$
d) E is constant

144. A solenoid of inductance L and resistance r is connected in parallel to a resistance R. A battery of e.m.f. E and of negligible internal resistance is connected across this parallel combination. At $t = 0$ battery is removed

a) Current in the inductor just after removing the battery is $\frac{E(r+R)}{rR}$
b) Total energy dissipated in the solenoid and the resistor long time removing the battery is $\frac{1}{2}\ L\ \frac{E^2(R+r)^2}{r^2R^2}$
c) The amount of heat generated in the solenoid due to removing the battery is $\frac{E^2L}{2r(r+R)}$
d) The amount of heat generated in the solenoid due to removing the battery is $\frac{E^2L}{2R(r+R)}$

145. A solenoid has 2000 turns wound over a length of 0.3 m. Its cross-sectional area is equal to1.2×10^{-3} 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 e.m.f. induced in the coil is

a) 0.6 mV
b) 60 mV
c) 48 mV
d) 0.48 mV

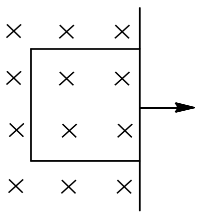
146. A simple LR circuit is connected to a battery at time $t = 0$. The energy stored in the inductor reaches half its maximum value at time

a) $\frac{R}{L}$ In $\left[\frac{\sqrt{2}}{\sqrt{2}-1}\right]$
b) $\frac{L}{R}$ In $\left[\frac{\sqrt{2}-1}{\sqrt{2}}\right]$
c) $\frac{L}{R}$ In $\left[\frac{\sqrt{2}}{\sqrt{2}-1}\right]$
d) $\frac{R}{L}$ In $\left[\frac{\sqrt{2}-1}{\sqrt{2}}\right]$

147. Two circular, similar, coaxial loops carry equal currents in the same direction. If the loops are brought nearer, what will happen?

a) Current will increase in each loop
b) Current will decrease in each loop
c) Current will remain same in each loop
d) Current will increase in one and decrease in the other

148. A square loop of area 2.5×10^{-3}m^2 and having 100 turns with a total resistance of 100 Ω is moved out of a uniform magnitude field of 0.40 T in 1 s with a constant speed. Then work done the in pulling the loop is

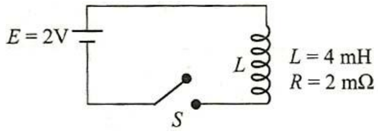


a) 0
b) 1 mJ
c) 1 μJ
d) 0.1 mJ

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

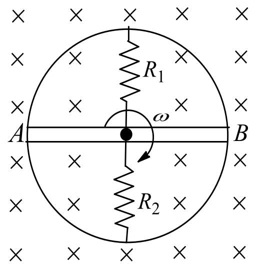
a) $\frac{BR}{A}$ b) $\frac{AB}{R}$ c) ABR d) B^2A/R^2

150. The cell in the circuit shown in fig is ideal. The coil has an inductance of 4 mH and a resistance of 2 mΩ. The switch is closed at $t = 0$. The amount of energy stored in the inductor at $t = 2$ s is (take $e = 3$)



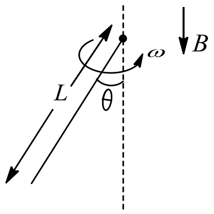
a) $\frac{4}{3}$ J b) $\frac{8}{9} \times 10^3$ J c) $\frac{8}{3} \times 10^{-3}$ J d) 2×10^3 J

151. $AB$is a resistanceless conducting rod which forms a diameter of a conducting ring of radius r rotating in a uniform magnetic field B as shown in figure. The resistors R_1 and R_2 do not rotate. Then the current through the resistor R_1 is



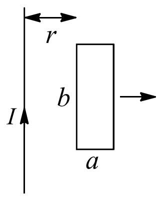
a) $\frac{B\omega r^2}{2R_1}$ b) $\frac{B\omega r^2}{2R_2}$ c) $\frac{B\omega r^2}{2R_1R_2}(R_1 + R_2)$ d) $\frac{B\omega r^2}{2(R_1 + R_2)}$

152. A rod of length L rotates in the form of a conical pendulum with an angular velocity ω about its axis as shown in figure. The rod makes an angle θ with the axis. The magnitude of the motional emf developed across the two ends of the rod is



a) $\frac{1}{2}B\omega L^2$ b) $\frac{1}{2}B\omega L^2 \tan^2\theta$ c) $\frac{1}{2}B\omega L^2 \cos^2\theta$ d) $\frac{1}{2}B\omega L^2 \sin^2\theta$

153. A rectangular loop of wire with dimensions shown in figure is coplanar with a long wire carrying current$I$. The distance between the wire and the left side of the loop is r. The loop is pulled to the right as indicated. What are the directions of the induced current in the loop and the magnetic forces on the left and the right sides of the loop [when the loop is pulled?



Induced current	Force on left side	Force on right side

a)

Counter clockwise	To the left	To the right

b)

Counter clockwise	To the right	To the left

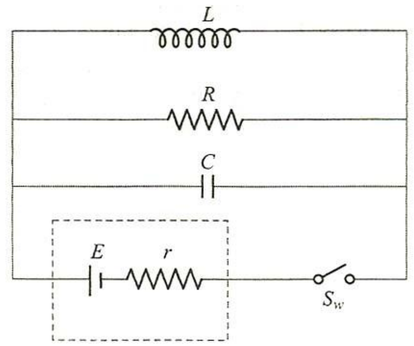
c)

clockwise	To the right	To the left

d)

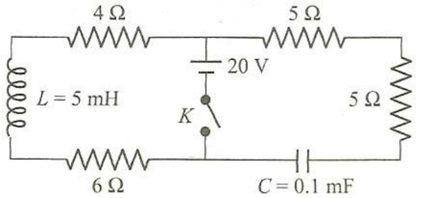
clockwise	To the left	To the right

154. A pure inductor L, a capacitor C and a resistance R are connected across a battery of e.m.f. E and internal resistance r as shown in the figure. Switch S_w is closed at $t = 0$, select the correct alternative(s)



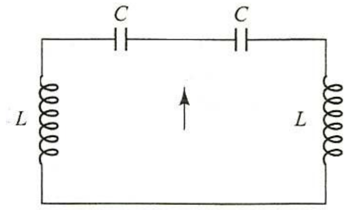
a) Current through resistance R is zero all the time
b) Current through resistance R is zero at $t = 0$ and $t \to \infty$
c) Maximum charge stored in the capacitor is CE
d) Maximum energy stored in the inductor is equal to the maximum energy stored in the capacitor

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



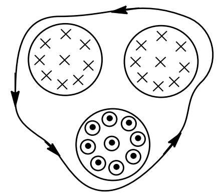
a) 2 A b) 3.5 A c) 2.5 A d) 0

156. The natural frequency of the circuit shown in fig is



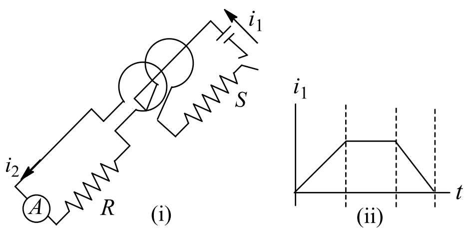
a) $\frac{1}{\sqrt{LC}}$ b) $\frac{1}{\sqrt{2LC}}$ c) $\frac{2}{\sqrt{LC}}$ d) None of these

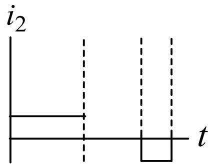
157. Figure shows three regions of magnitude filed each of area A, and in each region, magnitude of magnetic field decreases at a constant rate α. If $\vec{E}$ is the induced electric field, then value of the line integral $\oint \vec{E}.d\vec{r}$ along the given loop is equal to

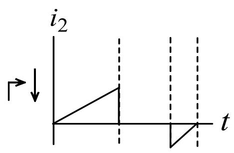


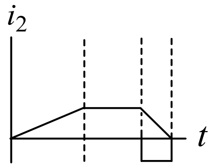
a) αA b) $-\alpha A$ c) $3\alpha A$ d) $-3\alpha A$

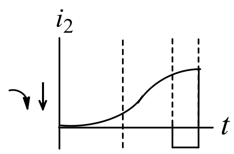
158. The current through the coil in figure varies as shown in figure. Which graph best shows the ammeter A reading as a function of time?



a) 

b) 

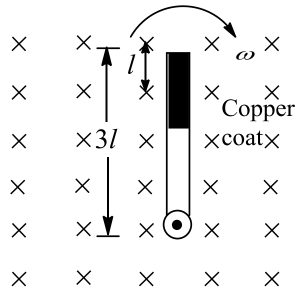
c) 

d) 

159. A long solenoid having 200 turns per cm carries a current of 1.5 A. At the centre of the solenoid is placed a coil of 100 turns of cross-sectional area $3.14 \times 10^{-4} \text{m}^{-2}$ having its axis parallel to the field produced by the solenoid. When the direction of current in the solenoid is reversed within 0.05 s, the induced e.m.f. in the coil is

a) 0.48 V b) 0.048 V c) 0.0048 V d) 48 V

160. A wooden stick of length 3ℓ is rotated about an end with constant angular velocity ω in a uniform magnetic field B perpendicular to the plane of motion. If the upper one-third of its length is coated with copper, the potential difference across the whole length of the stick is



a) $\frac{9B\omega\ell^2}{2}$ b) $\frac{4B\omega\ell^2}{2}$ c) $\frac{5B\omega\ell^2}{2}$ d) $\frac{B\omega\ell^2}{2}$

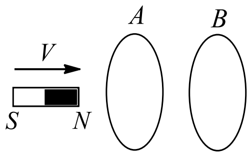
Multiple Correct Answers Type

161. The magnetic flux ϕ linked with a conducting coil depends on time as $\phi = 4t^n + 6$, where nn is a positive constant. The induced emf in the coil is e

a) If $0 < n < 1, e \neq 0$and $|e|$ decreases with time b) If $n = 1, e$ is constant

c) If $n > 1, |e|$ increases with time d) If $n > 1, |e|$ decreases with time

162. A bar magnet moves towards two identical parallel circular loops with a constant velocity v, as shown in figure



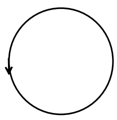
a) Both the loops will attract each other

b) Both the loops will repel each other

c) The induced current in A is more than that in B

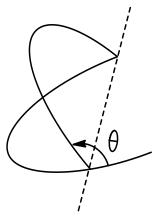
d) The induced current is same in both the loops

163. A field line is shown in the figure. This field cannot represent

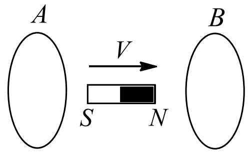


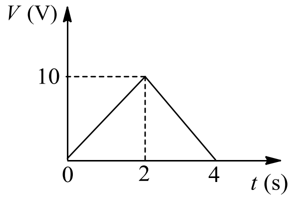
a) Magnetostatic field b) Electrostatic field c) Induced electric field d) Gravitational field

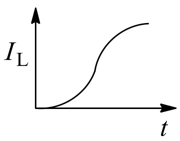
164. A uniform circular loop of radius a and resistance R is placed perpendicular to a uniform magnetic field B. One half of the loop is rotated about the diameter with angular velocity ω is shown in figure. Then, the current in the loop is

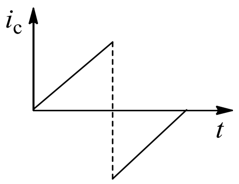


a) Zero, when θ is zero b) $\frac{\pi a^2 B\omega}{2R}$, when θ is zero c) Zero, when $\theta = \pi/2$ d) $\frac{\pi a^2 B\omega}{2R}$, when $\theta = \pi/2$

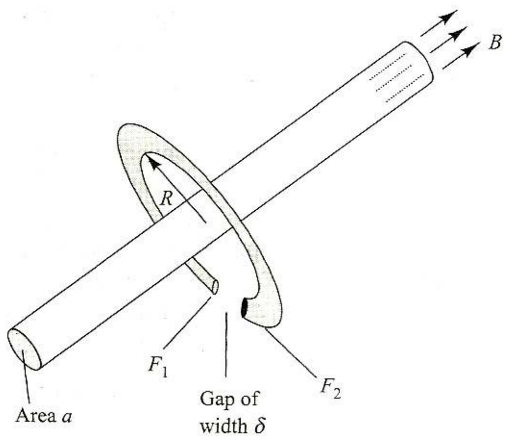
165. A conducting loop rotates with constant angular velocity about its fixed diameter in a uniform magnetic field, whose direction is perpendicular to that fixed diameter
a) The emf will be maximum at the moment when flux is zero
b) The emf will be '0' at the moment when flux is maximum
c) The emf will be maximum at the moment when plane of the loop is parallel to the magnetic filed
d) The phase difference between the flux and the emf is $\pi/2$
166. A bar magnet is moved between two parallel circular loops A and B with a constant velocity v as shown in figure


a) The current in each loop flows in the same direction
b) The current in each loop flows in opposite directions
c) The loops will repel each other
d) The loops will attract each other
167. The potential difference across a 2 H inductor as a function of time is shown in fig. At $t = 0$, current is zero. Choose the correct statement


a) Current at $t = 2$ s is 5 A
b) Current at $t = 2$ s is 10 A
Current versus time graph across the inductor will be
c) 

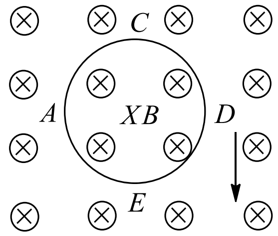
d) Current versus time graph across inductor will be


168. The magnitude of the earth's magnitude filed at the north pole is B_0. A horizontal conductor of length ℓ moves with a velocity$v$. The direction of v is perpendicular to the conductor. The induced emf is
a) Zero, if v is vertical
b) $B_0\ell v$, if v is vertical
c) Zero, if v is horizontal
d) $B_0\ell v$, if v is horizontal
169. A highly conducting ring of radius R is perpendicular to and concentric with the axis of a long solenoid, as shown in figure. The ring has a narrow gap of width δ in its circumference in figure. 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 $\beta > 0$. Assume that no charge can flow across the gap, the face (s) accumulating an excess of positive charge is/are



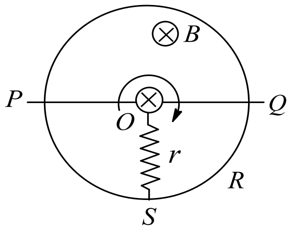
a) F_1
b) F_2
c) F_1 and F_2 both
d) Different to conclude as data given are insufficient

170. 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. When the speed of the ring is v,



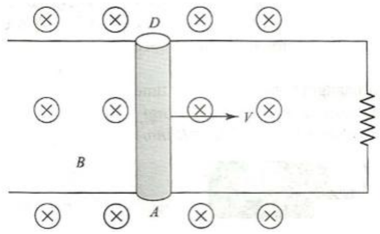
a) No current flows in the ring
b) A and D are at the same potential
c) C and E are at the same potential
d) The potential difference between A and D is $2BRv$, with D at a higher potential

171. In figure, R is a fixed conducting ring of negligible resistance and radius a. $PQ$is a uniform rod of resistance r. It is hinged at the centre of the ring and rotated about this point in clockwise direction with a uniform angular velocity ω. There is a uniform magnetic field of strength B pointing inward and r is a stationary resistance. Then



a) Current through r is zero
b) Current through r is $(2B\omega a^2)/5r$
c) Direction of current in external resistance r is from centre to circumference
d) Direction of current in external resistance r is from circumference to centre

172. The conducting AD moves to the right in a uniform magnetic field directed into the plane of the paper



a) The free electron in AD will move towards A
b) D will acquire a positive potential with respect to A
c) A current will flow from A to D in AD in closed loop
d) The current in AD flows from lower to higher potential

173. The uniform magnetic field perpendicular to the plane of a conducting ring of radius a chnages at the rate of α, then

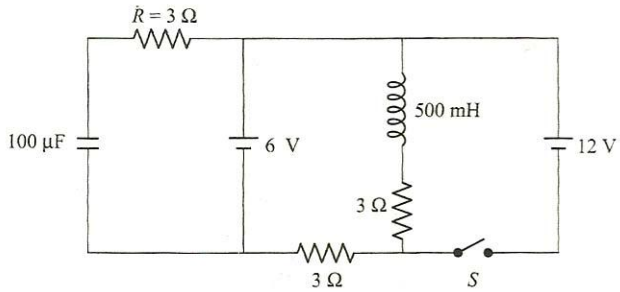
a) All the points on the ring are at the same potential

b) The emf induced in the ring is $\pi a\alpha^2$

c) Electric field intensity E at any point on the ring is zero

d) $E = (a\alpha)/2$

174. In the given circuit, the switch is closed at $t = 0$. Choose the correct answers



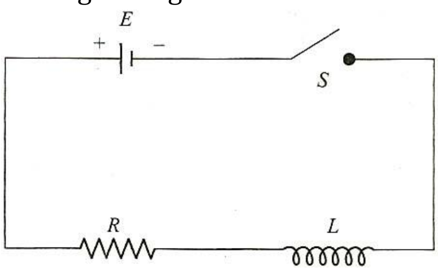
a) Current in the inductor when the circuit reaches the steady state is 4 A

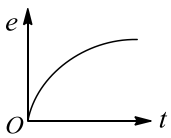
b) The net change in flux in the inductor is 1.5 Wb

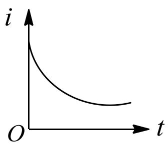
c) The time constant of the circuit after closing S is 555.55 s

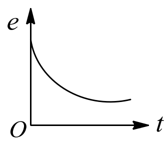
d) The charge stored in the capacitor in steady state is 1.2 mC

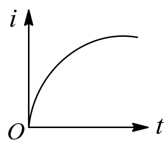
175. Switch S of the circuit shown in fig is closed at $t = 0$. If e denotes the induced e.m.f. in L and I is the current flowing through the circuit at time t, which of the following graphs is/are correct?



a) 

b) 

c) 

d) 

176. The accumulation of the charge on the gap faces will cease when the total electric filed within the ring becomes zero. For this to happen, the electric filed E_0 in the gap is

a) $E_0 = \frac{a\beta}{\delta}$

b) $E_0 = \frac{2a\beta}{\delta}$

c) E_0Is dependent of R for $R > \sqrt{\frac{a}{\pi}}$

d) E_0Is independent of R for $R > \sqrt{\frac{a}{\pi}}$

177. 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

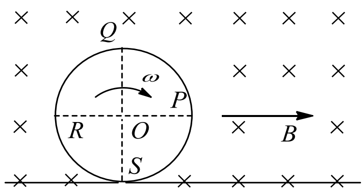
a) $<$ g when it is above R and moving towards R

b) $>$ gwhen it is above R and moving towards R

c) $<$ g when it is below R and moving away from R

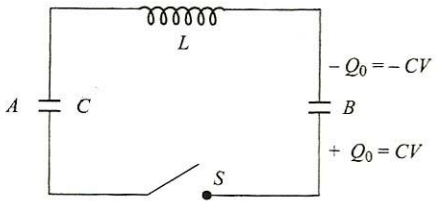
d) $>$ gwhen it is below$R$ and moving away from R

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



a) Due to translation, induced emf across $PS - Bvr$
b) Due to rotation, induced emf across $QS = 0$
c) Due to translation, induced emf across $RO = 0$
d) Due to rotation, induced emf across $OQ = Bvr$

179. An inductor and two capacitors are connected in the circuit as shown in Fig. Initially capacitor A has no charge and capacitor B has CV charge. Assume that the circuit has no resistance at all. At $t = 0$, switch S is closed, then [given $LC = \frac{2}{\pi^2 \times 10^4} s^2$ and $CV = 100$ mC]



a) When current in the circuit is maximum, charge on each capacitor is same
b) When current in the circuit is maximum, charge on capacitor A is twice the charge on capacitor B
c) $q = 50(1 + \cos 100\,\pi t)$ mC, where q is the charge on capacitor B at time t
d) $q = 50(1 - \cos 100\,\pi t)$ mC, where q is the charge on capacitor B at time t

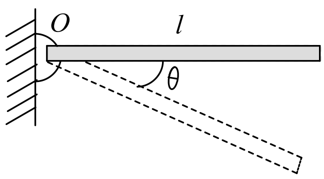
180. In the above problem, the plane of the coil is initially kept parallel to B. The coil is rotated by an angle θ about the diameter perpendicular to B and charge of amount Q flows through it. Choose the correct alternatives

a) $\theta = 90°, Q = (Ban/R)$
b) $\theta = 180°, Q = (2Ban/R)$
c) $\theta = 180°, Q = 0$
d) $\theta = 360°, Q = 0$

181. 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)

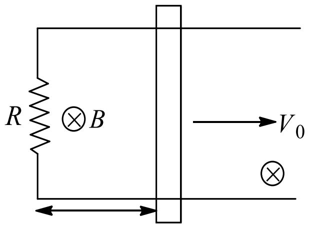
a) The emf induced in the loop is zero if the current is constant
b) The emf induced in the loop is finite if the current is constant
c) The emf induced in the loop is zero if the current decreases at a steady rate
d) The emf induced in the loop is finite if the current decreases at a steady rate

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



a) $\ell^{3/2}$
b) ℓ^2
c) $\sin\theta$
d) $(\sin\theta^{1/2})$

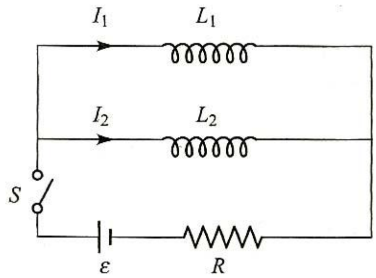
183. A conducting rod of length ℓ is moved at constant velocity v_0 on two parallel, conducting, smooth, fixed rails, which are placed in a uniform constant magnetic filed B perpendicular to the plane of the rails as shown in figure. A resistance R is connected between the two ends of the rails. Then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



a) The thermal power dissipated in the resistor is equal to the rate of work done by an external person pulling the rod
b) If applied external force is doubled, then a part of the external power increases the velocity of the rod
c) Lenz's law is not satisfied if the rod is accelerated by an external force
d) If resistance R is doubled, then power required to maintrain the constant velocity V_0 becomes half

184. In the above problem, if the coil rotates with a constant angular velocity ω, the emf induced in it
a) Is zero
b) Changes non-linearly with time
c) Has a constant value$= BAn\omega$
d) Has a maximum value $= BAn\omega$

185. In the circuit shown in Fig, the switch is closed at $t = 0$



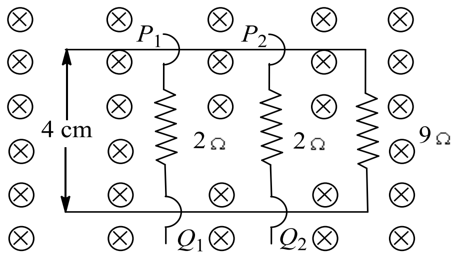
a) At $t = 0, I_1 = I_2 = 0$
b) At any time $t, \frac{I_1}{I_2} = \frac{L_2}{L_1}$
c) At any time $t, I_1 + I_2 = \frac{\varepsilon}{R}$
d) At $t = \infty, I_1$ and I_2 are independent of L_1 and L_2

186. A circular loop of radius$r$, having N turns of a wire, is placed in a uniform and constant magnetic field$B$. The normal of the loop makes an angle θ with the magnetic field. Its normal rotates with an angular velocity ω such that the angle θ is constant. Choose the correct statement from the following
a) Emf in the loop is $NB\omega r^2/2 \cos\theta$
b) Emf induced in the loop is zero
c) Emf must be induced as the loop crosses magnetic lines
d) Emf must not be induced as flux does not change with time

187. Two different coils have self-inductances $L_1 = 8$ mH and $L_2 = 2$ mH. The current in the second coil is also increased at the same constant rate. At a certain instant of 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_1, V_2 and W_2, respectively. Then
a) $\frac{i_1}{i_2} = \frac{1}{4}$
b) $\frac{i_1}{i_2} = 4$
c) $\frac{W_1}{W_2} = \frac{1}{4}$
d) $\frac{V_1}{V_2} = 4$

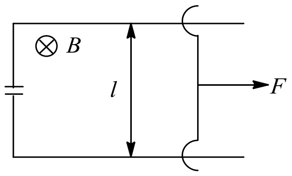
188. A flat coil, C, of n turns, area A and resistance R, is placed in a uniform magnetic field of magnitude B. The plane of the coil is initially perpendicular to B. The coil is rotated by an angle θ about a diameter and charge of amount Q flows through it. Choose the correct alternatives
a) $\theta = 90°, Q = (BAn/R)$
b) $\theta = 180°, Q = (BAn/R)$
c) $\theta = 180°, Q = 0$
d) $\theta = 360°, Q = 0$

189. In the figure shown below, the wires P_1Q_1 and P_2Q_2 are made to slide on the rails with same speed of 5 cm s^{-1}. In this region, a magnetic field of 1 T exists. The electric current in the 9 Ω resistance is



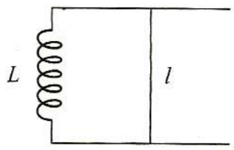
a) Zero if both wires slide towards left
b) Zero if both wires slide in opposite directions
c) 0.2 mA if both wires move towards left
d) 0.2 mA if both wires move in opposite directions

190. A conducting wire of length ℓ and mass m can slide without friction on two parallel rails and is connected to capacitance C. The whole system lies in a magnetic filed B and a constant force F is applied to the rod. Then



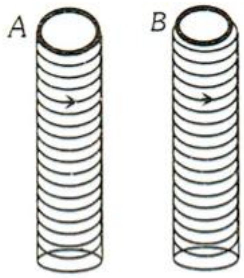
a) The rod moves with constant velocity
b) The rod moves with an acceleration of $(F)/(m + B^2\ell^2C)$
c) There is constant charge on the capacitor
d) Charge on the capacitor increases with time

191. Two parallel resistanceless rails are connected by an inductor of inductance L at one end as shown in Fig. A magnetic field B exists in the space which is perpendicular to the plane of the rails. Now a conductor of length ℓ and mass m is placed transverse on the rail and given an impulse J towards the rightward direction. Then choose the correct option(s)



a) Velocity of the conductor is half of the initial velocity after a displacement of the conductor $d = \sqrt{\frac{3J^2L}{4B^2\ell^2m}}$
b) Current flowing through the inductor at the instant when velocity of the conductor is half of the initial velocity is $i = \sqrt{\frac{3J^2}{4\,Lm}}$
c) Velocity of the conductor is half of the initial velocity after a displacement of the conductor $d = \sqrt{\frac{3J^2L}{B^2\ell^2m}}$
d) Current flowing through the inductor at the instant when velocity of the conductor is half of the initial velocity is $i = \sqrt{\frac{3J^2}{mL}}$

192. 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 the 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)



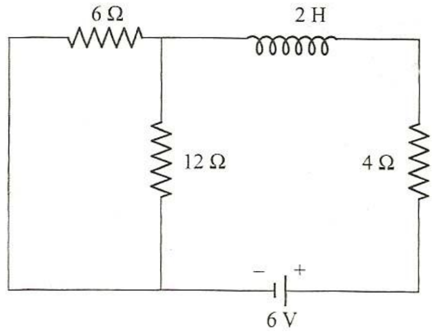
a) $\rho_A > \rho_B$ and $m_A = m_B$

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 $m_A < m_B$

193. For the circuit shown in fig, which of the following statements is/are correct?



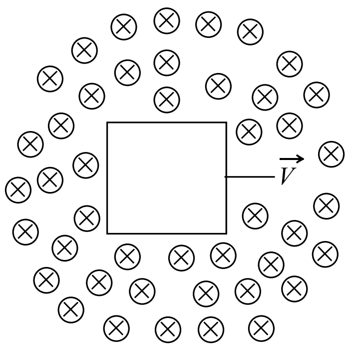
a) Its time constant is 0.25 s

b) In steady state, current through the inductance will be equal to zero

c) In steady state, current through the battery will be equal to 0.75 A

d) None of these

194. A conducting square loop of side L and resiatnce R moves in its plane with a uniform velocity v perpendicular to one of its sides. A magnetic induction B, constant in time and space, pointing perpendicular and into the plane of the loop exists everywhere



The current induced in the loop is

a) BLv/R clockwise

b) BLv/R anticlockwise

c) $2BLv/R$ anticlockwise

d) Zero

195. The S.I. unit of inductance, the henry, can be written as

a) Weber/ampere

b) Volt-second/ampere

c) Joule/(ampere)^2

d) Ohm-second

196. An infinite current-carrying conductor is placed along the z-axis and a wire loop is kept in the xy plane. The current in the conductor is increasing with time. Then the

a) Emf induced in the wire loop is zero

b) Magnetic flux passing through the wire loop is zero

c) Emf induced is zero but magnetic flux is not zero

d) Emf induced is not zero but magnetic flux is zero

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 197 to 196. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

197

Statement 1: Two coaxial conducting rings of different radii are placed in space. The mutual inductance of both the rings is maximum if the rings are also coplanar

Statement 2: For two coaxial conducting rings of different radii, the magnitude of magnetic flux in one ring due to current in the other ring is maximum when both the rings are coplanar

198

Statement 1: Lenz's law violates the principle of conservation of energy

Statement 2: Induced emf always opposes the change in magnetic flux responsible for its production

199

Statement 1: The quantity L/R possesses dimensions of time

Statement 2: To reduce the rate of increase of current through a solenoid, we should increase the time constant (L/R)

200

Statement 1: In electric circuits, wires carrying currents in opposite directions are often twisted together

Statement 2: If the wires are not twisted together, the combination of the wires forms a current loop. The magnetic field generated by the loop might affect adjacent circuits or components

201

Statement 1: A metal piece and a non-metal (stone) piece are dropped from the same height near earth's surface. Both will reach the earth's surface simultaneously

Statement 2: There is no effect of earth's magnetic field on freely falling body

202

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

203

Statement 1: The magnetic field at the ends of very long current-carrying solenoid is half to that at the centre

Statement 2: If the solenoid is sufficiently long, the field within it is uniform

204

Statement 1: An electric lamp is connected in series with a long solenoid of copper with air core and then connected to an a.c. source. If an iron rod is inserted in the solenoid, the lamp will become dim

Statement 2: If an iron rod is inserted in the solenoid, the inductance of the solenoid increases

205

Statement 1: A spark occurs between the poles of a switch when the switch is opened

Statement 2: Current flowing in the conductor produces magnetic field

206

Statement 1: The back emf in a dc motor is maximum when the motor has just been switched on

Statement 2: When motor is switched on it has maximum speed

207

Statement 1: Time-dependent magnetic field generates electric field

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

208

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

209

Statement 1: An aircraft files along the meridian, the potential at the ends of its wings will be the same

Statement 2: Whenever there is change in the magnetic flux e.m.f. induces

210

Statement 1: An induced emf is generated when magnet is withdrawn from the solenoid

Statement 2: The relative motion between magnet and solenoid induced emf

211

Statement 1: Eddy current is produced in any metallic conductor when magnetic flux is changed around it

Statement 2: Electric potential determines the flow of charge

212

Statement 1: Soft iron is used as a core of transformer

Statement 2: Area of hysteresis loop for soft iron is small

213

Statement 1: The energy of a charged particle moving in a uniform magnetic field does not change

Statement 2: Work done by magnetic field on the charge is zero

214

Statement 1: A transformer cannot work on dc supply

Statement 2: dc changes neither in magnitude nor in direction

215

Statement 1: An electric motor will have maximum efficiency when back emf becomes equal to half of applied emf.

Statement 2: Efficiency of electric motor depends only on magneitude of back emf.

216

Statement 1: The induced e.m.f and current will be same in two identical loops of copper and aluminium when rotated with same speed in the same magnetic field

Statement 2: Induced e.m.f. is proportional to rate of change of magnetic field while induced current depends on resistance of wire

217

Statement 1: Inductance coil are made of copper

Statement 2: Induced current is more in wire having less resistance

218

Statement 1: Self-inductance is called the inertia of electricity

Statement 2: Self-inductance is the phenomenon, according to which an opposing induced e.m.f. is produced in a coil as a result of change in current or magnetic flux linked in the coil

219

Statement 1: Making or breaking of current in a coil produces no momentary current in a coil producers no momentary current in the neighbouring coil of another circuit.

Statement 2: Momentary current in the neighbouring coil of another circuit is an eddy current.

220

Statement 1: Only a change in magnetic flux will maintain an induced current the coil

Statement 2: The presence of large magnetic flux through a coil maintains a current in the coil if the circuit is continuous

221

Statement 1: An emf $\vec{E}$ is induced in a closed loop where magnetic flux is varied. The induced $\vec{E}$ is not a conservative field

Statement 2: The line integral $\vec{E}.\vec{dl}$ around the closed loop is non zero

222

Statement 1: An artificial satellite with a metal surface is moving above the earth in a circular orbit. A current will be induced in satellite if the plane of the orbit is inclined to the plane of the equator

Statement 2: The current will be induced only when the speed of satellite is more than 8 km/sec

223

Statement 1: Induced potential across a coil and therefore induced current is always opposite to the direction of current due to external source

Statement 2: Lenz's law states that induced emf always opposes the cause due to which it is being produced

224

Statement 1: In the phenomenon of mutual induction, self induction of each of the coils persists

Statement 2: Self induction arises when strength of current in same coil changes. In mutual induction, current is changing in both the individual coils

225

Statement 1: The mutual inductance of two coils is doubled if the self inductance of the primary or secondary coil is doubled.

Statement 2: Mutual inductance is proportional to the self inductance of primary and secondary coils.

226

Statement 1: No electric current will be present within a region having uniform and constant magnetic field

Statement 2: Within a region of uniform and constant magnetic field$\vec{B}$, the path integral of magnitude field $\oint \vec{B}.\vec{dl}$ along any closed path is zero. Hence from Ampere circuital law $\oint \vec{B}.\vec{dl} = \mu_0 I$ (where the given terms have usual meaning), no current can be present within a region having uniform and constant magnetic field

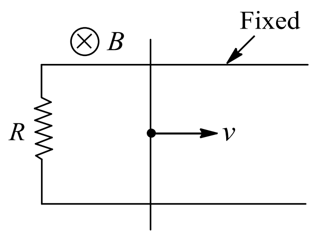
227

Statement 1: An ac generator is based on the phenomenon of self-induction

Statement 2: In single coil, we consider self-induction only

228

Statement 1: A resistance R is connected between the two ends of the parallel smooth conducting rails. A conducting rod lies on these fixed horizontal rails and a uniform constant magnetic field B exists perpendicular to the plane of the rails as shown in figure. If the rod is given a velocity v and released as shown in figure, it will stop after some time. The total work done by magnetic filed is negative



Statement 2: If force acts opposite to direction of velocity its work done is negative

229

Statement 1: Faraday's laws are consequence of conservation of energy

Statement 2: In a purely resistive ac circuit, the current lags behind the e.m.f. in phase

230

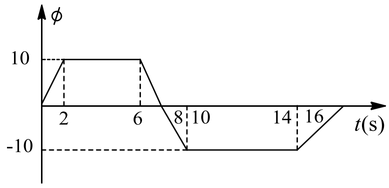
Statement 1: An emf is induced in a long solenoid by a bar magnet that moves while totally inside the solenoid along axis of the solenoid

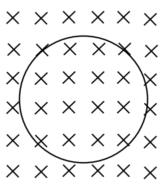
Statement 2: As the magnet moves inside the solenoid the flux through individual turns of the solenoid changes

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II**.

231. Magnetic flux in a circular coil of resistance 10 Ω changes with time as shown in figure. Cross indicates a direction perpendicular to paper inwards. Match the following



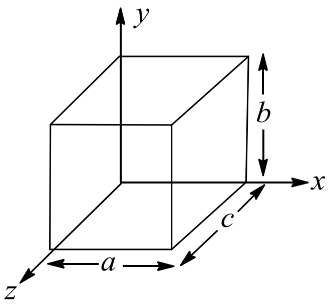


	Column-I		**Column- II**
(A)	At 1 s, induced current is	(p)	Clockwise
(B)	At 5 s, induced current is	(q)	Anticlockwise
(C)	At 9 s, induced current is	(r)	Zero
(D)	At 15 s, induced current is	(s)	2 A

CODES :

	A	**B**	**C**	**D**
a)	c	a	b	b
b)	a	b	b	c
c)	b	b	c	a
d)	b	c	a	b

232. Figure shows a metallic solid block, placed in a way so that its faces are parallel to the coordinates axes. Edge lengths along axes x, y and z are a, b and c respectivbely. The block is in a region to uniform magnetic field of magnitude 30 mT. One of the edge lengths of the block is 25 cm. The block is moved at 4 ms^{-1} parallel to each axis and in turn, the resulting potential difference V that appears across the block is measured. When the motion is parallel to the y-axis, $V = 24$ mV; with the motion parallel; to the z-axis, $V = 36$ mV; with the motion parallel to the x-axis, $V = 0$. Using the given information, correctly match the dimensions of the block with the values given



	Column-I		Column- II
(A)	a	(p)	20 cm
(B)	b	(q)	24 cm
(C)	c	(r)	25 cm
(D)	$(bc)/a$	(s)	30 cm

CODES :

	A	**B**	**C**	**D**
a)	d	a	b	c
b)	a	b	c	d
c)	b	c	d	a
d)	c	d	a	b

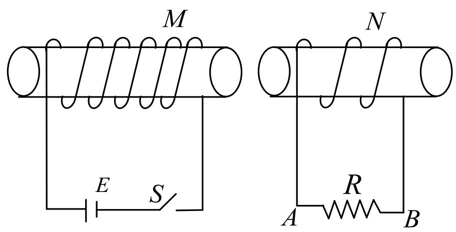
233. Column I given situations involving a charged particle which may be realized under the condition given in column II. Match the situations in column I with the conditions in column II

	Column-I		Column- II
(A)	Increase in speed of a charged particle	(p)	Electric field uniform in space and constant in time
(B)	Exert a force on an electron initially at rest	(q)	Magnetic field uniform in space and constant in time
(C)	Move a charged particle in a circle with uniform speed	(r)	Magnetic field uniform in space but varying with time
(D)	Acceleration a moving charged particle	(s)	Magnetic field non-uniform in space but constant with time

CODES :

	A	**B**	**C**	**D**
a)	A,c	a,c	b,d	a,b,c,d
b)	a,b,c,d	a,c	a,c	b,d
c)	a,c	b,d	a,c	a,b,c,d
d)	a,b,c,d	a,c	b,d	a,c

234. Fig shows two coaxial coils M and N. Column I is regarding some operations done with coil M and column II about induced current in coil N

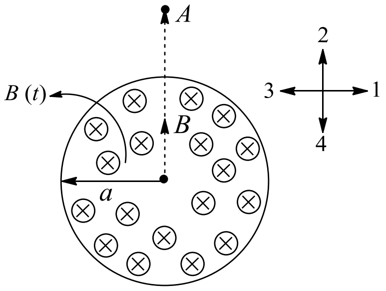


Column-I		Column- II	
(A)	Just after switch S is closed	(p)	Current is induced from A to B
(B)	Switch S is opened after keeping it closed for a long time	(q)	Current is induced from B to A
(C)	After switch S is closed for a long time	(r)	No current is induced
(D)	Just after switch S is closed while moving M away from N	(s)	

CODES :

	A	**B**	**C**	**D**
a)	b	c	a	d
b)	a	b	c	a
c)	a	b	a	c
d)	b	d	c	a

235. A uniform but time varying magnetic field $B(t)$ exists in a cylindrical region of radius a and is directed into the plane of the paper, as shown in figure. The magnetic field decreases at a constant rate inside the region. If r is the distance from the axis of the cylindrical region then match column I with column II



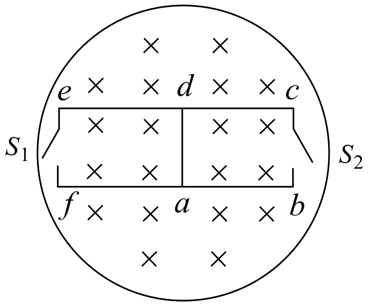
Column-I		Column- II	
(A)	Induced electric filed at point A	(p)	Directed along 3
(B)	Induced electric filed at point B	(q)	Directed along 1
(C)	Force on an electron placed at point A	(r)	Increases as r
(D)	Force on an electron placed at point B	(s)	Decreases as $1/r$

CODES :

	A	**B**	**C**	**D**
a)	A,d	a,c	b,d	b,c
b)	a,c	b,d	b,c	a,d

c)	b,d	b,c	a,d	a,c
d)	b,c	a,d	a,c	b,d

236. The magnetic filed in the cylindrical region shown in figure increases at a constant rate of 10.0 mTs^{-1}. Each side of the square loop $abcd$ and $defa$ has a length of 2.00 cm and a resistance of 2.00 Ω. Correctly match the current in the wire ad in four different situations s listed in column I with the values given in column II

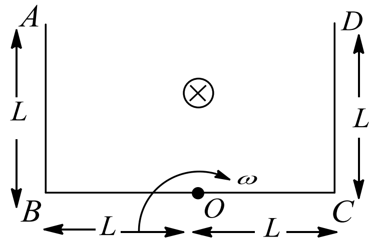


Column-I	Column- II
(A) The switch S_1 is closed but S_2 is open	(p) 5×10^{-7}A, d to a
(B) S_1 is open but S_2 is closed	(q) 5×10^{-7}A, a to d
(C) Both S_1 and S_2 are open	(r) 2.5×10^{-8}A, d to a
(D) Both S_1 and S_2 are closed	(s) No current flows

CODES :

	A	B	C	D
a)	d	d	a	b
b)	a	d	d	b
c)	b	a	d	d
d)	d	d	a	b

237. A frame $ABCD$ is rotating with an angular velocity ω about an axis passing through the point O perpendicular to the plane of paper as shown in the figure. A uniform magnetic filed $\vec{B}$ is applied into the plane of the paper in the region as shown below. Match the following



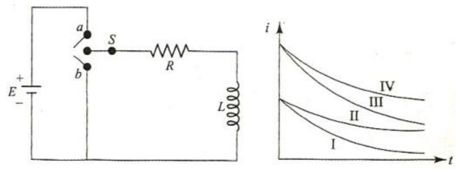
Column-I	Column- II
(A) Potential difference between A and O is	(p) Zero
(B) Potential difference between O and D is	(q) $\frac{B\omega L^2}{2}$
(C) Potential difference between C and D is	(r) $B\omega L^2$

(D) Potential difference between A and D is | (s) Constant

CODES :

	A	B	C	D
a)	C,d	b,d	a,d	c,d
b)	c,d	c,d	b,d	a,d
c)	b,d	a,d	c,d	c,d
d)	a,d	c,d	c,d	b,d

238. The switch S in the circuit is connected with point a for a very long time, then it is shifted to position b. The resulting current through the inductor is shown by curves in the graph for four sets of values for the resistance R and inductance L (given in column 1). Which set corresponds with which curve?



Column-I	Column- II
(A) R_0 and L_0	(p) I
(B) $2R_0$ and L_0	(q) II
(C) R_0 and $2L_0$	(r) III
(D) $2R_0$ and $2L_0$	(s) IV

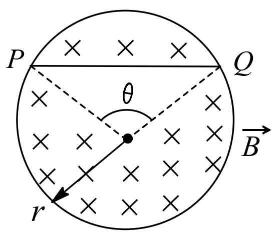
CODES :

	A	B	C	D
a)	B	a	d	c
b)	d	b	c	a
c)	c	a	d	b
d)	a	c	b	d

239. Column I shows the cylindrical region of radius r where a downward magnetic field $\vec{B}$ exists, where $\vec{B}$ is increasing at the rate of dB/dt. A rod PQ is placed in different citation as shown. Match the column I with the correct statement in column II regarding the induced emf in rod

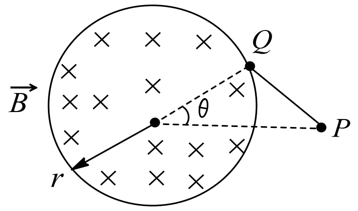
Column-I | **Column- II**

(A)



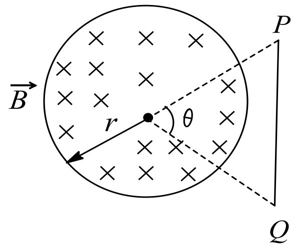
(p) Induced emf in rod PQ is $\frac{1}{2}r^2\theta\frac{dB}{dt}$

(B)



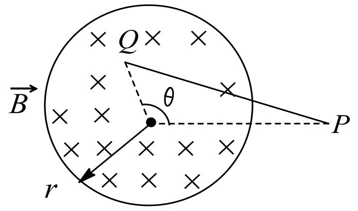
(q) Induced emf in rod PQ is less than $\frac{1}{2}r^2\theta\frac{dB}{dt}$

(C)



(r) End P is positive with respect to point Q

(D)

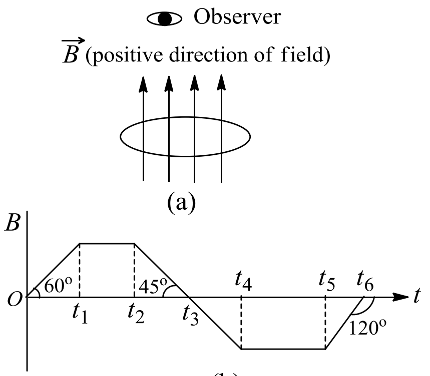


(s) End Q is positive with respect to point P

CODES :

	A	B	C	D
a)	A,d	a,c	b,d	a,d
b)	b,c	a,d	a,c	b,d
c)	a,c	b,d	a,d	a,d
d)	b,d	a,d	a,d	a,c

240. A conducting loop is held in a magnetic field such that the field is oriented perpendicular to the area of the loop as shown in figure (a). At any instant. Magnetic flux density over the entire area has the same value but it varies with time as shown in figure (b)



(b)

Column-I | **Column- II**

(A) Induced current in the coil is in the clockwisesence — (p) For $t_2 < t < t_3$

(B) Induced current in the coil is in the anticlockwise sense — (q) For $t_3 < t < t_4$

(C) Induced current is zero — (r) For $t_5 < t < t_6$

(D) Induced current is maximum — (s) For $t_4 < t < t_5$

CODES :

	A	B	C	D
a)	c	a,b	d	c
b)	a,b	d	c	c
c)	d	c	c	a,b
d)	c	c	a,b	d

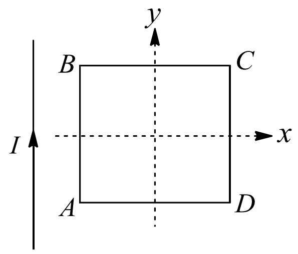
241. Column I gives certain situations in which a straight metallic wire of resistance R is used and column II gives some resulting effects. Match the statements in Column I with the statements in Column II

Column-I		Column- II	
(A)	A charged capacitor is connected to the ends of the wire	(p)	A constant current flows 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

CODES :

	A	B	C	D
a)	q	r,s	r,s	p,q,r
b)	r,s	p,q,r	r,s	q
c)	p,q,r	r,s	q	r,s
d)	r,s	q	p,q,r	r,s

242. A long current carrying wire and a loop made of conducting wire are placed in $x-y$ plane, such that the long wire is parallel to y-axis. Column I is regarding some changes made in the position of loop and Column II indicates the resulting effects



Match the columns

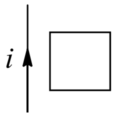
Column-I		Column- II	
(A)	If loop is moved away from the wire while keeping in $x-y$ plane,	(p)	Current is induced in the loop in anticlockwise direction
(B)	If loop is moved toward the wire while keeping in $x-y$ plane	(q)	Current is induced in the loop is clockwise direction

(C)	If loop is rotated about x-axis, then just after this	(r)	No emf is induced in the loop
(D)	If loop is rotated about y-axis, then just after this	(s)	The wire will attract or repel the loop

CODES :

	A	**B**	**C**	**D**
a)	B,d	a,d	c	c
b)	a,d	c	c	b
c)	a	d	c	b
d)	a	b	c	d

243. A square loop is placed near a long straight current carrying wire as shown in figure. Match the following table



	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 anticlockwise
(C)	If loop is moved away from the wire	(r)	Wire will attract the loop
(D)	If loop is moved toward the wire	(s)	Wire will repel the loop

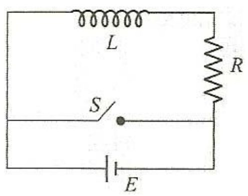
CODES :

	A	**B**	**C**	**D**
a)	A,c	b,d	b,d	a,c
b)	b,d	a,c	a,c	b,d
c)	a,c	a,c	b,d	b,d
d)	a,b	a,b	c,d	c,d

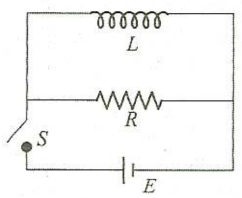
244. In column I some circuits are given. In all the circuits except in (i), switch S remains closed for long time and then it is opened at $t = 0$; while for (i), the situation is reversed. Column II tells something about the circuit quantities. Match the entries of column I with the entries of column II

Column-I | **Column- II**

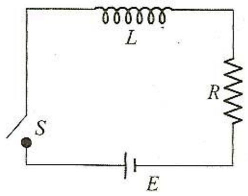
(A)



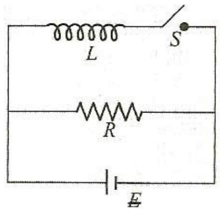
(p) Induced e.m.f. can be greater than E

(B) 

(q) Induced e.m.f. would be less than E

(C) 

(r) Finally, energy stored in inductor is zero

(D) 

(s) Finally, energy stored in inductor is non-zero

CODES :

	A	B	C	D
a)	C	c	a,c	a,c
b)	b	d	c	a
c)	a	c	a	b
d)	c	d	b	a

245. Match the following columns

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

CODES :

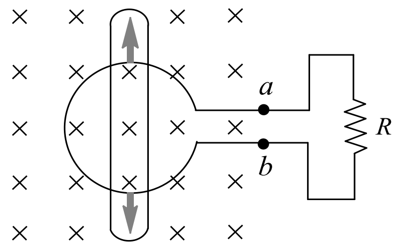
	A	B	C	D
a)	Q,s	p	q,r,s	q,s
b)	p	q,s	q,s	q,r,s
c)	q,r,s	q,s	p	q,s
d)	q,s	q,r,s	q,s	p

Linked Comprehension Type

This section contain(s) 42 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 246 to -246

A flexible circular loop 20 cm in diameter lies in a magnetic field with magnitude 1.0 T, directed into the plane of the page as shown in figure. The loop is pulled at the points indicated by the arrows, forming a loop of zero area in 0.314 s

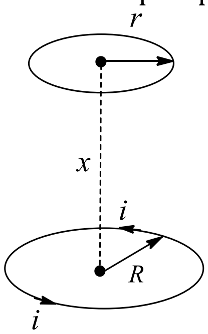


246. The average induced emf in the circuit is

a) 0.2 V b) 0.1 V c) 1 V d) 10 V

Paragraph for Question Nos. 247 to - 247

Figure shows two parallel and coaxial loops. The smaller loop (radius r) is above the larger loop (radius$R$), by distance $x \gg R$. The magnitude filed due to current i in the larger loop is nearly constant throughout the smaller loop. Suppose that x is increasing at a constant rate of $dx/dt = v$

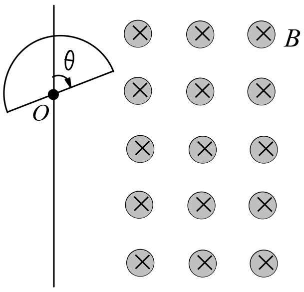


247. Determine the magnitude flux through the smaller loop as a function of x

a) $\frac{\mu_0 i R^2 \pi r^2}{x^3}$ b) $\frac{\mu_0 i R^2 \pi r^2}{2x^3}$ c) $\frac{2\mu_0 i R^2 \pi r^2}{x^3}$ d) $\frac{\sqrt{2}\mu_0 i R^2 \pi r^2}{x^3}$

Paragraph for Question Nos. 248 to - 248

A wire loop enclosing a semicircle of radius R is located on the boundary of a uniform magnetic field$B$. At the moment$t = 0$, the loop is set into rotation with constant angular acceleration α about an axis O. The clockwise emf direction is taken to be positive

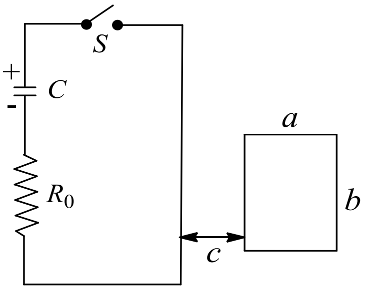


248. The variation of emf as a function of time is

a) $\frac{1}{2}BR^2\alpha t$ b) $\frac{3}{2}BR^2\alpha tA$ c) $\sqrt{3}\,BR^2\alpha t$ d) $\frac{BR^2\alpha t}{\sqrt{2}}$

Paragraph for Question Nos. 249 to - 249

In the circuit shown in figure, the capacitor has capacitance has capacitance $C = 20\ \mu F$ and is initially charged to 100 V with the polarity shown. The resistor R_0 has resistance 10 Ω. At time $t = 0$, the switch is closed. The smaller circuit is not connected in any way to the larger one. The wire of the smaller circuit has a resistance of 1.0 Ωm^{-1} and contains 25 loops. The larger circuit is a rectangle 2.0 m by 4.0 m, while the smaller one has dimensions $a = 10.0$ cm and $b = 20.0$ cm. the distance c is 5.0 cm. (The figure is not drawn to scale). Both circuits are held stationary. Assume that only the wire nearest to the smaller circuit produced an appreciable magnetic filed through it

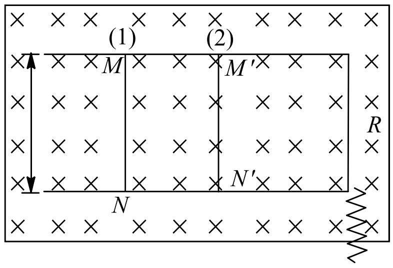


249. The current in the larger circuit 200 ms after closing S is

a) $\frac{5}{e}$A b) $\frac{2}{e}$A c) $\frac{15}{e}$A d) $\frac{10}{e}$A

Paragraph for Question Nos. 250 to - 250

Two long parallel conducting rails are placed in a uniform magnetic field. On one side, the rails are connected with a resistance R. Two rods MN and $M'N'$ each resistance r are placed as shown in figure. Now on the rods MN and $M'N'$ forces are applied such that the rods move with constant velocity v

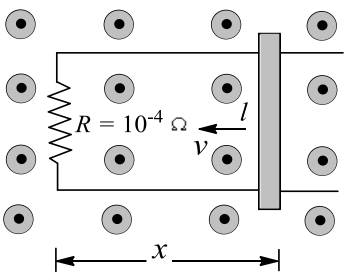


250. The current flowing through resistance R if both the rods move with the same speed v towards right is

a) $\frac{B\ell v}{R+(r/2)}$ b) $\frac{2B\ell v}{R+r}$ c) Zero d) $\frac{3B\ell v}{2(R+r)}$

Paragraph for Question Nos. 251 to - 251

A metal bar is moving with a velocity of $v = 5\text{ cm s}^{-1}$ over a U-shaped conductor. At $t = 0$, the external magnetic field is 0.1 T directed out of the page is increasing at a rate of0.2 T s^{-1}. Take $\ell = 5$ cm, and at $t = 0, x = 5$ cm

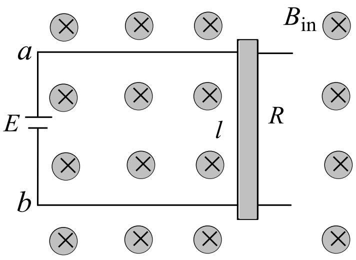


251. The emf induced in the circuit is

a) 125 μV b) 250 μV c) 100 μV d) 300 μV

Paragraph for Question Nos. 252 to - 252

In figure shown, the rod has a resistance R, the horizontal rails have negligible friction. A battery of emf E and negligible internal resistance is conneted between points $a$and b. The rod is released from rest

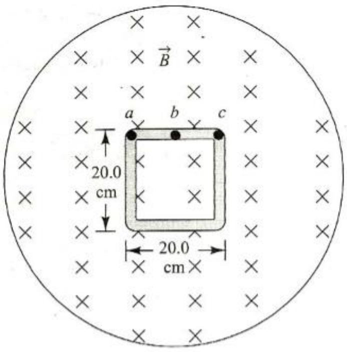


252. The velocity of the rod as function of time is

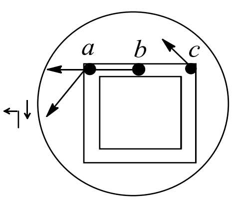
a) $\frac{E}{B\ell}(1-e^{-t/\tau})$ b) $\frac{E}{B\ell}(1+e^{-t/\tau})$ c) $\frac{3}{2}\frac{E}{B\ell}(1-e^{-t/\tau})$ d) $\frac{E}{2B\ell}(1-e^{-t/\tau})$

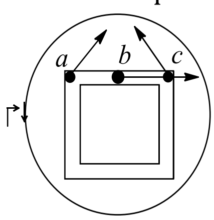
Paragraph for Question Nos. 253 to - 253

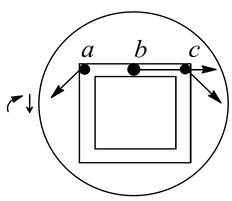
A square conducting loop, 20.0 cm on a side is placed in the same magnetic field as shown in figure; centre of the magnetic field region, where $dB/dt = 0.035\ \mathrm{Ts}^{-1}$

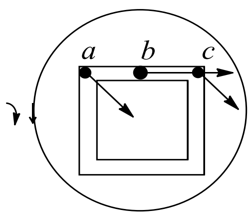


253. The directions of induced electric field at points a, b and c

a) 

b) 

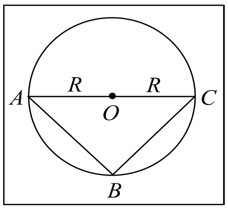
c) 

d) 

Paragraph for Question Nos. 254 to - 254

In a very long solenoid of radius R, if the magnetic field changes at the rate of dB/dt. $AB = BC$

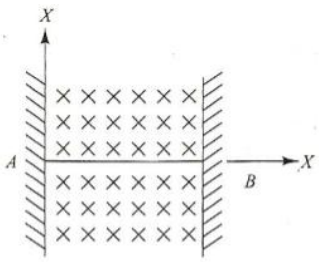
254. The induced emf for the triangular circuit ABC shown in figure is



a) $R^2\left(\frac{dB}{dt}\right)$ b) $4R^2\left(\frac{dB}{dt}\right)$ c) $\frac{1}{2}R^2\left(\frac{dB}{dt}\right)$ d) $2R^2\left(\frac{dB}{dt}\right)$

Paragraph for Question Nos. 255 to - 255

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



255. 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) $\frac{(AB)\omega}{k}$

Paragraph for Question Nos. 256 to - 256

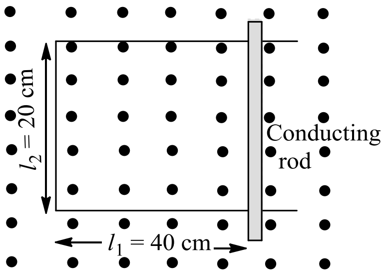
A fan operates at 200 V (dc) consuming 1000 W when running at full speed. Its internal wiring has resistance 1 Ω. When the fan runs at full speed, its speed becomes constant. This is because the torque due to magnetic field inside the fan is balanced by the torque due to air resistance on the blades 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 itP_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 e. Answer the following questions when the fan is running at full speed

256. The current flowing into the fan and the value of back emf$e$ is

a) 200 A, 5 V b) 5 A, 200 V c) 5 A, 195 V d) 1 A, 0 V

Paragraph for Question Nos. 257 to - 257

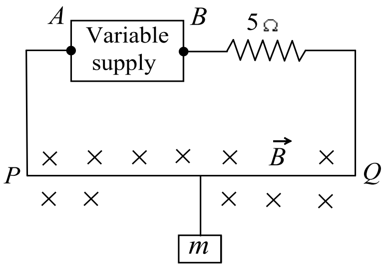
Figure shows a conducting rod of negligible resistance that can slide on a smooth U-shaped rail made of wire of resistance can slide on a smooth U-shaped rail. Made of wire or resistance1 Ωm^{-1}. Position of the conducting rod at $t = 0$ is shown. A time dependent magnetic field $B = 2T$ (tesla) is switched on at $t = 0$



257. The current in the loop at $t = 0$ due to induced emf is
a) 0.16 A, clockwise b) 0.08 A, clockwise c) 0.08 A, anticlockwise d) Zero

Paragraph for Question Nos. 258 to - 258

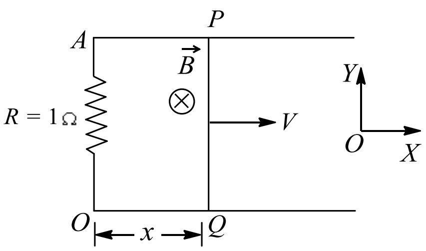
A brilliant student of physics developed a magnetic balance to weigh objects. The mass m to be measured is hung from the centre of the bar. Bar is kept in a uniform magnetic field of 1.5 T directed into the plane of the figure. Battery voltage can be adjusted to vary the current in the circuit. The horizontal bar shown is 60 cm long and is made of extremely light weight material. It is connected to the battery via a resistance. There is no tension in the supporting wires. The magnetic force only supports the hanging weight



258. Which point of battery terminal is positive?
a) A b) B c) Either A or B d) Cannot be found

Paragraph for Question Nos. 259 to - 259

Consider two parallel, conducting frictionless tracks kept in a gravity-free space as shown in figure. A movable conductorPQ, initially kept at OA, is given a velocity 10 ms^{-1} towards right. The space contains a magnetic field which depends upon the distance moved by conductor PQ from the OA line and given by



$\vec{B} = cx(-\hat{k})$[c=constant=I S.I. unit]

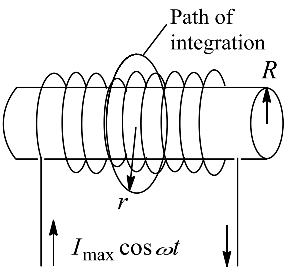
The mass of the conductor PQ is 1 kg and length of PQ is 1 m. answer the following questions based on the above passage

259. The distance travelled by the conductor when its speed is 5 m/s is

a) $\left(\frac{15}{2}\right)^{1/3}$ b) $\left(\frac{10}{3}\right)^{1/3}$ c) $(10)^{1/3}$ d) None of the above

Paragraph for Question Nos. 260 to - 260

A long solenoid of radius R has n turns of wire per unit length and carries a time varying current that varies sinusoidally as $I = I_{\max}\cos\omega t$, where $I_{\max}$ is the maximum current and ω is the angular frequency of the alternating current source (shown in fig)

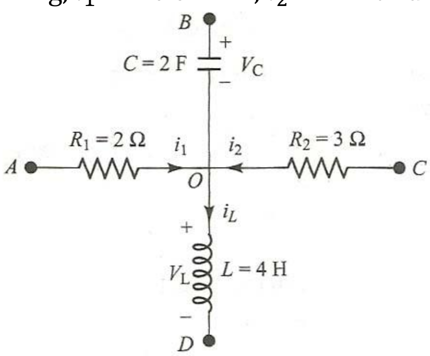


260. The magnitude of the induced electric field inside the solenoid, a distance $r < R$ from its long central axis is

a) $\frac{3\mu_0 n I_{\max}\omega}{2} r\sin\omega t$ b) $\frac{\mu_0 n I_{\max}\omega}{2} r\cos\omega t$ c) $\mu_0 n I_{\max}\omega r\sin\omega t$ d) $\frac{\mu_0 n I_{\max}\omega}{2} r\sin\omega t$

Paragraph for Question Nos. 261 to - 261

In fig, $i_1 = 10\,e^{-2t}$ A, $i_2 = 4$ A and $V_C = 3e^{-2t}$ V

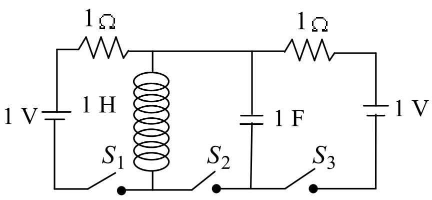


261. The current i_L is

a) $[2 - 2(1 - e^{-2t})]$ A b) $[2 + 2(1 - e^{-2t})]$ A c) $[3 - 2(1 - e^{-2t})]$ A d) $[2 + 3(1 - e^{-2t})]$ A

Paragraph for Question Nos. 262 to - 262

In the circuit shown, switches S_1 and S_3 have been closed for 1 s and S_2 remained open. Just after 1 s, switch S_2 is closed and S_1 and S_3 are opened. Find after that instant $(t = 0)$:

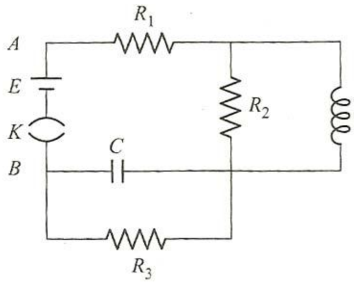


262. The maximum current in the containing inductor and capacitor only (only S_2 is closed)

a) $\sqrt{3}\left(1-\frac{1}{e}\right)$ b) $\sqrt{2}\left(1-\frac{1}{e}\right)$ c) $\sqrt{3}\left(1+\frac{1}{e}\right)$ d) $\sqrt{2}\left(1+\frac{1}{e}\right)$

Paragraph for Question Nos. 263 to - 263

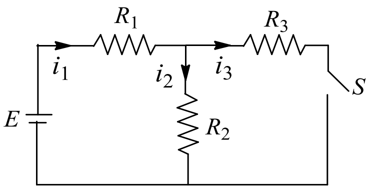
In the given circuit, all the symbols have their usual meanings. At $t = 0$, key K is closed. Now answer the following question



263. At $t = 0$, the equivalent resistance between A and B is

a) $R_1 + R_2 + R_3$ b) $R_1 + R_2$ c) $R_1 + R_3$ d) Indeterminate

Paragraph for Question Nos. 264 to - 264



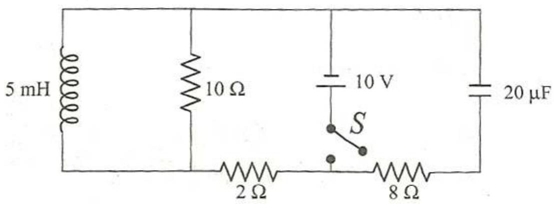
In the circuit shown in the fig, $E = 15$ V, $R_1 = 1\Omega, R_2 = 1\ \Omega, R_3 = 2\ \Omega$ and $L = 1.5$ H. The currents flowing through R_1, R_2 and R_3 and i_1, i_2 and i_3, respectively

264. Immediately after turning the switch S on,

a) $i_1 = i_2 = 7.5$ A, $i_3 = 0$ A b) $i_1 = i_3 = 5$ A, $i_2 = 0$ A
c) $i_1 = i_2 = 9$ A, $i_3 = 0$ A d) $i_1 = i_2 = i_3 = 0$ A

Paragraph for Question Nos. 265 to - 265

In the given circuit at $t = 0$, switch S is closed



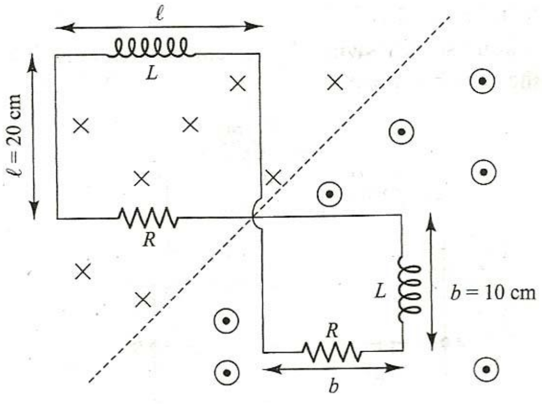
265. The current through the 10 Ω resistor at any instant $t(0 < t < \infty)$ will be

a) $\frac{1}{6}e^{-(1000/3)t}$ b) $\frac{5}{6}e^{-(1000/3)t}$ c) $\frac{1}{6}e^{(1000/3)t}$ d) $\frac{6}{5}e^{(1000/3)t}$

Paragraph for Question Nos. 266 to - 266

In Fig, there is a frame consisting of two square loops having resistors and inductors as shown. This frame is placed in a uniform but time varying magnetic field in such a way that one of the loops is placed in crossed magnetic field and the other is placed in dot magnetic field. Both magnetic fields are perpendicular to the planes of the loops

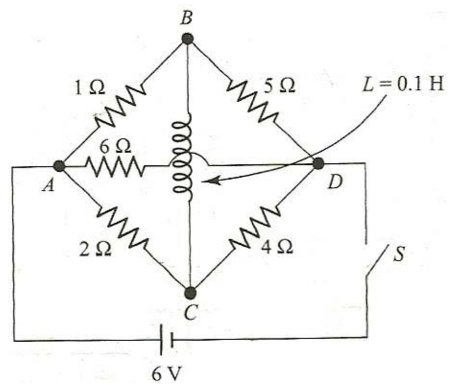
If the magnetic field is given by $B = (20 + 10\,t)\text{Wb m}^{-2}$ in both regions [$\ell = 20$ cm, $b = 10$ cm and $R = 10\ \Omega, L = 10$ H),



266. The direction of induced current in the bigger loop will be
   a) Clockwise
   b) Anticlockwise
   c) First clockwise for some time, then anticlockwise, and so on
   d) First anticlockwise for some time, then clockwise, and so on

Paragraph for Question Nos. 267 to - 267

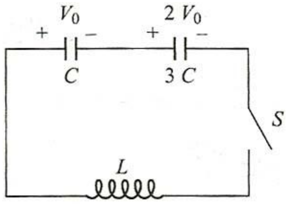
There is no current in any part of this circuit for time $t < 0$. Switch S is closed at $t = 0$



267. The rate at which the current through the inductor increases initially is
   a) Zero   b) 10 A s^{-1} c) 1 A s^{-1} d) 5 A s^{-1}

Paragraph for Question Nos. 268 to - 268

Two capacitors of capacitance C and $3C$ are charged to potential difference V_0 and $2\,V_0$, respectively, and connected to an inductor of inductance L as shown in fig. Initially the current in the inductor is zero. Now, switch S is closed

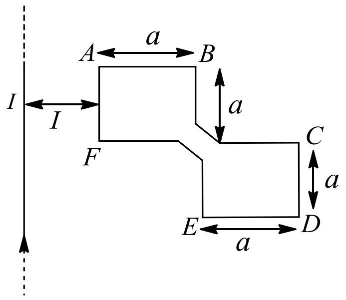


268. The maximum current in the inductor is

a) $\frac{3V_0}{2}\sqrt{\frac{3C}{L}}$ b) $V_0\sqrt{\frac{3C}{L}}$ c) $2V_0\sqrt{\frac{3C}{L}}$ d) $V_0\sqrt{\frac{C}{L}}$

Paragraph for Question Nos. 269 to - 269

In Fig, there is a conducting loop $ABCDEF$ of resistance λ per unit length placed near a long straight current-carrying wire. The dimensions are shown in the figure. The long wire lies in the plane of the loop. The current in the long wire varies as $I = I_0(t)$

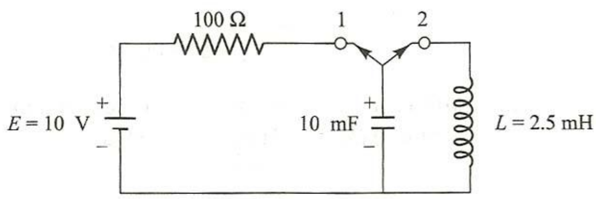


269. The mutual inductance of the pair is

a) $\frac{\mu_0 a}{2\pi}$ In $\left(\frac{2a+\ell}{\ell}\right)$ b) $\frac{\mu_0 a}{2\pi}$ In $\left(\frac{2a-\ell}{\ell}\right)$ c) $\frac{2\mu_0 a}{\pi}$ In $\left(\frac{a+\ell}{\ell}\right)$ d) $\frac{\mu_0 a}{\pi}$ In $\left(\frac{a+\ell}{\ell}\right)$

Paragraph for Question Nos. 270 to - 270

In fig initially the capacitor is charged to a potential of 5 V and then connected to position 1 with the shown polarity for 1 s. After 1 s, it is connected across the inductor at position 2

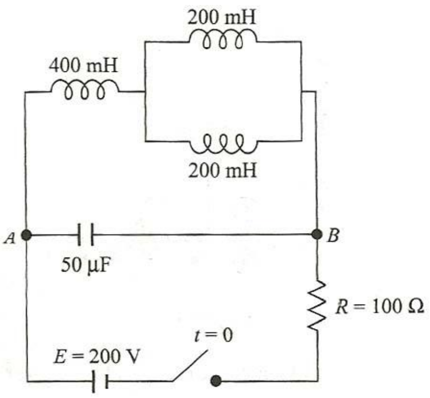


270. The potential across the capacitor after 1 s of its connection to position lis

a) $5\times10^3\left(2+\frac{1}{e}\right)$ V b) $5\times10^3\left(2-\frac{1}{e}\right)$ V c) $5\times10^3\left(1+\frac{2}{e}\right)$ V d) None of these

Paragraph for Question Nos. 271 to - 271

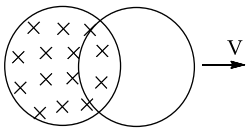
In the circuit shown, switch S_1 was closed for a long time. At time $t = 0$ the switch is opened



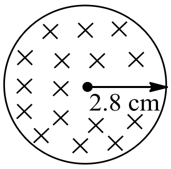
271. Find the maximum potential difference across the plates of the capacitor after the switch is opened
a) 100 V
b) 200 V
c) 300 V
d) 400 V

Integer Answer Type

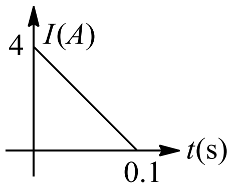
272. A uniform magnetic filed$B = 0.5$ T exists in a circular region of radius $R = 5$ m. A loop of radius $R = 5$ m encloses the magnetic filed at $t = 0$ and then pulled at uniform speed $v = 2$ m/s in the plane of the paper. Find the induced emf (in V) in the loop at time $t = 3$ s



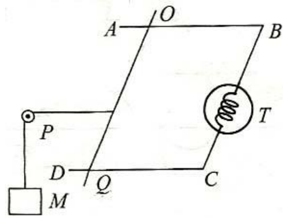
273. The magnitude filed of a cylindrical magnet that has a pole face radius 2.8 cm can be varied sinusoidally between the minimum value 16.8 T and the maximum value 17.2 at a frequency of $50/\pi$ Hz. Cross section of the magnetic field created by the magnet is shown in figure. At a radial distance of 2 cm from the axis, find the amplitude of the electric field (in units of $\times 10^2$ mN/C) induced by the magnetic field variation



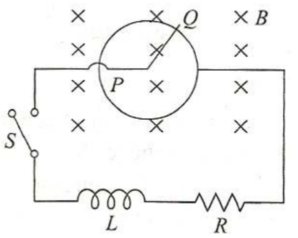
274. A long coaxial cable consist of two thin-walled conducting cylinders with inner radius 2 cm an outer radius 8 cm. the inner cylinder carries a steady current 0.1 A, and the outer cylinder provides the return path for that current. The current produces a magnetic field between the two cylinders. Find the energy stored in the magnetic field for length 5 m of the cable. Express answer in nJ (use In2=0.7)
275. Some magnetic flux is changed from a coil of resistance10 Ω. As a result, an induced current is developed in it, which varies with time as shown in figure. Find the magnitude of the change in flux through the coil in weber



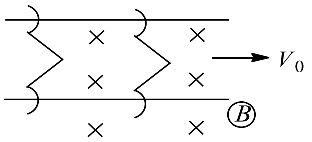
276. In figure, $ABCD$ is a fixed smooth conducting frame in horizontal plane.$T$is a bulb of power 100 W, P is a smooth pulley and OQ is a conducting rod. Neglect the self inductance of the loop and resistance of any part other than the bulb. The mass M is moving down with constant velocity 10 m/s. Bulb lights at its rated power due to induced emf in the loop due to earth's magnitude field. Find the mass M (in kg) of the block (g=10 m/s^2)



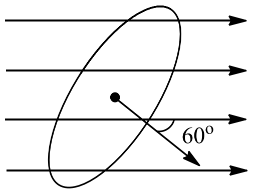
277. A long solenoid of diameter 0.1 m has 2×10^4 turns per metre. At the centre of the solenoid a 100 turn coil of radius 0.01 m is placed with its axis coinciding with the solenoid axis. The current in the solenoid is decreased at a constant rate from $+2$ A to -2 A in 0.05 s. Find the total charge (in μC) flowing through the coil during this time when the resistance of the coil is $40\pi^2\ \Omega$
278. Fig shows a circuit having a coil of resistances $R = 2.5\ \Omega$ and inductance L connected to a conducting rod PQ which can slide on a perfectly conducting circular ring of radius 10 cm with its centre at 'P'



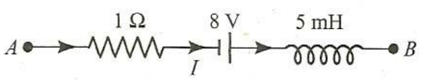
Assume that friction and gravity are absent and a constant uniform magnetic field of 5 T exists as shown as shown in fig. At $t = 0$, the circuit is switched on and simultaneously a time varying external torque is applied on the rod so that it rotates about P with a constant angular velocity 40 rad/s. Find the magnitude of this torque (in mNm) when current reaches half of its maximum value. Neglect the self inductance of the loop formed by the circuit
279. In figure, there are two sliders and they can slide on two frictionless parallel wires in uniform magnetic filed$B$, which is present everywhere. The mass of each slider is m, resistance R and initially these are at rest. Now, if one slider is given a velocity$v_0 = 16$ m/s, what will be the velocity (in m/s) of other slider after long time. (neglect the self-induction)



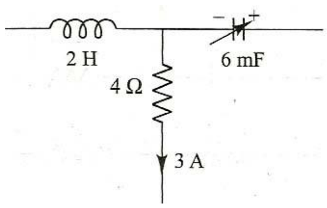
280. Two coils, 1 and 2 have a mutual inductance $M = 5$ H and resistance $R = 10\ \Omega$ each. A current flows in coil 1, which varies with time as: $I_1 = 2t^2$, where t is time. Find the total charge (in C) that has flown through coil 2 between $t = 0$ and $t = 2$ s
281. A circular coil of wire consists of exactly 100 turns with a total resistance0.20 Ω. The area of the coil is100 cm^2. The coil is kept in a uniform magnetic field Bas shown in figure. The magnitude field is increased at a constant rate of 2 T/s. find the induced current in the coil in A



282. In the circuit what is potential difference $V_B - V_A$ (in V) when current I is 5 A and is decreasing at the rate of 10^3 A/s?



283. Fig shows a part of a bigger circuit. The capacity of the capacitor is 6 mF and is decreasing at the constant rate 0.5 mF s^{-1}. The potential difference across the capacitor at the shown moment is changing as follows $\frac{dV}{dt} = 2\ Vs^{-1}, \frac{d^2V}{dt^2} = \frac{1}{2} Vs^{-2}$

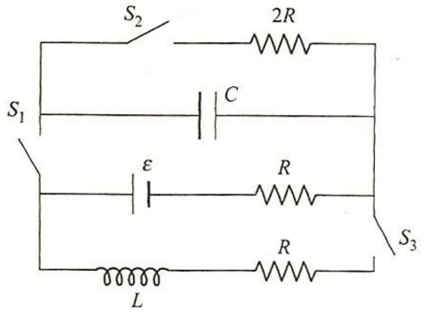


The current in the 4 Ω resistor is decreasing at the rate of 1 mA s^{-1}. What is the potential difference (in mV) across the inductor at this moment?

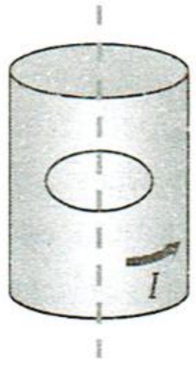
284. A current of 2 A is increasing at a rate 4 A/s through a coil of inductance 1 H. Find the energy stored in the inductor per unit time in the units of J/s

285. A capacitor of capacity 2 μF is charged to a potential difference of 12 V. It is then connected across an inductor of inductance 6 μH. What is the current (in A) in the circuit at a time when the potential difference across the capacitor is 6.0 V?

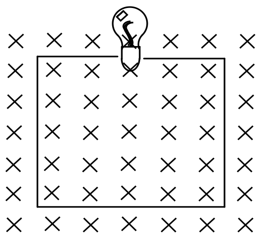
286. In the given circuit, initially switch S_1 is closed, and S_2 and S_3 are open. After charging of capacitor, at $t = 0, S_1$ is opened and S_2 and S_3 are closed. If the relation between inductance, capacitance and resistance is $L = 4CR^2$, then find the time (in s) after which current passing through capacitor and inductor will be same (given $R = \text{In } 2 \text{ m}\Omega, \text{L} = 2 \text{ mH}$)



287. 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 0.005 ohm 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 $I = I_0 \cos(300\ t)$ where I_0 is constant. If the magnetic moment of the loop is $N\ \mu_0 I_0 \sin(300t)$ then 'N' is



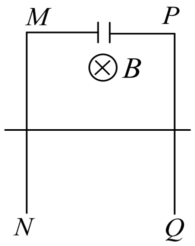
288. A square wire loop of 10.0 cm side lies at right angles to a uniform magnetic field of 7 T



A 10 V light bulb is in a series with the loop as shown in figure. The magnetic field is decreasing steadily to zero over a time interval Δt. For what value of t (in ms), the bulb will shine with full brightness?

289. Figure shows a conducting rod of length $l = 10$ cm, resistance R and mass $m = 100$ mg moving vertically downward due to gravity. Other parts are kept fixed. Magnetic field is $B = 1\text{T}$. MN and PQ are vertical, smooth, conducting rails. The capacitance of the capacitor is $C = 10$ mF. The rod is released from rest.

Find the maximum current (in mA) in the circuit



: ANSWER KEY :

1)	d	2)	b	3)	d	4)	a	5)	a,b,c,d	6)	b,c	7)	a.,c	8)	
5)	c	6)	b	7)	d	8)	c		a,d						
9)	d	10)	c	11)	b	12)	b	9)	a,d	10)	a,c,d	11)	b,d	12)	
13)	d	14)	d	15)	b	16)	a		a,b,c,d						
17)	d	18)	c	19)	b	20)	a	13)	a,b,d	14)	a,b	15)	c,d	16)	
21)	a	22)	c	23)	a	24)	c		a,d						
25)	b	26)	b	27)	a	28)	a	17)	a,c	18)	a,b,c,d	19)	a.,c	20)	
29)	d	30)	d	31)	c	32)	c		a,c,d						
33)	c	34)	c	35)	d	36)	d	21)	a,c	22)	b, d	23)	a,b,d	24)	
37)	d	38)	d	39)	a	40)	a		b,d						
41)	b	42)	c	43)	c	44)	a	25)	a,b	26)	b,d	27)	a,c,d	28)	
45)	a	46)	d	47)	b	48)	b		a,b,d						
49)	b	50)	c	51)	b	52)	a	29)	b,c	30)	b,d	31)	a,.b	32)	
53)	b	54)	b	55)	a	56)	b		b,d						
57)	a	58)	d	59)	d	60)	a	33)	a,c	34)	d	35)	a,b,c,d	36)	
61)	c	62)	b	63)	b	64)	a		a,b						
65)	a	66)	a	67)	c	68)	a	1)	a	2)	d	3)	b	4)	c
69)	c	70)	a	71)	c	72)	a	5)	d	6)	e	7)	b	8)	a
73)	a	74)	b	75)	a	76)	a	9)	b	10)	d	11)	c	12)	c
77)	b	78)	d	79)	b	80)	d	13)	e	14)	a	15)	b	16)	a
81)	d	82)	a	83)	b	84)	b	17)	a	18)	a	19)	c	20)	e
85)	b	86)	b	87)	a	88)	d	21)	a	22)	b	23)	d	24)	c
89)	d	90)	b	91)	d	92)	c	25)	a	26)	c	27)	d	28)	b
93)	b	94)	b	95)	c	96)	d	29)	c	30)	a	31)	e	32)	d
97)	d	98)	b	99)	b	100)	d	33)	c	34)	d	1)	d	2)	d
101)	a	102)	c	103)	d	104)	b		3)	a	4)	b			
105)	e	106)	b	107)	c	108)	a	5)	c	6)	c	7)	b	8)	c
109)	d	110)	b	111)	c	112)	b	9)	b	10)	a	11)	a	12)	a
113)	a	114)	a	115)	d	116)	b	13)	b	14)	a	15)	b	1)	b
117)	a	118)	a	119)	a	120)	b		2)	b	3)	a	4)	d	
121)	a	122)	d	123)	a	124)	c	5)	a	6)	b	7)	a	8)	a
125)	a	126)	c	127)	d	128)	c	9)	a	10)	a	11)	c	12)	a
129)	d	130)	d	131)	d	132)	b	13)	a	14)	a	15)	d	16)	b
133)	b	134)	c	135)	a	136)	d	17)	b	18)	b	19)	a	20)	b
137)	c	138)	c	139)	c	140)	a	21)	b	22)	b	23)	a	24)	a
141)	d	142)	d	143)	d	144)	c	25)	b	26)	b	1)	8	2)	2
145)	c	146)	c	147)	b	148)	d		3)	7	4)	2			
149)	b	150)	b	151)	a	152)	d	5)	1	6)	8	7)	5	8)	8
153)	d	154)	b	155)	c	156)	a	9)	4	10)	5	11)	8	12)	4
157)	b	158)	a	159)	b	160)	c	13)	8	14)	6	15)	1	16)	6
1)	a,b,c	2)	a,c	3)	b,d	4)		17)	7	18)	5				
	a,d														

: HINTS AND SOLUTIONS :

1 **(d)**
Induced emf: B (effective length) $v = B2Rv$

2 **(b)**
Polarity of emf will be opposite in the two cases while entering and while leaving the coil. Only in option (b) polarity is changing.

3 **(d)**
Induced current in $B = 0.006 \text{ A} = 6 \times 10^{-3}$ A
Induced e. m. f. in $B = \times 10^{-3} \times 4 \text{ V} = 24 \times 10^{-3}$ V
Now, $M\frac{dI}{dt} = 24 \times 10^{-3}$
or $dI = \frac{24\times10^{-3}\times0.02}{3\times10^{-3}}$ A $= 0.16$ A

4 **(a)**
$i = i_0\, e^{-t/t_0}$
$\left(-\frac{di}{dt}\right) = \frac{i_0}{t_0}e^{-t/t_0}$
$\left(-\frac{di}{dt}\right) = \frac{i_0}{t_0} = r$
∴ The desired time is $\frac{i_0}{r}$ or t_0

5 **(c)**
When the electron is closest, flux due to magnetic field of electron's motion is maximum through the loop. So slope of flux-time graph will be zero or induced emf will be zero

6 **(b)**
$\frac{L}{R} = 2 \times 10^{-3}$ ...(i)
$\frac{L}{R+90} = 0.5 \times 10^{-5}$ ...(ii)
From (i) and (ii), on solving, we get
$L = 60$ mH and $R = 30\ \Omega$

7 **(d)**
Let M be the mutual inductance between X and Y.
By definition
$E = M\frac{dI}{dt} = MI'; M = \frac{E}{I'}$
The flux linked with X is $\phi_X = MI_0 = \frac{E}{I'}I_0$

8 **(c)**
Use Lenz's law. Induced emf of the current opposes the change in flux through it

9 **(d)**
When inductances are connected like this in series, then $L = L_1 + L_2 + 2M$

10 **(c)**
Let v is the velocity of conductor any time, then induced emf, $e = Blv$ ...(i)
Charge on capacitor: $q = Ce = CBlv$
Current in circuit: $I = \frac{dq}{dt} = CBl\frac{dv}{dt}$
For conductor: $mg - IBl = \frac{mdv}{dt}$
$\Rightarrow mg - CB^2l^2\frac{dv}{dt} = \frac{mdv}{dt} \Rightarrow \frac{dv}{dt} = \frac{mg}{m + CB^2l^2}$
This is the acceleration of conductor which is constant

11 **(b)**
Let E be the electric filed at a distance r from the centre of the disc. Then
$eE = m\omega^2 r$
or $E = \frac{m\omega^2 r}{e}$
$\therefore P.D. = \int_{r=0}^{r=a} Edr$
$= \int_0^a \frac{m\omega^2 r}{e}\,dr = \frac{m\omega^2 a^2}{2e}$

12 **(b)**
$P = Fv = BI\ell v = 1.25 \times 10^{-3} \times 50 \times 0.1 \times 1$ W
$= 6.25 \times 10^{-3}$ W=6.25 mW
An iterating alternating
$P = EI = (Blv)I$

13 **(d)**
Net change in magnetic flux passing through the coil is zero
∴ Current (or emf) induced in the loop is zero

14 **(d)**
Initial flux through the coil, $\phi_{Bi} = +NBA$
Final flux through the coil, $\phi_{Bf} = -NBA$
When the coil is turned through 180° its flux reverse; the angle between magnetic field and area vector is reversed
$\Delta\phi_B = \phi_{Bf} - \phi_{Bi} = -NBA - (NBA) = -2NBA$
$Q = \frac{\Delta\phi_B}{R} = \frac{2NBA}{R}$

15 **(b)**
Initial flux: $\phi_i = -\int_a^{2a}\frac{\mu_0 Ia}{2\pi}\frac{dx}{x} = -\frac{\mu_0 Ia}{2\pi}\text{In } 2$
Final flux : $\phi_f = \frac{\mu_0 Ia}{2\pi}\text{In } 2$
Change flown : $q = \frac{\Delta\phi}{r} = \frac{\phi_f - \phi_i}{r} = \frac{\mu_0 Ia}{\pi r}\text{In } 2$

16 **(a)**
For first case: 2 mV= $M \times 5$
For second case: $e = M \times 2$
Solve to get $e = 0.8 \text{ mV} = 8 \times 10^{-4}$ V

17 **(d)**
When the coil is within the field, there is no charge in the magnetic flux passing through it.

Thus, no current will be induced and the acceleration will be g. But according to Lenz's law, the induced current will oppose its motion when it enters or leaves the field. Therefore, acceleration will be less than g

18 **(c)**

The magnetic field produced by the square loop is parallel to the plane of the circular loop. Hence the mutual inductance is zero

19 **(b)**

Inductors 5 mH and 10 mH are connected in parallel, hence equivalent inductance

$L_{eq} = \frac{5\times10}{5+10} = \frac{50}{15} = \frac{10}{3}$ mH

Current at steady state, $I = \frac{20}{5} = 4$ A

As L_1 and L_2 are in parallel

$$I_1 = I\left(\frac{L_2}{L_1+L_2}\right) = 4\left[\frac{10}{10+5}\right] = \frac{8}{3}\text{ A}$$

20 **(a)**

In accordance with Faraday's law of electromagnetic induction, the changing magnetic field induces an electric filed in the ring. Let us imagine the ring to be divided into differential elements of length ds and denote the tangential component of the induced electric filed by E. The charge on element ds of the ring is $dQ = Q\frac{ds}{2\pi r}$, Where r is the radius of the ring. The force exerted on it is $dF_1 = dQE$, and the resultant torque is $d\tau = r\,dF_t$

Thus, the total torque experienced by the ring is

$$\tau = \int d\tau = \int rQ\frac{ds}{2\pi r}E_t = \frac{Q}{2\pi}\int E_t ds$$

The induced electromotive force along the ring is directly proportional to the rate of change in the magnetic flux, we have

$$\int E_t ds = \frac{d\Phi}{ds} = \pi r^2\frac{dB}{dt}$$

As a result of the torque, the ring, which has a moment of inertia$I = mr^2$, starts to spin with angular accelerationα. During a time interval dt its anguilar velocity changes by

$$d\omega = \alpha dt = \frac{\tau}{I}dt = \frac{Q}{2\pi}\left(\pi r^2\frac{dB}{dt}\right)\frac{1}{mr^2}dt = \frac{Q}{2m}\,dB$$

Since the magnetic field strength increases from zero to B, the final angular velocity of the ring will be

$\omega = (QB/2m)$

⇒ The final angular velocity does not depend on the radius of the ring, the time over which the magnetic flux changes, or even on how the magnetic flux increases with time

⇒ In our calculation we ignored the magnetic field produced by the rotating ring

⇒ Except in the case of a *cylindrical symmetric* uniform induced, it is not possible to find the actual value of the induced electric filed within the ring because the geometrical structure of the magnetic field is unknown and we do not know the position of the ring in the magnetic field. We can determine the total induced electromagnetic force, but not the electric filed itself

21 **(a)**

$$\Delta q = \frac{\Delta\phi}{R}$$

$\phi_i = 0$

$$\phi_f = \left(\frac{\mu_0}{2}\frac{i}{b}\right)(\pi a^2) = \frac{\mu_0 i a^2\pi}{2b}$$

$$\therefore\ \Delta\phi = \phi_f - \phi_i = \frac{\mu_0 i a^2\pi}{2b}$$

So, $\Delta q = \frac{\mu_0 i a^2\pi}{2Rb}$

22 **(c)**

By Lenz's law, clockwise current is induced in both loops. Greater the area, large will be the induced emf Outer loop has grater area

23 **(a)**

Emf induced in coil, $\varepsilon = -\frac{\Delta\phi}{\Delta t} = -\frac{(\phi_2-\phi_1)}{t_2-t_1}$

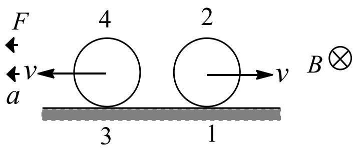
$$\phi_2 = BA_2 - B\,\frac{4a}{2\times3}\times\frac{4a}{3}\times\sin 60° = \frac{4\sqrt{3}}{9}\,Ba^2$$

$\phi_1 = Ba^2$

Work done, $W = \varepsilon q = \varepsilon I\Delta t = Ba^2\left(1-\frac{4\sqrt{3}}{9}\right)i$

24 **(c)**

$$V_2 - V_1 = \frac{1}{2}B\omega(2R)^2 = 2\,BR\,(\omega R) = 2\,BRv$$



$V_3 - V_4 = 2\,BRv$ But $V_1 = V_3$

$\Rightarrow V_2 - V_4 = 4BRv$

25 **(b)**

$$f = \frac{1}{2\pi\sqrt{LC}}, f + 50 = \frac{f}{2\pi\sqrt{LC/K}}$$

$$\Rightarrow K = \left(\frac{f+50}{f}\right)^2 = \left(1+\frac{50}{f}\right)^2$$

$$\Rightarrow K = 1 + \frac{100}{f} = 1 + \frac{100}{10{,}000} = 1.01$$

26 **(b)**

Magnetic field produced by a current I in a large square loop at its centre,

$B \propto \frac{I}{L} \Rightarrow B = K\frac{1}{L}$

$\therefore$ Magnetic flux linked with the smaller loop,

$\phi = BS \Rightarrow \phi = \left(K\frac{I}{L}\right)(l^2)$

Therefore, the mutual inductance

$M = \frac{\phi}{I} = K\frac{\ell^2}{L}$ or $M \propto \frac{\ell^2}{L}$

27 **(a)**

$U = \frac{1}{2}Li^2$

Rate $= \frac{dU}{dt} = (Li)\left(\frac{di}{dt}\right)$

At $t = 0, i = 0, \therefore$ rate $= 0$

At $t = \infty, i = i_0$ but $\frac{di}{dt} = 0,$

Therefore, rate $= 0$

28 **(a)**

For a solenoid, $L = \mu_0 N^2 \frac{A}{\ell}$. If x is the length of the wire and a is the area of cross-section, then

$R = \frac{\rho x}{a}$ and $m = axD$

$Rm = \frac{\rho x}{a}\, axD, x = \sqrt{\frac{Rm}{\rho D}}$

Also, $x = 2\,\pi r N, N = \frac{x}{2\pi r}$ $\quad \left(\because L = \frac{\mu_0 N^2 A}{\ell}\right)$

$\therefore\ L = \mu_0\left(\frac{x}{2\pi r}\right)^2 \frac{\pi r^2}{\ell} = \frac{\mu_0}{4\pi\ell}\frac{Rm}{\rho D}$

29 **(d)**

$\xi = \frac{d\phi}{dt} \Rightarrow i = \frac{\xi}{R} = \frac{1}{R}\frac{d}{dt}(BA) = \frac{A}{R}\frac{dB}{dt}$

Where πr^2 = area of the loop of radius r and R =resistance of the loop of length $(2\pi r)$ and area of cross section πa^2

$R = \frac{\rho\ell}{\pi a^2} = \frac{\rho(2\pi r)}{\pi a^2}$

Further mass of wire is $m = (\pi a^2)(2\pi r)(d)$

$i = \frac{(\pi a^2)(\pi r^2)}{\rho(2\pi r)}\frac{dB}{dt}$

$i = \frac{(\pi a^2)(2\pi r)}{4\pi\rho}\frac{dB}{dt} \Rightarrow i = \frac{m}{4\pi\rho d}\frac{dB}{dt}$

30 **(d)**

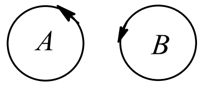
Induced emf between O and Q is

$\frac{1}{2}B\omega(2r)^2 = B\omega 2r^2 = 2\,Bvr$

But net induced emf in the ring will be zero. Hence no current flows in the ring

31 **(c)**

When the current in loop A incraeses, the magnetic lines of force in loop B also increases as loop A is near loop B. This induces an emf in B is such a direction that current flows in opposite direction in B (as compared to A in the nearer parts). Since currents are in opposite directions, loops B is repelled by loop A



32 **(c)**

Flux through a closed circuit containing an inductor does not change instantaneously

$\therefore L\left(\frac{E}{R}\right) = \frac{L}{4}(i) \Rightarrow i = \frac{4E}{R}$

33 **(c)**

Just before opening the switch, the current in the inductor is $\frac{E}{R}$. Energy stored in it $= \frac{1}{3}L\left(\frac{\varepsilon}{R}\right)^2$

This energy will dissipate in resistors R_1 and R_2 in the ratio $\frac{1}{R_1}$ and $\frac{1}{R_2}$

34 **(c)**

The current at time t is given by

$i = i_0(1 - e^{-t/\tau})$

Here $i_0 = \frac{E}{R}$ and $\tau = \frac{L}{R}$

$\therefore q = \int_0^{\tau} idt = \int_0^{t} i_0\,(1 - e^{-t/\tau})dt$

$= \frac{i_0\tau}{e} = \frac{\left(\frac{E}{R}\right)\left(\frac{L}{R}\right)}{e} = \frac{EL}{eR^2}$

35 **(d)**

According to Lenz's law, emf of same magnitude in clockwise direction is induced in the two loops into which the figure is divided. So, current is induced in the clockwise direction in the outer boundary but no current is there in wire AB

36 **(d)**

Volume of the balloon at any instant, when radius is r,

$$V = \frac{4}{3}\pi r^3$$

Time rate of change of volume,

$$\frac{dV}{dt} = 4\pi r^2 \frac{dr}{dt}$$

Time rate of change of radius of balloon,

$$\frac{dr}{dt} = \frac{1}{4\pi r^2}\frac{dV}{dt}$$

Flux through rubber band at the given instant,

$\phi = B(\pi r^2)$

Induced emf$= -\frac{d\phi}{dt} = -\frac{d}{dt}(B\pi r^2) = -2\pi r B\frac{dr}{dt}$

$$= -2\pi r B\left(\frac{1}{4\pi r^2}\frac{dV}{dt}\right) = -\frac{B}{2r}\frac{dV}{dt}$$

As volume of the balloon is decreasing, $\frac{dV}{dt}$ is negative

$$E_{\text{induced}} = \frac{(0.04)}{2\times 10\times 10^{-2}}\times(-100\times 10^{-6})$$
$$= 20\ \mu\text{V}$$

37 **(d)**

Since all the wires are connected between rim and axle, they will generate induced emf is parallel, hence it is same for any number of spokes

38 **(d)**

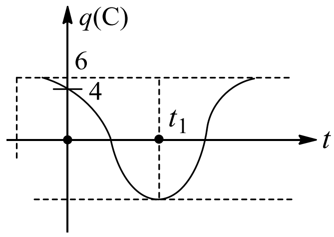
$B\ell Vt = \text{constant}$

$$B = \frac{C}{\ell V t}$$

39 **(a)**

$i = \sqrt{5}$ A

$$\frac{q_m^2}{2C} = \frac{q^2}{2C} + \frac{1}{2}Li^2 \Rightarrow q_{\max} = 6\ \text{C}$$



$q = Q\cos(\omega t + \delta)$, at $t = 0, q = 4$

$$\Rightarrow 4 = 6\cos\delta \Rightarrow \cos\delta = \frac{2}{3} \Rightarrow \delta = \cos^{-1}\left(\frac{2}{3}\right)$$

Change on the capacitor is maximum at $t = t_1$

For this $\omega t_1 + \delta = \pi$

$$\Rightarrow t_1 = \frac{1}{\omega}(\pi - \delta) = \sqrt{LC}(\pi - \delta)$$
$$= 2\left[\pi - \cos^{-1}\left(\frac{2}{3}\right)\right]$$

40 **(a)**

$$R_{\text{eq}} = \frac{5R}{6} \Rightarrow I = \frac{6E}{5R} = 1\ \text{A}$$

41 **(b)**

$e = (\vec{v}\times\vec{B}).\vec{\ell}$

$e = [\hat{\imath}\times(3\hat{\imath} + 4\hat{\jmath} + 5\hat{k})].5\hat{\jmath}$

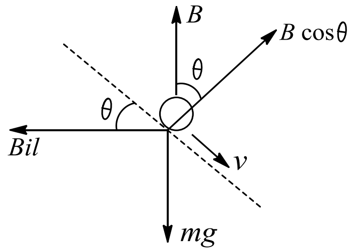
$\Rightarrow e = -25$ V

42 **(c)**

$BI\ell\cos\theta = mg\sin\theta$ (i)

Here induced emf across slider is $(B\cos\theta)lv$

$\therefore$ induced current $I = \frac{Blv\cos\theta}{R}$



From equation (i)

$$B\ell\cos\theta\frac{B\ell\, v\cos\theta}{R} = mg\sin\theta$$

$$\therefore\ v = \frac{mg\, R\sin\theta}{B^2\ell^2\cos^2\theta}$$

43 **(c)**

Induced emf$= B\ell v$. R is internal resistance of seat of emf, i.e., of rod

Total resistance of circuit$= R + \frac{R_1R_2}{R_1+R_2}$

$$\therefore\ I = \frac{B\ell v}{R + \frac{R_1R_2}{(R_1+R_2)}} = \frac{B\ell v(R_1+R_2)}{R_1R_2 + R(R_1+R_2)}$$

44 **(a)**

$\vec{\ell}, \vec{v}$ and $\vec{B}$ are coplanar

46 **(d)**

$L = \frac{\phi}{I}, \phi = NAB$

$B = \mu_0 nI$

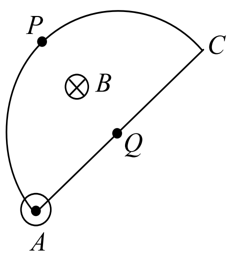
where $n = \frac{N}{2\pi R}$

$$\therefore\ \phi = N\pi r^2\left(\mu_0\frac{N}{2\pi R}I\right)$$

$$\phi = \frac{\mu_0 N^2 r^2 I}{2R}$$

$$L = \frac{\phi}{I} = \frac{\mu_0 N^2 r^2}{2R}$$

47 **(b)**
When the copper rod is rotated, flux linked with the circuit varies with time
Therefore, an emf is induced in the circuit.
At time t, plane of semi-circle makes angle ωt with the plane of rectangular part of the circuit.
Hence, component of the magnetic induction normal to plane of semi-circle is equal to $B\cos\omega t$
Flux linked with semiconductor part is
$\phi_1 = \frac{1}{2}\pi a^2 B\cos\omega t$
Let area of rectangular part of the circuit be A
∴ Flux linked with this part is
$\phi_2 = BA$
∴ Total flux linked with the circuit is
$\phi = \frac{1}{2}\pi a^2 B\cos(\omega t) + BA$
∴ Induced emf in the circuit,
$e = -\frac{d\phi}{dt} = \frac{1}{2}\pi\omega a^2 B\sin(\omega t)$
Since resistance of the circuit is negligible, therefore, potential difference across the capacitor is equal to induced emf in the circuit
∴ Change on the capacitor at time t is $q = Ce$
$= \frac{1}{2}\pi\omega a^2 \mathrm{CB}\sin(\omega t)$
But current $I = \frac{dq}{dt} = \frac{1}{2}\pi\omega^2 a^2 \mathrm{CB}\cos(\omega t)$

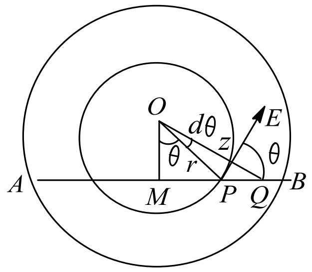
48 **(b)**


We connect a conducting wire from A to C and complete the semiconductor loop. The emf in the semiconductor loop is zero because its magnitude flux does not change
∴ emf of section APC + emf of section $CQA = 0$
∴ emf of section APC = emf of section $AQC = 2BR^2\omega$

49 **(b)**
Effective resistance is 4 Ω
$I = \frac{E}{R} = \frac{B\ell v}{R}$ or $v = \frac{IR}{B\ell}$
or $v = \frac{1\times10^{-3}\times4}{2\times10\times10^{-2}}$ $\mathrm{ms^{-1}}$
or $\mathrm{v} = 0.02\ \mathrm{ms^{-1}} = 2\ \mathrm{cm\ s^{-1}}$

50 **(c)**
Because A and C are at equal distance from B, and their flux across B is in opposite direction, so at any time flux in B will be zero. Hence no emf is induced

51 **(b)**
$e = E - i\,R$
Clearly, the graph is a straight line with negative slope

52 **(a)**
Consider a point on the circumference of a circle of radius$r (r < R)$. Let E be the electric filed along the tangents to the circle. Then E is given by
$E = \frac{r}{2}\frac{dB}{dt}$


Now consider a point P in the rod and a small distance $d\ell = PQ$ along AB
$\varepsilon = \int \vec{E}\cdot\vec{d\ell} = \int \frac{r}{2}\frac{dB}{dt}\,d\ell\cos\theta$
$= \frac{(OM)}{2}\frac{dB}{dt}\int d\ell = \frac{\sqrt{R^2-\ell^2}}{2}\frac{dB}{dt}\,2\ell$
$\Rightarrow \varepsilon = \sqrt{R^2-\ell^2}\left(\frac{dB}{dt}\right)\ell \quad \left[\therefore \int d\ell = 2\ell\right]$

53 **(b)**
Equivalent inductance
$L_{eq} = L + 2L = 3L, C_{eq} = C + 2C = 3C$
∴ Frequency of oscillation
$f = \frac{1}{2\pi\sqrt{L_{\mathrm{eq}}C_{\mathrm{eq}}}} = \frac{1}{6\pi\sqrt{LC}}$

54 **(b)**
$E(2\pi r) = \pi a^2\frac{dB}{dt}$ for $r \geq a$
$\Rightarrow E = \frac{a^2}{2r}\frac{dB}{dt} \Rightarrow E \propto \frac{1}{r}$

55 **(a)**
$L = \frac{\mu_0 N^2 \pi r^2}{\ell}$
Length of wire $= N\,2\pi r$ =Constant (= C, suppose)
$\therefore L = \mu_0\left(\frac{C}{2\pi r}\right)^2\frac{\pi r^2}{\ell}$
$\therefore L \propto \frac{1}{\ell}$
∴ Self-inductance will become $2L$

56 **(b)**
$I_{t=\infty} = I_0$
$I_{t=1\mathrm{s}} = I_0\left(1 - e^{-\frac{10}{5}\times1}\right)$

$$= I_0(1-e^{-2}) = I_0\left(1-\frac{1}{e^2}\right)$$

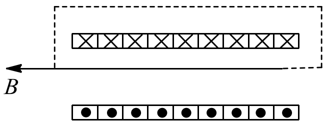
$$\therefore = \frac{I_{t=\infty}}{I_{t=1s}} = \frac{I_0 e^2}{I_0(e^2-1)} = \frac{e^2}{e^2-1}$$

57 **(a)**

$$\oint \vec{B}\cdot d\vec{\ell} = \mu_0 I \Rightarrow B2b = \mu_0 I$$

$$\Rightarrow B = \frac{\mu_0 I}{2b} \rightarrow due\ to\ one\ tape$$

Net field $= 2\,B$



Magnetic flux passing through this double tape

$$\phi = 2BA = 2B\,(\ell\, h) \Rightarrow \ \phi = \frac{\mu_0 I}{b}\ell h$$

$$L = \frac{\phi}{I} = \frac{\mu_0 \ell h}{b} \ \Rightarrow \frac{L}{\ell} = \frac{\mu_0 h}{b}$$

58 **(d)**

Cross ⊗ magnetic field passing from the closed loop is increasing. Therefore, from Lenz's law induced current will produce dot ⊙ magnetic field. Hence, induced current is anticlockwise.

59 **(d)**

$$E = \frac{Mdi}{dt} = Ma, i = \frac{Ma}{R}(1-e^{-tR/L})$$

60 **(a)**

Force on the wire $= i\ell B$,

$$\therefore \text{Acceleration} = \frac{i\ell B}{m}$$

$$\therefore \text{Velocity} = \frac{i\ell Bt}{m}$$

61 **(c)**

In uniform magnetic field, change in magnetic flux is zero. Therefore, induced current will be zero.

62 **(b)**

$\phi_2 = N_2 B_1 A$ or $\phi_2 = N_2 \frac{\mu_0 N_1 I_1}{L}$ A

or $\phi_2 = \frac{\mu_0 N_1 N_2 A}{L} I_1$

comparing with $\phi_2 = MI_1$, we get $M_2 = \frac{\mu_0 N_1 N_2 A}{L}$

63 **(b)**

$I = \frac{I_0}{\alpha}$ at $t = t_0$

Since $I = I_0 e^{-t_0/\tau} \Rightarrow \frac{1}{\alpha} = e^{-t_0/\tau}$

$\alpha = e^{-t_0/\tau} \Rightarrow t_0 = \tau \log_e \alpha$

$$\tau = \frac{t_0}{\log_e \alpha}$$

64 **(a)**

From Lenz's law if one rod is moved away from the second rod then the second rod will be attracted towards the first rod so as to oppose the change in flux

65 **(a)**

Given, $L_1 = 1$ mH, $L_2 = 2$ mH, $R_1 = 1\Omega, R_2 = 2\Omega$

In the first circuit,

$L = L_1 + L_2$ and $R = R_1 + R_2$

$$\tau_1 = \frac{L}{R} = \frac{3\text{mH}}{3\Omega} = 1 \text{ ms}$$

In the second circuit,

$$L = \frac{L_1 L_2}{L_1 + L_2} = \frac{2\times10^{-6}}{3\times10^{-3}} = \frac{2}{3}\times10^{-3}$$

$$R = \frac{R_1 R_2}{R_1 + R_2} = \frac{2}{3}\ \Omega$$

$$\tau_2 = \frac{\frac{2}{3}\times10^{-3}}{2/3} = 1 \text{ ms}$$

In the third circuit,

$L = L_1 + L_2 = 3$ mH

$$R = \frac{R_1 R_2}{R_1 + R_2} = \frac{2}{3}\ \Omega$$

$$\tau_3 = \frac{L}{R} = \frac{3\times10^{-3}}{2/3} = \frac{9}{2}\text{ ms}$$

66 **(a)**

When the switch is closed, the current flows through the coil which sets up a magnetic flux ϕ through the ring. The motion of the ring will be such that, by Lenz's law, it opposes the sudden increase in flux linkage. Hence, the ring moves away from the coil towards E (east)

67 **(c)**

Let i_1 be the current in the circuit before shifting

$i_1 = \frac{E}{R}$ ...(i)

Since the flux associated with the inductors will be same just before and just after shifting, therefore

$i_1\,5L = i_2\,9L$

$$i_2 = \frac{5}{9}\frac{E}{R}$$

68 **(a)**

Here $A = 10\times5 = 50\text{ cm}^2 = 50\times10^{-4}\text{m}^2$

$$E = \frac{d\phi}{dt} = A\frac{dB}{dt} = 50\times10^{-4}\times0.02 = 10^{-4}\text{ V}$$

Power dissipated in the form of heat

$$= \frac{E^2}{R} = \frac{10^{-4}\times10^{-4}}{2} = 0.5\times10^{-8}\text{W}$$

$= 5\times10^{-9}\text{W} = 5$ nW

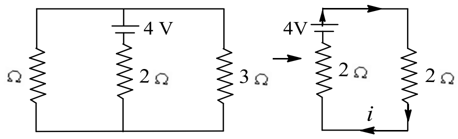
69 **(c)**

Motional emf

$e = Bv\ell$

$e = (2)(2)(1) = 4\,V$

This acts as a cell of emf $E = 4$ V and internal resistance $r = 2\ \Omega$. The simple circuit can be drawn as follows :



∴ Current through the connector

$i = \frac{4}{2+2} = 1\,A$

Magnetic force on connector

$F_m = i\ell B = (1)(1)(2) = 2\text{N}$ (towards left)

Therefore,, to keep the connector moving with a constant velocity, a force of 2 N will have to be applied towards right

70 **(a)**

$ma_0 = eE \Rightarrow E = \frac{ma_0}{e}$

71 **(c)**

ω_r =constant

$\Rightarrow LC$ = constant

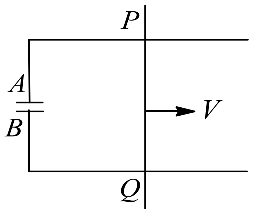
$\Rightarrow L\,dC + CdL = 0 \Rightarrow \frac{dL}{L} = -\frac{dC}{C} = -1\%$

72 **(a)**

$q = CV = C(Bv\ell)$

$= (10 \times 10^{-6})(4)(2)(1)$

$= 80\ \mu\text{C}$ =constant



Magnetic force on the electron in the conducting rod PQ is towards$Q$. Therefore, A is positively changed and B is negatively charged

73 **(a)**

The current is given by

$i = i_0\left(1 - e^{-\frac{1}{\tau}}\right) \Rightarrow \frac{di}{dt} = \frac{i_0}{\tau}e^{-t/\tau}$

Energy stored in the form of magnetic field energy is

$U_B = \frac{1}{2}Li^2$

∴ Rate of increase of magnetic field energy is

$R = \frac{dU_B}{dt} = Li\frac{di}{dt} = \frac{Li_0^2}{\tau}\left(1 - e^{-t/\tau}\right)e^{-t/\tau}$

This will be maximum when $\frac{dR}{dt} = 0$

$\Rightarrow e^{-t/\tau} = 1/2$

Substituting,

$R_{\max} = \frac{Li_0^2}{\tau} = \frac{Li_0^2}{\tau}\left(1 - \frac{1}{2}\right)\left(\frac{1}{2}\right)$

$= \frac{Li_0^2}{4\tau} = \left[\frac{L(E/R)^2}{4(L/R)}\right] = \frac{E^2}{4R}$

74 **(b)**

$E_i - ir_1 = 0 \Rightarrow i = \frac{E_1}{r_1} = \frac{3}{1} = 3\,\Omega$

$i = \frac{10}{3R+2}, \frac{10}{3R+2} = 3, R = \frac{4}{9}\Omega$

75 **(a)**

When energy on both is same, means energy on capacitor is half of its maximum energy

$\frac{q^2}{2C} = \frac{1}{2}\frac{Q^2}{2C} \Rightarrow q = \frac{Q}{\sqrt{2}}$

$\Rightarrow Q\cos\omega t = \frac{Q}{\sqrt{2}} \Rightarrow \cos\omega t = \frac{1}{\sqrt{2}}$

$\Rightarrow \omega t = \frac{\pi}{4} \Rightarrow t = \frac{\pi}{4\omega} = \frac{\pi}{4}\sqrt{LC}$

76 **(a)**

Induced emf$\int_a^b BV\,dx = \int_a^b \frac{\mu_0 I}{2\pi x}\,BVdx$

$\Rightarrow$ Induced e.m.f $= \frac{\mu_0 IV}{2\pi}\text{In}\left(\frac{b}{a}\right)$

$\Rightarrow$ Power dissipated $= \frac{E^2}{R}$

Also, power= $FV \Rightarrow F = \frac{E^2}{VR}$

$\Rightarrow F = \frac{1}{VR}\left[\frac{\mu_0 IV}{2\pi}In\left(\frac{b}{a}\right)\right]^2$

77 **(b)**

ϕ (flux linked) $= a^2B\cos 0° - b^2B\cos 180°$

$= (a^2 - b^2)B$

$E = -\frac{d\phi}{dt} = -(a^2 - b^2)\frac{dB}{dt}$

where $B = B_0, \sin\omega t, B_0 = 10^{-3}T, \omega = 100$

$\therefore I_{\max} = (a^2 - b^2)\frac{B_0\omega}{R}$

and $R = (4a + 4b)r = 4(a+b)r$

$\therefore I_{\max} = \frac{(a-b)B_0\omega}{4r} = \frac{(1-0.4)\times 10^{-3}\times 100}{4\times 5\times 10^{-3}}$

$= 3\text{ A}$

78 **(d)**

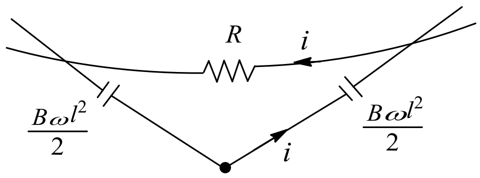
Magnetic flux in ⊗ direction through the coil is increasing. Therefore, induced current will produce magnetic filed in ⊙ direction. Thus, the current in the loop is anticlockwise. Magnetic of induced current at any instant of time is

$i = \frac{e}{R} = \frac{Bv(FG)}{\rho(FG + GD + DF)}$

When the wire AH moves downwards FG, GD and DF all increase in the same ratio. Therefore, i is constant

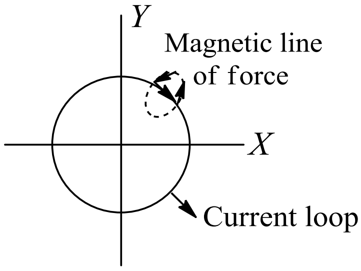
79 **(b)**

$i = \frac{\frac{B\omega\ell^2}{2} + \frac{B\omega\ell^2}{2}}{R} = \frac{B\omega\ell^2}{R}$



80 **(d)**

The magnetic lines of force created due to current will be in such a way that on $x - y$ plane these lines will be perpendicular. Further, these lines will be in circular loops. The number of lines moving downward in $x - y$ plane will be same in number to that coming upward of the $x - y$ plane. Therefore, the net flux will be zero. One such magnetic line is shown in figure



∴ (d) is the correct option

81 **(d)**

∴ Energy spent $= \frac{1}{2}LI^2$

82 **(a)**

At $t = 0$, the branch containing L will offer infinite resistance while that the branch containing the capacitor will be effectively a short circuit. Hence, $(i)_{t=0} = \frac{\varepsilon}{R}$. Similarly at $t = \infty$, L will offer zero resistance whereas C will be an open circuit.

Hence effective resistance $= R + \frac{6\times3R}{6+3} =$

$3R$ $(i)_{t=\infty} = \frac{\varepsilon}{3R}$

The required ratio $= \frac{\varepsilon}{R} \times \frac{3R}{\varepsilon} = 3:1$

83 **(b)**

Let I_1 is the length of wire, then

$$I_1 = 2\pi rN \Rightarrow Nr = \frac{I_1}{2\pi} \Rightarrow L = \frac{\mu_0\pi}{l}\frac{l_1^2}{4\pi^2}$$

$$\Rightarrow l_1 = \sqrt{\frac{Ll\,4\pi}{\mu_0}} = \sqrt{\frac{10^{-3}\times1\times4\pi}{4\pi\times10^{-7}}} = 10^2 \text{ m}$$

$$= 0.10 \text{ km}$$

84 **(b)**

$$|e| = B\frac{dA}{dt}$$

$$|e| = B\left(\frac{A_2 - A_1}{t_2 - t_1}\right)$$

$$|e| = \frac{1\left(\frac{\pi}{4} - 0\right)}{(1-0)}$$

$$e = \frac{\pi}{4} \text{ V}$$

85 **(b)**

The current is short circuited through inductor. In steady state, current will pass through inductor instead of 20 Ω

Then current through 30 Ω is:

$$I = \frac{3}{30} = 0.1 \text{ A}$$

86 **(b)**

The power dissipated in the resistor,

$$P = \frac{dW}{dt} = I^2 R$$

Since the current through resistor varies with time, we must integrate

The total energy produced as heat in the resistor

$$W = \int_0^\infty I^2R\ dt$$

The current in an RL circuit is $I = I_0e^{-(R/L)t}$

$$W = \int_0^\infty I_0^2\, e^{-(2R/L)t}R\ dt = \frac{I_0^2}{-2R/L}\left[e^{-\frac{2R}{L}t}\right]_0^\infty$$

$$= \frac{1}{2}LI_0^2$$

We can integrate by substituting

Note that the total heat produced equals the energy $(1/2)\ LI_0^2$ originally stored in the conductor

87 **(a)**

Component of weight along the inclined plane $= mg\sin\theta$

Again, $F = BI\ell = B\frac{B\ell v}{R}\ \ell = \frac{B^2\ell^2v}{R}$

Now, $\frac{B^2\ell^2v}{R} = mg\sin\theta$ or $v = \frac{mg\ R\sin\theta}{B^2\ell^2}$

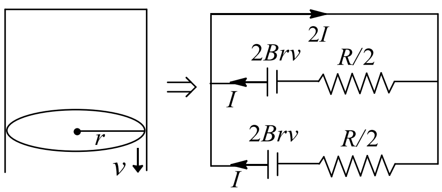
88 **(d)**

$E = L\frac{dI}{dt}$ or $dI = \frac{E}{L}\ dt$

or $I = \frac{2}{4}t = 0.5\ t \Rightarrow t = 2I = 2\times5 = 10\text{s}$

89 **(d)**

$$I = \frac{2Brv}{R/2} = \frac{4Brv}{R}$$



Current in the top horizontal $= 2I = \frac{8Brv}{R}$

90 **(b)**

Emf induced across the rod AB is

$e = \vec{B}.(\vec{\ell}\times\vec{v})$

$= B\ell v\sin\theta$

$= 2\times2\times2\times\sin 30$

$e = 4\text{ V}$

Free electrons of the rod shift towards right due to force $q(\vec{v} \times \vec{B})$
Thus, end P is at higher potential
or $V_p - V_Q = 4$ V. thus, choice (b) is correct

91 **(d)**
Let current i flows in the bigger ring, then the magnetic field on its axis

$$B = \frac{\mu_0 i R^2}{2(R^2+x^2)^{3/2}}$$

Flux linked with the smaller ring: $\phi = B\pi r^2$

$$\phi = \frac{\mu_0 i R^2}{2(R^2+x^2)^{3/2}}\pi r^2 = M\,i$$

$$\therefore M = \frac{\mu_0 \pi R^2 r^2}{2(R^2+x^2)^{3/2}}$$

92 **(c)**

$$\phi_A = \frac{\mu_0 i\pi R^2}{2\pi(R^2+x^2)^{3/2}}\pi r^2$$

$$\Rightarrow E_A = -\frac{d\phi}{dt}$$

$$= \frac{-\mu_0 i\pi}{2}R^2r^2(-3/2)(R^2+x^2)^{-5/2}2x$$

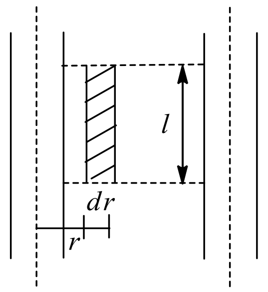
E_A is maximum when $\frac{dE_A}{dx} = 0$

$$\Rightarrow \frac{d}{dx}\frac{x}{(R^2+x^2)^{5/2}} = 0$$

or $(R^2+x^2)^{5/2} - \frac{5x}{2}(R^2+x^2)^{3/2}2x = 0$
or $R^2 + x^2 - 5x^2 = 0$
or $x = \frac{R}{2}$

93 **(b)**
Since the wires are infinite, so the system of these two wires can be considered as a closed rectangle of infinite length and breadth equal to d. Flux through the strip:

$$\phi = \int_a^{d-a}\frac{\mu_0 I}{2\pi r}(ldr) = \frac{\mu_0 Il}{2\pi}\text{ In}\left(\frac{d-a}{a}\right)$$



The other wires produces the same result, so the total flux through the dotted rectangle is

$$\phi_{\text{total}} = \frac{\mu_0 Il}{\pi}\text{ In}\left(\frac{d-a}{a}\right)$$

The total inductance of length l

$$L = \frac{\phi_{\text{total}}}{I} = \frac{\mu_0 l}{\pi}\text{ In}\left(\frac{d-a}{a}\right)$$

Inductance per unit length $= \frac{L}{l} = \frac{\mu_0}{\pi}\text{ In}\left(\frac{d-a}{a}\right)$

94 **(b)**
Magnetic field at the centre of a large coil $E \propto \frac{\mu_0 I}{2R}$.
Magnetic flux linked with smaller coil $= \frac{\mu_0 I}{2R} \times \pi r^2$

$$M = \frac{\phi}{I} = \frac{\mu_0\pi r^2}{2R}$$

$$\therefore M \propto \frac{r^2}{R}$$

95 **(c)**

$$BI\ell = mg\text{or } B\frac{Bv\ell}{R}\ell = mg\text{or } v = \frac{mgR}{B^2\ell}$$

96 **(d)**
The magnetic field at the centre of the coil is $B(t) = \mu_0 n I_1$. As the current increases, B will also increase with time till it reaches a maximum value (when the current becomes steady). The induced emf in the ring

$$e = \frac{d\phi}{dt} = \frac{d}{dt}(\vec{B}\cdot\vec{A})$$

$$= A\frac{d}{dt}(\mu_0 n I_1)$$

$\therefore$ The induced current in the ring

$$I_2(t) = \frac{|e|}{R} = \frac{\mu_0 nA}{R}\frac{dI_1}{dt}$$

$$I_2 B \propto I_1\frac{dI_1}{dt}$$

$$\Rightarrow\ I_2B = K\,I_0[1-e^{-t/\tau}]\left(\frac{I_0}{\tau}\,e^{-t/\tau}\right)$$

$$= \frac{KI_0^2}{\tau}\,[e^{-t/\tau}][1-e^{-t/\tau}]$$

At $t = 0$ and $t = \infty, I_2B = 0$

97 **(d)**
Given that $\phi = at\,(T-t)$
Induced emf, $E = \frac{d\phi}{dt} = \frac{d}{dt}\,[at\,(T-t)]$
$= at(0-1) + a(T-t)$
$= a(T-2t)$
So, induced emf is also a function of time
$\therefore$ Heat generated in time T is

$$H = \int_0^T\frac{E^2}{R}dt = \frac{a^2}{R}\int_0^T(T-2t)^2\,dt = \frac{a^2T^3}{3R}$$

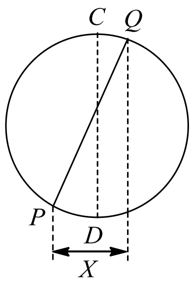
98 **(b)**
In the $r - t$ graph, it is clear that from a to b there is no change in radius and hence no change in area and magnetic flux. Same is the situations from c to d
Now, $|e| = \frac{d}{dt}(\phi)$

$$|e| = B\frac{d}{dt}(\pi r^2) = B\pi 2r\frac{dr}{dt}$$

Since $r \propto t, \therefore \frac{dr}{dt} =$ constant
$\therefore |e| \propto r$

99 **(b)**

When the ring falls vertically, there will be an induced emf across A and $B(e = Bv(2r))$
Note that there will be a potential difference across any two points on the ring, and the line joining these has a projected length in the horizontal plane. For example, between points P and Q there is a projected length x in the horizontal plane



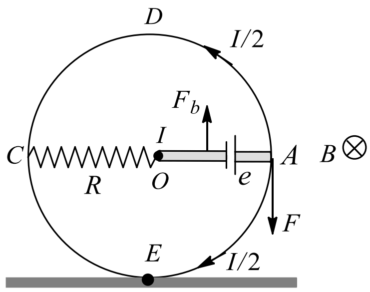
$\therefore$P.D.across P and Q is
$V = B\,vx$
But for points C and $D, x = 0$
Therefore, P.D.=0
Hence (b)

100 **(d)**
Coefficient of mutual inductance M is given by
$$|M| = \frac{e_1}{(di_2/dt)} = \frac{\phi_2}{i_1}$$
$$\therefore\ \phi_2 = \frac{e_1 i_1}{(di_2/dt)} = \frac{(25.0 \times 10^{-3})(3.6)}{(15)}$$
$= 6 \times 10^{-3} = 6$ mWb

101 **(a)**
The current in L for steady state $= \frac{E}{R_1}$
$\therefore$ Energy stored in $L = \frac{1}{2} L I_0^2 = \frac{1}{2} L \frac{E^2}{R_1^2}$

102 **(c)**
$\vec{F}_m \perp \vec{v}$
$\therefore\ \theta = 90° + 30° = 120°$

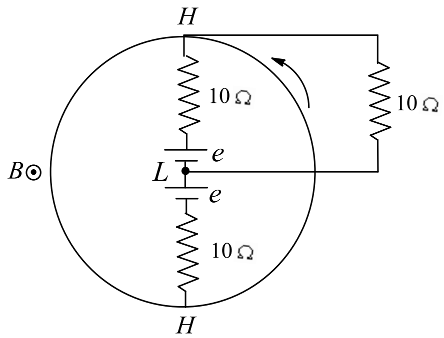
103 **(d)**
Induced emf in the spoke is shown in figure below



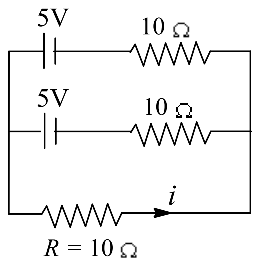
$$e = \frac{1}{2} B\omega r^2, I = \frac{e}{R} = \frac{B\omega r^2}{2R}$$
There will be no induced emf separately in parts ADC or AEC
$$F_b = IrB = \frac{B^2 \omega r^3}{2R}$$
Balancing torque about E : $Fr = F_b\, r/2 \Rightarrow\ F = \frac{F_b}{2} = \frac{B^2 \omega r^3}{4R}$
Note: Force due to currents $I/2$ will act on circular parts also, but their torque about E will be zero

104 **(b)**
Let there be an element dx of rod at a distance x from the wire
Emf developed in the element, $dE = B\,dx\,v$
$$\therefore\ dE = \left(\frac{\mu_0}{4\pi}\frac{2I}{x}\right) dxv$$
$$\therefore\ \ E = \frac{\mu_0 I v}{2\pi}\int_a^b \frac{dx}{x} = \frac{\mu_0 I v}{2\pi}\log_e \frac{b}{a}$$
$$\therefore\ E = \frac{4\pi \times 10^{-7} \times 100 \times 5}{2\pi}\log_e \frac{100}{1}$$
$= 4.6 \times 10^{-4}\text{V} = 0.46$ mV

105 **(e)**
Emf induced between centre of the ring and the rim is
$$e = \frac{1}{2} B\omega R^2 = \frac{1}{2}(50)(20)(0.1)^2 = 5\ V$$



Now the circuit can be drawn as follows:



$$\therefore i = \frac{5}{10+5} = \frac{1}{3}\text{A}$$

106 **(b)**
Apply Lenz's law

107 **(c)**
$M = \frac{\mu_0 N_1 N_2 A}{\ell} = a$, here $\ell = 1$ m
$= 503 \times 10^{-6}$ H

108 **(a)**
For $t < t_0, E = L\frac{di}{dt} \Rightarrow i = \frac{E}{L} t$
For $t > t_0, L\frac{di}{dt} = 0 \Rightarrow i =$ constant

109 **(d)**
At $t = 0$, for the purpose of current calculation in circuit, inductor can be assumed as open and

capacitor as short circuited

110 **(b)**

In steady state: $P = I^2R$

Energy in inductor $= \frac{1}{2}LI^2$

After connecting x and z, the whole energy of inductor with go into heat so heat produced:

$H = \frac{1}{2}LI^2 = \frac{1}{2}L\frac{P}{R} = \frac{1}{2}P\tau$

111 **(c)**

$$L = \frac{\mu_0 N^2 A}{\ell}$$

If x is the length of the solenoid with r as radius, then

$x = 2\pi r N, A = \pi r^2$

$$\therefore L = \mu_0\left(\frac{x^2}{4\pi^2 r^2}\right)\frac{\pi r^2}{\ell} \quad \left[\therefore N = \frac{x}{2\pi r}\right]$$

$$\therefore x = \sqrt{\frac{4\pi L\ell}{\mu_0}}$$

112 **(b)**

Let current i_1 in the straight wire be upward. Then the magnetic field due to the straight wire has magnitude $B_1 = \mu_0 i_1/2\pi r$ at a distance r. In accordance with right hand rule, B_1 points inward to the plane of page. We consider a differential strip of thickness dr, area $dA_2 = a\,dr$. Magnetic flux through area dA, $d\phi_B = B_1\,(a\,dr)$

Total flux through the loop,

$$\phi_B = \int B_1\, a\, dr = \int_c^{c+b} \frac{\mu_0 i_1}{2\pi r}\, a\, dr$$

$$= \frac{\mu_0 i_1 a}{2\pi}\int_c^{c+b}\frac{dr}{r} = \frac{\mu_0 i_1 a}{2\pi}\ \text{In}\left(\frac{c+b}{c}\right)$$

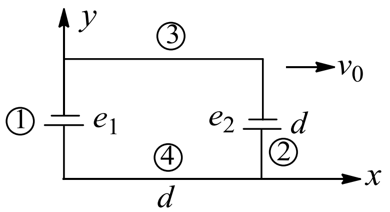
Therefore mutual inductance,

$$M = \frac{\phi}{i_1} = \frac{\mu_0 a}{2\pi}\ \text{In}\left(1 + \frac{b}{c}\right)$$

113 **(a)**

Magnetic field at side (1): $B_1 = B_0$

Induced emf in (1): $e_1 = B_0 v_0 d e$



Magnetic field at side (2): $B_2 = B_0\left[1 + \frac{d}{a}\right]$

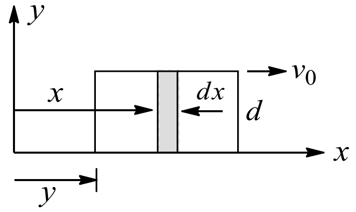
Induced emf in (2): $e_2 = B_0\left(1 + \frac{d}{a}\right)v_0 d$

Induced emf in 3 and 4 will be zero

Net emf: $e = e_2 - e_1 = \frac{B_0 v_0 d^2}{a}$

Alternate method:

Let at any instant, the loop is at a distance y as shown below. Let us take anticlockwise direction to be positive



Flux through a strip of width dx: $d\phi = B_0\left[1 + \frac{x}{a}\right](d)(dx)$

Net flux : $\phi = B_0 d\int_y^{y+d}\left(1 + \frac{x}{a}\right)dx \Rightarrow \phi = B_0 d\left[x + \frac{x^2}{2x}\right]_y^{y/d}$

$$\Rightarrow \phi = B_0 d\left[d + \frac{1}{2a}[(y+d)^2 - y^2]\right]$$

$$\Rightarrow \phi = B_0 d\left[d + \frac{1}{2a}d(2y + d)\right]$$

$$e = -\frac{d\phi}{dt} = -B_0 d\left[\frac{1}{2a}d\frac{2dy}{dt}\right]$$

$$\Rightarrow e = -\frac{B_0 d^2}{a}\frac{dy}{dt} = -\frac{B_0 d^2}{a}v_0$$

Negative sing indicates that emf induced is clockwise

114 **(a)**

$|\vec{E}|$ =Magnitude of induced emf

$= \frac{B\ell^2}{2}\omega, \ell = \sqrt{2}r \quad$ (i)

115 **(d)**

Magnetic force $F = IlB$ acts upwards and weight acts downwards

$a = \frac{mg - F}{m}$, depends upon mg and F

116 **(b)**

A motional emf, $e = B\ell v$, is induced in the rod. Or we can say a potential difference is induced between the two ends of the rod. Due to this potential difference, there is an electric filed in the rod

117 **(a)**

At $t = 0$, i.e., when the key is just pressed, no current exists inside the inductor. So 10 Ω and 20 Ω resistors are in series and a net resistance of $(10 + 20) = 30\Omega$ exists across the circuit

Hence, $I_1 = \frac{2}{30} = \frac{1}{15}$A

As $t \to \infty$, the current in the inductor grows to attain a maximum value, i.e., the entire current passes through the inductor and no current passes through 10 Ω resistor

Hence, $I_2 = \frac{2}{20} = \frac{1}{20}$A

118 **(a)**

Speed of the loop should be
$v = \frac{\ell}{t} = \frac{0.5}{2} = 0.25\text{m/s}$
Induced emf, $e = Bv\ell = (1.0)(0.25)(0.5) = 0.125$ V
$\therefore$ Current in the loop, $i = \frac{e}{R} = \frac{0.125}{10}$
The magnetic force on the left arm due to the magnetic field is
$F_m = i\ell B = (1.25 \times 10^{-2})(0.5)(1.0)$
$= 6.25 \times 10^{-3}\text{N}$
To pull the loop uniformly an external force of 6.25×10^{-3} N towards right must be applied
$\therefore W = (6.25 \times 10^{-3}\text{ N})(0.5\text{ m}) = 3.125 \times 10^{-3}$ J

119 **(a)**
Induced electric filed at point P:
$E = \frac{R}{2}\frac{dB}{dt}$ towards right
Acceleration of electron: $a = \frac{eE}{m} = \frac{eR}{2m}\frac{dB}{dt}$ towards left

120 **(b)**
Required emf
$$f = \left(\pi R^2 \frac{dB}{dt}\right)\frac{\theta}{2\pi} = \frac{R^2\theta}{2}\left(\frac{dB}{dt}\right)$$

121 **(a)**
Let $I =$ current in one loop. The magnetic field at the centre of the other co-axial loop at a distance ℓ from the centre of the first loop is
$$B = \frac{\mu_0}{4\pi}\frac{2I\,\pi a^2}{(a^2+\ell^2)^{3/2}}$$
where $p_m = I\,\pi a^2$
= magnetic moment of the loop
Flux through the other loop is
$\phi_{12} = B\,\pi a^2$
$$= \frac{\mu_0}{4\pi}\frac{2\,\pi a^2\,I}{(a^2+\ell^2)^{3/2}}\pi a^2$$
or $M = \frac{\phi_{12}}{I} = \frac{\mu_0}{4\pi}\frac{2\,\pi^2 a^4}{(a^2+\ell^2)^{3/2}}$
$$= \frac{\mu_0\,\pi a^4}{2(a^2+\ell^2)^{3/2}} = \frac{\mu_0 \pi a^4}{2\ell^3}(a << I)$$

122 **(d)**
We have
$I = I_0(I - e^{-t/\tau})$
But $I_0 = \frac{V}{R}$ and $\tau = \frac{L}{R}$
$$\therefore\ I = \frac{V}{R}\left(1 - e^{-Rt/L}\right) = \frac{12}{6}[1 - e^{-6t/8.4\times10^{-3}}]$$
$= 1$ (given)
$\therefore\ t = 0.97 \times 10^{-3}\text{ s} = 1\text{ ms}$

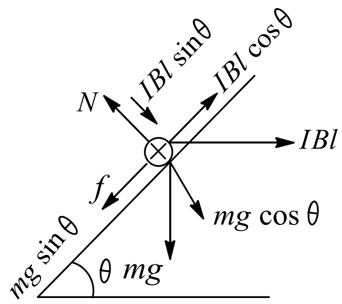
123 **(a)**
$$I = \frac{B\ell v}{R}$$
$$I = \frac{5 \times 10^{-2} \times 0.3 \times 0.2}{5}\text{ A} = 0.6\text{ mA}$$
Area and flux are decreasing. So, current flows to increase the flux. Clearly, current should be clockwise. So, it flows from B to C through 5Ω

124 **(c)**
The mutual inductance M remains the same whether X or Y is used as the primary

125 **(a)**
When current flows in any of the coils, the flux linked with the other coil will be maximum in the first case. Therefore, mutual inductance will be maximum in case(a)

126 **(c)**
Constancy of flux Implies that $\frac{E}{R}L_1 = i(L_1 + L_2)$
i.e., $i = \frac{E\,L_1}{R(L_1+L_2)}$

127 **(d)**
The front view of the arrangement is shown in figure



From initial condition, $mg\sin\theta = \mu\,mg\cos\theta$
$\Rightarrow\ \mu = \tan\theta$
$ma = IB\ell\cos\theta - mg\sin\theta - \mu N$
$N = mg\cos\theta + IB\ell\sin\theta$
$$\Rightarrow a = \frac{IB\ell}{m}\cos\theta - 2g\sin\theta - \frac{IB\ell}{m}\frac{\sin^2\theta}{\cos\theta}$$
$$= \frac{IB\ell}{m}\frac{\cos 2\theta}{\cos\theta} - 2g\sin\theta$$
Now, $s = \frac{1}{2}at^2 = \frac{1}{2}\left[\frac{IB\ell}{m}\frac{\cos 2\theta}{\cos\theta} - 2g\sin\theta\right]t^2$

128 **(c)**
Magnetic field due to larger loop
$$= \frac{\mu_0 1}{2r} = \frac{4\pi \times 10^{-7} \times 1}{2 \times 0.1}\text{T} = 2\pi \times 10^{-6}\text{T}$$
Now, magnetic flux linked with the smaller loop, ϕ,
$= NBA\cos\omega t = 1 \times 2\pi \times 10^{-6} \times 5 \times 10^{-4}\cos\omega t$
$= \pi \times 10^{-9}\cos\omega t$ weber

129 **(d)**
$V = RI + L\frac{dI}{dt}$, at $t = 0, I = 0$, thus we have
$$\frac{dI}{dt} = \frac{V}{L} = \frac{1.6}{0.2} = 8\text{ A/s}$$

130 **(d)**

Electric field will be developed in the sides which are perpendicular to velocity

131 **(d)**

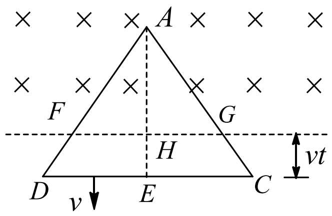
Induced emf depends upon vertical edge

132 **(b)**

Charge flown$=\frac{\text{change in flux}}{\text{Resistance}}=\frac{BA-0}{R}=\frac{BA}{R}$

133 **(b)**

Let $2a$ be the side of the triangle and b be the length AE



$\frac{AH}{AE}=\frac{GH}{EC}\Rightarrow GH=\left(\frac{AH}{AE}\right)EC$

or $GH=\frac{(b-vt)}{b}.a=a-\left(\frac{a}{b}vt\right)$

$\therefore FG=2GH=2\left[a-\frac{a}{b}vt\right]$

$\therefore$ Induced emf, $e=Bv(FG)=2Bv\left(a-\frac{a}{b}vt\right)$

$\therefore$ Induced current, $i=\frac{e}{R}=\frac{2Bv}{R}\left[a-\frac{a}{b}vt\right]$

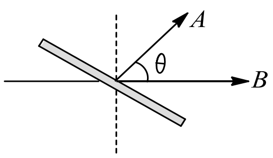
or $i=k_1-k_2t$

Thus $i-t$ graph is a straight line with negative slope and positive intercept

134 **(c)**

Let θ is the angle between area vector of coil and magnetic field. Then flux through coil:

$\phi=BA\cos\theta$



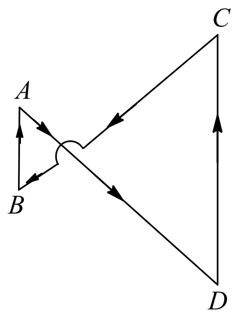
Induced emf: $e=-\frac{d\phi}{dt}=BA\sin\theta\left(\frac{d\theta}{dt}\right)$

$\Rightarrow\ e=BA\omega\sin\theta$

e is minimum, when $\theta=0°$, or when plane of coil is at right angle to magnetic field

135 **(a)**

Magnetic filed in ⊗ direction is increasing. Therefore, induced current will produce magnetic field in ⊙ direction. Thus, current in both the loops should be anticlockwise. But as the area of the loop on the right side is more, induced emf in this side will be more compared to the left side loop. Therefore, net current in the complete loop will be in a direction shown below:



136 **(d)**

$E2\pi\ell=\pi R^2\left(\frac{dB}{dt}\right);E=\frac{R^2}{2\ell}\left(\frac{dB}{dt}\right)$

$qE+mg=Kx$

$\Rightarrow x=\frac{qR^2}{K2\ell}\left(\frac{dB}{dt}\right)+\frac{mg}{K};\ \ x=\frac{1}{K}\left[mg+\frac{qR^2}{2\ell}\frac{dB}{dt}\right]$

137 **(c)**

No induced emf is set up as the magnetic field line of earth is not cut by the falling conductor

138 **(c)**

The change in magnetic flux is zero, hence the current in the ring will be zero

139 **(c)**

Induced e.m.f $e=L\frac{dI}{dt}=A\frac{dB}{dt}$

$\Rightarrow\int_0^1 dI=\int_0^B\frac{A}{L}dB\ \Rightarrow I=\frac{A}{L}B$

$\Rightarrow I_{\max}=\frac{A}{L}B_{\max}=\frac{10^{-2}}{10\times10^{-3}}\times0.1=0.1\text{ A}$

$=100\text{ mA}$

140 **(a)**

Consider the force on an electron in PQ. This electron experience a force towards Q. Free electrons in PQ tend to move towards N. So M will be positively charged

141 **(d)**

Potential difference across capacitor

$V=Bv\ell=$ constant

Therefore, change stored in the capacitor is also constant. Thus, current through the capacitor is zero

142 **(d)**

Induced electric field (in clockwise sense):

$E=\frac{a^2}{2R}\frac{dB}{dt}$

$I\omega=\int\tau\,dt$

$\Rightarrow mR^2\omega=\int qER\,dt\int\frac{qa^2}{2R}\frac{dB}{dt}\,R\,dt$

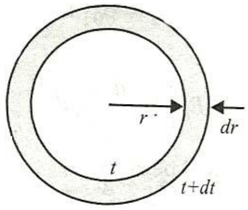
$=\frac{\lambda2\pi R}{2R}a^2R\int dB$

$\Rightarrow\ \omega=\frac{B_0\pi a^2\lambda}{mR}$

$\Rightarrow \vec{\omega} = -\frac{B_0 \pi a^2 \lambda}{mR} \hat{k}$ (because clockwise sense)

143 **(d)**

Let radius of the loop is r at any time t and in further time dt, radius increases by dr



Then change in flux: $d\phi = (2\pi r dr)B$

$$\Rightarrow e = \frac{d\phi}{dt} = 2\pi r \left(\frac{dr}{dt}\right)\frac{k}{r}$$

$$\Rightarrow e = 2\pi ck \text{ (constant)} \left[\because \frac{dr}{dt} = c, B = \frac{k}{r}\right]$$

144 **(c)**

Applying KVL in the outer loop, we get

$I_0 r - E = 0$

$$\Rightarrow I_0 = \frac{E}{r}$$

$\therefore$ Initial energy in solenoid $= U_0 = \frac{1}{2}LI_0^2 = \frac{E^2L}{2r^2}$.

This energy will be dissipated in the form of heat in r and R after opening of the switch. Since the same current flows through these resistances, therefore heat generated in each resistor is directly proportional to its resistance

$\therefore$ Heat generated in solenoid

$$= \frac{r}{r+R}U_0$$

$$= \left[\frac{r}{r+R}\right]\frac{E^2L}{2r^2} = \frac{E^2L}{2r(r+R)}$$

145 **(c)**

Since, $\varepsilon = \frac{d\phi}{dt} = \frac{d}{dt}(NBA)$

$$\varepsilon = \frac{d}{dt}[NA(\mu_0 nI))];\ \varepsilon = NA\mu_0 n\left(\frac{dI}{dt}\right)$$

Where N is total number of turns in the coil and n is the number of turns per unit length in the solenoid

$$\varepsilon = (300)(1.2\times10^{-3})(4\pi\times10^{-7})\times\frac{2000}{0.3}\times\frac{4}{0.25}$$

$$\varepsilon = 4.8\times10^{-2}\text{V} = 48\text{ mV}$$

146 **(c)**

$$U_{\max} = \frac{1}{2}LI_0^2, U = \frac{U_{\max}}{2}$$

$$\Rightarrow \frac{1}{2}LI^2 = \frac{1}{2}\left[\frac{1}{2}LI_0^2\right] \Rightarrow I_0^2\left[1-e^{-t/\tau}\right]^2 = \frac{I_o^2}{2}$$

$$\Rightarrow e^{-t/\tau} = 1 - \frac{1}{\sqrt{2}} = \frac{\sqrt{2}-1}{\sqrt{2}}$$

$$\Rightarrow -\frac{t}{\tau} = \text{In}\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right) \Rightarrow t = \tau\,\text{In}\left(\frac{\sqrt{2}}{\sqrt{2}-1}\right)$$

147 **(b)**

When the loops are brought nearer, magnetic flux linked with each loop increases. Thus the current will be induced in each loop in a direction opposite to its own current in order to oppose the increase in magnetic flux. This is in accordance with Lenz's law. So, the current will decrease in each loop

148 **(d)**

$$W = F\ell(NIB\ell)\ell = NB\ell^2\left(\frac{BVN\ell}{R}\right)$$

$$= \frac{N^2B^2\ell^3}{R}V = \frac{N^2B^2\ell^3}{R}\frac{\ell}{t} = \frac{N^2B^2\ell^4}{Rt} = 0.1\text{ mJ}$$

149 **(b)**

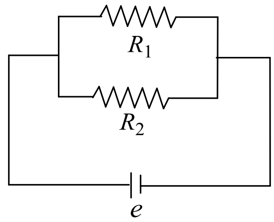
$$Q = \frac{\Delta\phi}{R} = \frac{\phi_2-\phi_1}{R} = \frac{BA-0}{R} = \frac{BA}{R}$$

150 **(b)**

Use $i = \frac{E}{R}[1-e^{-t/\tau}]$ and $U = \frac{1}{2}Li^2$

151 **(a)**

The equivalent diagram is



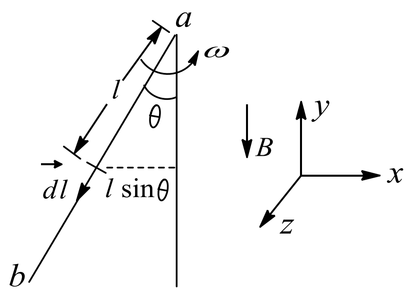
The induced emf across the centre and any point on the circumcentre is

$$|\vec{e}| = \frac{1}{2}B\omega\ell^2 = \frac{B\omega r^2}{2}$$

$\therefore$ Current through $R_1 = \frac{B\omega r^2}{2R_1}$

152 **(d)**

$$\varepsilon\int(\vec{v}\times\vec{B}).\overrightarrow{dl}$$



$$\Rightarrow \varepsilon = \int\left[(l\sin\theta)\omega\hat{k}\times B(-\hat{j})\right].[dl\sin\theta\,(-\hat{\imath}) + dl\cos\theta\,(-\hat{j})]$$

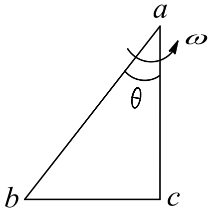
$$\Rightarrow \varepsilon = \int[B\omega l\sin\theta\,\hat{\imath}].[dl\sin\theta\,(-\hat{\imath}) + dl\cos\theta\,(-\hat{j})]$$

$$= -B\omega\sin^2\theta\int_0^L l dl = -\frac{1}{2}B\omega\sin^2\theta\, L^2$$

$$\Rightarrow \varepsilon = V_b - V_a = -\frac{1}{2}B\omega L^2\sin^2\theta$$

Negative sing indicates that end b will be negative w.r.t. a

Alternate Method :



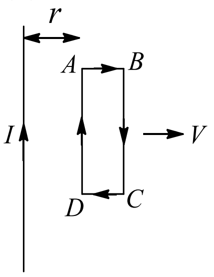
Consider two more conductors $ac$and bc. This completes a closed loop. The net emf induced in this closed loop should be zero, as net flux through this loop always remains zero

$e_{ab}+e_{bc}+e_{ca}=0$

But $e_{bc}=\frac{1}{2}B\omega(L\sin\theta)^2, e_{ca}=0$ putting the values, we get

$e_{ab}=-\frac{1}{2}B\omega(L\sin\theta)$^2

153 **(d)**



As the flux decreases, to maintain flux, current in the loop is clockwise. Force on DA due to the long wire is towards left while on BC is towards right

154 **(b)**

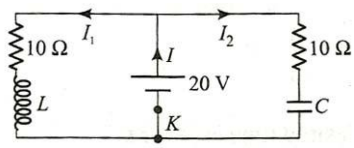
At $t=0$ charge on C is zero, so p.d across C is zero, p.d. across R is also zero. Hence there is no current in R.

At $t=\infty$, current through L is maximum and constant, so p.d. across L is zero, therefore p.d. across R is zero. Hence no current in R

155 **(c)**

Current in branches containing L an R will flow independently

$$I_1=\frac{20}{10}\left(1-e^{-\frac{t}{5\times10^{-4}}}\right)=\frac{3}{2}=1.5\text{ A}$$



$$I_2=\frac{20}{10}e^{-\frac{t}{10^{-3}}}=1.0\text{ A}$$

$I=I_1+I_2=2.5$ A

156 **(a)**

$$\omega=\frac{1}{\sqrt{L_{\text{eq}}L_{\text{eq}}}}=\frac{1}{\sqrt{2LC/2}}=\frac{1}{\sqrt{LC}}$$

157 **(b)**

As anticlockwise direction is positive, so area vector out wards is positive. So net flux through the given loop is

$\phi=-BA-BA+BA=-BA$

$$\oint\vec{E}.\overrightarrow{dr}=-\frac{d\phi}{dt}=-\frac{d(-BA)}{dt}=A\frac{dB}{dt}=A(-\alpha)$$

$$\Rightarrow\oint\vec{E}.\overrightarrow{dr}=-\alpha A$$

158 **(a)**

Let M is mutual inductance of coils, then the flux in second coil is

$\phi_2=Mi_1$

$$e_2=\frac{d\phi_2}{dt}=M\frac{di_1}{dt}$$

$$i_2=\frac{e_2}{R}=\frac{M}{R}\frac{di}{dt}\Rightarrow i_2\propto\frac{di}{dt}$$

159 **(b)**

$B=\mu_0 nI=4\pi\times10^{-7}\times200\times10^2\times1.5=3.8\times10^{-2}$ T

$\phi=BA=3.8\times10^{-2}\times3.14\times10^{-4}$

$=1.2\times10^{-5}$ Wb

When the current in the solenoid is reversed, the change in magnetic flux,

$d\phi=2\times(1.2\times10^{-5})=2.4\times10^{-5}$ Wb

∴ Induced e. m. f., $e=N\left(\frac{d\phi}{dt}\right)$

$$=100\times\left(\frac{2.4\times10^{-5}}{0.05}\right)=0.048\text{ V}$$

160 **(c)**

$$e=\int_{2l}^{3l}B\omega\,x\,dx=\frac{5B\omega l^2}{2}$$

161 **(a,b,c)**

$\phi=4t^n+6$

$$\frac{d\phi}{dt}=4nt^{n-1}$$

$$|e|=4nt^{n-1},|e|=\frac{4n}{t^{1-n}}$$

162 **(a,c)**

Current induced in both A and B will be in same direction. So they will attract each other

$A$is closer to magnet, so rate of change of flux in A will be more. So more current is induced in A

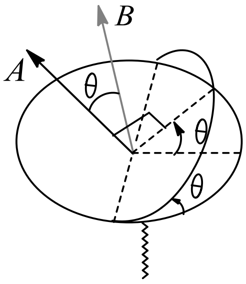
163 **(b,d)**

The magnetostatic field lines and induced electric field lines can form closed loops.

Hence, (b) and (d) are correct option

164 **(a,d)**

$\theta=\omega t$. Only half circular part will be involved in inducing emf, so effective area $A=\frac{\pi a^2}{2}$



$\phi = BA\cos\theta$

$e = -\frac{d\phi}{dt} = +BA\sin\theta\left(\frac{d\theta}{dt}\right) \Rightarrow e = \frac{B\pi a^2}{2}\ \omega\sin\theta$

$I = \frac{e}{R} = \frac{B\pi a^2\omega}{2R}\sin\theta$

Clearly $I = 0$, when $\theta = 0°$ and when

$\theta = \frac{\pi}{2}, I = \frac{B\pi a^2\omega}{2R}$

165 **(a,b,c,d)**

$\phi = BA\cos\theta, \theta = \omega t$

$e = \frac{-d\phi}{dt} = BA\omega\sin\theta$

At $\theta = \frac{\pi}{2}, \phi = 0$ and e is maximum. At $\theta = 0, \phi$ is maximum and e is zero. Emf is maximum when $\theta = \frac{\pi}{2}$ and for this plane of loop is parallel to magnetic field. Clearly phase difference between flux and emf is $\pi/2$

166 **(b,c)**

Thought based

167 **(a.,c)**

$V = L\frac{dI}{dt} \Rightarrow \int_0^I dI = \frac{1}{L}\int_0^t Vdt$

$\Rightarrow I = \frac{1}{L}$[Area under $v - t$ graph from $t = 0$ to $t = t$]

At $t = 2$ s, $I = \frac{1}{2}\left[\frac{1}{2} \times 2 \times 10\right] = 5$ A

For $t = 0$ to 2 s, $V = 5t$

$I = \frac{1}{L}\int_0^t 5t\ dt = \frac{1}{2}\left[\frac{5t^2}{2}\right]_0^t = \frac{5t^2}{4}$

For $t = 2$ to 4 s, $V = -5t + 20$

$I = \frac{1}{2}\int_0^t (-5t + 20)\ dt \Rightarrow I = \frac{-5t^2}{4} + 10t$

Hence the correct graph is (c)

168 **(a,d)**

At the poles, the earth's magnetic field is vertical

169 **(a,d)**

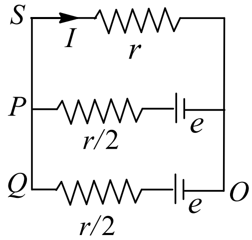
Apply Lenz's law

170 **(a,c,d)**

No emf is induced because flux through the ring does not change. Hence no current flows in the ring. Emf is induced between A and D because length AD is perpendicular to v. But no emf is induced across CE because length CE is parallel to v

171 **(b,d)**

Equivalent circuit



Circuit is from S to O, i.e., from circumference to centre

$I = \frac{e}{r + r/4} = \frac{4}{5r}\left(\frac{1}{2}B\omega a^2\right) \Rightarrow I = \frac{2B\omega a^2}{5r}$

172 **(a,b,c,d)**

Use concept of motional emf

173 **(a,b,d)**

$\phi = \pi a^2 B$

$e = \pi a^2\frac{dB}{dt} = \pi a^2\alpha$

$E2\pi a = e \Rightarrow E = \frac{\pi a^2\alpha}{2\pi a} = \frac{\alpha a}{2}$

Let R be the resistance of the ring. Then current in the ring is $i = e/R$

Consider a small element $d\ell$ on the ring,

Emf induced in the element, $de = \left(\frac{e}{2\pi a}\right)d\ell$

Resistance of the element, $dR = \left(\frac{R}{2\pi a}\right)\ d\ell$

∴ Potential difference across the element

$= de - idR$

$= \left(\frac{e}{2\pi a}\right)d\ell - \left(\frac{e}{R}\right)\left(\frac{R}{2\pi a}\right)d\ell = 0$

174 **(a,b)**

At $t < 0, I_L = \frac{6}{6} = 1$ A

At $t >> 0, I_L = \frac{12}{3} = 4$ A

∴ $|\phi| = L[i_f - i_i] = 500 \times 10^{-3} \times 3 = 1.5$ Wb

∴ (a) and (b) are the correct choices

175 **(c,d)**

When switch is just closed in the circuit shown, at that moment current through the circuit is zero. Hence, e.m.f. induced across inductance L will be equal to e.m.f. E of the battery

But as the current through the circuit increases, the induced e.m.f. in the solenoid decreases. But induced e.m.f. in the solenoid is equal to $|e| = L\frac{di}{dt}$

Since di/dt decreases as time passes, therefore the graph for induced e.m.f. e and time t will be as shown in option (c)

Hence (a) is wrong and (c) is correct

The graph for current should be such that at

initial moment current is zero and current increases with time in such a way that the rate of increase of current gradually decreases. Hence, slope of the current-time curve should decreases with time. Therefore, the graph between current and time will be as shown in option (d)
Hence (b) is wrong and (d) is correct

176 **(a,d)**

$E = \frac{|\xi|}{\delta} = \frac{a\beta}{\delta}$

This expression is independent of R as long as the radius of the ring exceeds the radius $\sqrt{\frac{a}{\pi}}$ of the solenoid

177 **(a,c)**

Use Lenz's law. The motion of ring will be opposed

178 **(a,b,c,d)**

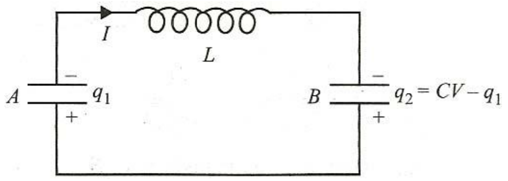
Due to rotation, emf= $\frac{Br^2\omega}{2}$

Due to translation indeed emf= Bvr

Where r is the separation

179 **(a.,c)**

Let at any time, charge and current in the circuit wire are as shown



$I = \frac{dq_1}{dt}$

Applying Kirchhoff's law:

$\frac{CV - q_1}{C} - \frac{q_1}{C} - L\frac{dI}{dt} = 0 \Rightarrow \frac{CV - 2q_1}{LC} = L\frac{d^2q_1}{dt^2}$

$\Rightarrow \frac{d^2q_1}{dt^2} = -\frac{2}{LC}\left(q_1 - \frac{CV}{2}\right)$

$\Rightarrow q_1 - \frac{CV}{2} = A\sin(\omega t + \delta)$ ...(i)

Where $\omega = \sqrt{\frac{2}{LC}} = 100\pi$ rad/s

At $t = 0, q_1 = 0 \Rightarrow 0 - \frac{CV}{2} = A\sin\delta$ ...(ii)

Differentiating (i), $\frac{dq_1}{dt} - 0 = A\omega\cos(\omega t - \delta)$

$\Rightarrow I = A\omega\cos(\omega t + \delta)$ ...(iii)

At $t = 0, I = 0 \Rightarrow A\omega\cos\delta \Rightarrow \delta = \frac{\pi}{2}$

From (ii), $A = \frac{CV}{2}$

From (i), $q_1 = \frac{CV}{2} - \frac{CV}{2}\sin\left(\omega t + \frac{\pi}{2}\right)$

$\Rightarrow q_1 = \frac{CV}{2}(1 - \cos\omega t)$ ....(iv)

$\Rightarrow q_1 = 50(1 - \cos 100\pi t)$ mC

Now, $q_2 = CV - q_1 = \frac{CV}{2}(1 + \cos\omega t)$ (v)

$= 50\,(1 + \cos 100\pi t)$

From (ii), $I = -A\omega\sin\omega t$

Current in the circuit is maximum for $\omega t = \frac{\pi}{2}$

And for $\omega t = \frac{\pi}{2}$, we see from (iv) and (v) that

$q_1 = q_2 = \frac{CV}{2}$

180 **(a,c,d)**

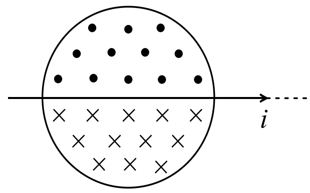
Charge flowing in the circuit = $\frac{\Delta\phi}{R}$

Where, $\Delta\phi$ =change in flux

$= \phi_{\text{final}} - \phi_{\text{initial}}$

and R = resistance in the circuit

181 **(a,c)**



$(\phi)_{loop} = 0$ for all cases

So induced $emf = 0$

182 **(b, d)**

Potential difference = $\frac{1}{2}B\omega\ell^2$

From energy conservation : $mg\frac{\ell}{2}\sin\theta = \frac{1}{2}\,I\omega^2$,

where $I = \frac{m\ell^2}{3}$

$\Rightarrow \omega \propto (\sin\theta)^{1/2} \Rightarrow e\alpha\omega \Rightarrow e \propto (\sin\theta)^{1/2}$

Also $e \propto \ell^2$

183 **(a,b,d)**

Rate of work done by external agent is $Fv = BILv$ and thermal power dissipated in the resistor $= eI = (BvL)$ clearly both are equal , hence (a)

If applied external force is doubled, the rod will experience a net force and hence acceleration. As a result velocity increases, hence (b)

Since, $I = \frac{e}{R}$

On doubling R, current and hence required power becomes half

Since, $P = BILv$

Hence (d)

184 **(b,d)**

If the normal to the plane of the coil makes an angle θ with the direction of B, the flux linked with the coil is

$\phi = BAn\cos\theta$

$= BAn\cos(\omega t)$

(the coil rotates with an angular velocity ω)

e.m.f. $= e = \frac{-d\phi}{dt} = BAn\omega\sin(\omega t)$

185 **(a,b)**

The coils are in parallel, so

$$L_1 \frac{dI_1}{dt} = L_2 \frac{dI_2}{dt} \Rightarrow \int L_1\, dI_1 = \int L_2\, dI_2$$

$\Rightarrow$ Initially $I_1 = 0, I_2 = 0 \Rightarrow C = 0$

So $L_1 I_1 = L_2 I_2$

186 **(b,d)**

Flux remains constant here, so emf induced is zero

187 **(a,c,d)**

$V_1 = L_1 \frac{dI_1}{dt}$ and $V_2 = L_2 \frac{dI_2}{dt}$

But $\frac{dI_1}{dt} = \frac{dI_2}{dt}$ (given)

$\therefore \frac{V_1}{V_2} = \frac{L_1}{L_2} = \frac{8}{2} = \frac{4}{1}$

Again, same power is given to the two coils

$\therefore V_1 I_1 = V_2 I_2$ or $\frac{I_1}{I_2} = \frac{V_2}{V_1} = \frac{1}{4}$

Again, energy $= \frac{1}{2} L I^2$

$$\therefore \frac{W_2}{W_1} = \frac{\frac{1}{2} L_2 I_2^2}{\frac{1}{2} L_1 I_1^2} = \left(\frac{L_2}{L_1}\right)\left(\frac{I_2}{I_1}\right)^2 = \frac{2}{8}(4)^2 = \frac{4}{1}$$

188 **(a,b,d)**

Charge flowing in the circuit $= \frac{\Delta\phi}{R}$

Where, $\Delta\phi$ =change in flux

$= \phi_{\text{final}} - \phi_{\text{initial}}$

and R = resistance in the circuit

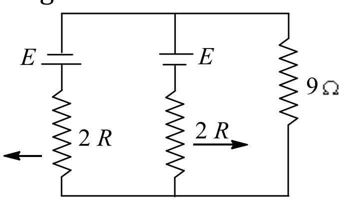
189 **(b,c)**

Each wire can be replaced by a battery whose emf is equal to

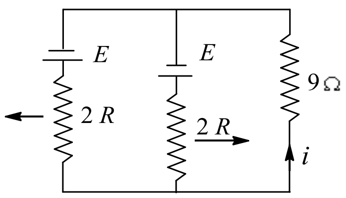
$B\ell v = 1 \times 4 \times 10^{-2} \times 5 \times 10^{-2}$

$= 20 \times 10^{-4}$ V

The polarity of the battery can be given by Fleming's right hand rule. When both wire move in opposite direction, the circuit diagram looks like as shown in figure. The effective emf of the two batteries shown in the diagram is zero. So, choice (b) is correct and choice (d) is wrong. When both wires move towards left, the circuit diagram looks like as shown in figure



(a)



(b)

Effective emf of two batteries shown is $E(= 20 \times 10^{-4}\text{V})$ and internal resistance is 1 Ω

Hence, current in the circuit is

$$i = \frac{20 \times 10^{-4}}{10} = 0.2 \text{ mA}$$

Hence, choice (c) is correct and choice (a) is wrong

190 **(b,d)**

$$i = \frac{dq}{dt} = \frac{d}{dt}(CvB\ell) = CB\ell \frac{dv}{dt} = CB\ell a$$

$\therefore F - CB^2\ell^2 a = ma$

$$\Rightarrow a = \frac{F}{M + B^2\ell^2 C}$$

$\Rightarrow$ emf increases

$\Rightarrow$ charge increases

191 **(a,.b)**

$L\frac{di}{dt} = Bv\ell \Rightarrow \int di = \frac{B\ell}{L} \int v\, dt \Rightarrow i = \frac{Bl}{L} x$ ...(i)

$F = ma \Rightarrow -iB\ell = mv\frac{dv}{dx}$

$$\Rightarrow -\frac{B^2\ell^2 x}{L} = mv\frac{dv}{dx}$$

$$\Rightarrow -\frac{B^2\ell^2}{mL}\int_0^d x\, dx = \int_{v_0}^{v_0/2} v\, dv$$

$$\Rightarrow -\frac{B^2\ell^2 d^2}{2mL} = \frac{-3v_0^2}{8}, v_0 = \frac{J}{m}$$

$$\Rightarrow d = \sqrt{\frac{3J^2 L}{4 B^2\ell^2 m}}$$

Put $x = d$ in (i), $i = \frac{B\ell}{L}\sqrt{\frac{3J^2L}{4B^2\ell^2 m}} = \frac{3J^2}{4Lm}$

192 **(b,d)**

The horizontal component of magnetic field due to solenoid will exert force on ring in vertical direction

$F = B_H i(2\pi r), F\Delta t = mV$

$$i = \frac{(\Delta\phi/\Delta t)}{\left(\rho\frac{(2\pi r)}{A}\right)}, B_H i(2\pi r)\Delta t = mV$$

$$V = \frac{B_H \Delta\phi A}{\rho m} = \frac{K}{\rho m}$$

$$h = \frac{V^2}{2g} = \frac{K^2}{\rho^2 m^2}$$

$$h_A > h_B \Rightarrow \frac{K^2}{\rho_A^2 m_A^2} > \frac{K^2}{\rho_B^2 m_B^2} \Rightarrow \rho_B m_B > p_A m_A$$

Using this, we get (b) and (d) are correct

193 **(a,c)**

In the circuit shown in the figure in problem, 6Ω and 12Ω resistance are in parallel with each other and their parallel combination is in series with 4Ω and the inductance of 2H. Hence, equivalent resistance of these three resistance is equal to 8Ω.

Therefore, the time constant for the circuit is
$\lambda = \frac{L}{R} = \frac{2}{8} = 0.25$ s
Hence (a) is correct
In steady state, no e. m. f. will be induced in the inductance. Hence current through the circuit will be equal to E/R where R is the equivalent resistance. Hence, the steady state current will be equal to $6/8 = 0.75$ A
Hence (c) is correct and (b) is wrong

194 **(d)**
Since the rate of change of magnetic flux is zero, hence there will be no net induced emf and hence no current flowing in the loop

195 **(a,b,c,d)**

1. $L = \frac{\emptyset}{i}$ or henry $= \frac{\text{weber}}{\text{ampere}}$

2. $e = -L\left(\frac{di}{dt}\right)$

$\therefore\ L = -\frac{e}{(di/dt)}$

or henry $= \frac{\text{volt−second}}{\text{ampere}}$

3. $U = \frac{1}{2}Li^2$

$\therefore\ L = \frac{2U}{i^2}$

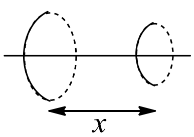
or henry $= \frac{\text{joule}}{(\text{ampere})^2}$

4. $\tau = \frac{L}{R}$

$\therefore L = R\tau$ or henry = ohm-second

196 **(a,b)**
As $\vec{B} \perp \vec{A}$, hence $\phi = 0$ and $e = 0$

197 **(a)**
It is obvious that flux linkage in one ring due to current in other coaxial ring is maximum when $x = 0$ (as shown) or the rings are also coplanar. Hence under this condition their mutual induction is maximum



198 **(d)**
Lenz's law is based on conservation of energy and induced emf always opposes the cause of it, i.e., change in magnetic flux

199 **(b)**
The relation of induced emf is $e = \frac{Ldi}{dt}$ and current i is given by $i = \frac{e}{R} = \frac{1}{R}.\frac{L.di}{dt} \Rightarrow \frac{di}{dt} = i\frac{R}{L} = \frac{i}{L/R}$
In order to decrease the rate of increase of current through solenoid we have to increase the time constant $\frac{L}{R}$

200 **(c)**
If the wires are twisted together, they can be formed as a single wire carrying currents in opposite directions. In this pattern, in wires no magnetic field is induced which does not affect adjacent circuits

201 **(d)**
When a metal piece falls from a certain height then eddy currents are produced in it due to earth's magnetic field. Eddy currents oppose the motion of piece. Hence metal piece falls with a smaller acceleration (as compared to g). But no eddy currents are produced in non-metal piece. Hence it drops with acceleration due to gravity. Therefore non-metal piece will reach the earth's surface earlier

202 **(e)**
Lenz's Law is based on conservation of energy and induced emf always opposes the cause of it, *i.e.*, change in magnetic flux

203 **(b)**
For solenoid $B_{\text{end}} = \frac{1}{2}(B_{\text{in}})$

Also for long solenoid, the magnetic field is uniform within it but this reason is not explaining the assertion

204 **(a)**
If inductance of solenoid increases, reactance of circuit also increases, then obviously current will decrease and lamp becomes dim

205 **(b)**
According to Lenz's law, induced emf are in a direction such as to attempt to maintain the original magnetic flux when a change occurs. When the switch is opened, the sudden drop in the magnetic field in the circuit induces an emf in a direction that attempts to keep the original current flowing. This can cause a spark as the current bridges the air gap between the poles of the switch. (The spark is more likely in circuits

with large inductance)

206 **(d)**

Back $emf\ e \propto \omega$. At start $\omega = 0$ so $e = 0$

207 **(c)**

Electric filed generated from time dependent magnetic field obeys Lenz's law

208 **(c)**

The manner in which the two coils are oriented determines the coefficient of coupling between them.

$M = K\sqrt{L_1 L_2}$

When the two coils are wound on each other, the coefficient of coupling is maximum and hence mutual inductance between the coils is maximum

209 **(e)**

As the aircraft files, magnetic flux changes through its wings due to the vertical component of the earth's magnetic field. Due to this, induced emf is produced across the wings of the aircraft. Therefore, the wings of the aircraft will not be at the same potential

211 **(b)**

When a metallic conductor is moved in a magnetic field; magnetic flux is varied. It disturbs the free electrons of the metal and sets up an induced emf in it. As there are no free ends of the metal, $i.e.$, it will be closed in itself so there will be induced current

212 **(a)**

Hysteresis loss in the core of transformer is directly proportional to the hysteresis loop area of the core material. Since soft iron has narrow hysteresis loop area, that is why soft iron core is used in the transformer

213 **(a)**

The force on a charged particle moving in a uniform magnetic field always acts in direction perpendicular to the direction of motion of charge. As work done by magnetic field on the charge is zero, $W = FS\cos\theta$, so the energy of charged particle does not change

214 **(a)**

Transformer works on ac only, ac changes in magnitude as well as in direction

215 **(c)**

Since, the efficiency of an electric motor is given by

$$\eta = \frac{\text{output power}}{\text{input power}}$$

From the above relation, it is quite clear that maximum output power corresponds maximum efficiency of motor.

Now, output power is given by

$$= e\ i = \frac{e(E - e}{R}$$

To obtain maximum output power differentiating Eq.(i) with respect to e which will be equal to zero.

So, $\frac{d}{de}[\frac{e(E-e)}{R}]= 0 \Rightarrow e = \frac{E}{2}$

Thus, when back emf becomes equal to half of the applied emf, the efficiency of motor will be maximum.

216 **(e)**

Since both the loops are identical (same area and number of turns) and moving with a same speed in same magnetic field. Therefore same emf is induced in both the coils. But the induced current will be more in the copper loop as its resistance will be lesser as compared to that of the aluminium loop

217 **(a)**

The inductance coils made of copper will have very small ohmic resistance. Due to change in magnetic flux a large induced current will be produced in such an inductance coil which will offer appreciable opposition to the flow of current

218 **(b)**

Self-inductance of a coil is its property by virtue of which the coil opposes any change in the current flowing through it

219 **(d)**

Before making current in a coil, the current is zero and before breaking the current is maximum. In other words, it is constant in both the cases. Obviously on making or breaking the current in a circuit, the current starts changing magnetic field, which in turn produces induced current in the neighbouring coil of the circuit.

220 **(c)**
Presence of magnetic flux cannot produce current

221 **(a)**
Induced electric field is non conservative. Also
$\oint \vec{E}\,.\,\vec{d}l = -\frac{d}{dt}\int \vec{E}.\vec{d}s \neq 0$

222 **(c)**
When the satellite moves in inclined plane with equatorial plane (including orbit around the poles), the value of magnetic field will change both in magnitude and direction. Due to this, the magnetic flux through the satellite will change and hence induced currents will be produced in the metal of the satellite. But no current will induced if satellite orbits in the equatorial plane because the magnetic flux does not change through the metal of the satellite in this plane

223 **(d)**
When current due to external source decreases, induced current will be in same direction

224 **(b)**
Mutual inductance is the phenomenon according to which an opposing e.m.f. produces flux in a coil as a result of change in current or magnetic flux linked with a neighboring coil. But when two coils are inductively coupled, in addition to induced e.m.f. produced due to mutual induction, induced e.m.f. is also produced in each of the two coils due to self-induction

225 **(c)**
If two coils of inductance
$L_1$and L_2 are joined together, then their mutual ind

$M = k\sqrt{L_1L_2}$

It is clear from the relation, if self-inductances of primary and secondary coil are doubled the mutual inductance of the coils will be doubled.

226 **(a)**
$\oint \vec{B}.\overrightarrow{dl}$ along any closed path within a uniform magnetic field is always zero

227 **(e)**
ac generator is based on the principle of the electromagnetic induction. When a coil is rotated about an axis perpendicular to the direction of uniform magnetic field, an induced emf is produced across it

228 **(d)**
Magnetic field cannot do work, hence statement 1 is false

229 **(c)**
According to Faraday's laws, the conversion of mechanical energy into electrical energy is in accordance with the law of conservation of energy. It is also clearly known that in pure resistance, the emf is in phase with the current

230 **(d)**
Even through flux through individual lines changes, it remains unchanged for the solenoid as a whole. Therefore, no e.m.f. is induced in the long solenoid

231 **(d)**

1. At $t = 1$ s, flux is increasing in the inward direction, hence induced emf will be in anticlockwise direction

2. At $t = 5$ g, there is no change in flux, so induced emf is zero

3. At $t = 9$ s, flux is increasing in upward direction, hence induced emf will be in clockwise direction

4. At $t = 15$ s, flux is decreasing in upward direction, so induced emf will be in anticlockwise direction

232 **(d)**
Magnetic field is along x-axis because when the cube is moved along x-axis, there is no motional emf as $\vec{v} \times \vec{B} = 0$. When the block is moved along x-axis, force on the electrons is in direction
$-(\hat{j} \times \hat{\imath}) = \hat{k}$
Therefore, electric field will be created along z-axis
Now, $cvB = 24$ mV
$\Rightarrow c = 20$ cm
Similarly, $bvB = 36$ mV
$\Rightarrow b = 30$ cm
$\therefore a = 25$ cm

233 **(a)**

1. Speed of the charged particle cannot be changed by magnetic force because magnetic force does no work on charged particle. Only electric field in case (a) and induced electric field in case (c) can change speed of the charged particle

2. Magnetic field cannot exert force on the charged particle at rest. Only electric field

in case (a) and induced electric filed in case (c) can exert force on change initially at rest. In case (c) after the charged particle starts moving, the magnetic field can exert force on the change

3. A charged particle can move on a circle with a uniform speed due to uniform and constant magnetic field. Even within a region of non-uniform magnetic field, at all points on the circle, the field may be uniform, for example, on any circle concentric with a current-carrying ring

4. A moving charged particle is accelerated by electric field and also accelerated by magnetic field (provided v is not parallel to B)

234 **(b)**

i. Just after switch S is closed, flux in M starts increasing in left direction, so in N also the flux starts increasing in left direction. This will induce current in N in a direction so that the flux is in right direction. This is possible if induced current in N is from A to B

ii. In this case just reverse of (i) will happen, because after closing the switch, the flux in M starts decreasing in left direction

iii. After a long time of closing the switch, flux becomes constant. Hence, no current is induced

iv. Just after closing S, flux starts increasing, but because M moves away, so due to this flux through N will decrease. But there will be a net increase in flux in N in left direction. This is the case similar to (i)

235 **(c)**

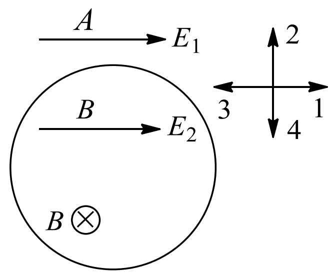
Since filed is decreasing, so induced electric field at both points A and B will be in clockwise direction or towards 1. Hence, force on an electron will be along 3 at both points A and B

For A: $E\ 2\pi r = \pi a^2 \frac{dB}{dt}$

$E \propto \frac{1}{r}$

For B: $E\ 2\pi r = \pi r^2 \frac{dB}{dt}$

$E \propto r$



236 **(c)**

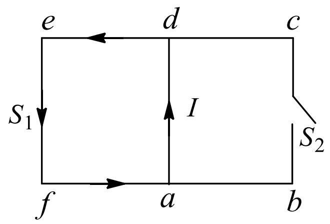
1. $\frac{dB}{dt} = 10 \times 10^{-3}\ T/s$

$A = 2^2 = 4\ cm^2 = 4 \times 10^{-4} m^2$

$E = \frac{d\phi}{dt} = A\frac{dB}{dt}$
$= 4 \times 10^{-4} \times 10 \times 10^{-3}$

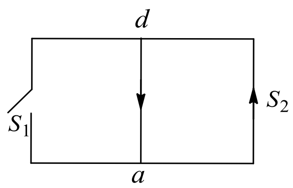
$= 4 \times 10^{-6}$ V

$I = \frac{e}{R} = \frac{4 \times 10^{-6}}{2 \times 4} = 5 \times 10^{-7}$A



The emf will be in anticlockwise direction, so current will be from a to d

2. Again, current will be in anticlockwise direction



This makes the direction of current from d to a, magnitude same as that in part (i)

3. If both are open, induced emf will develop, but no current will flow

4. If both are closed, then induced emf in the left part will tend to flow will from a to d and in right part, the current will tend to flow d to a, so, from the principle of superposition, no current will flow in ad

237 **(b)**

1. $e_{OA}=\frac{1}{2}B\omega(OA)^2=\frac{1}{2}B\omega\left(\sqrt{2}\,L\right)^2=B\omega L^2$

2. $e_{OD}=\frac{1}{2}B\omega(OD)^2=\frac{1}{2}B\omega\left(\sqrt{2}\,L\right)^2=B\omega L^2$

3. $e_{OC}=\frac{1}{2}B\omega L^2\ or\ e_{CD}=E_{OD}-E_{OC}=\frac{1}{2}B\omega L^2$

4. $e_A-e_O-B\omega L^2$

$e_D-E_o=B\omega L^2$

$e_A-e_D=0$

238 **(c)**

When the switch is connected with a for a long time, current in the circuit would be E/R and E/R is greater for (i) and (iii) than for (ii) and (iv)
Next, comparison is made on the basis of time constant. Shorter time constant means faster decay of the current

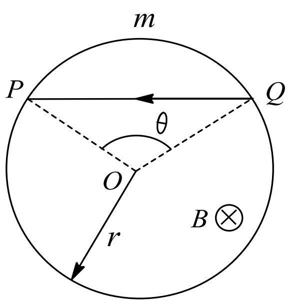
239 **(b)**

1. Area $OPMQO=\frac{1}{2}r^2\theta$

Flux in this area, $\phi 1=\frac{1}{2}r^2\theta B$

Induced emf in this area,

$$e_1=\frac{d\phi_1}{dt}=\frac{1}{2}r^2\,\theta\frac{dB}{dt}$$



Area $OPQ=r\sin\left(\frac{\theta}{2}\right)\,r\cos\left(\frac{\theta}{2}\right)=\frac{1}{2}r^2\sin\theta$

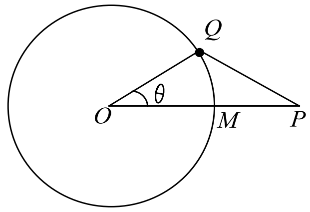
Induced emf in OPQ,

$$e_2=\frac{d\phi_2}{dt}=\frac{1}{2}r^2\sin\theta\frac{dB}{dt}$$

e_2 will be only in part PQ, because in OQ and OP induced emf will be zero, clearly, $e_2<e_1$, because area $OPQ<$ area $OPMQO$

Since B is increasing, so e.m.f. will be in anticlockwise direction. Hence end P will; be positive w.r.t Q

2. Here emf in OPQ will be due to flux changing in area OMQ. This area is $\frac{1}{2}r^2\theta$ the entire emf will be in part PQ. End Q will be positive



3.

4. Induced emf= $\frac{1}{2}r^2\theta\frac{dB}{dt}$. End P will be positive

5. Area in which flux is changing is less than $\frac{1}{2}r^2\theta$. End Q will be positive

240 **(a)**

We know that $e=-\frac{d\phi}{dt}=-A\frac{dB}{dt}$. If we take area vector in the upward direction, then anticlockwise direction will be positive. From o to t_1 and $t_5$tot_6, dB/dt is +ve. Hence induced emf e is –ve. So, induced current will be in clockwise direction. From $t_2$to t_4, dB/dt is –ve. Hence induced emf e is +ve. So, induced current will be in anticlockwise direction. From t_1 to t_2 and $t_4$to t_5, dB/dt is zero, hence, no emf is induced. Induced emf or current is maximum from 0 to t_1 and t_5 to t_6, because here magnitude of dB/dt is maximum

242 **(a)**

1. If loop is moved away, then flux through loop decrease in – ve z direction. To increase this decreasing flux, current induced should be in clockwise direction

Now, induced current in AB will be parallel to I, so that there will be net attraction between wire and loop
Hence (i)→(b,d)

1. Explain in the similar way as in (i)

In cases (iii) and (iv), just after the rotation is started, velocity of each element of the loop will be parallel or antiparallel to the magnetic field produced by I. Hence, no emf in induced

So (iii)→(c), (iv)→(c)

243 **(b)**

i.If current is increased, flux in the loop will increase in inside direction, then due to Lenz's law induced emf in the loop will be in anticlockwise direction. Due to this current, the current in the nearer side of loop to the wire will be in opposite direction to that of wire. Hence, there will be repulsion

2. This situation is opposite to part (i)

3. If loop is moved away, then flux decreases and this becomes similar to part (ii)

4. Similar to part (i)

244 **(a)**

i. Current in inductor when switch is open:

$I_0 = \frac{E}{R}$

Initially induced e. m. f will be equal to E and finally it is zero. So, energy stored will be zero

ii. Same as (i)

iii. **iv**. Here current becomes zero suddenly

So, $\frac{dI}{dt}$ is large

Hence, induced e.m.f $L\frac{dI}{dt}$ will be large. Finally, energy stored in inductor will be zero

246 **(b)**

$$\varepsilon_{\text{av}} = -\frac{\Delta\Phi_B}{\Delta t} = -B\frac{\Delta A}{\Delta t} = -B\ \frac{(-\pi r^2)}{\Delta t}$$

$$= \frac{1 \times \pi(0.10)^2}{0.314} = 0.1\text{ V}$$

Since the flux through the loop is decreasing, the induced current must produce a field that goes into the page. Therefore, the current flows in clockwise direction

$$I_{\text{av}} = \frac{\varepsilon_{\text{avc}}}{R} = \frac{0.1}{0.01} = 10\text{ A}$$

247 **(b)**

Magnetic field on the axis of a circular coil is given by

$$B = \frac{\mu_0 i R^2}{2(R^2 + x^2)^2}$$

Since $x >> R$, therefore, magnetic field at the centre of the smaller loop is

$$B \approx \frac{\mu_0 i R^2}{2x^3}$$

Flux linked with coil is

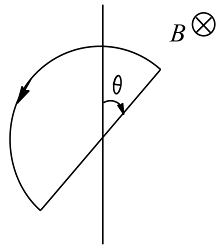
$$\phi = B(\pi r^2) = \frac{\mu_0 \pi i R^2 r^2}{2x^3}$$

From Faraday's law we have

$$E = -\frac{d\phi}{st} = \frac{3}{2}\frac{\mu_0 \pi i R^2 r^2}{x^4} v$$

248 **(a)**

Emf is induced in the loop because area inside the magnetic field is continually changing. From $\theta = 0\text{to}\ \pi, 2\pi\ to\ 3\pi, 4\pi\ to\ 5\pi$, the loop begins to enter the magnetic field. Thus the magnetic field passing through the loop is increasing. Hence, current in the loop is anticlockwise, and for $\theta = \pi\ to\ 2\pi, 3\pi\ to\ 4\pi, 5\pi\ to\ 6\pi$, etc. magnetic field passing through the loop is decreasing. Hence current in the loop is clockwise. Let at any time, angle rotated is θ, then $\theta = \frac{1}{2}\alpha t^2$



Area inside magnetic field $A = \frac{1}{2}R^2\theta =$

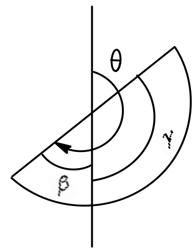
$\frac{1}{2}R^2\left(\frac{1}{2}\alpha t^2\right) = \frac{1}{4}R^2\alpha t^2$

Flux in the loop: $\phi = BA = \frac{B}{4}R^4\alpha t^2$

Emf: $e = -\frac{d\phi}{dt} = -\frac{B}{2}R^2\alpha t\ \Rightarrow e \propto t$

Time taken to complete first half circle: $t_1 = \sqrt{\frac{2\pi}{\alpha}}$

When the loop starts coming out : $\theta = \frac{1}{2}\alpha t^2$



$\beta = \theta - \pi, \gamma = \pi - \beta = \pi - \theta + \pi = 2\pi - \theta$

Area within magnetic field:

$$A = \frac{1}{2}R^2 y = \frac{1}{2}R^2(2\pi - \theta) = \pi R^2 - \frac{R^2\theta}{2}$$

Flux $\phi = BA = B\left(\pi R^2 - \frac{R^2\theta}{2}\right)$

Emf$e = -\frac{d\phi}{dt} = \frac{B}{2}R^2\alpha t$

$$e = \frac{BR^2}{2}\alpha t \Rightarrow e \propto t$$

Time taken to complete second half revolution

$$t_2 = \sqrt{\frac{4\pi}{\alpha}} - \sqrt{\frac{2\pi}{\alpha}}$$

We see that $t_2 < t_1$

We can write induced emf as

$e = (-1)^n \left[\frac{1}{2}BR^2\ \alpha t\right]$

Where $n = 1, 2, 3, \dots\dots\dots$ is the number of half revolutions completed by loop. Smaller time will be taken to complete the second half revolution as compared to the previous half revolution

249 **(d)**

The large circuit is a circuit with a time constant of

$\tau = RC = (10\ \Omega)(20 \times 10^{-6}\ \text{F}) = 200\mu\text{s}$

Thus, the current as a function of time is

$i = \left(\dfrac{100\ V}{10\ \Omega}\right) e^{-\frac{t}{200\mu s}}$

At $t = 200$ ms, we obtain

$i = (10\ \text{A})(e^{-1}) = 3.7\ \text{A}$

Assuming that only the long wire nearest the small loop produces an appreciable magnetic flux through the small loop,

$$\Phi_B = \int_c^{c+a} \frac{\mu_0 ib}{2\pi r}\ dr = \frac{\mu_0 ib}{2\pi}\ In\left(1 + \frac{a}{c}\right)$$

So the emf induced in the small loop at $t = 200$ ms

$$\varepsilon = -\frac{d\Phi}{dt} = -\frac{\mu_0 b}{2\pi}\text{In}\left(1 + \frac{a}{c}\right)\frac{di}{dt}$$

$$= -\frac{\left(4\pi \times 10^{-7}\frac{Wb}{A \times m^2}\right)(0.200\ m)}{2\pi} \times \text{In}(3.0)\left(-\frac{3.7\ A}{200 \times 10^{-6}\ s}\right)$$

Thus, the induced current in the small loop is

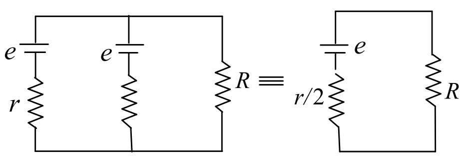
$$i' = \frac{\varepsilon}{R} = \frac{0.81\ \text{mV}}{25(0.600\ \text{m})\left(1.0\frac{\Omega}{\text{m}}\right)} = 54\mu\text{A}$$

Initially current in larger loop is maximum and afterwards decreases. Hence flux through the smaller loop decreases with time.

The induced current will act to oppose the decrease in the flux from the large loop. Thus, the induced current floes counterclockwise

250 **(a)**

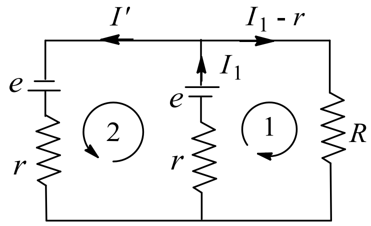
Case I



Fi

$$I = \frac{e}{R + (r/2)} + \frac{Blv}{R + (r/2)}$$

Case II



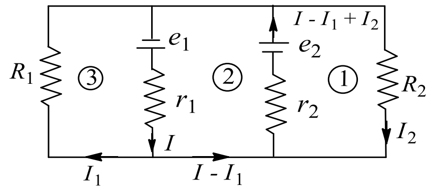
$-(I_1 - I')R - I_1 r + e = 0$ For loop (1) (i)

$r(I_1 + I') = 2e$ For loop (2) (ii)

Solve to get, $I_1 = I' = \frac{e}{R}$

Hence current in 'R' is zero

ii. $e_1 = Blv_1, e_2 = Blv_2$



For (1)→ $e_2 = (I - I_1 + I_2)r_2 + I_2 R_2$

For (2) → $e_1 + e_2 = (I - I_1 + I_2)r_2 + Ir_1$

For (3) → $e_1 = Ir_1 + I_1 R_1$

Solve to get $I_1 = \frac{BlR_2(v_1 r_2 - v_2 r_1)}{R_1 R_2(r_1 + r_2) + r_2 r_1(R_1 + R_2)}$

251 **(b)**

Let us take anticlockwise direction as positive, then area vector in upward direction will be positive

$\phi = BA = B\ell x$

$$e = -\frac{d\phi}{dt} = -\ell\left[B\frac{dx}{dt} + x\frac{dB}{dt}\right]$$

$$= -5 \times 10^{-2}[0.1 \times (-5 \times 10^{-2}) + 5 \times 10^{-2} \times 0.2]$$

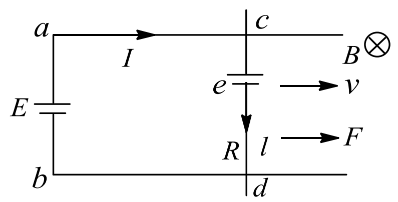
$= -250 \times 10^{-6}\ \text{V} = -250\ \mu\text{V}$

emf is coming out to be negative, so it should be clockwise

Current: $I = \frac{e}{R} = \frac{250 \times 10^{-6}}{10^{-4}} = 2.5\ \text{A}$

252 **(a)**

Due to applied emf, current will flow as shown. Due to this current and magnetic field B, force on the wire will act towards right and rod will start moving towards right. Let at any instant, its velocity is v. Due to this velocity, emf $e = Blv$ will be induced as shown



Net emf: $E - B\ell v, I = \frac{E - B\ell v}{R}$ ...(i)

$F = IB\ell = \left(\frac{E - B\ell v}{R}\right)B\ell$ ...(ii)

$$\Rightarrow m\frac{dv}{dt} = (E - B\ell v)\frac{B\ell}{R}$$

$$\frac{mR}{B\ell}\frac{dv}{dt} = E - B\ell v \;\Rightarrow \int_0^v \frac{dv}{E - B\ell v} = \int_0^t \frac{B\ell}{mR}\,dt$$

$$\Rightarrow \left[\frac{In\,(E - B\ell v)}{-B\ell}\right]_0^v = \frac{B\ell}{mR}\,t \;\Rightarrow\; \text{In}\left(\frac{E - B\ell v}{E}\right)$$

$$= \frac{-B^2\ell^2}{mR}t$$

$$\Rightarrow \frac{E - B\ell v}{E} = e^{-t/\tau} \;\Rightarrow v = \frac{E}{B\ell}\left[1 - e^{-t/\tau}\right]$$

Velocity will increase upto$t = \infty$, and at $t = \infty$, velocity will be maximum and constant

$v_{t=\infty} = \frac{E}{B\ell}$ →this is the required terminal velocity

Also, when the velocity is constant, net force on the rod will become zero, so putting F=0 in equation (ii), we get

$$v_{\text{terminal}} = \frac{E}{B\ell}$$

When the rod attains terminal velocity, then from equation (i), $I = 0$

253 **(a)**

Induced electric field should be anticlockwise

31. $I = \frac{\varepsilon}{R} = \frac{A}{R}\frac{dB}{dt} = \frac{L^2}{R}\frac{dB}{dt}$

$$= \frac{(0.20\text{ m})^2(0.0350\text{ T/s})}{1.90\ \Omega}$$

$= 7.37 \times 10^{-4}\,A$

32. $\varepsilon_{ab} = \frac{1}{8}\varepsilon$, But there is a potential drop of

$$V = \frac{IR}{8} = \frac{\varepsilon}{8}$$

So the potential difference $\varepsilon_{ab} - V$ is zero

254 **(a)**

$$|E| = \frac{d\phi}{dt} = A\frac{dB}{dt} = 2\left[\frac{1}{2}R\,R\right]\frac{dB}{dt} = R^2\frac{dB}{dt}$$

In loop ABC, emf induced due to branch AC is zero and contribution of emf due to AB and BC are equal; hence contribution of emf for the branch is

$$|E|_{AB} = \frac{R^2}{2}\left(\frac{dB}{dt}\right)$$

255 **(a)**

$y = 2A\sin kx\cos\omega t$

$$v = \frac{dy}{dt} = -2A\sin kx\;\omega\sin\omega t$$

$$v_{\max} = -2A\omega\sin kx\,, k = \frac{3\pi}{AB}$$

$$e = \int_0^{l=AB} Bv_{\max}\,dx = -2A\omega B\int_0^{AB}\sin kx\,dx$$

$$= +\frac{2\omega AB}{k}\left[\cos\frac{3\pi}{AB}\,AB - \cos\theta\right]$$

$$= \frac{-4(AB)\omega}{k}$$

$$\omega t = \frac{\pi}{2}$$

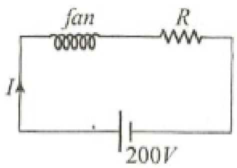
$$t = \frac{\pi}{2\omega}$$

For second harmonic $k = \frac{2\pi}{AB}$

256 **(c)**

The fan is running at 200 V, consuming 1000 W, then $I = \frac{1000}{200} = 5$ A

But as coil resistance is 1 Ω, power disspated by internal resistance as heat is $P_1 = I^2R = 25$ W



If V is the net emf across the coil, then

$\frac{V^2}{R} = 25$ W or $V = 5$ V

Net emf=source emf− back emf

or $V = V_S - e \Rightarrow e = 195$ V

The work done $P_2 = 1000 - 25 = 975$ W

257 **(a)**

$$\frac{dB}{dt} = 2\text{ T/s}$$

$$E = -\frac{AdB}{dt} = -800 \times 10^{-4}\text{m}^2 \times 2 = -0.16\text{ V}$$

$i = \frac{0.16}{1\,\Omega} = 0.16$ A, clockwise

At $t = 2$ s, $B = 4$ T, $\frac{dB}{dt} = 2$ T/s

$a = 20 \times 30\;cm^2$

$$= 600 \times 10^{-4}m^2, \frac{dA}{dt} = -(5 \times 20)cm^2/s$$

$= -100 \times 10^{-4}m^2/s$

$$E = -\frac{d\phi}{dt} = -\left[\frac{d(BA)}{dt}\right] = -\left[\frac{BdA}{dt} + \frac{AdB}{dt}\right]$$

$= -[4 \times (-100 \times 10^{-4}) + 600 \times 10^{-4} \times 2]$

$= -[-0.04 + 0.120] = -0.08$ V

Alternative : $\phi = BA = 2t \times 0.2(0.4 - vt)$

$= 0.16t - 0.4\,vt^2$

$$E = -\frac{d\phi}{dt} = 0.8\,vt - 0.16$$

At $t = 2$s

$E = 0.08$ V

At $t = 2$ s, length of the wire $= (2 \times 30 \text{ cm}) + 20$ cm$=0.8$ m

Resistance of the wire $= 0.8\ \Omega$

Current through the rod $= \frac{0.08}{0.8} = \frac{1}{10}$ A

Force on the wire is $= ilB$

$= \frac{1}{10} \times (0.2) \times 4 = 0.08$ N

Same force is applied on the rod in opposite direction to make net force zero

258 **(a)**

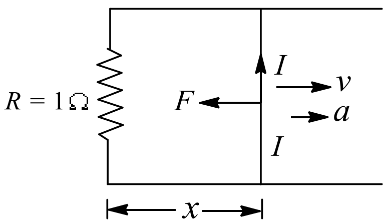
Current should enter the bar from P so that magnetic force is upwards

$ilB = mg$ or $\frac{V}{5} lB = mg$

or $m = \frac{150 \times 0.6 \times 1.5}{5 \times 10} = 2.7$ kg

259 **(a)**

Let anticlockwise direction is positive



$\phi = BA \cos 180° \; cx \; lx \cos 180° = -clx^2$

$e = -\frac{d\phi}{dt} = cl\, 2x \frac{dx}{dt}, \quad I = \frac{e}{R} = \frac{2clxv}{1} = 2cl\,x\,v$

This is positive so current is anticlockwise

$F = m(-a) \Rightarrow IBl = -mv\frac{dV}{dx} \Rightarrow 2c^2l^2x^2v$

$= -mv\frac{dv}{dx}$

$\Rightarrow 2c^2l^2 \int_0^x x^2\, dx = -\int_{10}^{5} m\, dv \Rightarrow 2c^2l^2\frac{x^3}{3}$

$= m(5)$

$\Rightarrow x^3 = \frac{15m}{2c^2l^2} \Rightarrow x = \left(\frac{15}{2}\right)^{\frac{1}{3}}$

Heat produced $=$ loss in KE of rod $= \frac{1}{2} \times 1[10^2 - 5^2] = \frac{75}{2} = 37.5$ J

Magnetic force is not doing any work

260 **(d)**

$E = \frac{r}{2}\frac{dB}{dt} = \frac{r}{2}\mu_0 n \frac{dI}{dt} \Rightarrow E = -\frac{\mu_0 nr}{2} I_{max}\omega \sin \omega t$

261 **(b)**

Instantaneous current in the capacitor,

$q = CV_C = (2)(3e^{-2t}) = 6e^{-2t}$A

Current $i_C = \frac{dq}{dt} = -12e^{-2t}$ A

This current flows from B to O

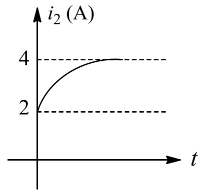
From KVL, we have

$i_L = i_1 + i_2 + i_C = 10e^{-2t} + 4 - 12e^{-2t}$

$= (4 - 2e^{-2t})\text{A} = [2 + 2(1 - e^{-2t})]$ A

i_L vs. time graph is as shown in Fig

i_L increases from 2 A to 4 A exponentially



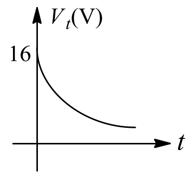
$V_L = L\frac{di_L}{dt}$

$= (4)\frac{d}{dt}(4 - 2e^{-2t}) = 16e^{-2t}$ V

V_L decreases exponentially from 16 A to 0 as shown in fig

To determine V_{AC}, we begin from A and end at C.

From KVL, we have

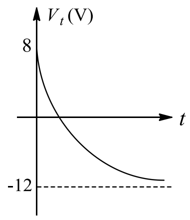


$V_A - i_1R_1 + i_2R_2 = V_C$

$V_A - V_C = i_1R_1 - i_2R_2$

Substituting the values, we have

$V_{AC} = (10e^{-2t})(2) - (4)(3)$

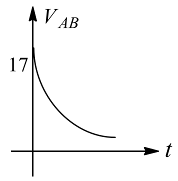


$V_{AC} = (20e^{-2t} - 12)$V

At $t = 0, V_{AC} = 8$ V

At $t = \infty, V_{AC} = -12$ V

Therefore, V_{AC} decreases exponentially from 8 V to -12 V



Similarly, we have from A to B

$V_A - i_1R_1 + V_C = V_B$

$V_{AB} = V_A - V_B = i_1R_1 - V_C$

Substituting the values, we have

$V_{AB} = (10e^{-2t})(2) - 3e^{-2t}$

$V_{AB} = 17e^{-2t}$ V

Thus, V_{AB} decreases exponentially from 17 V to 0.

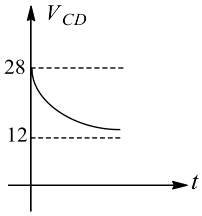
As we move from C to D,

$V_C - i_2R_2 - V_L = V_D$

$V_{CD} = V_C - V_D = i_2R_2 + V_L$

Substituting the values we have,

$V_{CD} = (4)(3) + 16e^{-2t}$



$V_{CD} = (12 + 16e^{-2t})$ V

At $t = 0, V_{CD} = 28$ V

and at $t = \infty, V_{CD} = 12$ V

i.e., V_{CD} decreases exponentially from 28 V to 12 V

262 **(b)**

S_1 and S_2 are closed for 1 s

Charge on capacitor

$q = CE(1 - e^{-t/RC}) = 1 - \frac{1}{e}$ ...(i)

The current in inductor,

$I = \frac{E}{R}(1 - e^{-tR/L}) = 1 - \frac{1}{e}$ ...(ii)

Now S_1 ad S_3 are opened and S_2 is closed,

It is LC circuit,

$q = q_{\max} \sin(\omega t + \phi)$ ...(iii)

$I = (q_{\max})\omega \cos(\omega t + \phi)$ ...(iv)

As total energy (Magnetic + electrical) is constant

$\frac{1}{2}LI_{\max}^2 = \frac{1}{2}\frac{q_{\max}^2}{C} = \frac{1}{2}LI^2 + \frac{1}{2}\frac{q^2}{C}$ ...(v)

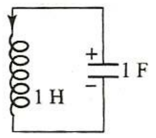
$q_{\max} = \sqrt{2}\left(1 - \frac{1}{e}\right)$ ...(vi)

$I_{\max} = \sqrt{2}\left(1 - \frac{1}{e}\right)$ ...(vii)

From (iii) at $t = 0$, we get

$\left(1 - \frac{1}{e}\right) = \sqrt{2}\left(1 - \frac{1}{e}\right)\sin\phi \Rightarrow \frac{\pi}{4}$ or $\frac{3\pi}{4}$

After closing S_2, circuit will be as shown. Direction of current shows that charge on capacitor will be decreasing. Hence $\phi = 3\pi/4$



$$q = \sqrt{2}\left(1 - \frac{1}{e}\right)\sin\left(\omega t + \frac{3\pi}{4}\right)$$

Where, $\omega = \frac{1}{\sqrt{LC}} = 1$

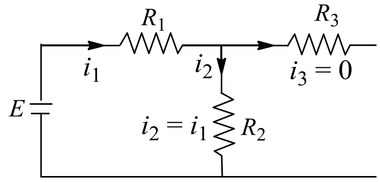
$$q = \sqrt{2}\left(1 - \frac{1}{e}\right)\sin\left(t + \frac{3\pi}{4}\right)$$

263 **(b)**

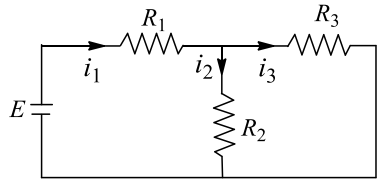
At $t = 0$, capacitor will behave like a short circuit and the inductor as open circuit but as $t \to \infty$, the nature is just opposite

264 **(a)**

At $t = 0$, circuit can be considered as follows:



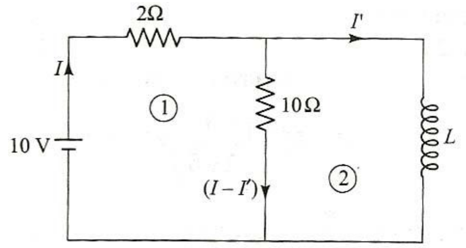
After a long time, circuit can be considered as follows:



Immediately after closing $S, \frac{di_3}{dt} \neq 0$. Because induced e.m.f. $\frac{Ldi_3}{dt} \neq 0$

265 **(b)**

From loop, applying Kirchhoff's law,



$12\,I - 10\,I' = 10$ ...(i)

From loop (ii)

$$-L\frac{dI'}{dt} + 10I - 10\,I' = 0$$

$I - I' = \frac{L}{10}\frac{dI'}{dt}$ ...(ii)

Solving simultaneously (i) and (ii), we have

$I' = 5 - 5e^{-\frac{5t}{3L}}$ ...(iii)

and $I = 5 - \frac{25}{6}e^{-\frac{5t}{3L}}$ ...(iv)

$$I - I' = \frac{5}{6}e^{-\frac{1000t}{3}}$$

$$E_L = \frac{1}{2}L(I')^2; E_L = \frac{125}{2}\left(1 - e^{-\frac{1000t}{3}}\right)^2 \text{ mJ}$$

Current in the inductor at $t = \infty, I' = 5$ A

$$E_L(t \to \infty) = \frac{1}{2} \times 5 \times 10^{-3}(5)^2$$

$E_L = 62.5$ mJ

$$E_C(t \to \infty) = \frac{1}{2}CV^2 = \frac{1}{2} \times 20 \times 10^{-6} \times 100$$

$= 1$ mJ

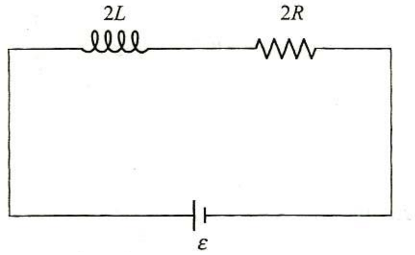
266 **(b)**

Since the field is increasing in inside direction in bigger loop, so the current will be induced to oppose this increasing flux. Hence in anticlockwise direction

$\phi = BA = B(l^2 + b^2)$

$$|\varepsilon| = \left|\frac{d\phi}{dt}\right| = \frac{dB}{dt}(\ell^2 + b^2) = 0.5 \text{ V}$$

$$i = \frac{\varepsilon}{2R}\left[1 - e^{-\frac{t2R}{2L}}\right] = \frac{0.5}{20}[1 - e^{-t}]$$



$$i = \frac{1}{40}[1 - e^{-t}]$$

267 **(b)**

Initially there is no current in the inductor

So initially, $V_A - V_B = \left(\frac{6}{1+5}\right) \times 1 = 1\text{ V}$ ...(i)

$V_A - V_C = \left(\frac{6}{2+4}\right) \times 2 = 2\text{ V}$ ...(ii)

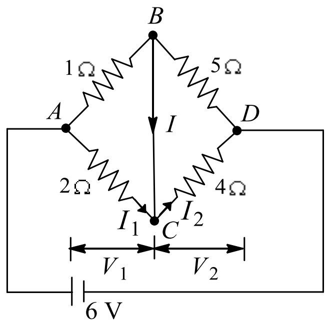
From (i) and (ii), $V_B - V_C = 2 - 1 = 1\text{ V}$

$\Rightarrow V_B - V_C = L\frac{di}{dt}$

$\Rightarrow 1 = 0.1\frac{di}{dt} \Rightarrow \frac{di}{dt} = 10\text{ As}^{-1}$

Current through 6 W resistor will remain constant because it is independently connected to 6 V.

After a long time, inductor will behave like a simple wire



1Ω and 2Ω are in parallel, their equivalent is $\frac{2}{3}$ Ω

5Ω and 4Ω are in parallel, their equivalent is $\frac{20}{9}$ Ω

$$V_1 = \frac{\frac{2}{3} \times 6}{\frac{2}{3} + \frac{20}{9}} = \frac{18}{13}\text{ V}, V_2 = V - V_1 = 6 - \frac{18}{13} = \frac{60}{13}\text{ V}$$

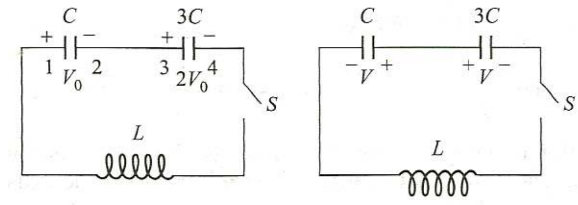
$$I_1 = \frac{V_1}{2} = \frac{18}{13 \times 2} = \frac{9}{13}\text{ A}, I_2 = \frac{V_2}{4} = \frac{60}{13 \times 4} = \frac{15}{13}\text{ A}$$

Current through inductor: $I = I_2 - I_1 = \frac{15}{13} - \frac{9}{13} = \frac{6}{13}$ A

268 **(a)**

When current is maximum $\frac{di}{dt} = 0$

∴ e.m.f. across $L = 0$, so potential difference across the capacitor will be same



From the law of conservation of charge on plates 2 and 3, $3CV + CV = 6CV_0 - CV_0$

$\Rightarrow V = \frac{5V_0}{4}$

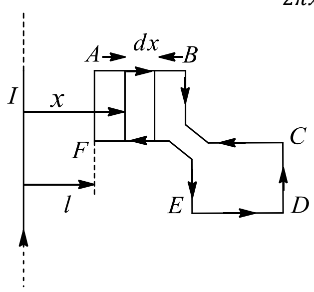
Loss in energy of capacitor = energy stored in inductor

$$\Rightarrow \frac{1}{2}CV_0^2 + \frac{1}{2}3C(2V_0)^2 - \frac{1}{2} \times 4CV^2 = \frac{1}{2}LI^2$$

$$\Rightarrow I = \frac{3}{2}V_0\sqrt{\frac{3C}{L}}$$

269 **(a)**

Consider a strip at a distance x from the wire of thickness dx. Magnetic flux associated with this strip $\phi = B(x)adx = \frac{\mu_0 Ia}{2\pi x}dx$



$$\phi = \frac{\mu_0 Ia}{2\pi}\left[\int_l^{a+1}\frac{dx}{x} + \int_{a+l}^{2a+l}\frac{dx}{x}\right]$$

$$= \frac{\mu_0 Ia}{2\pi}\text{ In}\left(\frac{2a+l}{l}\right)$$

$$M = \frac{\phi}{I} \Rightarrow M = \frac{\mu_0 a}{2\pi}\text{ In}\left(\frac{2a+l}{l}\right)$$

$$e = -M\frac{dI}{dt}$$

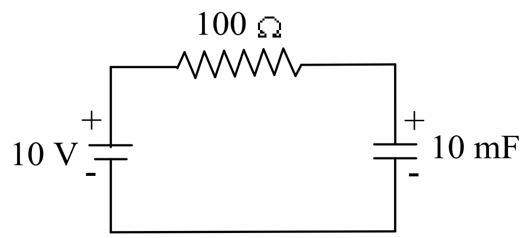
$$e = -MI_0 = -\frac{\mu_0 I_0 a}{2\pi}\text{ In}\left(\frac{2a+l}{l}\right)$$

Heat produced $= \frac{\varepsilon^2}{R}t = \frac{\left[\frac{\mu_0 I_0}{2\pi}\text{ In}\left(\frac{2a+l}{l}\right)\right]^2 at}{8\lambda}$

270 **(b)**

Initial charge $= CV_0 = Q_0$

$= 10 \times 10^{-3} \times 5 = 50$ mC



When capacitor is connected at position 1

$$E - IR - \frac{q}{C} = 0$$

$\int_0^t \frac{1}{RC} dt = \int_{Q_0}^{q} \frac{dq}{EC-q}$ or $q = 50[2 - e^{-t}]$ mC

At $t = 1$ s, $q = 50\ [2 - e^{-t}]$

Voltage across the capacitor at that time

$$V = \frac{q}{C} = \frac{50[(2 - 1/e)]}{10 \times 10^{-3}} = 5 \times 10^3[2 - (1/e)] \text{ V}$$

$$\frac{1}{2}Li^2 = \frac{1}{2}CV^2 \Rightarrow i = \left(2 - \frac{1}{e}\right) \times 10^4 \text{ A}$$

Frequency $= \frac{1}{2\pi\sqrt{LC}} = \frac{100}{\pi}$ Hz

271 **(b)**

The equivalent inductance $L = 500$ mH. Just before opening the switch, current through the inductors is

$$I_M = \frac{200}{100} = 2 \text{ A}$$

Potential drop across the resistor is $2 \times 100 = 200$ V

Hence, across capacitor potential difference is zero. So energy stored

$$U = \frac{1}{2}L(2)^2 = \frac{1}{2} \times 500 \times 10^{-3} \times 2^2 = 1 \text{ J}$$

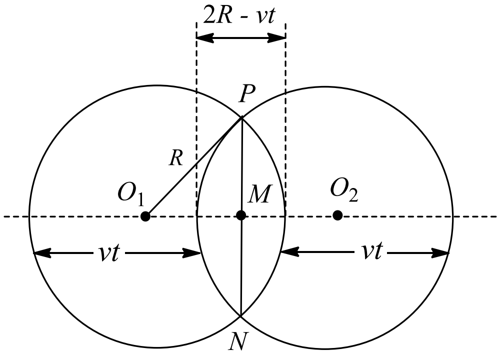
$$\frac{1}{2}LI_M^2 = \frac{1}{2}CV_{\text{max}}^2 = 1 \text{ J}$$

$$V_{\text{max}} = I_M\sqrt{\frac{L}{C}} = 2 \times \sqrt{\frac{500 \times 10^{-3}}{50 \times 10^{-6}}} = 200 \text{ V}$$

$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{500 \times 10^{-3} \times 50 \times 10^{-6}}} = 200 \text{ rad/s}$$

272 **(8)**

$$O_1M = (vt - R) + \left(\frac{2R - vt}{2}\right) = \frac{vt}{2}$$



$$\ell = PN = 2\sqrt{R^2 - (O_1M)^2} = 2\sqrt{R^2 - \left(\frac{vt}{2}\right)^2} = \sqrt{4R^2 - v^2t^2}$$

so $E = Bvl = Bv\sqrt{4R^2 - v^2t^2}$

given $R = 5$ m, v=2 m/s, $t = 3$ s

$E = 0.5 \times 2\sqrt{4 \times 25 - 4 \times 9} = 8$ V

273 **(2)**

$$\int \vec{E}\vec{d\ell} = -A\frac{dB}{dt}$$

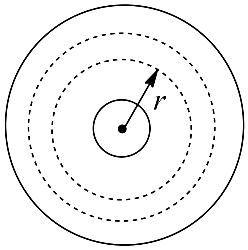
As $B = 17 + (0.2)\sin(\omega t + \phi)$;

$E(2\pi r) = -\pi r^2(0.2)\omega\cos(\omega t + \phi)$

$$E = -\frac{r}{2}(0.2)\omega\cos(\omega t + \phi)$$

Magnitude of the amplitude$= \frac{r}{2}(0.2)\omega = 2 \times 10^2$ mN/C

274 **(7)**



The magnetic field inside is only due to current of the inner cylinder

$$B = \frac{\mu_0 i}{2\pi r}$$

Magnetic field energy density is not uniform in the space between the cylinder. At a distance r from the centre

$$u_B = \frac{B^2}{2\mu_0} = \frac{\mu_0 i^2}{8\pi^2 r^2}$$

Energy in volume of element (length ℓ)

$$dU_B = u_B\, dV = \frac{\mu_0 i^2}{8\pi^2 r^2}(2\pi r\ell)dr = \frac{\mu_0 i^2 \ell}{4\pi}\frac{dr}{r}$$

$$U_B = \frac{\mu_0 i^2 \ell}{4\pi}\int_a^b \frac{dr}{r} = \frac{\mu_0 i^2 \ell}{4\pi}\,\ell n\frac{b}{a}$$

Using values, we get $U = 7$ nJ

275 **(2)**

$$\Delta\phi = R(\Delta q) = R\int idt$$

$= R$ [area under $i - t$ graph]

$$= \frac{1}{2}(4)(0.1)(10) = 2\text{Wb}$$

276 **(1)**

The rate of electrical energy consumed in the bulb=rate of loss of gravitational PE of the mass $= Mgv = 100$ W. Hence $M = \frac{100}{10\times 10} = 1$kg

277 **(8)**

The mutual inductance of solenoid coil system

$M = \mu_0 n_1 N_2 A_2 = \mu_0 n_1 N_2 \pi r_2^2$

$= 4\pi \times 10^{-7} \times 2 \times 10^4 \times 100 \times \pi \times (0.01)^2$

$= 8\pi^2 \times 10^{-5}$ H

EMF induced in the coil: $e_2 = -M\frac{\Delta i}{\Delta t}$

$$= -8\pi^2 \times 10^{-5} \times \left(\frac{-2 - 2}{0.05}\right) = 640\,\pi^2 \times 10^{-5} \text{ V}$$

Required charge:

$$q = i\,\Delta t = \frac{e}{R}\,\Delta t = \frac{640 \times \pi^2 \times 10^{-5}}{40\,\pi^2} \times 0.05 = 8\ \mu\text{C}$$

278 **(5)**

Induced EMF $= \frac{1}{2} B\omega\ell^2$

Maximum current: $i_0 = \frac{B\omega\ell^2}{2R}$

Torque about the hinge P is

$$\tau = \int_0^t i(dx)Bx \Rightarrow \tau = \frac{1}{2} iB\ell^2$$

Putting $i = i_2/2$, we get: $\tau = \frac{B^2\omega\ell^4}{8R} = 5$ mNm

279 **(8)**

After long time, from conservation of momentum

$mv_0 = 2mv; v = \frac{v_0}{2} = 8$ m/s

280 **(4)**

$$e = M\frac{dI}{dt} = M\,4t = 20t$$

$$i = \frac{e}{R} = \frac{20t}{10} = 2t, q = \int Idt = \int_0^2 2tdt = 4 \text{ C}$$

281 **(5)**

The total flux through N turns of the coil,

$\phi_{\text{total}} = NBA\cos\theta$

According to Faraday's law of electromagnetic induction

$$E_{\text{induced}} = -\frac{d\phi}{dt} = -\frac{d}{dt}(NBA\cos\theta)$$

$$= -(NA\cos\theta)\frac{dB}{dt}$$

The current induced in the coil,

$$I_{\text{induced}} = \frac{E_{\text{induced}}}{R} = 5 \text{ A}$$

282 **(8)**

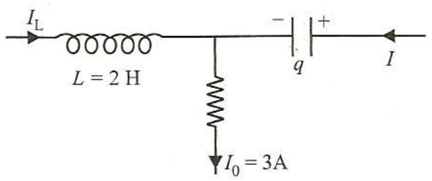
$$V_A - IR + E - L\frac{dI}{dt} = V_B$$

$$\Rightarrow V_A - 5 \times 1 + 8 - 5 \times 10^{-3}(-10^{-3}) = V_B$$

$$\Rightarrow V_B - V_A = 8 \text{ V}$$

283 **(4)**

$$q = CV, I = \frac{dq}{dt} = C\frac{dv}{dt} = V\frac{dC}{dt}, I_L = I_0 - I$$



$$\frac{dI_L}{dt} = \frac{dI_0}{dt} - \left[C\frac{d^2V}{dt^2} + \frac{dv}{dt}\frac{dC}{dt} + \frac{dV}{dt}\frac{dC}{dt} + V\frac{d^2C}{dt}\right]$$

$$= -1 \times 10^{-3} - \left[6 \times 10^{-3} \times \frac{1}{2} + 2(-0.5 \times 10^{-3}) + 2(0.5 \times 10^{-3}) + 0\right]$$

$$= -2 \times 10^{-3} \text{ A/s}$$

$$V_L = L\frac{dI_L}{dt} = 2 \times 2 \times 10^{-3} = 4 \times 10^{-3} \text{ V} = 4 \text{ mV}$$

284 **(8)**

Potential difference across the coil is $V = L\frac{di}{dt}$

or $V = (1)(4) = 4$ V

Now energy stored per unit time = power

$= Vi = (4)(2) = 8$ J/s

285 **(6)**

From energy conservation: $\frac{1}{2}CV_0^2 = \frac{1}{2}CV^2 + \frac{1}{2}LI^2$

$$\Rightarrow \frac{1}{2} \times 2 \times 10^{-6} \times 12^2 = \frac{1}{2} \times 2 \times 10^{-6} \times 6^2 + \frac{1}{2} \times 6 \times 10^{-6} I^2$$

$\Rightarrow I = 6$ A

286 **(1)**

After charging, charge on capacitor $= C\varepsilon$

Now, at $t = 0$ two circuits are formed

1. Discharging of capacitor

$$q = C\varepsilon\, e^{-t/\tau_C} = C\varepsilon e^{-t/2RC}$$

$$i_1 = -\frac{dq}{dt} = \frac{\varepsilon}{2R} e^{-t/2RC}$$

2.Growth of current in $L - R$ circuit

$$i_2 = \frac{\varepsilon}{2R}[1 - e^{-t/\tau_L}]$$

Now, $i_1 = i_2$

$\frac{\varepsilon}{2R} e^{-t/\tau_C} = \frac{\varepsilon}{2R}[e^{-t/\tau_L}]$ ...(i)

Give $L = 4CR^2$

$$\frac{L}{2R} = 2RC = \frac{1}{\text{In } 2} \Rightarrow \tau_C = \tau_L = \frac{1}{\text{In } 2}$$

Solve to get $t = 1$ s

287 **(6)**

Flux through circular ring

$$\phi = (\mu_0 nI)\pi r^2$$

$$\phi = \frac{\mu_0}{L}\pi r^2 I_0 \cos 300t$$

$$i = \frac{d\phi}{Rdt}$$

$$i = \frac{\mu_0 \pi r^2 I_0}{RL}.\sin 300t \times 300$$

$$= \mu_0 I_0 \sin 300t \left[\frac{\pi^2.300}{RL}\right] \Rightarrow M = I.\pi r^2$$

On comparing,

$$\therefore N = \mu_0 I_0 \sin 300t \left[\frac{\pi^2 r^4.300}{RL}\right] \quad [\text{Take } \pi^2 = 10]$$

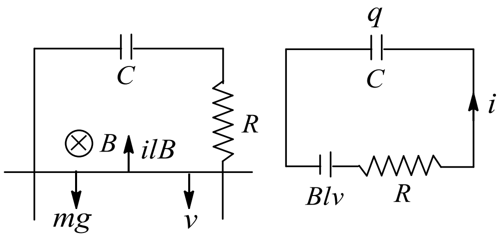
$$= \frac{10 \times 10^{-4} \times 300}{0.005 \times 10} \Rightarrow N = 6$$

288 **(7)**

Induced emf should be equal to 10 V

$$e = A\frac{dB}{Dt} \Rightarrow 10 = \left(\frac{10}{100}\right)^2 \frac{7}{\Delta t} \Rightarrow \Delta t = 7 \text{ ms}$$

289 **(5)**



By Newton's law, $mg - ilB = m\frac{dv}{dt}$ (i)

Using KVL $Blv = iR + \frac{q}{C}$ (ii)

Differentiating equation (ii) w.r.t time, we get

$Bl\frac{dv}{dtr} = R\frac{di}{dt} + \frac{i}{C}$ (iii)

Eliminating $\frac{dv}{dt}$ from equations (i) and (iii), we get

$$mg - ilB = \frac{m}{Bl}\left[R\frac{di}{dt} + \frac{i}{C}\right]$$

$$\Rightarrow mg\,Bl - iB^2l^2 = m\left(R\frac{di}{dt} + \frac{mi}{C}\right)$$

I will be maximum when $\frac{di}{dt} = 0$. Use this in equation (iv)

$$\Rightarrow mg\,B\ell C = i(B^2\ell^2C + m)$$

$$\Rightarrow i_{\max} = \frac{mgB\ell C}{m + B^2\ell^2C}$$